Improving Greek Medical Facilities in Central Macedonia

Paul Nikolaidis, Dimitrios Xanthidis

Abstract—The monitoring and exploring competencies of GIS health mapping can enhance health knowledge communicability in health society and thus provide a grater consensus among all health stakeholders. The persistence to investigate further the need for reallocation of the public hospitals in the Central Macedonia region of Greece gave birth to the illustration of a density map produced by the involvement of Arc-GIS software as a health monitoring and exploring paradigm. The resulting suggestion was the progression of Giannitsa's General Hospital equipment and staff because of its strategic position concerning the homelands of the patients involved in this research.

Keywords—E-Health, Health Provision, Patients' Density Map

I. INTRODUCTION

Handling geographical information with computer systems to enable the better understanding of the world triggers the need to place information in geographical context. That "where" issue of every human activity plays a special role in comprehending human life. Geographical Information Systems have undertaken the need to address such matters and they proved to be an effective way of monitoring and visualizing many aspects of human life [1].

"With a single collection of tools, GIS is able to bridge the gap between curiosity-driven science and practical problem solving" [2]

This is already done for several areas of societal issues and of scientific fields like, for instance, archaeology, geology, topography, demographics, etc. In those fields GIS plays a very important role either directly as a core application or as an aid instrument for mapping and analyzing data and revealing new patterns that could lead to better understanding of existing knowledge or to generate new knowledge that needs further consideration.

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But GIS can contribute also, as Luc Loslier strongly states in the International Workshop held in Sri Lanka, in Health planning and Health education. The appropriate establishment of Health centres can be considered as part of the health planning. This "where" problem of health centres can be addressed by GIS facilities which can suggest a more robust distribution of hospitals and, as consequence, of health provisions in general [3].

So, in the case of public Health, the element of right location is of critical importance for the establishment of medical health centres. The Greek National Health System is based mainly on public hospitals to address the health needs of chronic disease patients. Therefore their distribution attracts a significant interest. So, in this case the following quest could be justified: are secondary public health centres in the region, allocated for chronic disease people, situated in the appropriate locations for the cause?

II. AIMS AND OBJECTIVES

More specifically, this research study aims at helping evaluate the public hospital centres distribution of Central Macedonia through the spatial analysis of chronic disease patients' geography. With that goal in mind the following objectives had to be fulfilled:

- Map public hospital centres in Central Macedonia Northern Greece,
- Examine the data looking for health inequalities at county scale explaining the current situation,
- Investigate a better allocation proposal for public hospitals' through a density map.

III. LITERATURE REVIEW

Jones Christopher believes that GIS can deal effectively with the "where" problem and, through the analysis of data, can monitor and visualize human life addressing the "where" issue. He depicts GIS more as a computer-based handling tool than a method for discovering new knowledge. Longley, Goodhild, Maquire and Rhind underpin this GIS scientific approach clearly in page 13 and in the "Gallery of Applications" chapter they mention Health as a GIS application area [2].

Health is one more sector where GIS has found a fertile ground for producing great outcomes. One of the main reasons that GIS can produce a significant performance in utilizing health services is mentioned in the Ellen's Cromley and Sara's McLaferty work titled as "Public Health and GIS". This is to aid health care reform

for a better provision of health care services. The book is geographically focused on the United States of America and treats GIS as a computer based system that can lead health management [4].

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. It has been made very clear that a GIS system like Arc-GIS can be very successful. Through their tutorials they revealed the applicability of GIS in many areas of human activity and especially for health sector. They explained the used technology and gave relevant case studies and they pointed out the reasons that strengthen the necessity of GIS in improving Health management effectiveness [5].

The provision of better healthcare services can have a positive impact to public health indexes because of treatment reasons and because of psychological reasons as well, like the feeling of security in certain areas that have a Hospital nearby that can cover all patients' needs. As Dr Cathrine Emma Jones stated:

"Health Inequalities People in disadvantaged circumstances prone, to more illness, to greater distress, to more disability and to shorter lives" [6]

A study conducted by Maniou and Iakovidou revealed the current situation in Greece public and private sector 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 [7].

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, epidemiological, demographic, environmental data that affect public health in a short 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 analyze these kinds of data.

These days in Greece the MHSS prepares a reformation of clinics and management departments in public hospitals. This fact opened an extensive discussion in the society for the effectiveness of such plans and brought out once again the problems that chronic disease patients facing in GNHS [8].

In Greece there has been a research exploitation of GIS systems, from public universities and private organizations mostly for seismology predictions, mapping of archaeological areas, cadastral projects, coastal mapping, agriculture, etc [9].

As far as Healthcare provision concerns, little has been done. 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, Greece, where the benefits of such systems is needed to enhance health management in order to improve health provision, prediction and education promotion.

For example, there should be a redistribution evaluation for every health unit in the country, to prevent inequalities in the GNHS, depended on geographical factor. It is an acceptable problem from Greece authorities and GIS can facilitate the efforts to find most appropriate areas for placing health units. At this point GIS specialists should be particularly thoughtful and sensitive for disabled people and people with special clinical needs when they are going to suggest such areas and when they care for such projects they should bear in mind the significance of health determinants.

IV. METHODOLOGY

A. Study Area

Central Macedonia (CM from now on, Fig.1) 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 peripheral units (counties) and 38 municipalities and as a region presents increased percentages of Chronic Disease Patients (CDP from now on) which have complaints about current public health services provision and so worthy of research investigation [10].
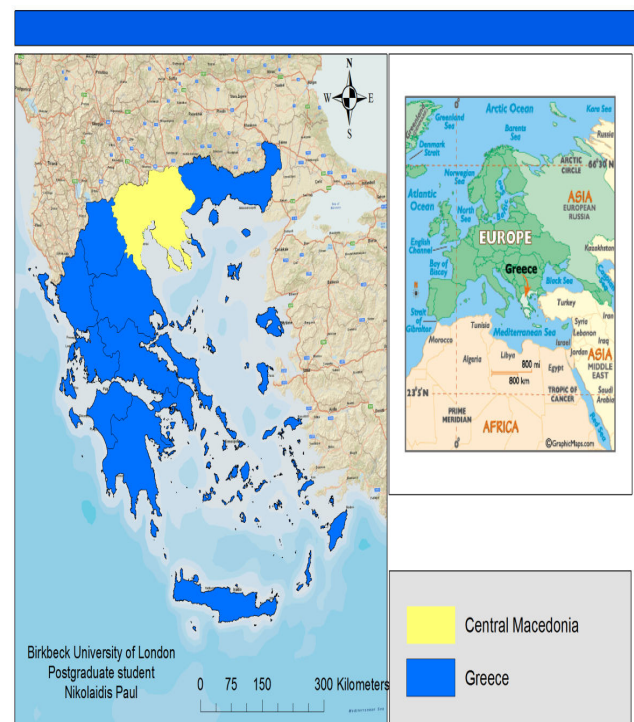

Fig. 1: Central Macedonia in Greece

B. Initiating research

At first the research began with an opening of a circle of contacts with medical staff in CM to discover the categories of Chronic Disease Patients that have an urgent and continuous need for hospital treatment and to find the ways to possibly administer a questionnaire in public hospitals with relevant health units. Of all the CDP categories mentioned three of them were chosen to be the representatives for this research purposes. This was done due to time constraints and because they could reveal the current situation as being severe CDP cases. Thus, the cancer patients, the renal failure patients and thalassemia patients became the three categories of CDP that this research focused on.

This research also decided to be concentrated to the secondary health level, meaning hospitals in CM, for almost the same reasons and because hospitals are more important for CDP than health centres of the first health level and that is because they have an immediate and frequent dependence for hospitals services. The research was focused also in public hospitals due to the fact that Greece is in a middle of an economic crisis. This influenced negatively the purchasing power of the people and so their ability to address health services in private hospitals.

As a consequence nowadays more people tend to seek for treatment at public hospitals that provide their services to anyone almost for free. Thus public hospitals accessibility and the quality of their health services should attract more attention.

As the conversations with medical staff, managers and staff of relevant associations and the Internet research revealed, CDP have to visit a hospital for treatment very often. 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 chemotherapy, maybe radiotherapy sessions and frequently medical examinations. All of them are also bound with the hospitals because of the special medical examinations they have to take every so often to help their doctors monitor their current health situation. So they are severe CDP cases and, hence, worthy to be the CDP representatives.

Another online investigation was followed to find all relevant articles and links about CDP and their health system environment especially in CM. From this search every association and medical units related to those patients were found as well as special information about the total populations of the three CDP categories in CM given the balance necessary for the survey sample.

Arc-GIS software is the instrument of choice suitable for the editing and presentation of all available data. The first Geographical outcome of this software was the map of Greece in Fig. 1 to spot easily the researched area. 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 WORLD-ATLAS site. The second geographical action necessary for this research purposes was to produce a point map layer of Public Hospitals in CM. A full recording of Greek Hospitals can be found on the MHSS Internet resource site.

At this point, the research was directed at finding all the hospitals of CM that have an immediate medical relationship with the chosen CDP categories. It was decided that in the end, the important and chosen hospitals should be only those that maintain special staff and equipment that could respond to any medical treatment necessary for those CDP. So, an Internet research began once again which leaded to a list of hospitals proper for our chosen CDP.

All of these hospitals are treating CDP but not all of them have special clinics or departments with full equipment dedicated to them. After communicating with those hospitals, interviewing CDP and by the Internet research it was clear that about ten (10) hospitals had to be excluded from the list of proper CM Hospitals for the selected CDP. Even if some of them where performing treating procedures, it was certain that they did not have permanent or specialized enough staff. For example, the General Hospital of George Genimatas has no Dialysis Unit (DU) or Thalassemia Unit (TU) or special Cancer Clinic (CC) inside. So, even if it performs cancer surgeries it cannot be included to CDP proper Hospitals' list. The General Hospital for Infectious Diseases and the Hospital for Venereal and Skin Diseases are two more cases that have no specialized units for the three chosen CDP and in addition, they are about to shut operations shortly. One more example of marginally excluded hospital is that of Poligyros General Hospital in Chalkidiki County where the phone call made there by the researcher revealed that there is only one thalassemia patient treated with no special equipment for RBC transfusion. So, the research proceeded with excluding those Hospitals from the mentioned Hospitals' list and finally retained a list of ten (10) Hospitals capable of ensuring treatment safety in all manners for those CDP.

After exclusion, georeferencing and symbolization procedures taken place in Esri's software (Arc-GIS), the researchers managed to create a CM Hospitals point layer on top of CM Municipalities polygon layer as shown in Fig. 2 (next section) in order to present the current allocation reality of public CDP hospitals in CM region.

C.   The Sample of Chronic Disease Patients

First the research sought some characteristics of the current socioeconomically status of CDP in CM, their general opinion about the GNHS and their accessibility 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 Geostatistical and Geo-visualization analysis.

Afterwards, the CDPs 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 other individuals that could influence their opinions.

The sample taken for further research consisted of a balanced mix of a fair analogy of CDP survey participants based on the population of each category in the CM. To be more precise, the total population of renal failure patients in CM is approximately 3,000 people when the total national population is about 12,000. And in the case of thalassemia patients the numbers are 800 and 3,500 respectively. Thus, their share in this sample was relatively small. The cancer patients' number on the other hand was much higher and their percentage in the sample much larger. 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, of about 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 CDPs 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 acquaintants. All CDP gave their consent to be part in this research.

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 geo-referencing 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, expenses accessibility level and satisfaction level. The chosen and most appropriate scale would be the county scale.

Another georeferencing of CDP according to their municipalities' city halls coordinates was performed insight Arc-Map. More specifically, a CDP point layer in Municipality residency scale was created giving to its point feature population attributes. Kernel density estimation (KDE) analysis followed over this point layer using the spatial analyst tool in arc-toolbox. The CDP percentage field was chosen to be the weight factor of this analysis. So a transformation from vector discrete units to raster continuous surface took place and the required CDP density map was displayed [11], right above the choropleth CDP population layer map of CM in county scale and the Public Hospitals' point layer map of those CDP in CM. Another layer showing the rest (non valid) Public Hospitals was also illustrated. After some symbolization actions and after selecting a 50%

transparency for the CDP density map the final output map was ready. Finally, the results endorsed an answer to the main quest of this paper despite the fact that the Geostatistical analysis performed earlier weakened the need for continuation.

V.   FINDINGS

A.   Map public hospital centres in Central Macedonia, Northern Greece

The first outcome of this research was to reveal the geo-distribution of public hospitals in CM. Thus, after collecting information about CDP's public hospitals' allocation over CM and with the involvement of Arc-GIS this research managed to illustrate the below map as a starting point of its findings.
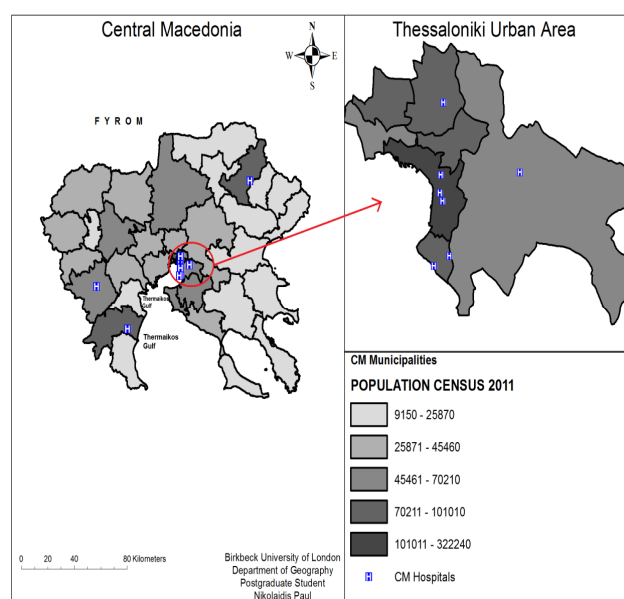

Fig.2: Spatial Distribution of Population and Public Hospitals in CM

From observing the left and the right side of the map above it is clear that Hospitals are located into urban areas and, basically, the most populated Thessaloniki Urban Area. In addition, a hospitals' point layer was created as decided it was necessary for the third face of this research.

In the second face of exploring CDP's data this research attempted to present a contemporary profile and maybe discover some kind of inequalities. The results taken from the analysis made over the demographic pies showed that as far as their education concerns, 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.

Moreover, the profession demographic pie depicted that the majority of the CDP's sample population consists of people that works to the educational sector (15%), to

the services provision sector (13%), as traders (10%) and they are mostly (Other 44%) pensioners.

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.

B. Spatial exploration of sample data

By continuing the profile efforts aforementioned the research moved on to the presentation of a geo-reality by exploiting the CDP's residencies information in County scale.

Starting the Geovisualization attempt of viewing this sample, the maps in the Fig. 3 and Fig. 4 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 there are more public hospitals than maps of this section illustrate but of no interest for the study yet since they are not employing specialized staff for the case.
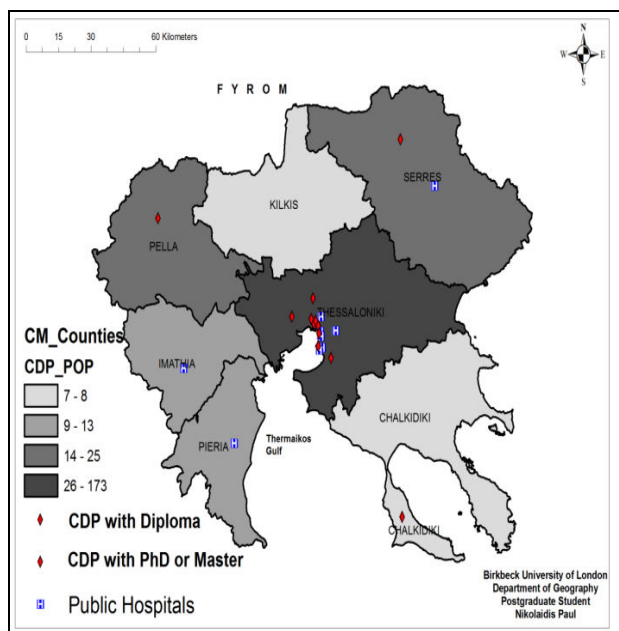

Fig.3: Spatial Distribution of Higher Education CDP

As a result of the visualization of Fig. 3 and Fig. 4 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. But Fig. 4 also illustrates the wide 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.
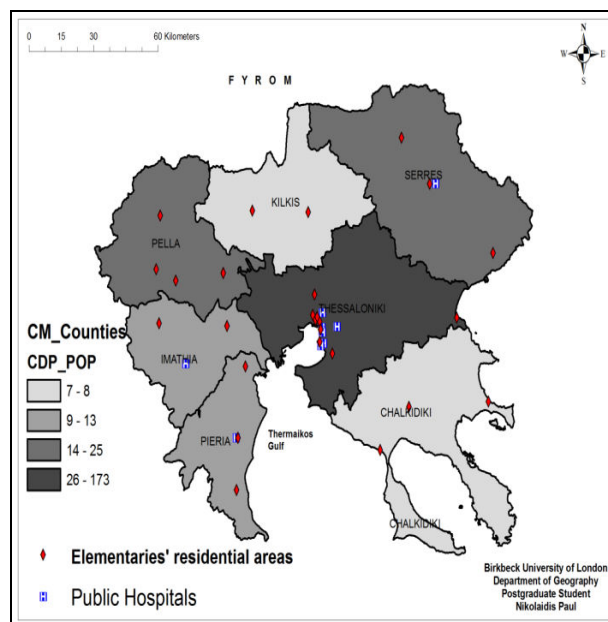

Fig.4: Spatial Distribution of Elementary CDP

The inner spatial analysis performed by profession, in Arc-Map showed that Teacher's residential points are clustered in Thessaloniki urban area and generally close to their preferred Hospitals (Fig.5).
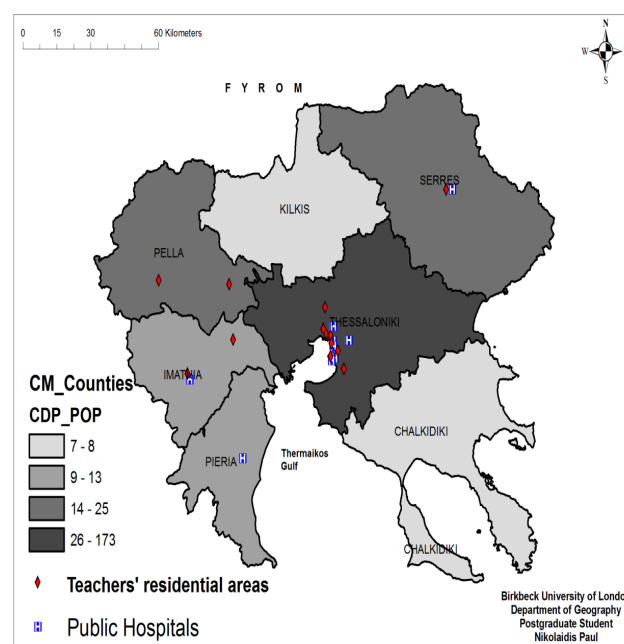

Fig.5: Spatial Distribution of CDP Teachers over CM

On the other hand, and even if there is some kind of concentration around Thessaloniki's public hospitals, the pensioners seem to appreciate the county side as a homeland more than other professions (Fig.6).
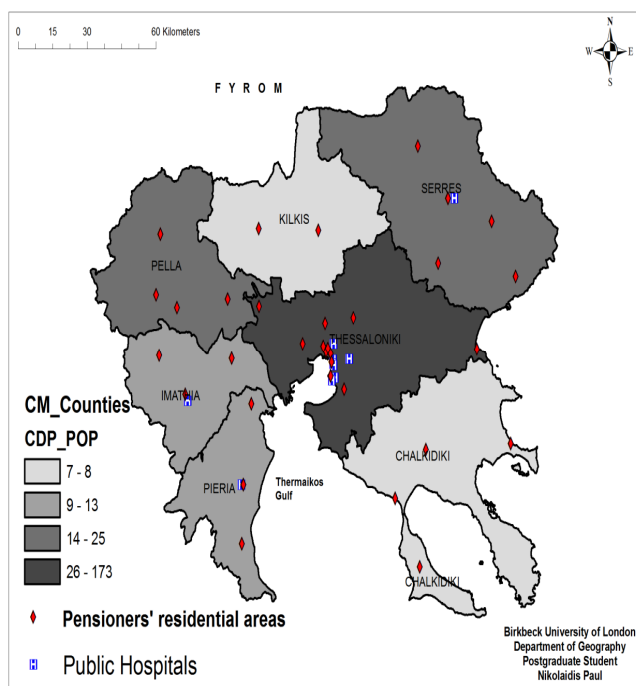

Fig. 6: Spatial Distribution of CDP Pensioners over CM

As to the income level, by performing a multi-layer spatial analysis on low, middle and high income CDP residences projections (layers) the research showed that 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.
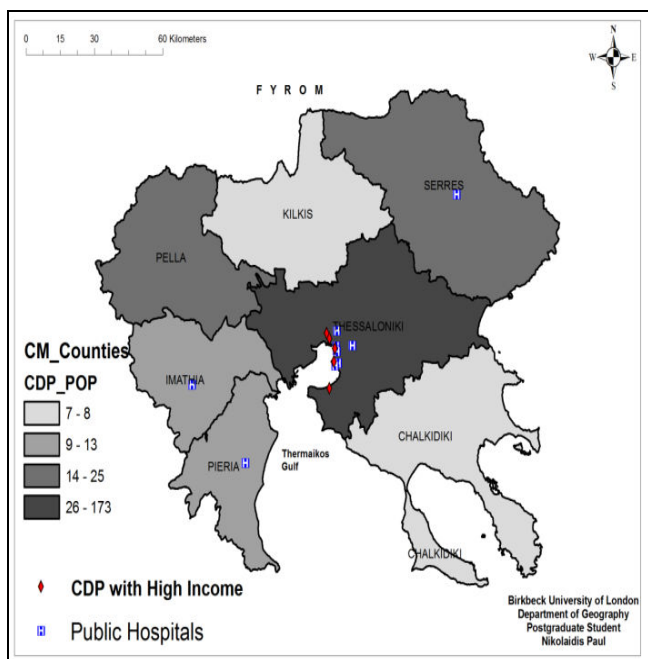

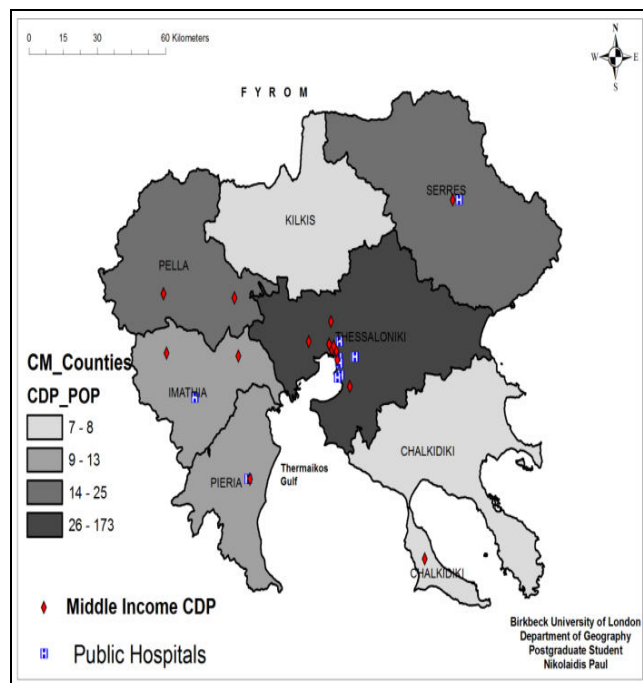Fig.7: Spatial Dispersion of High Income CDP

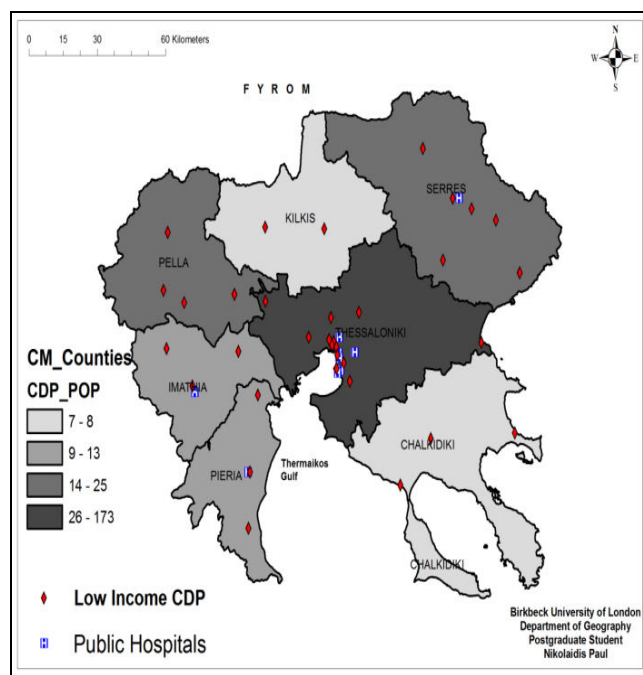Fig.8: Spatial Dispersion of Middle Income CDP

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 double-layer 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.

C.   Evaluation of Public Hospitals' allocation

Despite the results of the first part which revealed high satisfaction levels among CDP and low expenses needs to access public hospitals [12], the researcher with persistence proceeded to a CDP Kernel Density Estimation analysis. The target was to investigate if there was an urgent need for Public Hospitals' reallocation to get them closer to CDP. At this point the researcher decided once again to exploit the Arc-GIS facilities using the spatial analyst of arc-toolbox functionality. Inside spatial analyst he performed a kernel density analysis of CDP population percentages over CM (with 100 cell size and 50 Km radius choice). The result can be seen in the figure below.
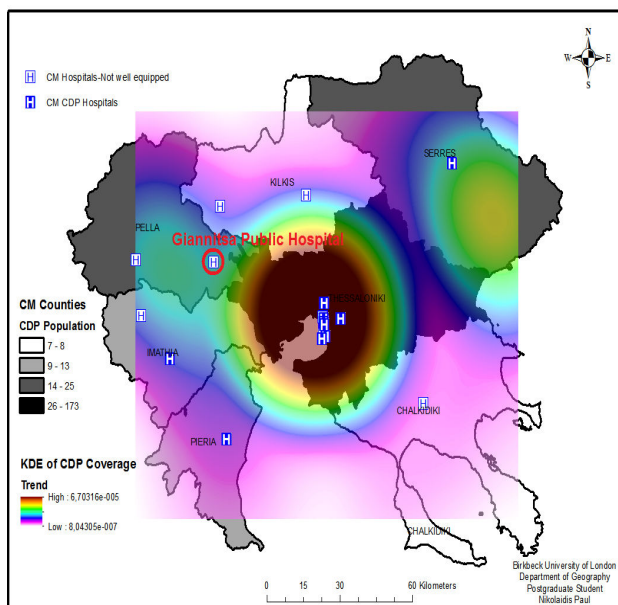

Fig.10: Evaluation of CDP Public Hospitals' places

Fig. 10, i.e. the evaluation map illustrates the projection of the four shapefiles (layers) mentioned in the end of the methodology section.

The transparency level of output density raster projection enhanced the visualization procedure over the final evaluation map. This CDP residencies' KDE illustration is pointing out that Thessaloniki county posses the highest CDP percentage rates (brown colour). Furthermore, a tension of high CDP percentage rates can be detected in South-East of Serres County (Yellow and Green areas) and another slight tendency this time North-West of Pellas County.

The choropleth map depicts Thessaloniki County as the highest CDP population county followed by Serres and Pella Counties. On the other hand in the Public Hospitals point layers it can be seen that Chalkidiki, Kilkis and Pella Counties are those with no well-equipped public hospitals.

As a general comment, the Public Hospitals' establishments are well allocated. But there is the Pella County that presents relatively high percentages of CDP

who seem to be far from well-equipped Public Hospitals. In order to have an equitable sharing of CDP travelling distances and according to the above density raster projection, the researcher proposes Giannitsa Hospital (in the red circle of Fig. 7) as the Public Hospital that should be shortly upgraded. The reasons for this proposition stemmed by the fact that Hospital of Giannitsa is spotted in the light blue area of density map, between two Green areas and near the Yellow ring which indicates Hospital's capability to serve many more CDP than other Hospitals of the area. In addition, Pella's County is recorded as the third most CDP populated County behind Thessaloniki and Serres Counties.

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 [12], 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 definitely be an extra care for low or no income CDPs and this is something that private and public health associations and organizations might need 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 preference to live near them.

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

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.

Subsequently, and during the GIS visualisation phase a need for seeking new knowledge was brought into the surface. 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 that is the geographical division of Greece in Health Districts (seven to be precise). Then, a Health District research of CDP could be interesting.

Another dimension of high importance is the translation of high CDP satisfaction levels towards Public Hospitals and their preference to live near them. Of course the selection of residency factor is not investigated in depth at this research. But some CDP subgroups present high residential concentrations in Thessaloniki urban area, like CDP teachers (Fig. 5), high educated CDP (Fig. 3) and CDP with high income (Fig. 9). This means that the above CDP categories indicated a higher ability in choosing their residential areas. This geographic phenomenon can be detected in CDP combined subgroups too, like Teachers with Thalassemia for instance. This fact triggers the need for further behavioral investigation on CDP subgroups to find health inequalities by comparing their accessibility level with other CDP or detecting the behavior of combined CDP subgroups.

There could be concerns also, about the chosen administrative boundaries scale. In this country the administrative boundaries division plan is called "Kalikratis" (implemented from 2010 onwards) and divides Greece only into provinces and municipalities. However, in this research the old county division scale (which is a subdivision of the provinces scale) was decided to be the appropriate scale for this sample CDP data.

The dimension of time should 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. Then, the resulting dynamic map of changing residences over time could investigate the internal migration of CDP in more detail.

Maybe there should 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 [13].

Moreover 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 selected 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 [14].

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

All the above drive this research to the conclusion that CDPs of Central Macedonia believe that they enjoy high quality of medical services in CM Public Hospitals. As a concequence they recognize that GNHS treats them well. (At this point it is only reasonable to say, due to the fact that Greece is in the middle of an economic crisis, the above general picture is prone to be altered in the near future).

There is a small scale monetary adjustment that could be thought of as crucial, given the current financial environment in Greece, which is the recommendation that can be depicted from density analysis illustration (Fig. 10) that Giannitsa's public hospital be upgraded with more medical equipment and specialized staff so to be able to provide a substantial improvement of treatment to its CDPs.

In conclusion, despite some minor technical and methodological difficulties, with the right editing and beyond cartography, the answers to geospatial questions have been given with close promiximity to reality. 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 region.

GIS introduced, in this research study, a socio-spatial dialectic that created new knowledge and made clear the need for further understanding and visualization over results so to find new ways of gaining knowledge.

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