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Assessment of Under-5 Mortality Rates in İstanbul Using the Geographic Information System

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ORIGINAL INVESTIGATION

ABSTRACT

Objective: Analyzing mortality rates and the reasons for these in Turkey's urban allocations using geographic information systems (GISs) is a new research area. While planning health services, knowing the mortality rates and reasons according to age and residential area are a big source of information for health planners and people who provide health services. The aim of this research is to analyze the deaths of children under the age of 5 years in big cities depending on a socioeconomic range using GIS. Further, this should make it possible to determine geographically risky places.

Materials and Methods: The deaths of children under the age of 5 years that occurred between 2005 and 2009 were analyzed. Date from the Turkish Statistical Institute (Turk Stat) concerning population and age-specified deaths, İstanbul Metropolitan Municipality (IMM) cemetery directorate death records, and the Ministry of Finance land unit prices (to determine the socioeconomic level of the districts) were used as data resources. The Z value of each year's death rate, depending on the districts age ranges and average of all years' Z values, was calculated and is shown on the map.

Results: While the under-5 mortality rate was 19.37 per 1000 in 2005, it was 14.31 per 1000 in 2009. Deaths of children under the age of 5 years took place particularly in Istanbul on the European side (in districts where the land value is low).

Conclusion: Priority should be given to health promotion programs in areas with a low socioeconomic level in particular where premature death rates are observed to be more common.

Keywords: Geographical Information GIS, Health Geography, under-5 mortality rates, Socioeconomic Indicators, International Classification of Diseases-10

INTRODUCTION

"Health geography," in other words "medical geography," is a branch of research covering the relationship between human diseases and environmental circumstances. While doing this, in addition to the value it gains from the medical and geographical fields, it also benefits from sociology, antroplogy, economy, psychology, statistics, and mapping; as a result of this, it allows an integrated perspective of illness and public health.

Today, two fundamental approaches are gaining attention in health geography: first, geographical epidemiyolgy, which examines the geographical distribution of diseases, and second, techniques providing a visual aspect to health planning and health services' spatial range (1).

Knowing the geographical dispersion of diseases is one of the essential conditions for a country's health politics and investment in healthcare (2). With the developments in geographic information system (GIS) technology and statistical methods, health and population data can be evaluated together in an area that is geographically defined. Furthermore, investigating theological positional changes in health risks is also possible. GIS is used in following and analyzing events related with health, such as disease outbreaks. In addition, mapping diseases, geographical correlation studies, environmental risk evaluation, and the health compilation of applications can be conducted with GIS (3).

The aim of this study is to study the causes and range of deaths of children under the age of 5 years in counties of İstanbul; the other aims are to spatially determine the socioeconomic range, investigate the piling up of Z value death rate in towns, and compare the educational level and age-specified death rates to investigate GIS as a critical tool in analyzing community health and in creating health plans and programs.

Background

Ecological studies

In ecological studies, substantial data are generally used, and it is possible to form ecological conclusions via the calculated speeds of groups (4, 5). Ecological analyses are criticized by some societies because they do not

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expose individual cause-conclusion correlations. However, to observe a problem from a bird's eye view is a good starting point. Furthermore, as an alternative to expensive and more complex studies, it is a rather economical method, i.e., a low-cost starting tool to obtain a general perspective. Ecological studies use population inventories and remote detection data as sources. In this way, a specific area can be examined with the most suitable perspective (4, 6). Therefore, ecological studies have become the center of interest of epidemiologists. Examples that can be given of ecological studies are as follows: deaths that have occurred due to a heatwave in France, breast cancer incidence, and a community's average fat consumption levels (7).

Research area: İstanbul

İstanbul is one of the oldest, most crowded, and most important global cities in terms of economy, where it is ranked 34th worldwide In addition, it is the most crowded city in Europe (8). İstanbul is located in the northwest of Turkey, along the Bosphorus and Marmara sea area and surrounding the Haliç. Its coordinates are 41°01'N 28°58'E. Geographically, İstanbul is between the Asia and Europe. As a consistently growing and developing city, currently, İstanbul has 39 counties (8).

According to the 2009 Address Based Population Registration Systems population census results, the total population of Istanbul is 12915158, and the most crowded county is Bagcılar among the 39 counties; the least crowded is Prince Islands (Table 1) (9).

Socioeconomic aspects of health

The existence of socioeconomic disparities are known both in child and grown-up health in Turkey as well as in most countries (including developed countries) (10). Although socioeconomic disparities are known in child health, there are some obstacles in determining these disparities. The most common obstacle is the scantiness of socioeconomic information in survey systems. Because socioeconomic indicators are directly related to health outcomes, without sufficient socioeconomic data, it is not possible to fully understand health disparities (11).

Methods that can dissipate the deficity of the socioeconomic date in surveys include using the geographical coding and location rates (12). Using the location rate as a socioeconomic indicator does not give information on individual aspects, but rather gives information regarding the composition of the people living in an area and area characteristics (e.g., poverty rate, existence of an easily reachable health center, proximity to dump sites, etc.) (13). This infomation can not only be used for a specific group issue, like child health, but can also be used for whole communities in an area, but it has to be nonreliant on indicators such as age, gender, and education level (12). This potential solution though has a problem: there is no consensus regarding which socioeconomic scale makes a difference in each geographical area, which presents challenges in assessing socioeconomic disparities in health (11, 13).

Different variants are thus used to determine the socioeconomic imparities (poverty rate, house member's income rate, unemployment rate, population intensity, being landlord rate, Z scores). Utilizing this variety can be more efficient in etiological studies, but it complicates the comparisons of different studies (11).

Values in the region are necessary to evaluate the effects of the socioeconomic effects of the regions people live in on their health outcomes (14).

Children from families with low socioeconomic conditions have a high risk of being born with a low birth weight, malnutrition, being exposed to passive smoking, and infection. Besides, educational opportunities are more restricted (14).

Causes of under-5 mortality

Child mortality in low-income countries is a key topic for public health. One of the millennium development goals in 2010 was to reduce child mortality by two-thirds by 2015 (15). In most developing countries, child mortality declined considerably. Unfortunately this decline did not show a homogeneous dispersion geographically. Disparities were seen between inland and cross-nations. These disparities can be due togeographical differences and/or large-scale environmental and socioeconomic factors, as well as

Table 1. İstanbul county no

No	County names	No	County names	No	County names	No	County names
1	Adalar	12	Fatih	22	Şişli	32	Çatalca
2	Avcılar	13	Gaziosmanpaşa	23	Tuzla	33	Arnavutköy
3	Bakırköy	14	Güngören	24	Ümraniye	34	Ataşehir
4	Bağcılar	15	Kadıköy	25	Üsküdar	35	Başakşehir
5	Bahçelievler	16	Kağıthane	26	Zeytinburnu	36	Beylikdüzü
6	Bayrampaşa	17	Kartal	27	Esenler	37	Çekmeköy
7	Beşiktaş	18	Küçükçekmece	28	Sultanbeyli	38	Esenyurt
8	Beykoz	19	Maltepe	29	Büyükçekmece	39	Sancaktepe
9	Beyoğlu	20	Pendik	30	Şile	40	Sultangazi
11	Eyüp	21	Sarıyer	31	Silivri		

*The numbering sequence IMM County (8)
IMM: İstanbul Metropolitan Municipality

individual/household factors, health risk factors, and health care factors, including the quality of health services and access to them (5, 16-18).

Under-1 mortality is rather difficult to prevent due to endogenous causes (congenital anomalies, prematurity, low birth weight). The effects of external factors on 1- and 4-year-old child mortality rates are increasing; for instance, family education level is directly related with child health (nutrition, hygiene, education, access to health services) (19).

Z score (standard deviation score)

When versatile values are standardized and differences from the measurement units areremoved, a comparision between the versatiles with different values is possible. The standardization of verstaile values can be done in many ways, such as the usage of Z scores. The Z score method is a standardization method suggested by WHO, because it provides the opportunity to compare the different ages using a range of parameters and shows a reference scatter (20, 21).

The most important advantage of the Z score in research is that it can be used in community screening, and also that avarages and standard deviations can be calculated; for instance, it expresses how many standard deviations away the person or group in the research group is from the median value of the reference group or person. As understood from the below formula, the Z score can be calculated by substracting the survey value from the average value of the reference group and dividing it by the reference group standard deviation (2-1) (20).

$$Z\ Score = \frac{Xi - Xav.}{S} \quad (2\text{-}1)$$

Xi) Data value, Xav) Average of data

S) Standard Deviation.

MATERIALS and METHODS

This research has been designed based on an ecological study. The research area comprised all the counties in İstanbul. This work covers deaths of children under the age of 5 years between the years 2005 and 2009. The dependent variants of this research are: age and Z score. The independent variants are: the district that the dead child used to live, the average value of the dead child's district, and the educational limit in the district (university graduate limit).

Research data were provided from IMM's cemetery directorates' death records between the years 2005 and 2009. Under-5 mortalities were chosen from these records as the study data. The adresses where the dead child used to live were classified according to the counties they were related to. The mortality rate and under-5 mortality rates in towns were determined over each year and by town. The reasons for death indicated in the data were sorted by UHS-10 classifications, first level, section 21. The primary four causes of death were determined according to this classification.

To determine the under-5 mortality rates, 2007, 2008, and 2009 census data of the counties were used. The data were sourced from TurkStat (22). Also, the 2005 and 2006 age specified populations were calculated by TurkStat's year specified population increase rate (9).

Using the Ministry of Disctricts 2010 land values, county land prices were calculated and were then seperated into 5 categories, from the lowest to the highest value. First the land values were sequenced from small to large. Then, they were allocated in 20% segments (23). A thematic map that indicates the counties by their value was created.

Using TurkStat's population inventory data based on the address, education data were determined by calculating the collage and gradute education percentages in each county (9). Then, the graduate and collage education percentages in counties were entered into the ArcView database and shown as a scatter map.

For the years 2005 to 2009, Z values were calculated seperately for all the age groups' death rates and the average death rate in the selected 5 years. These results were shown on the map at a district level.

Statistical analysis

The SPSS 15.0 (SPSS Inc.; Chicago, IL, USA) program was used in the research for database arrangement and for calculation of the Z values. GIS applications were done by the ArcView 9.3.1 (License number 103149 37149490) software program. The population under the age of 5 years, the death rate through the years, land value codes of counties, and main four mortality reasons in towns were entered into the database of the ArcView 9.3.1 software. Scatter and thematic maps were generated by processing the instructions in the database. While obtaining the death rate scatter maps for the under-5 age group, the findings were seperated into four color groups.

RESULTS

The research findings are composed of age specified death rates, death rates by reasons, and place value findings. In the selected 5 years (2005–2009), the total deaths of children under the age of 5 years was determined as 23107.

While the evaluation was set at the county level, it was observed that the central counties had higher average values (Figure 1).

It was found that, the counties with the highest educational level percentage were Kadiköy, Beşiktaş, and Bakırköy. While the lowest educational percentage counties were as follows: Sancaktepe, Şile, Zeytinburnu, Esenler, Kağıthane, Bağcılar, Sultangazi, Gaziosmanpaşa, Esenyurt, Arnavutköy, Silivri, and Çatalca. Con-

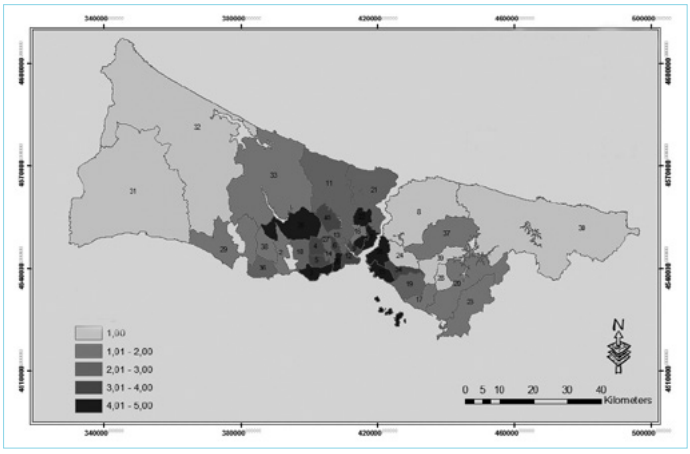

Figure 1. Place value at the county level

sidering the Z value using the under-5 mortality rates, towns such as Gaziosmanpaşa, Zeytinburnu, and Bağcılar are the districts that demonstrate differences in terms of a low college graduation level and high death rates.

In 2005, the under-5 mortality rate was 19.35 per 1000; in 2006, it was down to 14.63 per 1000 and in 2007 it was down to 11.24 per 1000; however, in 2008, it increased and was 14.79 per 1000, whereas in 2009 it was down to 14.31 per 1000 (Figure 2).

When examining under-5 mortaility rates in Istanbul, it is seen that the death rate held in two levels. From years 2005 to 2009, there was a decline. In Figure 2, the max. and min. values by years can be seen. Figure 3 shows the under-5 mortality rates for 2005 to 2009, which arescattered by district.

Between the years 2005 and 2009, the under-5 mortality rates was dispersed in two levels (death rates per 1000: min. 1.38 to max. 25.35) (Figure 3). In the selected 5 years, under-5 mortality rates of over 10 deaths per 1000 were observed, as seen in the continuously monitored counties in yellow.

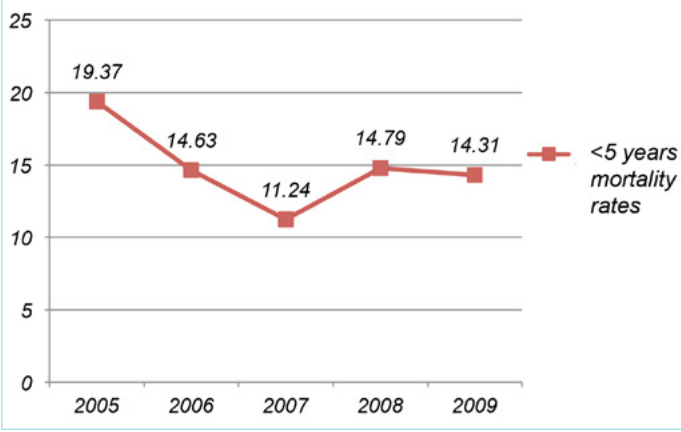

Figure 2. **Under-5 mortality rates (2005-2009)**

According to the Z values obtained from the average under-5 mortality rate of children between the years 2005 and 2009, two counties indicated differences more than the 1.96 limit (Figure 4), namely Bağcılar (Z value: 3.10) and Fatih (Z value: 2.19).

According to the Z values obtained each year from the under-5 mortality rate of children between the years 2005 and 2009, six cities indicated differences of more than the 1.96 limit (Figure 5), namely Zeytinburnu (3.00), Güngören (1.99), Gaziosmanpaşa (2.49), Büyükçekmece (2.49), Bağcılar (4.40), and Fatih (3.58).

When the primary causes for deaths of children under the age of 5 years were examined, it was found that they were related to cardiovascular system diseases (31.2%), perinatal period (22.7%), respiratory system diseases (12.1%), and causes other than disease or mortality reasons (8.2%).

DISCUSSION

Geographic information system is a useful information output method in terms of monitoring epidemiologic data in residential areas to characterize the health priorities of the population living there, and to assist in determining and visualizing risky areas. The data collected in this study allowed an effective method to be utilized to show the death rates by categories of age and to allow determination of the relatively risky areas in a city's geography. GIS studies conducted in Turkey though are rather few compared to the number of studies conducted in more developed countries.

Naturally, in the land values map of İstanbul, the land values of central areas are noticeably rather high. Considering the land value instead of the socioeconomic level of individuals has been used as a socioeconomic determinant in a lot of studies, and utilization of land value is also suggested (14). This method is a way of signifying the economic level of an area. In this respect, it is a proper criterion for an ecological perspective. The disadvantage of land value utilization is the difficulty to introduce differences, especially while applying it over wide areas. In this study, rich and relatively poor

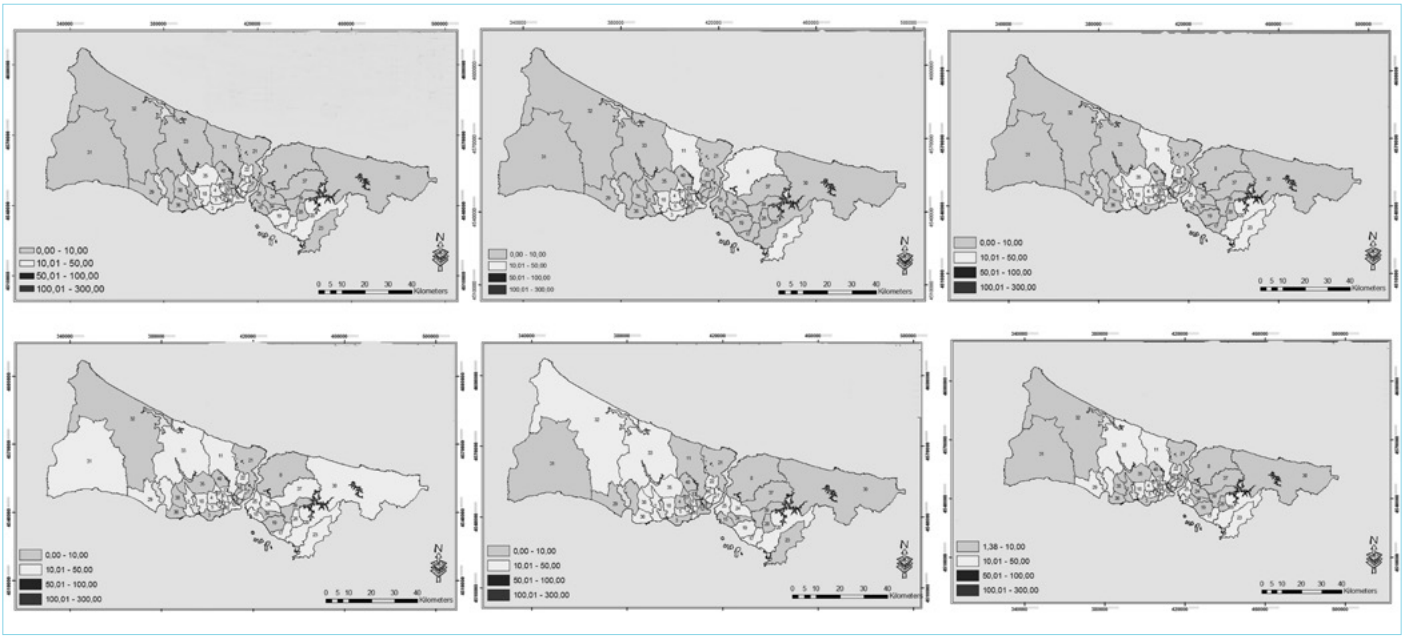

Figure 3. **Under-5 mortality rates scattered by districts (2005-2009)**

areas of İstanbul were determined in land value terms by county. In summary, the map of land value forms a base showing the socioeconomic differences. To clearly emphasize these differences, Z values were used on the map.

In the graduation made by the causes of under-5 mortality, it is noticed that cardiovascular issues are in the first rank. This, however, can be explained by the incorrect input of data. For this age group, perinatal causes, such as congenital anomalies, are the main causes of death. Most probably, cardiac failures in premature births, such as cardiac anomalies frequently seen in congenital anomalies, were grouped as cardiovascular causes in the database. For the realistic evaluation of the causes of deaths, the training of "Importance of Data's Input of Deaths Causes" should be added to physicians' professional development programs (24).

In this study, the average under-5 mortality rate of children was found to be 14.86%. Investigation of TurkStat 2003 and 2008 deaths of children under the age of 5 years in İstanbul showed figures in 2003 of 37% and in 2008 of 23%. When the death rates decreased, TurkStat's forecasts become difficult and the reliability gap enlarges. The derived under-5 mortality rates are within the reliability gap calculated by TurkStat. Within the selected years for the under-5 mortalities, the rates decreased consistently. Studies realized by land value in Istanbul also show that in thinly scattered

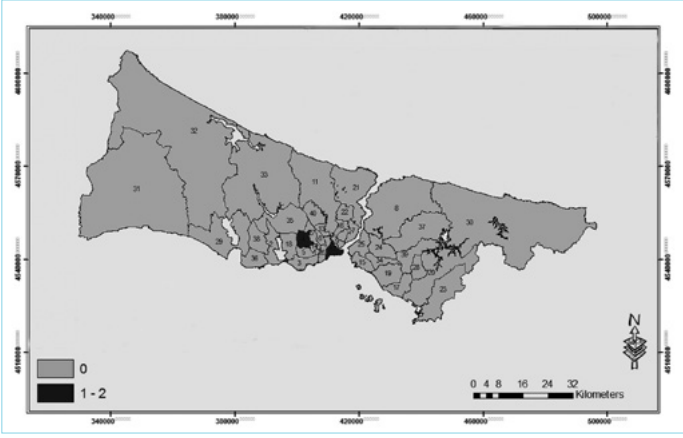

Figure 4. Z values average of under-5 mortality rates between 2005 and 2009

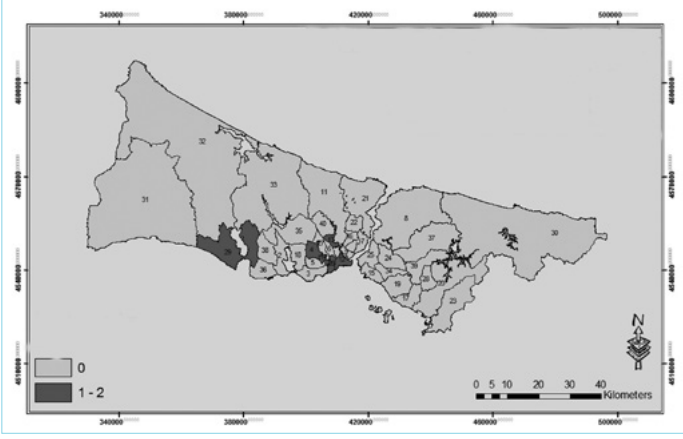

Figure 5. Z values of each year of under-5 mortality rates between 2005 and 2009

populations and in low land value zones, especially in the European side, the death rates differs, compared with the other zones (25).

Wood's investigations in morality studies conducted for the countryside–city comparison focused especially on child morality, because this indicator is affected by changes in population density (18). Also, according to Defo's studies, a high population density has negative effects on infant and child mortality (26).

However in İstanbul, considering some counties have rather high death rates within the 2005–2009 period, groupings were noticed in low land value zones such as Bağcılar, Büyükçekmece, Güngören, and Gaziosmanpaşa. Conflicting results from Fatih, Bağcılar, and Zeytinburnu were also included in these groups. Relatively high land values are also found in these counties when analyzed by district. Because low land valued districts can take place also in these counties, the districts average land value is close to the center, but many families living there have low socioeconomic levels, hence these are unsatisfactory criteria to explain socioeconomic characteristics. Fatih is a county where most of the important sanitary facilities of İstanbul are settled together. There are ten private, six state, and three university hospitals in Fatih. So, the high numbers of deaths in these facilities need to be considered in the address declaration.

In Turkey, as the main causes of death in cities, in the first rank is perinatal causes at 36.3%, followed by congenital anomalies at the rate of 14.1%, total lower respiratory infection at 10.9%, diarrhea at 6.2%, and, for the 0–14-year-old category, traffic accidents at 3.0% (27).

According to The National Studies of Disease Loads and Cost Effectiveness, for 1–4 year olds, mortality rates were calculated for boys as 8.9% and for girls as 8.5% (26). Studies conducted by Eggmann show the causes of deaths in 1–4 year olds as, first, traffic accidents (13.2%), second, cancer (8.4%), and third, cardiovascular diseases (28).

One-fifth of total deaths in the world are children. With the increase in development levels in many countries, infant and 15–59 year olds' deaths are ranked lower among other age categories. Considering the under-5 mortalities in the world, the main causes are respiratory diseases, birth, and birth defects (29).

CONCLUSION

As a process in the management of city health, the definition of inequality by locations, confirmation of risky zones by diseases, supplying and simplifying the meaning of required information for health personnel makes GIS applications effective methods to conduct continuous health surveillance and to comment on the results.

In İstanbul, the central zones are high land value zones. In the case of microsectionalizing, the land value can be more effective as a measure than the socioeconomic values. To stabilize the counties for outstanding death rates, the Z value approach is useful to form clumps of data. In the counties of Büyükçekmece and Gaziosmanpaşa in particular, deaths in early ages are forming bigger clumps than in the other counties.

It was observed in İstanbul that under-5 mortality rates gradually decreased and differed from the Turkey-wide results, showing that urban death rates also decrease. However, it was observed that in in relatively peripheral zones in the city, the death rates are higher.

Considering under-5 mortality rates, this is evidence for an inequality of health care in that area.

It is known that in under-5 mortalities, prenatal causes, and congenital anomalies are the most common causes of deaths. To decrease deaths to these, it is very important to realize communal intervention studies (30).

In the case where child mortality data are obtainable, prioritizing healthcare services and health inquiries and regional analysis are important. In the National Mortality Studies, discrepancies need to be prepared by zones and then analyzed. In the case of the similarity between the mortality trends in neighboring zones, it is possible that mortality is related to the similar social, economic, and/or environmental inter-regional factors. Furthermore, if the mortality rates trace a specific pattern in a region, this is most probably related to local factors (specification of health systems) (5).

Ethics Committee Approval: Ethics committee approval was not obtained due to the retrospective nature of this study.

Informed Consent: Written informed consent was not obtained due to the retrospective nature of this study.

Peer-review: Externally peer-reviewed.

Authors' Contributions: Conceived and designed the experiments or case: ÜTB, BH. Performed the experiments or case: ÜTB, BH. Analyzed the data: ÜTB, Hİ. Wrote the paper: ÜTB, Hİ, BH. All authors have read and approved the final manuscript.

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