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Spatial point pattern analysis of lung cancer in an urban area: Izmir case

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ABSTRACT: In health area, in order to conduct a reliable analysis of the diseases that present threat to public health and to develop control strategies, it is necessary to investigate firstly how the disease are geographically distributed, secondly regions where disease is observed more dense, and thirdly their geo-statistical aspects. The aim of the study is to prepare spatially distribution map of the lung cancer cases in Izmir, Turkey. Approximately 20.000 cases, which have been confirmed in terms of accuracy by World Health Organization (WHO), were distributed on Izmir map via GIS. Spatial statistics were performed and the relations of geographical factors and the cancer data were discussed. Smart maps with tabular data and displaying cancer cases on a spatially distribution maps have been achieved as end products. ArcGIS and Spatial Statistics module are used for the study.

1 INTRODUCTION

In health area, in order to conduct a reliable analysis of the diseases that present threat to public health and to develop control strategies, it is necessary to investigate how the disease are geographically distributed, regions where disease is observed more dense and their geo-statistical aspects. From the medical geography perspective it is vital to monitor geographical pattern of diseases and to evaluate their association with the environment (Meade & Earickson, 2000).

World Health Organization (WHO) emphasizes that public health is not just a matter of health centers, among other influences; the planning/design of land has a basic role. A range of diseases, respiratory problems, diabetes, mental illness and some forms of cancer occur depending on factors mediated by urban planning. Factors such as healthy exercise, air quality, fresh food and local social networks are influenced by the physical nature. Initiatives such as Healthy Cities that was started in 1988 by WHO and Sustainable Cities Programme of UN-HABITAT/UNEP seek to improve the physical, mental, social and environmental well-being of people living in urban areas (Barton et al. 2010).

In health-related environmental research, there is a concluded need to develop improved epidemiologic, spatial and statistical methods for assessment of relationships between environment and health. Spatial epidemiology, also called medical geography is a specialization within geography that deals with the spatial aspects of health and healthcare assessment. The goal of medical geography is to improve the understanding of various factors that influence the health of individuals and populations. The foundation of medical geography is the idea that health is linked to a place or location.

Cancer is a term used for diseases in which abnormal cells divide without control and are able to invade other tissues. Cancer is not just one disease but many diseases. There are more than hundred different types of cancer (National Cancer Institute, 2011). Especially, although the lung cancer has been the least common at the beginning of the 20th century, currently it is leading cause of death in the world and the most common cancer among men. In Turkey, the lung cancer has 26.3% ratio among the other types and is the most common cancer type (Eser, 2008).

Geographic Information Systems (GIS) are used as a common tool to be equipped with an electronic environment in which linking the exposure model with the demographic, migration and health data of the exposed population. The integration of the model in a GIS together with individual data and information from routine health statistics proves its usefulness in demarking the exposed population (Poulstrup & Hansen, 2004).

Identifying trends in cancer data is a vital aspect when assessing the surveillance of a disease, and important factors associated with the disease. Trends in cancer data can reveal places where there is a higher than expected incidence of a cancer. Areas with higher than expected incidences of a cancer are also called cancer clusters. A cancer cluster is defined as greater than expected number of cancer cases that occurs within a group of people, in a geographic area, or over a period of time.

The main objective of this research is to prepare spatially distribution map of the lung cancer cases within the scope of Izmir Metropolitan Area between the years 1995 and 2007. This study will primarily try to answer the questions below:

1. What is the vital point in mapping the spatial distribution of cancer cases?
2. Is it possible to make GIS based spatial statistical analyses of cancer data?

Spatial statistical analyses will be performed and the relations of the geographical factors and the cancer data will be discussed. It is aimed to generate smart maps and tabular data and to produce maps displaying distribution of cancer cases maps as an end product. To accomplish this aim, distribution of registered cancer cases are spatially illustrated both at the neighborhood level and at the district level within the Izmir Metropolitan Municipality depending on scale where data are available. The study area covers the entire administrative boundaries of Izmir province. ArcGIS and Spatial Statistics module is used for the study.

2 THE ROLE OF GIS IN ENVIRONMENTAL HEALTH RESEARCH

The GIS technology has widely been used for years to explore spatial distribution of diseases and particularly different cancer types and to investigate the cause and effect relationships from different perspectives. Cockings et al. (2003) and Goldberg et al. (2008) emphasized the importance of using spatially referenced health data to analyze the spatial distribution. All studies in this research area require a detailed and accurate data, as well as advanced spatial statistics. At this point advances in GIS offers powerful analytical tools to investigate spatial distribution of cancer. Wang (2004); Amin et al. (2010) and Goodman et al. (2010) used clustering method to examine where specific cancer types are more intense. Wang et al. (2006) showed the effectiveness of GIS technology to calculate spatial statistics to explore the incidence rates and mortality of cervical cancer as well as Pap Smear test results in specific regions of New Brunswick, Canada. Jerrett et al. (2005); Hwang et al. (2006) and Cornelis et al. (2008) have carried out a different analysis to investigate the effects of environmental factors. The common purpose of these studies is to find out how environmental, geographical factors and certain land-use types affect the incidence rates of specific cancer types. Brody et al. (2004); Brewer (2006) and Parrott et al. (2010) conducted researches based on time-series data. The results of these studies give insights of how environmental or other factors could affect the spatial distribution of cancer over time. GIS applications are summarized in environmental hazard surveillance, exposure assessment and health outcomes surveillance.

2.1 *Hazard Surveillance*

GIS has been used as a tool to monitor the spatial distribution of environmental hazards whether they are clustered or randomly distributed and to manage the database about hazard locations. Samples that collected at different points are entered in GIS and then they can be mapped to display geographic differences. Aelion et al. (2009) has pointed that spatial interpolation methods such as inverse distance weighting and kriging are used to estimate concentrations of contaminants at locations where no measurements are available.

The result maps show the high-density environmental hazard areas with a constant surface. It is important to understand how environmental hazards move and change through environmental factors such as air, water, soil and wind in space and in a specific time, how human interactions change from place to place. Therefore, these methods can also be enlarged to estimate all these mentioned factors. Chakraborty & Armstrong (1995) used GIS-based plume models to model atmospheric dispersion of chemicals around accident sites consisting transport of hazardous materials. Root & Emch (2010) confirmed that hydrologic models of surface and groundwater systems and network models of municipal water supply to trace the waterborne flows of pollutants. Many environmental indicators are visualized by using GIS methods such as natural and built environmental features. Built environments include a series of features that can be either hazardous or beneficial for human health.

2.2 *Exposure Surveillance*

Maantay and McLafferty (2011) mentioned that exposure surveillance examines the conditions that people were exposed to environmental hazards and the processes of exposure itself and its results in terms of health effect. GIS implementations are seen as focusing on the environmental processes that influence human contact with hazardous substances. The required data in exposure assessment, which are defined as population and environmental hazard data, are seen well linked to each other via GIS tools (Jerrett et al. 2005). GIS applications such as overlay and spatial buffering have been largely used to estimate populations exposed to environmental hazards. Overlay links variables based on geographic location on map. In spatial buffering, GIS identifies the zone that falls within a specific distance of a point, poly-line or area.

2.3 *Outcomes Surveillance*

Outcomes surveillance monitors the health impacts of environmental exposures. GIS is used to create maps of health outcomes and to analyze associations between outcome data and environmental hazards and exposures by researchers. Analyzing spatial clusters or “hotspots” of health outcomes is significant in case they are the presence of an environmental hazard that is responsible for the spatial clustering of any diseases.

The relationship between health outcomes and environmental hazards and exposure are required to be linked data on hazards exposures and outcomes via GIS. There are analyses providing important information about cause of the diseases (etiology) by indicating potential environmental alerts.

Maantay & McLafferty (2011) have mentioned that assessment of hazards, exposures and health outcomes; geospatial techniques have an important role in planning public health interventions to reduce environmental health concerns. These interventions are defined as environmental modifications aimed to reduce disease transmission and exposure to hazards; medical strategies including vaccination and treatment; mobility strategies to alter human activity patterns and interactions; and behavioral strategies that focus on knowledge, education and experiences.

In summary, the connections between environmental hazards, exposures and health outcomes are fundamentally spatial, depending on the interactions between people and hazards through space and time. The data management, geo-monitoring and spatial analysis applications of GIS is valuable tools for environmental health assessment.

3 GIS BASED LUNG CANCER CASE DISTRIBUTION OF IZMIR PROVINCE

3.1 *Study Area and Data*

Izmir Province, the west of the Anatolian Peninsula, is located in the middle of the Aegean coasts. It is surrounded by Balikesir from North, Manisa from east and Aydin from south. City lands, $37^{o}45^{'}$ and $39^{o}15^{'}$ north latitude and $26^{o}15^{'}$ and $28^{o}20^{'}$ east longitude, is torn between. The distance of the north-south is approximately 200 km and the distance of the east-west is 180 km, shown in Figure 1 (www.izmir.gov.tr, 2012). The project area is Izmir Province with its 30 districts, which nine of these are in Izmir Greater Municipality (IBSB) borders. Table1 and Figure 2 show the Izmir Province Districts in terms of Greater Municipality and Metropolitan Districts list on the map.

GIS-based distribution of cancer cases while creating of the database has a database of existing cancer (listed below) data has been used. Demographical data types are categorized as Name – Surname, Address information, Birth place, Birth date, Age of the diagnosis, Gender, Treatment history.

As digital data, GIS based Izmir map with its province border, districts, neighborhoods, roads and buildings is used. Demographic and cancer data as tabular data, population between 1995 and 2007 and Izmir total cancer cases approximately 20.000 are used. These data have some limitations. These are:

- Record of the address information is on a single line.
- There are missing address data.
- There are data out of Izmir province.
- There are data duplications.

As software, MS Office is used for converting the CanReg format to excel or dbase file. ArcGIS is used for producing digital maps, analyzing and making queries.

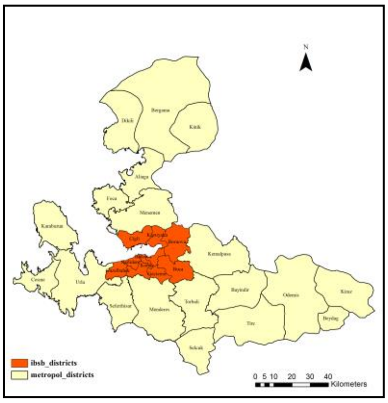

Figure 1. Izmir Map of Districts

Table 1. The Districts of Izmir Province

Greater Municipality Districts	Metropolitan Districts
Konak, Karsiyaka, Balcova, Bornova, Buca, Cigli, Narlidere, Guzelbahce, Gaziemir	Aliaga, Kinik, Kemalpasa, Torbali, Tire, Odemis, Kiraz, Beydag, Bergama, Menemen, Foça, Dikili, Bayındır, Menderes, Seferihisar, Urla, Cesme, Karaburun, Selcuk

3.2 *Methodology*

In the study, firstly, cancer data of Izmir province is documented on annual bases and database is indexed. The existing database structure (in MS Excel format) is modified to meet the aim of this study and, correlated with digital maps through geocoding of cases. Spatial statistical analyses are performed.

Due to data limitations, while preparing the database, categorization address information column as avenue, street, number, apartment name, zip code and county has give the possibility of street-level inquiry. Address information is kept under a single line; which is a disadvantage for the study. This part is separated in the database as street, street, number, apartment name, zip code, county-level data. Thus, it is possible to make queries about address data. Izmir Cancer Registry Center (ICRC) has begun to be kept centrally by Turkish ID numbers since 2006. For this reason, the information about the ID Number was not being created in the database. Izmir population data and growth rate is provided by Turkish Statistical Institute.

Additionally, in the metropolitan area, the cases that contain only the name of neighborhood or district in the address column are shown in the centre of the settlement. On the other hand, in

IBB districts, the cases that have street information without door number are shown in the relevant street center. Also the street information without neighborhood or districts is a constraint due to many streets with same number in different districts. Address line with the exception of the province of Izmir (Manisa, Aydın, Denizli) are not included in the study. Finally, although in a small number, duplications were encountered in metropolitan districts data.

Neighborhoods primarily on the basis of the spatial density of data connections as will be discussed. There are two main reasons. The first one is lack of the written addresses for determination of the point. The second one is the lack of digital road and building maps of whole Izmir. Especially within the boundaries of Izmir Greater Municipality address the remaining cases can be defined according to the information point. However, detailed digital maps of the neighborhood-level digital maps will be used for non-municipalities.

Canreg software used for the registration process has an extension "mb0" and this format cannot be exported to other commonly used database management software. However, existing dataset could be saved as a simple text file or MS Excel file.

Address information is stored in a single column in CanReg database so extracting the address information in a correct format is not an easy task. Therefore this address information has been processed to separate street name, street number, apartment name, postal code, in a district level. Thus, it is possible to perform queries on address information. Izmir Cancer Registry Center (ICRC) has centrally begun to store records using Turkish Citizenship ID numbers since 2006. Hence, the ID Information is not included in the database. Izmir population data and growth rate is provided by Turkish Statistical Institute

Additional to cancer case maps, cancer hospitals are shown on the map in order to observe the density of diagnosis. The distance analyses between hospitals are also performed. These analyzes are linked with the patient's address information.

The study's methodology is explained as levels:

1. To collect cancer data from ICRC and convert it to excel file format.
2. To enter the case points into GIS environment and shape the databases according to the study.
3. To link demographic data with digital data.
4. To perform geo-statistical and spatial analysis.
5. To interpret analyzes and queries results.

It is aimed to generate smart maps and tabular data and to produce maps displaying distribution of cancer cases maps as an end product. To accomplish this aim, the distribution of registered cancer cases are spatially illustrated both at the neighborhood level and at the district level within the Izmir Metropolitan Municipality depending on scale where data are available.

3.3 *Spatial Pattern of the Lung Cancer Cases*

Identifying trends in cancer data is a vital aspect when assessing the surveillance of a disease, and important factors associated with the disease. Trends in cancer data can reveal places where there is a higher than expected incidence of a cancer. Areas with higher than expected incidences of a cancer are also called cancer clusters. A cancer cluster is defined as a greater than expected number of cancer cases that occurs within a group of people, in a geographic area, or over a period of time. Incidence is a measure of the risk of developing some new condition within a specified period of time. The incidence rate is the number of new cases per population in a given time period (http://en.wikipedia.org, 2012). A cancer incidence rate is the number of new cancers of a specific site/type occurring in a specified population during a year, usually expressed as the number of cancers per 100,000 populations at risk, shown in Equation 1 below.

$$Incidence = \left(\frac{CancerCase}{Population} \right) x100.000$$

The spread rate of cancer and spatial cluster analysis is an essential way in any exploratory investigation. Once the spatial patterns of cancer are identified, epidemiologist and other researchers should be able to conduct case control. By using statistical models to demonstrate a pattern of these cancer incidences in Izmir province areas where there are distinct geographical variations or clustering would indicate an association with environmental factors.

In Table 2, the total population, total cancer cases and related incidance rates of Izmir provience in the period of 1995-2007 is displayed. In Figure 2, the population increasing line is drawn and by its combination with case numbers incidance rate curve is also can be drawn in a specified period. Additionally, the population of Izmir graphic is shown in the second graphic in Figure 2. As seen in the incidence graphics, there are many breaking points in the incidence curve different from the case numbers. To show these breaking points spatially, thematic mapping method is used depending on the specified year populations.

Table 2. Population of Izmir, the lung cancer case and the incidence numbers (1995-2007)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Population	2948808	3040154	3127689	3210284	3301505	3355688	3420191	3464582	3506672	3566276	3634966	3681285	3800760
Case	787	869	1105	1052	1118	1413	1354	1582	1527	1742	1725	1866	1930
Incidance	798	869	1000	977	942	1354	1246	1207	1246	1434	1467	1545	1476

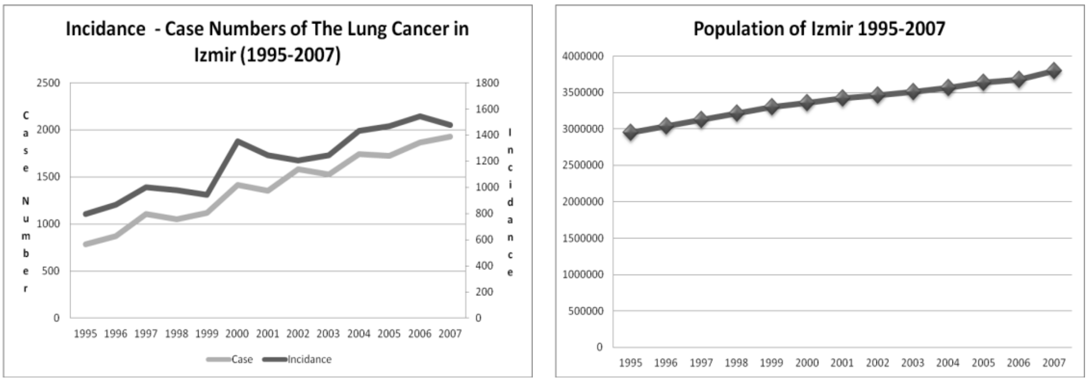

Figure 2. Graphics of the incidence - case numbers and population of Izmir

In Table 3, incidence numbers of the lung cancer, resultant incidence numbers of each district are shown per year. It has been determined, that there has been a continuous increasing in the lung cancer incidence over the years. Especially Bayindir, Karaburun, Urla and Foca districts have the maximum incidence rate. Starting, finishing and breaking points are spatialized in the Izmir Province map as the years 1995, 1997, 2000, 2002, 2004, 2006 and 2007 (Fig. 3).

Table 3. Incidence numbers of the lung cancer in Izmir (1995-2007)

INCIDANCE NUMBERS OF THE LUNG CANCER IN IZMIR (1995-2007)													
District Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Aliaga	12,9	17,4	22,9	27,1	38,4	36,7	39,3	31,3	41,6	54,9	35,2	39,5	33,31
Balcova	37,1	40,6	40,4	39,3	41,1	48,2	50,5	58,7	49,6	50,5	51,7	70,2	77,50
Bayindir	40,3	57,7	77,6	51,1	39,0	84,8	87,7	58,1	45,9	49,9	102,4	86,9	78,29
Bergama	29,8	26,7	36,7	31,3	36,6	43,3	45,8	49,9	35,6	47,4	41,2	64,9	62,39
Beydag	27,9	6,8	27,2	20,9	7,1	14,2	63,9	28,5	21,3	28,4	49,7	14,2	44,44
Bornova	17,4	20,2	21,6	25,9	18,3	23,4	30,3	37,9	33,2	37,0	40,1	40,2	38,64
Buca	26,9	26,7	34,0	35,9	33,3	38,3	27,6	39,2	35,3	40,4	39,8	50,5	42,65
Cesme	13,7	39,2	46,4	66,4	50,5	79,4	44,0	36,0	39,6	76,7	60,8	77,0	68,36
Cigli	17,5	28,4	23,0	21,6	25,7	32,2	37,6	37,4	37,3	51,5	40,0	56,6	36,74
Dikili	35,7	38,9	42,0	40,9	28,0	87,4	73,5	34,5	57,5	57,4	86,8	53,3	51,19
Foca	27,5	13,5	34,0	60,4	64,6	43,6	73,7	23,7	64,0	80,0	51,3	40,1	36,01
Gaziemir	12,1	28,2	31,1	27,6	31,2	34,4	20,6	32,5	37,9	49,3	32,2	33,4	30,19
Guzelbahce	35,1	42,1	48,6	24,0	54,5	53,6	67,9	56,6	27,1	58,3	55,5	40,8	36,35
Karaburun	48,7	32,8	32,1	81,0	15,8	40,8	12,9	69,2	55,2	70,2	56,3	115,4	87,06
Karsiyaka	20,4	22,8	30,7	29,9	29,6	34,2	37,6	41,9	41,0	47,2	44,5	46,1	39,65
Kemalpasa	19,7	24,1	28,1	24,3	32,5	45,0	22,6	39,0	43,9	49,7	63,8	47,9	63,59
Kinik	31,5	45,2	28,0	53,3	17,8	64,1	64,4	46,9	47,0	32,1	42,7	65,4	50,11
Kiraz	11,4	17,9	22,3	17,8	11,2	20,1	26,8	23,8	15,3	41,5	39,2	37,0	31,06
Konak	33,0	33,2	46,2	40,9	44,5	52,6	46,5	59,5	53,9	59,0	53,7	53,5	66,05
Menderes	13,8	27,3	43,5	42,7	25,7	53,2	52,0	27,1	44,8	32,8	56,7	56,9	57,75
Menemen	30,8	27,4	21,9	14,5	30,3	29,3	37,5	43,2	40,8	35,4	36,5	46,8	46,48
Narlidere	37,7	39,2	42,7	11,3	38,3	41,5	29,6	54,2	55,0	60,3	46,3	59,5	48,82
Odemis	27,8	23,6	33,8	33,0	38,2	35,8	38,0	41,6	54,1	55,3	50,7	52,3	56,92
Seferihisar	45,4	30,5	45,6	49,8	38,4	71,3	44,9	48,6	72,8	53,1	75,9	58,4	34,84
Selcuk	31,9	31,4	20,8	30,1	35,8	48,8	38,9	34,3	63,3	62,0	42,9	42,6	64,70
Tire	39,5	34,0	29,6	26,7	32,1	60,1	40,6	48,7	41,7	50,9	53,1	81,3	75,99
Torbali	30,4	31,9	37,4	16,5	31,9	40,5	44,5	43,7	36,8	38,2	44,5	33,9	44,35
Urla	42,3	61,5	52,4	32,5	51,8	97,5	47,0	61,0	54,7	64,7	74,0	80,9	72,83

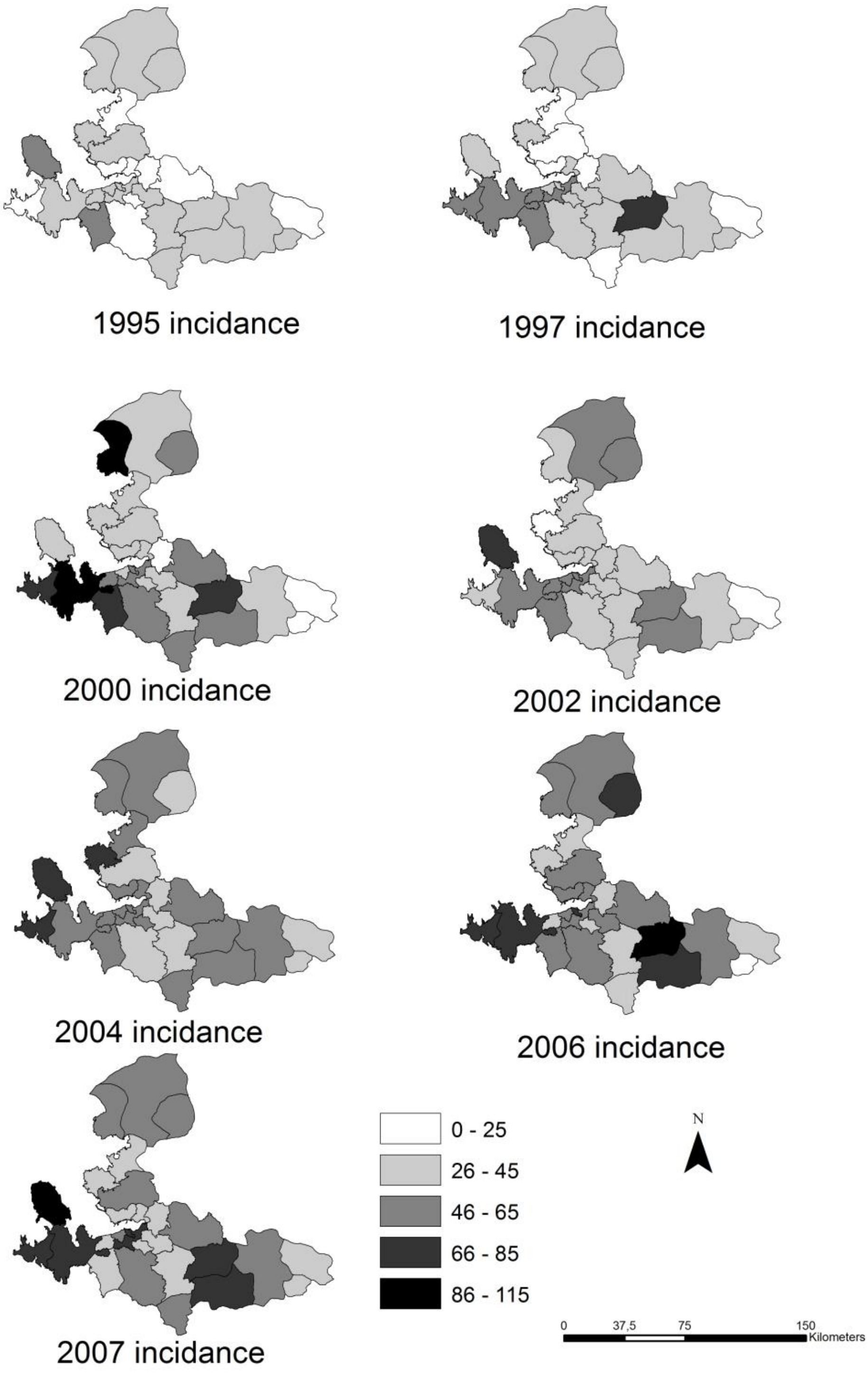

Figure 3. The thematic maps of the incidence rate of the lung cancer in Izmir

The lung cancer cases are classified as Metropolitan Area cases and Izmir Greater Municipality cases. Figure 4 shows the spatial based case distribution of the lung cancer of Izmir Province. In detail, Figure 5 represents the cases addressed into Izmir Greater Municipality. During the address entrance to ArcGIS there are some difficulties about the address information. Especially in Metropolitan area, some records have just “District Name” information. Therefore, the point of the case has been shown in the settlement area of the district. In Greater Municipality borders, whole address information is in street detail. Hence, the points of the cases belong to the street name and door number.

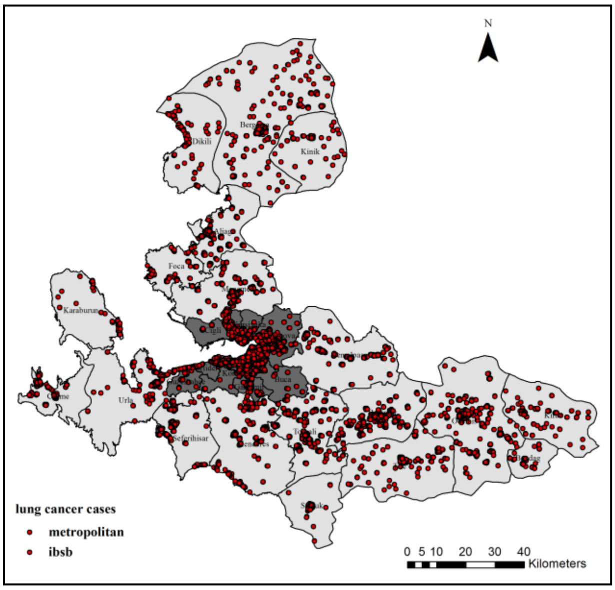

Figure 4. Spatial distribution of the lung cancer cases in Izmir

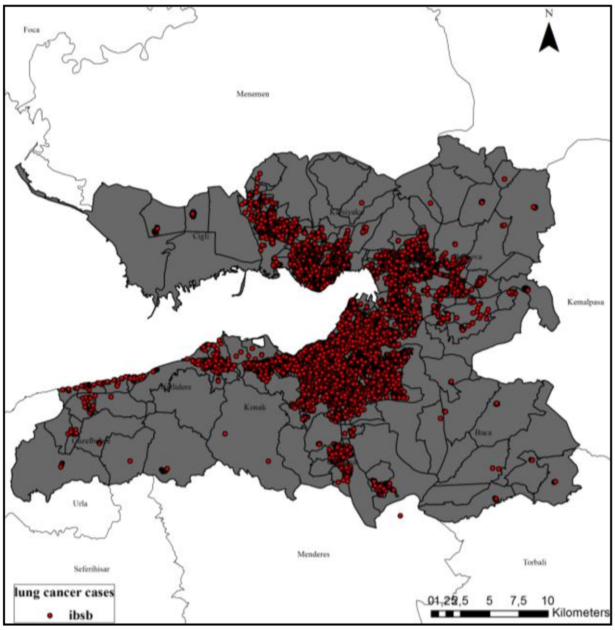

Figure 5. Spatial distribution of the lung cancer cases in Izmir Greater Municipality

3.4 *Spatial Statistics of the Lung Cancer Cases*

The spatial pattern warrants study in general, only when it is statistically significant. Spatial statistical cluster analysis detects nonrandom spatial patterns. The statistical cluster analysis is more objective than visual examinations of a thematic map. Cartographic techniques are defined as imperfect when it comes to detecting clusters. There are several descriptive techniques determining areas, with elevated rates, whether they are statistically significant or not (Wang, 2004).

Density informes where clusters in data exist, whether or not the clusters are statistically significant. Hotspot analysis uses vectors (not rasters) to identify the locations of statistically significant hot spots and cold spots in data. Points should be aggregated to polygons for this analysis. Hot spot analysis concentrate the spatial distribution of the case within a litimed geographical area that appear over time. It is controversial issue that there are particular environments affecting the rate of disease incidence in larger than expected concentrations, so-called hotspots.

In this study; for cluster analysis, to detect pattern within local scale, Getis-Ord Gi* (Hot Spot) statistics is calculated. This method is also known as Local Spatial Statistic. "...GI* identifies spatial association between mapped point *I* and the *j* points within distance d of *i* with respect to all *j*" (Ord&Getis, 2012, pp.532). "….the local G-statistics can identify significant clusters of high or low variable values, taken as a group, around some site *i*" (Ord&Getis, 2012, pp.532). Gi* compares local averages to global average and it identifies if local pattern of disease is different to what is generally observed across the whole study area. Gi statistics measures the concentration of high or low values for a given study area. The Hot Spot Analysis tool calculates the Getis-Ord Gi* statistic for each feature in the dataset. The calculated z-scores and p-values tells where features with either high or low values cluster spatially. This tool works by looking at each feature within the context of neighboring features. To be a statistically significant hot spot, a feature has a high value and be surrounded by high valued features. The local sum for a feature and its neighbors is compared proportionally to the sum of all features when the local sum is very different from the expected local sum, and when the difference is too large to be the result of a random chance, a statistically significant z-score occurs.

For statistically significant positive z-scores, the larger the z-score is, the more intense the clustering of high values is. For statistically significant negative z-scores, the smaller the z-score is, the more intense the clustering of low values is. If the z-score value is positive, the observed General G index is larger than the expected General G index, indicating high values for the attribute are clustered in the study area. If the z-score value is negative, the observed General G index is smaller than the expected index, indicating that low values are clustered in the study area.

The Hot Spot Analysis is performed as an area-based method, within neighborhoods of IBSB districts (Fig. 6), due to seventy percent of the total population lived in (Fig. 7). The case numbers falling into one neighborhood is calculated and joined spatially. 371 neighborhood units joined the analysis in the context of cancer case numbers. Hot and cold spots consisting of the high and low z-scores are calculated as seen in the figure. According to the Gi* statistics, some neighborhoods of the Balcova, Karsiyaka and Bornova are defined as spatially hotspot (Fig. 8).

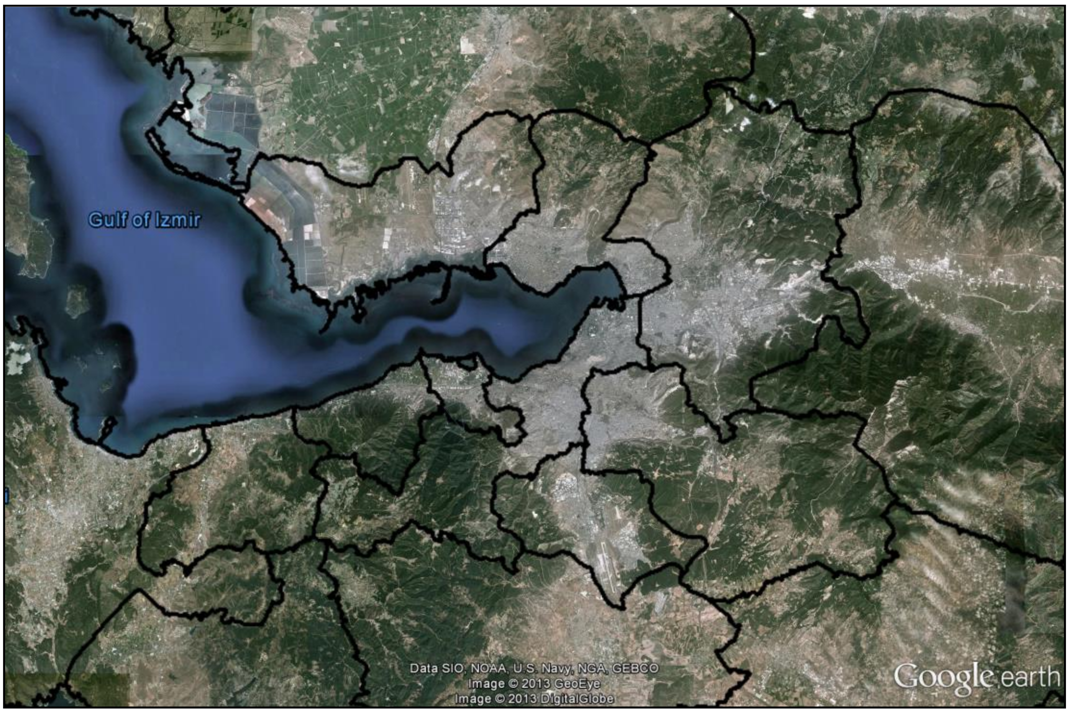

Figure 6. Districts of Izmir Greater Municipality

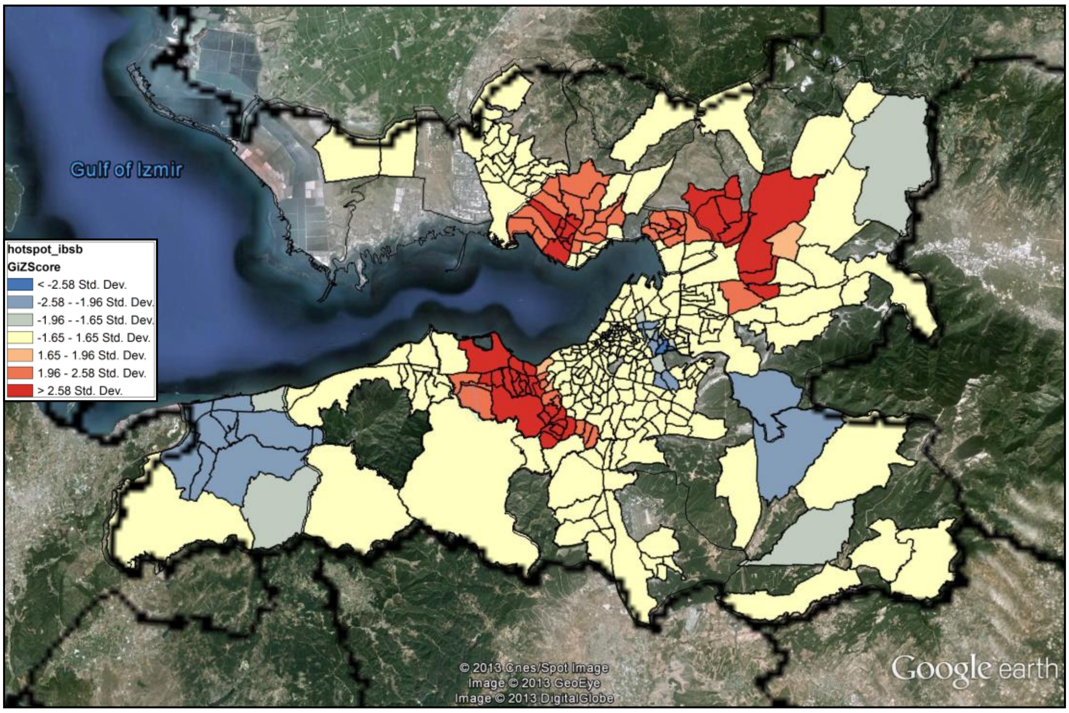

Figure 7. Result of the HotSpot Analysis (Neighborhood Based)

4 CONCLUSION

Geographic terms, such as place, area, neighborhood, and districts are increasingly finding their way into the epidemiologic literature, as advances in GIS technology make it ever easier to connect spatially referenced physical and social phenomena to population patterns of health and disease.

Development of GIS based cancer density maps can contribute to epidemiological studies in medical science as the aim of epidemiologic studies of examination of distribution of a health incidence in different societies and at different times to find out differences and to develop hypothesis of cause of disease. Thus use of GIS based analysis and inquiries as a decision support system in decision making process of medical science can be provided.

As interest increases in interventions for cancer prevention and control, geo-demographics data and GIS-based information displays begin to be used in cancer control and prevention activities (Natl. Cancer Inst., 2002 and Lubenow & Tolson, 2001)

For public health professionals, the goal is frequently to glean some insight from data. Rather than reporting the result of testing a formal statistical hypothesis, as in a classical scientific approach, they successively apply graphical or other visualization tools, data enhancement methods, and a mix of descriptive statistics and more formal data models (McEntee et al. 2008 and Parrott et al. 2010). For this purpose, different analyses have been performed in the study.

One area of increased interest in GIS and the spatial analysis of health data is that of establishing relationships between disease rates and exposures to environmental factors. Spatial analysis methods are also becoming embedded in spatial decision support systems for public health.

The results of this study are important for both academicians and local/central governments. From an academic point of view, this study requires an interdisciplinary collaboration in order to interpret the analyses. From local/central government's point of view, it is an important issue of planning of limited resources in developing countries. It is observed that perceptions of satisfaction about health planning services depends on the health services access, health institution in terms of personnel and equipment, health care organizations serving their fields and properties of these areas.

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