Big Data Processing of Diagnostic Imaging Examinations Using a Self-Developed Digital Platform

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Abstract: *Background:* The aim of this survey is the presentation of a health information system that is eligible for processing and archiving clinical and economic health data by creating an online database that spots the origin of data on digital maps. Data concerns the cost of imaging examinations, number of hospital beds and number of clinical examinations.

Methods: Geographical information Systems **(**GIS) can be used for the rational management of diagnostic imaging examinations and the creation of a data basement that contains clinical protocols, patients' history and financial data. Users can exchange large volumes of the specific data very fast even between health units and hospitals. GIS Statistics enables users to estimate several financial indicators. Data concerns 5 Greek Public Health Units (H.Us) in the 6th Health Region.

Results: GIS platform enables users to process big health data and share them on a geodatabase. SPSS analysis in combination with GIS statistics tools reveal an overtime increase of imaging exams in the majority of hospitals.

Conclusions: The presented digital platform is a very useful tool for the rational management of clinical and financial data of healthcare units. It provides easy access to big data and enables users to gain in time data from digital maps in order to improve public health.

Keywords: Geographic Information Systems, GIS, Hospital Units, Database, Diagnostic imaging examinations.

1. INTRODUCTION

In recent years healthcare policy makers have given prominence to cost control and rational financial management of healthcare services (Ahmed *et al*., 2020, Soltani *et al*., 2019). Healthcare quality improvement rises from the need for equal delivery of effective health programs. Regardless of the additional costs, all communities must be given equal access to medical treatment (Hu *et al*., 2021). Maximizing total health and reducing deaths is a major issue that depends on crucial factors, such as the equitable distribution of public funds (Vanness *et al*., 2021). The adequacy and availability of financial funds are of great concern when it comes to socialized healthcare system. In India for example, many deaths and diseases could be reduced if health budgets were rationally reallocated (Jacob *et al*., 2020).

A great number of methodological approaches have been developed in the area of reducing costs of pharmaceutical supplies (Sharma *et al*., 2020, Akbarpour *et al*., 2020). Big data technologies are also used in this area (Gou *et al*., 2021; Wang *et al*., 2018). These approaches depend on statistical methods that simplify decision making. The Cost-Benefit Analysis (CBA) is a useful tool for the assessment of the efficiency of Health Units (H.Us) (Brnjas *et al*., 2020, Rognoni *et al*., 2020). It is defined as a policy assessment method of the monetary quantification of different services or products. When performing CBA, the input cost variable determines the precision of the outcomes. For example, disease-related costs such as hypertension-related expenses can affect national budgets in countries like Canada (Commeau *et al*., 2021). New technology advances have led to the incorporation of Health Informatics in CBA.

Geographical Information Systems (GIS) are effective tools that can be used in the financial assessment of diagnostic imaging examinations. GIS signify the term 'space' in relation with phenomena, relations and data in order to extract conclusions and results (Lally et Bergmann, 2021). Both GIS and CBA show that managers can gain more economic benefits by adopting a vaccination strategy (Pearson *et al*., 2018). Although GIS were initially performed for the evaluation of disease expansion in different locations, they are also used for decision making. Big data problems that emerge from ionizing and non-ionizing

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exams, such as, CT scans, X-rays and MRI scans, can be solved by using GIS. They use spatial analytic tools that combine both statistics and georeferenced features. Users can perform complicated statistical analysis on interactive maps. The results can be presented on diagrams and can be shared on the web.

The objective of the specific survey is to create an online platform for processing big financial data of hospital units. The platform can be established in hospitals or Health Regions for the rational management of cost and income of imagining examinations.

2. METHODS

The ArcCatalog application is used for converting all data to shapefiles and lists them on tables. Tables consist of different features that inform users about the location of Health Units (H.Us), total cost of radiology departments and revenues in the period 2012 - 2015. Data is archived on digital tables and presented on digital maps. Financial data was related to clinical protocols and patients' medical records. Revenues concern diagnostic imaging exams (Magnetic Resonance Imaging - MRI) which are performed in 7 public Greek H.Us in the 6th Health Region. Data is summed up and listed per H.U. and technical features. Digitized data is presented on diagrams in the ArcCatalog application and archived on ArcGIS platform (Figure **1**).

The shapefiles are uploaded on ArcMap application and they are presented on a digital map template. Map templates are authorized by ESRI and are at users' disposal. Financial data is presented on bar diagrams and interactive maps are created. Users can focus on specific areas on the map and click on the diagrams. Pop-up windows emerge that consist of financial data. The results can be printed, stored and shared on the web in real time. By using Statistics, several statistical indicators are estimated, such as:

- total cost of radiology departments per revenue of MRI per year
- total cost of radiology departments per total cost of pharmaceutical supplies per year

Statistical data also concerns the standard deviation, total sum, minimum and maximum price and the average number of variables. The variables of cost, revenue, number of examinations and hospital beds were statistically tested, according to their level of significance by using the linear regression model. Available data is uploaded on the Map layout application and interactive maps are created.

3. RESULTS

The revenue results of GIS analysis are the following (Table **1** and Figure **2**):

- There is an overtime revenue increase of H.U. 1 in 2012 - 2015. In 2015, the revenue increase is estimated at almost 1.000%, namely 116.090 euros, compared to 2012. This is the greatest revenue increase rate in the 6th Health Region. A

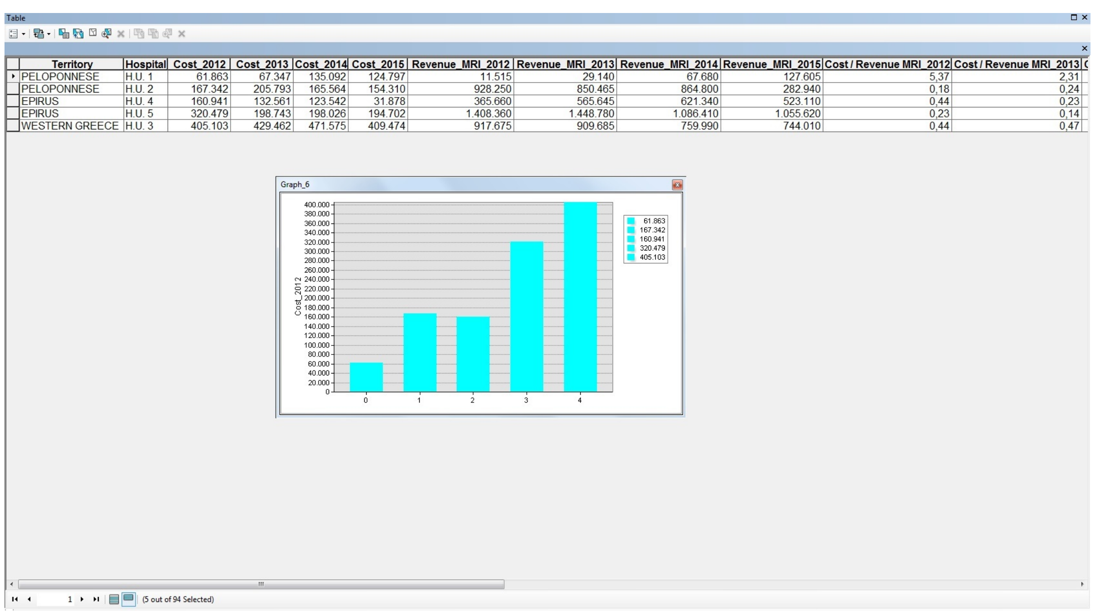

Figure 1: Digitized data on ArcGIS platform.

Table 1: Revenues of MRI Exams of Public Health Units in the 6th Health Region

Hospital Unit	Revenue 2012	Revenue 2013	Revenue 2014	Revenue 2015
H.U. 1	11.515	29.140	67.680	127.605
H.U. 2	928.250	850.465	864.800	282.940
H.U. 3	917.675	909.685	759.990	744.010
H.U. 4	365.660	565.645	621.340	523.110
H.U. 5	1.408.355	1.448.775	1.086.405	1.055.620

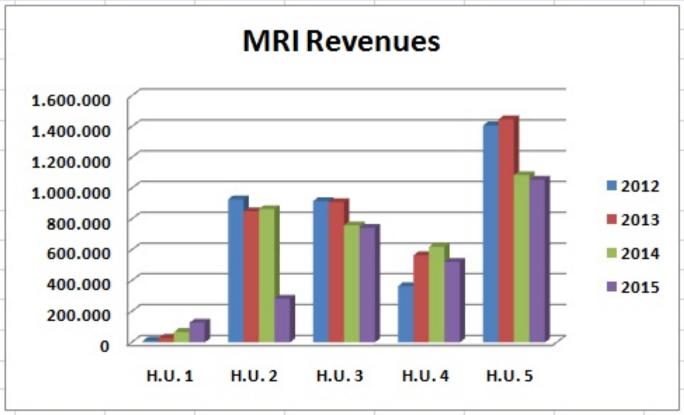

Figure 2: MRI revenue results of GIS analysis.

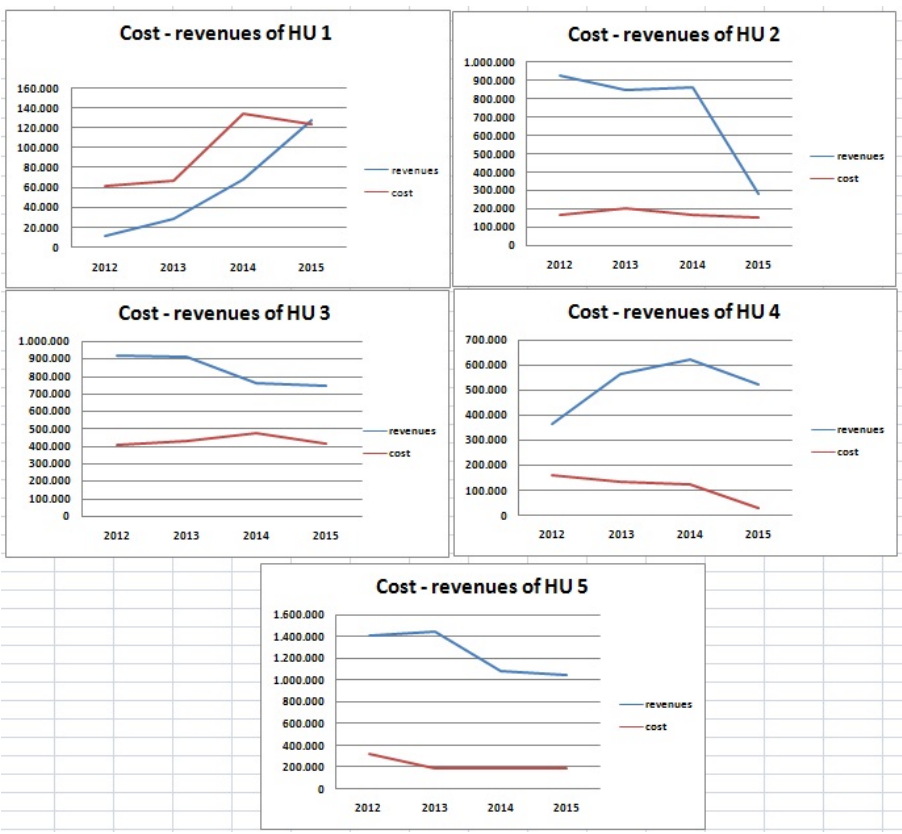

Figure 3: Comparative results between Hospital Units (H.U.).

financial damage is also displayed in Figure **2** (the cost line overcomes the revenues line)

- The revenues of H.U. 2 are decreased by 69.5% in 2015, compared to 2012. The decrease is estimated at 645.310 euros.

- An overtime revenue increase is also displayed by H.U. 3 in 2012 - 2015. The relevant rate is almost 19% and amounts to 173.665 euros.

- H.U. 5 displays the highest revenues compared to the other 4 H.Us. in 2012 – 2015 (Figure **3**).

The cost results of the radiology departments are also the following (Table **2** and Figure **4**):

- H.U. 1 displays an overtime cost increase in 2012 - 2014. The increase rate is almost 118% and amounts to 73.229 euros. In 2014 - 2015, there is a 7.6% decrease of the cost, namely 10.295 euros.

- The cost is estimated at almost 165.000 for H.U. 2, in 2012 and 2014 too. In 2015, the cost is 25% decreased, compared to 2013. The decrease rate equals to 51.483 euros.

- In 2012 - 2015, the cost of H.U. 3 is estimated at 41% of the total cost of all H.Us in the 6th Health Region. The total cost of H.U. 3 is almost 1.7 million euros.

- There is an overtime cost decrease for both H.U. 4 and H.U. 5 in 2012 - 2015. In the former, the cost decrease is estimated at 129.063 euros. In the latter, the cost decrease is almost 126.000 euros. The relevant rates are almost 80% and 39% respectively.

- In 2013 - 2015 there is an overtime cost decrease for the majority of public H.Us. In 2015, the decrease rates are almost 2% - 85%, namely 4.000 - 100.000 euros.

- H.U. 3 displays the highest cost compared to the other 4 H.Us. (Figure **3**)

4. DISCUSSION

Main Finding of this Study

The presented study reveals that GIS can be used to create an online platform that processes big data (financial health data, patients' medical records and demographic information). Several statistical tools that are used on the platform enable users to reach to conclusions and present them on digital maps. Health policy makers and health professionals can focus on specific areas on digital maps and gain the information needed in real time They can share their measurements and store their results on a database that is directly related to the location of the users. By using GIS database they can surveil the cost of

Table 2: Cost of Public H.Us in the 6th Health Region

Hospital Unit	Cost 2012	Cost 2013	Cost 2014	Cost 2015
H.U. 1	61.863	67.347	135.092	124.797
H.U. 2	167.342	205.793	165.564	154.310
H.U. 3	405.103	429.462	471.575	409.474
H.U. 4	160.941	132.561	123.542	31.878
H.U. 5	320.479	198.743	198.026	194.702

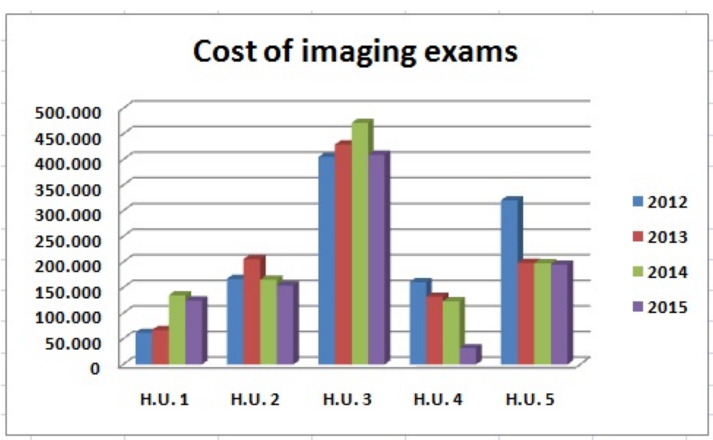

Figure 4: Comparative results of cost of diagnostic imaging exams.

diagnostic imaging examinations and adopt new methods of decreasing it (see Figure **5**). Figure **5** shows that users and health policy makers can compare the cost and revenues of imagining examinations of several health units in the highlighted 6th Health Region. Patients' medical records, their treatment methods and demographic data are also stored and edited on the same database without need of gaining information from different sources.

What is already known on this topic?

Until now GIS were used in order to integrate location data and connect data that concerns the spread of diseases without processing financial health data. The innovation of the presented study is the correlation of economical data with clinical data such as patients; medical history and treatment. GIS enable statistical analysis in real time and sharing of the results between Health Units in different locations. Users can compare their results and present them on digital maps even on mobile phones and tablets as well as anonymize specific financial variables and links in order to ensure safe data sharing (Cai *et al*., 2018). Relevant studies agree that there are possible cost savings in diagnostic imaging examinations in correlation with several illnesses such as breast cancer, (Mango *et al*., 2019, Hill *et al*., 2018). Some authors agree that technology can help to improve cost – effectiveness of orthopedic examinations especially during pandemic processes (Buvik *et al*. 2019, Tanaka *et al*. 2020, Augustine *et al*., 2020). Several studies also reveal that bringing diagnostic technology can develop more effective, efficient and prosperous health systems (Wurcel *et al*., 2019, Sony *et al*., 2019, Loncar-Turukalo *et al*., 2019).

What this study adds?

Greece Healthcare System doesn't support an effective financial surveillance system. The survey contributes to creating a cost surveillance system for the diagnostic imaging exams performed in public Hospital Units in correlation with clinical data and patients' medical history. The study adds a new aspect of GIS in presenting and processing financial and clinical data that give access to many users from different locations. The platform can be also used to create digital maps in order to study the effect of Covid-19 in healthcare systems and inspire other researchers in their surveys. Data can also be updated in order to support comparative study with new evidence regarding diagnostic tests,

Limitations of this study

The main limitations of this study concern data collection and funding of the platform. Once the data is collected digital maps require too much patience and time to be edited and created.

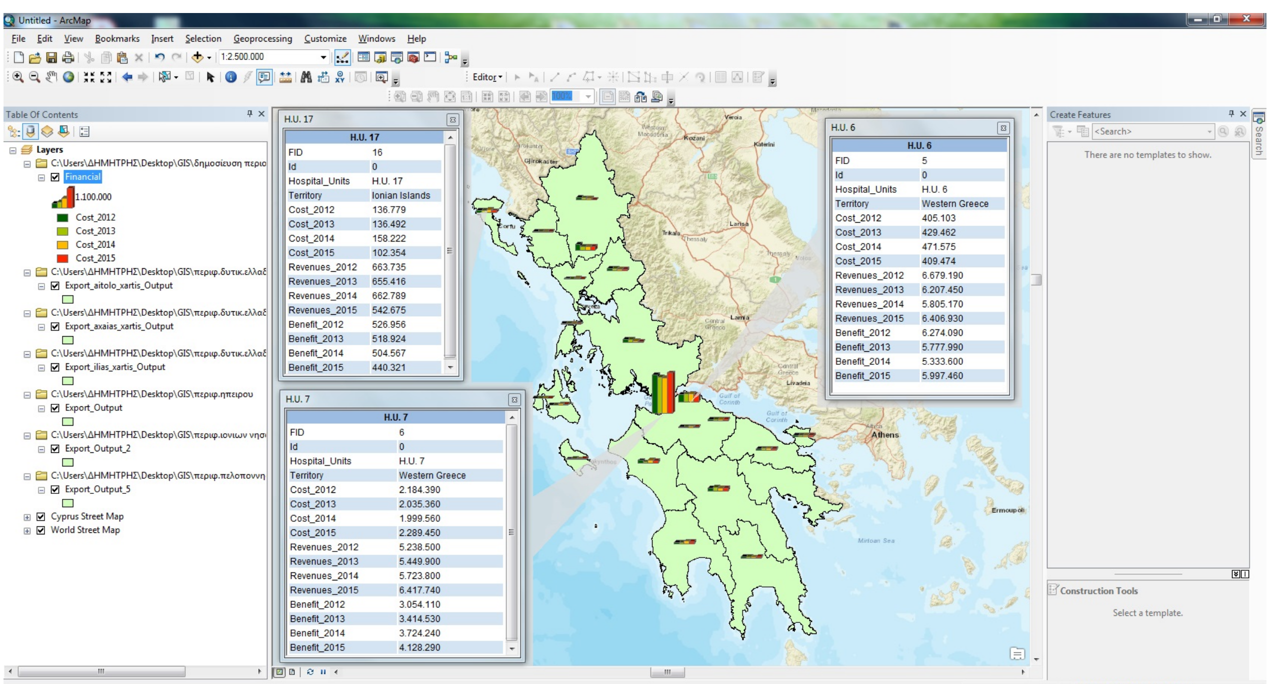

Figure 5: GIS interactive map that displays financial data.

5. CONCLUSIONS

GIS can be used for the rational management of diagnostic imaging examinations. Users can exchange large volumes of financial data very fast. Spatial analysis facilitates the estimation of statistical indicators. The results can be presented on interactive maps that are uploaded on a central acquisition system. The system acts as digital platform which enables users to edit, analyze and print all available data. Data is stored on a geodatabase that runs on a tablet or mobile phone. The platform can be connected with patients' electronic record in order to register medical and financial information. Information concerns patients' treatment methods, medical prescriptions, financial and statistical data. The potential geographical accessibility to healthcare treatment can be assessed by using spatial analytic tools. Digital GIS maps promote thorough analysis of Hospital Units' efficiency and contributes to improving healthcare services.

ABBREVIATIONS

GIS: Geographic Information Systems

CBA: Cost-Benefit Analysis

H.Us: Hospital Units

MRI: Magnetic Resonance Imaging

CT: Computerized Tomography

ESRI: Environmental Systems Research Institute

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AVAILABILITY OF DATA AND MATERIALS

Data utilized in this study is available upon request from the 6th Health Region

AUTHORS' CONTRIBUTIONS

All authors contributed to the interpretation of the results and editing of the final manuscript. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declare that they have no conflicts of interest that are directly or indirectly related to the research.

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