Evaluation of Greek Public Hospitals' allocation in Central Macedonia

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Abstract—In order to contribute to the deeper understanding of health domain and assist the community to prepare to meet possible health related risks, health monitoring and exploring procedures using Geographical Information Science are considered of critical importance. This study aimed at depthening of the understanding of the health environment in Central Macedonia, Northern Greece through the utilization of a socio-spatial dialectic. Arc-GIS software was the instrument of choice to organize and analyze the data in an effort to investigate the satisfaction level and the accessibility status of Chronic Disease Patients towards public hospitals of Central Macedonia in Greece. The final outcome revealed that there is no significant need to make adjustments in the distribution of public hospitals.

Keywords—Public Health Monitoring, GIS Visualization, Hospitals Acessibility Status.

I. INTRODUCTION

)*ITH a single collection of tools,* 667 Geographical Information Science (GIS from now on) is able to bridge the gap between curiosity-driven science and practical problem solving". [1] This is already done for several areas of societal issues and of scientific fields like, for instance archeology, geology, topography, demographics. development and landscape architecture [2] etc. In those fields GIS plays a very important role either directly or as an aid instrument for mapping and analyzing data and revealing new patterns that could lead to better understanding of knowledge that might already exist or generate new knowledge that needs further consideration [1].

Health is a scientific area of immense public interest and GIS contributes towards its improvement [3]. For instance Public health mapping with GIS have been adopted from World Health Organization to facilitate health planning programmes. So GIS can enforce wellbeing as a diagnostic tool in a Global, National or regional or even smaller area level, where data can be detected or created. Thus GIS can display, or even beter, reveal patterns of health diseases which can be opposed to health determinants distribution. This way the task of managing health population risks can be facilitated [4]. Hospitals are mostly secondary level medical health centers and their accessibility as a factor of pertaining quality public health is of great importance. Therefore, the promotion of better access to Hospital Centers can be of benefit to the public health improvement. GIS can contribute to the development of a robust and efficient health infrastructure suggesting optimum organization of the facilities needed. This has the potential to lead decision makers to the selection of the best and less costly system that might improve disability persons' access to the healthcare system [4].

Thereby, GIS could be utilized by the decision makers to help evaluate the current status of the health system in Central Macedonia of Nothern Greece addressing the following quests:

- Are disabled people generally satisfied with the way the secondary public healthcare system treats them?
- Are secondary public health centers in the region, allocated for chronic disease people, situated in the appropriate locations for the cause?

II. AIMS AND OBJECTIVES

This study aims to enforce the evaluation of the allocation of Public Hospitals in light of the human geography of disabled people (as a consequence of a chronic disease). With that goal in mind the following objectives had to be fulfilled:

- Map public hospital centers in Central Macedonia Nothern Greece,
- Create layers of disability population distribution in the region at county scale,
- Explore data for health inequalities at county scale.

III. LITERATURE REVIEW

The data acquisition, gathering and analysis are of most importance for Computer based systems and especially for those that describe the "where" issue of every human problem that needs a solution. Jones Christopher believes that GIS can deal effectively with the "where" problem and through analysis of data can monitor and visualize human life addressing the "where" issue [5]. He appreciates GIS more as a computer-based handling tool than a method for discovering new knowledge.

Dana Klimesova and Eva Ocelikova argue that

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"Geography is a framework for organizing our global knowledge and GIS is the technology for being able to create, manage, publish and disseminate this knowledge for whole society"[6]

Longley (*et al*) stresses this GIS scientific approach by clearly noting Health as a GIS application area [1].

Scientists can use GIS as a method and tool that can provide outstanding results in understanding of location and its relation to other health variables [7]. Public health investigation (diseases, morbidity and well-being) and Healthcare provision (diagnostic and treatment) are two areas of great interest for GIS analysts in the Health sector of human societies where GIS can be applicable [8]. Lang said it quite correctly:

"From contacting clinical field work in Kenya to constructing new Hospitals in Sweden, health professionals use GIS to visualize and analyze geographic elements in every branch of health management" [9].

A study conducted by Maniou and Iakovidou revealed the current situation in Greece public and private sector in their research with great details. They are illustrating many aspects of the Greek National Health System (GNHS from now on) and they are concluding that public health sector in Greece should consider to improve their services provisions and promote better health policies in order to be comparable with private health sector [10].

The Greek Ministry of Health and Social Solidarity (MHSS from now on) tried to improve the GNHS, by creating an interactive site where all the relevant agents (physicians, nurseries, health staff and public) can contribute towards the construction of robust and relevant databases. It is called the Health Map of Greece and presents with the aid of a GIS system, epidimiological, demographic, environmental data that affect public health in a sort or long term. One of its main data sources is the National Statistics Agency. The National School of Public Health also collaborated with the above Ministry to create and analyse these kinds of data.

These days in Greece the MHSS prepares a reformation of clinics and management departments in public hospitals. This fact opened a large discussion in society for the effectiveness of such plans and brought out once again the problems that chronic disease patients facing in GNHS [11].

In Greece there has been a research exploitation of GIS systems, from public universities and private organizations mostly for sysmology predictions, mapping of archeological areas, cadastral projects, coastal mapping, agriculture, etc. [12]. As far as Healthcare provision conserns, little has been made. Additionally from the Internet research emerged that there is not any kind of GIS integration with Healthcare management yet. Thus there is a great opportunity for researchers to apply GIS in Health area and especially here in Central

Macedonia where the benefits of such systems is needed to enhance health management in order to improve health provision, prediction and education promotion.

IV. METHODOLOGY

A. Study Area

Central Macedonia (CM from now on) is the study area and one of the thirteen administrative regions of Greece. It is cited in the north area of Greece and the city of Thessaloniki, the second largest in Greece, is its capital. It consists of 7 periferal units (counties) and 38 municipalities and as a region presents increased precentages of Chronic Disease Patients (CDP from now on) which have complaints about current public health services provision and so worthy of research investigation [13].

The cancer patients, the renal failure patients and thalassemia patients are the 3 catogories of CDP this research focused on as severe medical cases. As the conversations with medical staff, managers and staff of relevant associations and the internet research revealed, those CDP have to visit a hospital for treatment reasons many times. To be more specific, people who suffer from renal failure have to visit a hospital even three times a week for their dialysis. Thalassemia patients need RBC transfusion every 20-30 days and cancer patients need their chemiotherapy, maybe radiotherapy sessions and frequently medical examinations.

It was also decided to concentrate to the secondary public health level meaning public hospitals in CM because nowdays more people tend to address their health needs to public hospitals which provide their services to anyone almost for free. Thus public hospitals accessibility and the quality of their health services should attract more attention.

Arc-GIS software is the instrument of choice suitable for editing and presentation of all available data. The first Geographical outcome of this software was the map of Greece in Fig. 1 below. The spatial data needed for the Greece basic map layer were found after a quick Internet inquiry and downloaded from DIVA-GIS site and the WORLDATLAS site.

As a result and from observing the right side of the projection we can spot at a glance at which part of Europe, Greece resides and from observing the legent and the left side of the projection we can clearly indicate CM region among other regions. Both maps were produced in WGS84 Geodetic system and were projected in GGRS87 Greek Grid projection system. Of course the .gif map image of Europe did not undergo any topological transfomations because it was displayed directly as an image icon.



Fig. 1: Central Macedonia in Greece

B. Distribution of Hospitals

The second geographical action necessary for this research purposes was to produce a point map layer of Public Hospitals in CM and thus display the current situation of their distribution in municipality geographical scale and later on in county scale. A full mapping of Greek Public Hospitals in CM, necessary in part for this research, can be found on the MHSS Internet site. At first a new CM layer map was produced into Arc-GIS after inserting a spatial data file of Greece from the Greek Cadastral and Cartohgraphy Agency site [14]. At this point, all the hospitals of CM that have an immediate medical relationship with the chosen CDP categories were found through Internet. It was decided eventually that the public hospitals to be selected for the study would be only those that maintain special staff and equipment that could respond to any medical treatment necessary for those CDP.

The remaining 10 hospitals' geographic data formed, with the basic contribution of Arc-GIS, a new layer placed over CM layer. The georeferencing of pointhospitals was made by the address coordinates of the hospitals (Google Map) in decimal degrees (WGS84 datum) as longitude and latitude for every hospital's spatial reference and were transformed into meters as easting and northing, through CoordTrans software in order to fit in GGRS87 easting and northing projected cartecian system respectively [15].

To produce a map that clearly illustrates all hospitals, 2 new layers were exported, a polygon from CM Municipalities by selecting and exporting Thessaloniki's Urban Area Municipalities called "Thessaloniki Urban Area" and another likewise from CM Hospitals and "Thessaloniki Hospitals" layers ready and functioning. The 2 new layers were dragged and dropped into a second group layer. After the appropriate symbolization procedures with Arc-Map tools, the resulted projection was a choropleth map of CM Municipalites Population and Public Hospitals as the main layer at the left side and a choropleth map of Thessaloniki's Municipalities Population and Public Hospitals, magnified enough to be distinguished, as a second layer at the right side (Fig. 2). By observing the left and the right side of the map it can be detected that Hospitals are located mostly into urban areas and basically to most populated Thessaloniki Urban Area.

All the above describes the current location and distribution of Public Hospitals in CM. At this stage the research was requested to proceed in two basic methodological emergencies. First of all, to find the CDP sample size necessary for representing the entire population of CDP and secondly to construct a questionnaire that will be given for supplementation to CDP sample, in order to collect data needed for further processing.



Fig. 2: Spatial Distribution of Population and CDP Public Hospitals in CM

C. The Sample of Chronic Disease Patients

First the research sought some characteristics of the current socioeconomical status of CDP in CM, their general opinion about the GNHS and their accesibility status to public hospitals grouped into categories using MS Access. Next, demographic pie charts should be generated using MS Excel that would be imported into Arc-GIS in groups by country so as to perform a geo-statistical and geo-visualization analysis.

Next, the CDP were reached, mainly in hospitals, their associations and the researcher's circle of private contacts, to gather answers on specific questions as objective as possible away from medical staff or others which supposingly could influence their opinions. The sample consisted of a balanced mix of a fair analogy of CDP survey participants based on the population of each category in the CM.

The total population of renal failure patients in CM is approximately 3,000 people when the total national population is about 12,000. In the case of thalassemia patients the numbers are 800 and 3,500 respectively. The cancer patients number is much higher and the percentage in the sample much greater. This information was taken directly from the records of their associations in Thessaloniki, CM.

The survey was deployed for a period of 8 weeks (October, November 2011). The sample size, 258 participants) is appropriate considering the total population of the geographic area under study is around 2,500,000 residents yielding a rate of 1.03 respondents for every 10,000 individuals in the population close to the normal size of around 1,200 respondents of important public surveys on events like parliament elections in the country with a population around 9,000,000 and a ratio of around 1.3 respondents per 10,000 people. These CDP were approached in the 10 public hospitals and the 3 CDP associations in CM. There were also about 20 questionnaires or so filled up from author's circle of acquaintances. All gave their consent to participate.

The above sample population consists of people that work to the educational sector (15%), to the services provision sector (13%), as traders (10%) and they are mostly (Other 44%) pensioners. The other proffession's percentages thought off as too small to contribute towards a CDP profile. As far as their education 25% of the respondents have finished just the elementary education, 36% of them have a high school degree, 26% hold a bachelor's degree and 10% have a postgraduate degree, either a diploma (6%) or a Master's or Phd (4%). Just a 3% mentioned other education. Concerning their income 44% make up to 12,000 Euros annually, 30% make between 12,000 and 25,000, some 16% with 25,000 up to 50,000 and very few enjoy an income of 50,000-150,000 Euros (2%) or more than 150,000 (1%). There was a significant 7% unable or unwilling to answer. Most of the participants were 65 years old or more (31%), about a fifth of them (21%) between 50 and 65, a quarter of them (26%) between 35 and 49 and 17% of them were 18 to 34 years old. There was a small 4% of very young individuals and a negligent 1% that did not answer. There is no doubt that the statistics above prove the validity of the sample with only the part of the education shifting to some extend towards the less educated people.

D. Geovisualization methods

After the survey the patients' data collected were organized so as to be used in the Geostatistical and Geovisualization analysis that followed using Arc-GIS. This georeferencing was of critical importance for exploring the sample data with Arc-GIS grouped maps and producing 3 more Arc-GIS maps of CDP travel distance accessibility level, expences accessibility level and satisfaction level. The chosen and most appropriate scale would be the county scale. The desired outcome would be to evaluate at the end the satisfaction and accesibility levels of CDP and conclude if there is any need to reconsider the allocation of public hospitals.

V. FINDINGS

A. Spatial exploration of sample data

The inner spatial analysis performed by profession, in Arc-Map showed that Teachers residentials are clustered in Thessaloniki urban area and generally closely to their prefered Hospitals (Fig. 3). About the same phenomenon occurred for clerks and traders.



Fig. 3: Spatial Distribution of CDP Teachers over CM On the other hand pensionners are located in larger extent to less populated areas and further away from urban areas and as a consequence from their prefered Hospitals (Fig. 4).



Fig. 4: Spatial Distribution of CDP Pensioners over CM

The clustering of active workers above indicates their capability and their determination to live close to their prefered Public Hospitals and as such obtain a grater safety level for themselves.



Fig. 5: Spatial Distribution of Higher Education CDP over CM



Fig. 6: Spatial Distribution of Elementary CDP over CM

The maps in Fig. 5 and Fig. 6 resulted from Arc-GIS inserting the attribute of education of the participants from one of the first four questions. It should be noted, again, that although in these maps it looks as if there are no hospitals, actually there are but of no interest for the study since they are not employing specialized staff for the case.

From observing closer the Fig. 5 map, it seems that Thessaloniki, as a vibrant large city, attracts the most educated individuals and families and, consequently, it is the target of health policy makers to establish as many health centers well staffed and organized as possible. This is in contrast to map 6 that illustrates the dispersion of individuals with lower education who prefer the countryside of Central Macedonia and for whom there is no major effort to cover all their medical needs assuming they are in relatively close proximity to Thessaloniki. As to the rest of the educational levels analysis did not show significant inequalities in the distribution of CDP over CM at public hospitals.

As to the income level, by performing a multi-layer spatial analysis on low, middle and high income CDP residences projections (layers) the research shows the dispersion of CDP over CM is reflecting the decrease of income level (Fig. 7, 8 and 9). The center of their residencies concentration is once again located at Thessaloniki's urban area.



Fig. 7: Spatial Dispersion of High Income CDP over CM



Fig. 8: Spatial Dispersion of Middle Income CDP over CM



Fig. 9: Spatial Dispersion of Low Income CDP over CM

By using Arc-Map to illustrate CDP distribution over CM and after investigating every age category separately, no significant inequalities were observed. The research continued by grouping the age classification into two general categories, namely the youngsters (up to 49 years old) and the elders (from 50 to over 65 years old). But once again no differences were found in their doublelayer comparing procedure performed in Arc-Map. So no significant results could be possible to emerge and thus no map projection was thought to be necessary for further presentation.

B. Spatial distribution of CDP Accessibility



Fig. 10: CDP Distance Accessibility to CM Hospitals by County

The map of Fig. 10 illustrates responses on the distance to be covered to get access at the hospitals. In this map, the two darkest grey slices of the pies are relatively large comparing them to the light grey and white pie slices in all counties around Thessaloniki County. The map suggest that CDP in Thesaloniki's County travel short distances (light grey and white pie slices) and inside their County to approach second health public services and that all the other CDP around them are obliged to travel long distances every time they need a Public Hospital services. It also reveals a trend of CDP to travel to Hospitals of Thessaloniki County. This trend is more noteworthy for Imathia and Serres County because despite the fact that they have Public Hospitals in their capitals, they still depict high percentages in long distance travelling. This trend is examined further in the next section.

From the fact that 67.05% of the sample population (173/258) CDP live and work in Thessaloniki County and by observing the map one can draw the conclusion that generally CDP of CM do not have to make long distances to approach Public Hospitals. Therefore, their accessibility level depending on Distance Travel to Public Hospitals can be characterized as high. Thus, their degree of safety and satisfaction is enhanced by the distance determinant factor.



Fig. 11: CDP Cost Accessibility to CM Hospitals by County

As for the Travel Expences factor in CM region, map of Fig. 11 illustrates, in the two dark grey pie slices that cost levels are high in all counties around Thessaloniki and show a significant reduction inside Thessaloniki County. Generally speaking this was expected due to the fact that low income CDP (Fig. 7) account for the 74% of the sample. So CDP accessibility level depending on Travel Expences to Public Hospitals can be characterized as low. This fact declines their degree of safety and satisfaction.

C. Spatial Distribution of CDP Satisfaction

The existence of Public Hospitals and their level of quality in health service provisions prove the level of treatment that GNHS is determined to offer to CDP. So, as long as Public Hospitals supply high-quality health services to CDP their level of satisfaction will be high. Therefore their safety level will reach high standards and as a consequence the local society will strengthen its confidence to GNHS that would finally affect positively their morbidity status.

Responses on the level of satisfaction of CDP, illustrated in the map of Fig. 12, suggest that the level of satisfaction in CM region is high. As it can be observed the white, and the two lighter grey pie slices dominate over the whole terittory of CM which means that most CDP are totally or quite or marginally satisfied from the level of services that public hospitals have to offer.



Fig. 12: CDP Satisfaction Map of Public Hospitals Treatment

The small cut of dark grey pie slice in Thessaloniki County on the other hand shows that there are few dissapointed CDP. All the others are satisfied especially CDP at Kilkis, Serres, Chalkidiki and Pella. It is worth to note the marginally satisfied grey pie slices on the map because they indicate large percentages of defficiences complaints from CDP especially in Serres, Imathia, Pieria and Thessaloniki where Public Hospitals are located.

D. Accessibility vs Hospital Preference

The previous analysis suggests that the CDP in the sample are very satisfied with the treatment quality of Public Hospitals even if they spot deficiences. Even those who have to travel a lot to arrive to Public Hospitals and those who makes complaints about travel expences seems to be satisfied. There is no indication that accessibility level affect satisfaction level as much as expected.



Fig. 13: CDP Hospital Preference Map

So, the last part of the findings relate to the spatial preference behaviour of CDP for Public Hospitals. The map in Fig. 13 indicates that hospitals of Thessaloniki County are immensely more prefered (236/258 CDPs; 91.4%) than the rest of the counties' hospitals. However, analysis also shows that 223 out of 258 (86.4%) of CDP live in Counties with Hospitals which can address their health needs.

Thus, it could be argued that despite cost travel limitations most CDP prefer Thessaloniki's Hospitals to address their health needs for treatment. In addition even those who travel long distances to reach Hospitals (like CDP of Chalkidiki County or Kilkis County) present high levels of satisfaction. So, generally the confidence level of CDP to GNHS is influenced more by Public Hopsitals quality services than travel distance or travel expences of CDP.

VI. DISCUSSION AND CONCLUSIONS

Thessaloniki county and especially Thessaloniki urban area naturally depicts high numbers of population and therefore high numbers of CDP population. This, however, should not suggest other areas deserve less attention than Thessaloniki County. Thus, it was important for this study to approach much less populated areas and proceed to research trying to get a general CDP opinion about GNHS emerged by their accesibility level and level of satisfaction as far as CM Public Hospitals are concerned.

The high levels of satisfaction, suggested by this investigation, for second level public health services, discharge the need for Hospitals reallocation. Furthermore, the reality of 86.4 % of CDP living close to

Public Hospitals highlights that the accesibility levels are high due to travel distance and travel expences. This is further stressed by the fact they pay a small amount of money relative to the high quality of health services provided by Public Hospitals. Even the 13.6% of CDP that supposedly suffer serious travel expenses are reimbursed those by their public insurance company.

The uninsured CDP may have to pay much more for travelling but they can also have access to treatment in Public Hospitals with low expences. There should be surely an extra care for low or no income CDP and this is something that private and public health associations and organizations have the obligation to look after. Maybe their managers should consider performing a special GIS research to investigate the spatial behaviour of poor CDP in order to offer them what they really need so as to make their access to Public Hospitals easier. Another dimension of high importance is the interpretation of high CDP satisfaction levels towards Public Hospitals and their preferation trend to live near them.

Of course this paper can not refuse its uncertainty concerns arising in the implementation procedure like for instance the likelihood of different outcomes when choosing some other kind of division scaling as the dominant scale (Modifiable Area Unit Problem).

Another uncertainty concern of this research was to use geographical and attribute data as updated as possible. As a concequence, the uncertainty level of results was declined.

Because of the Arc-Map effectiveness in transforming geotedic systems (WGS84 to GGRS87 in this case) the overall uncertainty of the results was minored once again.

Uncertainty issues were faced also in the human recording and inserting sample data phase of this research. But, the uncertainty level depended on human error typing was rather small due to the small number of sample records of geodatabases and the excess precaution measures taken by the researcher.

Subsequently, and during the GIS visualisation face a need for seeking new knowledge arised. More specifically, the birth of new dimensions on the paper topic was experienced. For example, something else that could be thought off as important is the formal scale of Public Hospitals. Besides the secondary and primary healthcare division there is a larger one which is the geographical division of Greece in Health Districts (seven to be precise). So a Health District research of CDP could be interesting.

The dimension of time could be also inserted as a variable in this research and with dynamic cartography tools it could be possible to produce dynamic maps. For instance there could be another question for CDP in questionnaire's form that indicates their residency changes over time. So, the resulting dynamic map of changing residences over time could investigate the internal migration of CDP in more detail.

Maybe there could be a research with satelite images presenting, through GIS systems, the CDP residences

geography over time so to illustrate a trend pattern of CDP soil occupation in the future [16].

Moreover and even if the need for geographical reallocating of Public Hospitals does not seam necessary there could be a multiple criteria decision analysis (MCDA) performed to provision and suggest possible places for Hospitals permitable establishments in CM by using Arc-GIS spatial analysis abilities. The chosen criteria could be a Land Use Land Cover Analysis excluding the unavailable areas, a Proximity Road Analysis excluding by buffering, areas that are far from central roads and a CDP Density Analysis to find areas close to CDP clusters [17]. All of them could be processed and combined with spatial analyst tools that Arc-Map provides through arc-toolbox functionality.

Such as perceived, there are more analytical ways to extend the effectiveness of this research or find other research issues but due to time, human resources and financial limits they could not continued.

To bring it all together, this research illustrated that the majority of travel distances that CDP have to suffer to reach Public Hospitals are rather small and therefore, the travel expences is relatively small too, even if they claim otherwise. In addition CDP are in general satisfied by Public Hospitals' Health Services offered despite some observed defficiencies.

All the above drive this research to the conclusion that CDP of Central Macedonia believe that they enjoy high quality of medical services in CM Public Hospitals. As a concequence they are pretty sure that GNHS treats them fairly enough. Finally the research does not find any substantial reasons to suggest alternative locations for the establishment of CDP prefered Public Hospitals.

So, dispite the technical and methodological difficulties, with the right editing and beyond cartography, the answers to geospatial questions have been given with close promiximity to reality thanks to GIS analysis. This analysis resulted to a better understanding of CM health domain and highlighted the need of monitoring periodically the allocation of public hospitals in the terretory.

Nevertheless, GIS endorced a socio-spatial dialectic which created new knowledge and reincarnated the need for further understanding and visualization over results so to find new ways of gaining knowledge.

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