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著者	Ayca Hatice Turkan, Erdugan Funda, Aldemir Suleyman
journal or publication title	International Review for Spatial Planning and Sustainable Development
volume	8
number	4
page range	1-15
year	2020-10-15
URL	http://doi.org/10.24517/00062361

doi: 10.14246/irspsd.8.4_1

International review for spatial planning and sustainable development, Vol.8 No.4 (2020), 1-15
ISSN: 2187-3666 (online)
DOI: https://doi.org/10.14246/irspsd.8.4_1

Spatial Patterns of Infant Mortality in Turkey between 2011 and 2016

Ayça Hatice Türkan[1*], Funda Erdugan[2] and Süleyman Aldemir[3]
1 Department of Statistics, Faculty of Science and Literature, Afyon Kocatepe University
2 Department of Statistics, Faculty of Science and Letters, Kırıkkale University
3 Institute of Natural and Applied Sciences, Afyon Kocatepe University
** Corresponding Author, Email: aturkan@aku.edu.tr*

Received: April 09, 2019 Accepted: July 18, 2020

Keywords: Geovisualisation, Infant Health, Infant Mortality, Spatial Analysis, Spatial Autocorrelation

Abstract: Health studies are important for the evaluation of health services and the improvement of poor conditions as well as for the determination of the development levels of countries. The purpose of this study was to demonstrate the spatial patterns of infant mortality, which is considered an indicator of health conditions, in Turkey between 2011 and 2016. The existence of global autocorrelation was first studied using the infant mortality rate, the standardised mortality ratio, and the infant mortality rate which was corrected by Bayes smoothers. Local spatial autocorrelation analysis was performed to determine statistically significant hot spots or clusters in infant mortality. It was determined that the spatial distribution between 2011 and 2016 was not coincidental, and aggregation tendency and spatial dependence were observed in the data. According to local spatial statistics, spatial differences of South-eastern Anatolia and Eastern Anatolia regions appeared in Turkey in terms of infant mortality. Furthermore, the factors related to the infant mortality rate were considered. It was found that the age of marriage for women, the net schooling rates of females in secondary education, the number of midwives, and the gross domestic product (GDP) were related to infant mortality rates. It is important to determine different associated factors in the provinces with high infant mortality rates found in this study and to develop an understanding of what can be done to prevent infant mortality in the future. In the South-eastern Anatolia and Eastern Anatolia regions, it is necessary to produce and implement policies with the scope of reducing the infant mortality rate.

1. INTRODUCTION

Infant mortality in a country is related to child health and is also an objective and precise indicator for determining the socio-economic status and level of public health in the country. The infant mortality rate, defined as the number of deaths of children under the age of 1 year per 1,000 live births in a calendar year (Reidpath & Allotey, 2003), is a silent and significant measure of the quality of life in a society, the value given to different generations, various age groups and genders, and the power balances not discussed in a culture (Gürsoy-Tezcan, 1992).

According to the 2018 Annual Report of the United Nations International Children Emergency Fund, significant developments have been observed in the child survival rate since 1990. While the number of deaths of children under the age of 5 years per 1,000 live births around the world was 93 in 1990, it decreased to 39 in 2017. Children face the highest risk of death in the neonatal period. In 2017, 2.5 million infants died in their first month of life. While the infant mortality rate for every 1,000 live births is 18 in the neonatal period, it is 12 in infants who complete their first month but do not reach their first birthday and 10 in children between 1 and 5 years of age (United Nations Children's Fund (UNICEF) et al., 2017).

The mortality statistics of 2017 published by the Turkish Statistical Institute (2019a), however, reflect that the infant mortality rate corresponds to 9.2 infant deaths per 1,000 live births and 11.2 deaths in children under the age of 5 years. Moreover, the 2013 Turkish Demographic and Health Survey concluded that the mortality rate in children under the age of 5 years is 15 per 1,000 live births. This rate means that one in 66 children born alive dies before reaching their fifth birthday. The infant mortality rate is 7 in the neonatal period and 13 in infants who cannot reach their first year of life. Furthermore, 87% of deaths in early childhood occur in the first year of life (Hacettepe University Institute of Population Studies, 2014). Several important results and academic research studies regarding infant mortality in Turkey can be summarised as follows. Metintas et al. (2010) aimed to identify the determinants of infant mortality rate in a province in Turkey and found the most important factor influencing infant mortality rate was the rate of unschooled women. Cesur et al. (2017) examined the impact of primary healthcare on population health. They reported that the family medicine programme, launched in 2005 in Turkey, reduced the mortality rate by 25.6% among infants. Furthermore, Aydin et al. (2019) investigated the causes of infant mortality rate in a Turkish city. They evaluated a number of factors, such as educational levels of mothers, consanguineous marriages, maternal age, and the interval between pregnancies. Finally, Yılmaz (2019) examined the factors that affect the infant mortality rate in Turkey between 2009 and 2014. It was reported that the age of marriage of women and men, the size of the household, the number of persons per physician and midwife, and the education of women influenced the infant mortality rate.

Infant mortality analyses play an important role in the planning of health services, the determination of their priorities, the establishment of population policies and programmes, and the evaluation and comparison of services (Okyay et al., 2011; Taşkin & Atak, 2004). Undoubtedly, every child is extremely valuable for their parents and the society they live in. They also constitute the most vulnerable group in that society. The right to life is the most primary universal right, possessed by all children in the world from birth; minimising the number of preventable infant mortalities means that every infant will benefit from the efforts made for the right to life. To reduce these mortalities, it is necessary to analyse the answer to the question ‘Why do babies die?’ Studies in the literature reveal that social factors or biological variables are among the causes of mortality (Mosley & Chen, 1984). In social sciences studies, for example, income per capita, maternal education level, maternal age, household size, income level, and resources such as fuel, water, and electricity have been determined as the causal determinants of mortality (Mosley & Chen, 1984; Majumder & Islam, 1993; Eğri, 2010; Rutstein, 2000; Buor, 2003; Kayode, Adekanmbi, & Uthman, 2012). In medical studies, variables such as diseases, biological processes of diseases, infections, nutritional deficiencies, and low birth weights have been studied (Mosley & Chen, 1984; Rutstein, 2000).

Geographical information systems or spatial analysis methods are used in various health-related researches (Yuliantari, Hafsari, & Prima, 2018). The relationship between an effect and its relative position can be determined using spatial analysis (Fradelos et al., 2014; Wang, 2017). The spatial analysis process begins with the determination of a problem and is followed by the verification of the spatial pattern through visualisation methods, the analysis of the significance of the studied hypotheses by statistical methods, and the determination of risk factors or the analysis of the events (Wang, 2017). In this study, using spatial analysis, we focused on the examination of infant mortalities in Turkey in different provinces which vary in terms of social, cultural, geographical, and economic factors. It was considered that infant mortality can produce different clusters because of these differences among the provinces. The majority of studies on infant mortality in Turkey or abroad try to determine the causes of infant mortality by using traditional statistical techniques, without applying spatial information. However, understanding the spatial pattern of infant mortalities will help to assess the regional effects on the mortalities by geographical analysis, identifying the causes of death, and taking necessary precautions. Based on these motivations, the primary contribution of this study is to demonstrate the spatial distribution, mapping, and clustering tendencies of infant mortality in Turkey. We also examine the literature to determine the variables associated with infant mortality. Unfortunately, we are unable to control maternal factors, birth factors, diseases, demographic factors, economic factors, or factors related to living conditions in this study because annual data for Turkey are not available for the period covered in this research. For this study, we examine the relationship between several variables and the infant mortality rate. These variables include the average age of marriage for women, the average age of first marriage for women, net schooling rates of females in secondary education, the number of women aged 15-49 per midwife, the number of persons per physician, the number of persons per family medicine unit, gross domestic product by economic activity, and unemployment rate. In this context, the secondary contribution of the study is to provide policy-makers with the variables associated with infant mortality for related development strategies, which may reduce the differences among the provinces.

2. METHODS

In this study, the province, the largest administrative unit in Turkey, is used as a spatial unit (*Figure 1*). The data relevant to provinces used in this study is compiled from the birth and mortality statistics published by the Turkish Statistical Institute (2019c) for the years 2011 – 2016. The infant mortality rate for each province is calculated by dividing the number of infant deaths by the number of live births in the same year and then multiplying by 10^3. Infant mortality rate, therefore, is defined as the number of infant mortalities per 1,000 live births in a calendar year. In addition to the infant mortality rate, the standardised mortality ratio (SMR) is also used. Let θ_i be considered as unknown relative risk for spatial unit i with probability density function $f(\theta_i)$. Given that O_i is the observed number of deaths and E_i is the expected number of deaths in spatial unit i, standard maximum likelihood estimate of θ_i is given by $SMR = O_i/E_i$ under Poisson assumptions on O_i (Clayton & Kaldor, 1987; Jafari-Koshki, Schmid, & Mahaki, 2014; Saravana Kumar et al., 2017). If the national rate is p, the expected number of deaths in the spatial unit i, E_i, is the population size within spatial unit i, n_i, multiplied by the national rate: $E_i = n_i p$. The aim of the SMR is to calculate how many deaths would be expected in the spatial unit if the mortality rate were the same as in the general population. However, because fewer mortalities and diseases occur in locations with a lower population density, rough rates or standardised mortality ratios may not be reliable. When locations with a high population density are compared to ones with a low population density, ratios cannot represent the relative size. Locations with different population densities but equal SMR values may in reality be quite different from each other. Similarly, locations with high SMR values may have higher population densities. Empirical Bayes (EB) smoothers, developed with the assumption that the prior distribution of relative risk is gamma, normal or log-normal, are available to overcome the problems that arise from the differences in population volumes of locations and to estimate the relative risk in a more reliable manner (Clayton & Kaldor, 1987; Meza, 2003). For this purpose, when a Bayesian approach is adopted, the number of deaths in spatial units is considered to be Poisson-distributed, and Bayes estimations or smoothers correspond to the average of the posterior distribution (Saravana Kumar et al., 2017; Anselin, Lozano, & Koschinsky, 2006). Moreover, empirical Bayes estimations vary based on the assumption regarding prior distribution as well as the methods (e.g., maximum likelihood, method of moments) used to obtain the moments of prior distribution (Anselin, Lozano, & Koschinsky, 2006). Spatial empirical Bayes smoothing procedures were also introduced by adding spatial weights representing spatial relationships. We use the default empirical Bayes smoothers in GeoDa software in the current study. A more comprehensive technical background of these procedures is given in (Anselin, Kim, & Syabri, 2004; Anselin, Lozano, & Koschinsky, 2006; Marshall, 1991).

Figure 1. Geographical administrative distribution of Turkey

The EB approach consists of estimating the moments of the prior distribution from the data. In this context, the observed number of events in a spatial unit i $(i = 1, \dots, N)$, O_i (counts of death) is assumed to follow a Poisson distribution with mean $\pi_i P_i$. To state this more clearly, the distribution of O_i is conditional on the unknown risk parameter π_i and the population at risk P_i. Assume the unknown parameter π_i has a prior distribution characterised by a mean μ_i and variance σ_i^2. In the EB approach, the prior mean and variance are assumed to be constant and estimated by their corresponding sample moments. The method of moments estimators are:

$$\hat{\mu} = \frac{\sum_{i=1}^{N} O_i}{\sum_{i=1}^{N} P_i} \quad (1)$$

for the prior mean and

$$\hat{\sigma}^2 = \frac{\sum_{i=1}^{N} P_i(\hat{\pi}_i - \hat{\mu})^2}{\sum_{i=1}^{N} P_i} - \frac{\hat{\mu}}{\bar{P}} \tag{2}$$

for the prior variance, where $\bar{P} = \sum_{i=1}^{N} P_i/N$ is the average population at risk. The moment estimates in equations (1) and (2) are used to compute the weights:

$$w_i = \frac{\sigma^2}{\sigma^2 + (\mu/P_i)} \tag{3}$$

for the shrinkage estimator

$$\hat{\pi}_i^{EB} = w_i\hat{\pi}_i + (1 - w_i)\mu \tag{4}$$

where $\hat{\pi}_i$ is the crude rate and $\hat{\pi}_i = O_i/P_i$.

The spatial EB smoother is based on the same principle as the EB mentioned above, except for the computation of the priors. Instead of estimating a constant mean from all the data points, the prior mean for the crude rate at i is estimated as:

$$\hat{\mu}_i = \frac{\sum_{i\epsilon J_i} O_i}{\sum_{i\epsilon J_i} P_i} \tag{5}$$

where J_i is the local neighborhood set for i (including i). The local estimator for the prior of the variance is

$$\hat{\sigma}_i^2 = \frac{\sum_{i\epsilon J_i} P_i(\hat{\pi}_i - \hat{\mu}_i)^2}{\sum_{i\epsilon J_i} P_i} - \frac{\hat{\mu}_i}{\bar{P}_i} \tag{6}$$

where $\hat{\mu}_i$ is the local prior for the mean and $\bar{P}_i = \sum_{i\epsilon J_i} P_i/N$ is the local average population at risk. The local priors are then used to replace μ and σ^2 in equations (3) and (4).

The spatial autocorrelation analysis used in this study includes global statistics that identify the clustering factor and local statistics that determine the clusters (Anselin, Syabri, & Kho, 2006). Furthermore, in the present study, global and local Moran statistics are used to demonstrate the spatial relationship. The Moran's I statistic for spatial autocorrelation is given as

$$I = \left(\frac{1}{s^2}\right)\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})\left(y_j - \bar{y}\right)}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \tag{7}$$

where $\bar{y}$ is the mean value of y with the sample number of n; y_i is the value of the variable at location i; y_j is the value at other locations (where $j \neq i$); s^2 is the variance of y; and w_{ij} is the spatial weight between regions i and j (Waller & Gotway, 2004). The calculation of these statistics requires the establishment of a weight matrix, $W = \left(w_{ij}: i,j = 1,2,\ldots,n\right)$, which summarises the spatial relation between spatial units. In this context, the commonly used queen contiguity weight matrix is utilised. In this matrix, for spatial units with common borders or common vertices, the spatial weight,

w_{ij}, is equal to 1, and all others to 0. All spatial autocorrelation analyses are performed using GeoDa software. Additionally, a correlation test is conducted to determine the relationships between the infant mortality rate and the variables outlined at the end of Section 1.

3. RESULTS

A total of 85,196 infant mortalities were reported between 2011 and 2016 in Turkey. In the analysis of infant mortalities in 81 provinces between 2011 and 2016, it is observed that the mortality rate varied between 5 and 22 in 2011, 6 and 19.6 in 2012, 5.3 and 24.5 in 2013, 5.3 and 24.8 in 2014, 3.8 and 18.3 in 2015, and 3.1 and 18.2 in 2016. Firstly, crude infant mortality rates per 1,000 live births between 2011 and 2016 are mapped in *Figure 2*.

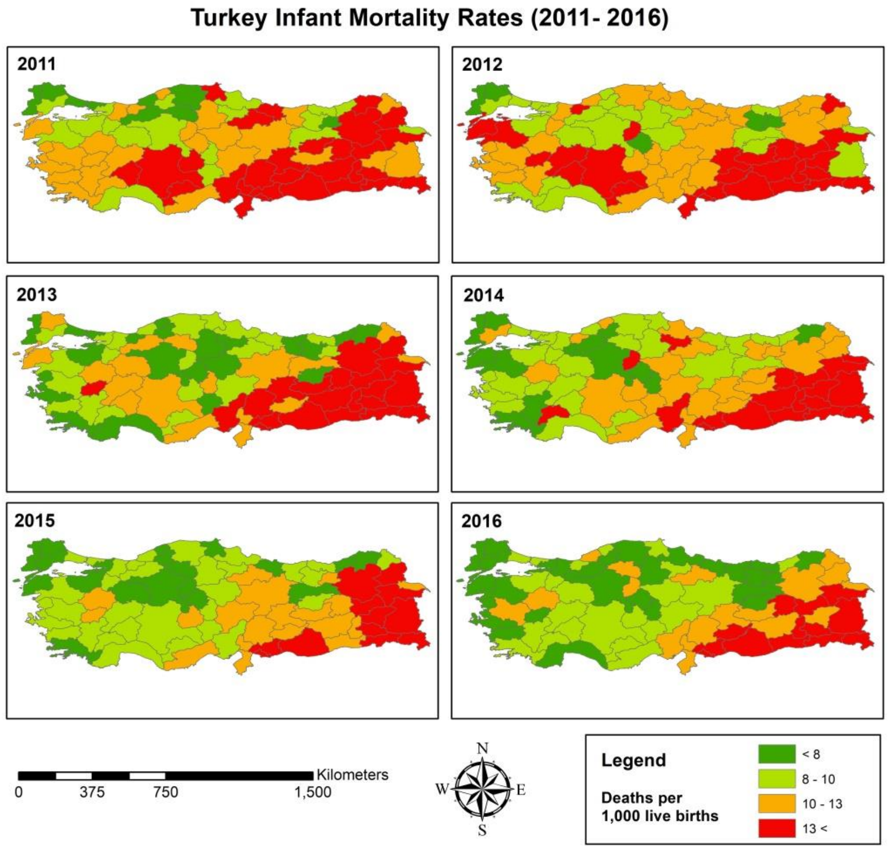

Figure 2. Maps of infant mortality rates (deaths per 1,000 live births) between 2011 and 2016

Standardised mortality ratios for infant mortalities between 2011 and 2016 are represented in the excess risk maps in *Figure 3*. Excess risk is defined as a ratio of the observed number of infant mortalities over the expected number of infant mortalities for a province. The expected number of infant mortalities is a number indicating what the number of deaths in the province would have been if that province had the same death rate as the country. Therefore, the country has an excess risk of 1. Moreover, values of the excess risk less than 1 indicate the provinces with fewer than expected infant mortalities; values greater than 1 indicate the provinces where the number of infant mortalities exceeds the expectation. It is observed that risk ratios over six years in Adıyaman, Ağrı, Bingöl, Bitlis, Diyarbakır, Gaziantep, Hakkari, Kars, Kahramanmaraş, Mardin, Muş, Siirt, Şanlıurfa, Batman, Şırnak and Kilis provinces are higher than the country average.

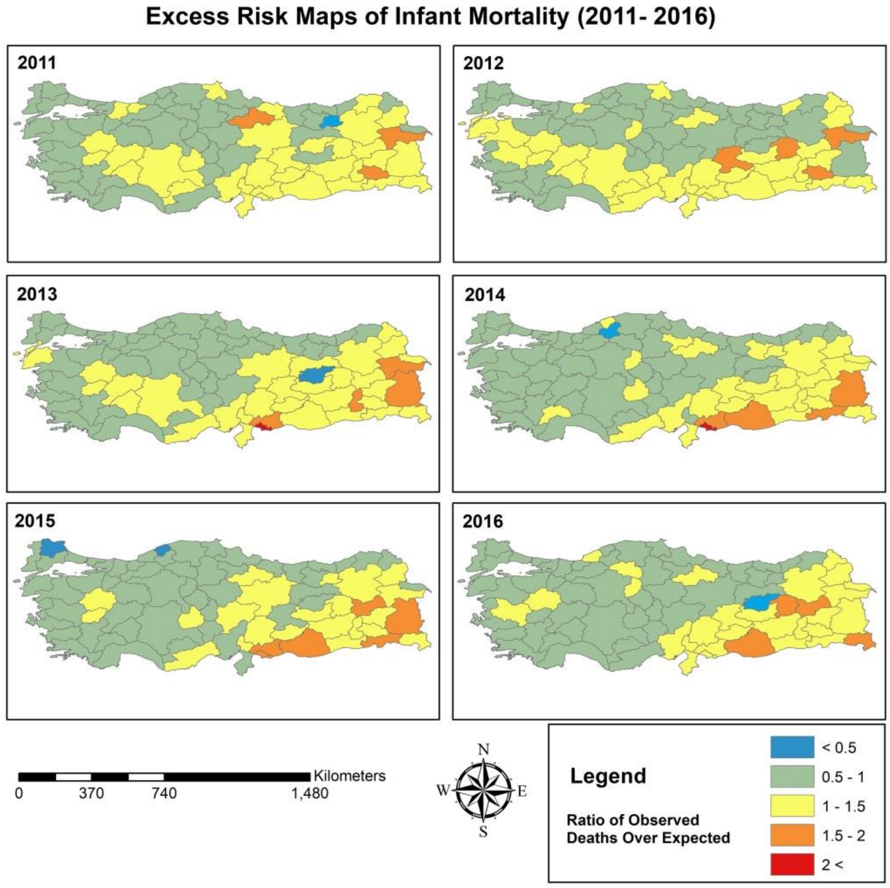

Figure 3. Excess risk maps of infant mortality between 2011 and 2016

The results of the global autocorrelation analysis for infant mortality rate, standardised mortality ratio, and the infant mortality rate which was corrected by empirical Bayes smoothers between 2011 and 2016 are given in *Table 1*. According to the test results, the null hypothesis expressing the spatial randomness of infant mortality between 2011 and 2016 was rejected, and a significant global spatial clustering was observed. Furthermore, all Moran's I values were found to be positive, which indicates positive spatial autocorrelation. This means the spatial clustering of similar values. It was also observed that Bayes smoothers allowed for the correction of Moran's I spatial autocorrelation test statistic and provided more significant results.

Following the determination of clustering in data through global Moran's I statistics, local Moran's I statistics were calculated using spatial empirical Bayes smoothing to determine the location of similar spatial patterns. Local Moran's I values/statistics were calculated for each province and show the spatial clustering degree of similar values around the province (Anselin, 1995). Local spatial autocorrelation results based on the local Moran's I statistic included cluster maps shown in *Figure 4* and significance maps shown in *Figure 5*. These maps were obtained at a significance level of p = 0.01 with 9,999 permutations. The provinces coloured with red show that provinces with high values are surrounded by those with high values, whereas the provinces coloured with blue show that provinces with low values are surrounded by those with low values. Purple- and light-purple-coloured provinces refer to outliers. Purple-coloured areas show that those with high values are surrounded by those with low values whereas light purple-coloured ones show that those with low values are surrounded by those with high values (Anselin, Syabri, & Kho, 2006). The most important of these classifications in spatial autocorrelation for infant mortality is undoubtedly the high–high relationship. Between 2011 and 2016, Adıyaman, Batman, Bitlis, Diyarbakır, Gaziantep, Mardin, and Muş appeared to be provinces appropriate for this type of relationship. The provinces with high-high and low-low relationships are given in *Table 2*. Green-coloured provinces in *Figure 5* represent the local Moran's I statistic found to be significant at different levels (p=0.01, p=0.001, p=0.00001). The darkest green-coloured provinces have high significant local Moran's I statistics (Anselin, Syabri, & Kho, 2006). Diyarbakır is the only province that appears to be appropriate for the high–high relationship at a significance level of p = 0.00001 in the years 2012, 2013, and 2016.

Table 1. Global Moran's I results for infant mortality rate, standardised mortality ratio, and empirical Bayes smoothers

		2011	2012	2013
Infant Mortality Rate	Moran's I	0.414839	0.381559	0.578718
	E(I)	-0.0125	-0.0125	-0.0125
	Sd	0.0722	0.0717	0.0704
	z-value	5.8988	5.4985	8.3984
	p-value	0.0001	0.0001	0.0001
SMR	Moran's I	0.414053	0.382235	0.57827
	E(I)	-0.0125	-0.0125	-0.0125
	Sd	0.0722	0.0717	0.0704
	z-value	5.8876	5.5071	8.3936
	p-value	0.0001	0.0001	0.0001
Empirical Bayes Smoother	Moran's I	0.421069	0.414249	0.645098
	E(I)	-0.0125	-0.0125	-0.0125
	Sd	0.0718	0.0716	0.0709
	z-value	6.0200	5.9589	9.2743
	p-value	0.0001	0.0001	0.0001
Spatial Empirical Bayes Smoother	Moran's I	0.594216	0.576675	0.832635
	E(I)	-0.0125	-0.0125	-0.0125
	Sd	0.0713	0.0714	0.0714
	z-value	8.4971	8.2513	11.8307
	p-value	0.0001	0.0001	0.0001
		2014	**2015**	**2016**
Infant Mortality Rate	Moran's I	0.55894	0.654461	0.511425
	E(I)	-0.0125	-0.0125	-0.0125
	Sd	0.0704	0.0713	0.0705
	z-value	8.1138	9.3546	7.4226
	p-value	0.0001	0.0001	0.0001
SMR	Moran's I	0.558854	0.654264	0.511019
	E(I)	-0.0125	-0.0125	-0.0125
	Sd	0.0704	0.0713	0.0705
	z-value	8.1134	9.3514	7.4161
	p-value	0.0001	0.0001	0.0001
Empirical Bayes Smoother	Moran's I	0.621805	0.683526	0.589709
	E(I)	-0.0125	-0.0125	-0.0125
	Sd	0.0708	0.0713	0.0704
	z-value	8.9561	9.7615	8.5484
	p-value	0.0001	0.0001	0.0001
Spatial Empirical Bayes Smoother	Moran's I	0.823626	0.805327	0.744696
	E(I)	-0.0125	-0.0125	-0.0125
	Sd	0.0705	0.0711	0.0705
	z-value	11.8538	11.5034	10.7296
	p-value	0.0001	0.0001	0.0001

Note: Sd stands for Standard Deviation

Table 2. Local Moran's I results

2011	**High-High**	**Adıyaman**, **Batman**, **Bitlis**, **Diyarbakır**, **Gaziantep**, **Mardin**, **Muş**, Van
	Low-Low	Çankırı, Edirne, İstanbul Kastamonu, Kırklareli, Tekirdağ, Bartın, Karabük
2012	**High-High**	**Adıyaman**, **Batman**, **Bitlis**, **Diyarbakır**, Elazığ, **Gaziantep**, **Mardin**, **Muş**, Şanlıurfa
	Low-Low	Çankırı, İstanbul, Kırklareli, Kocaeli, Kırıkkale
2013	**High-High**	**Adıyaman**, Ağrı, **Batman**, **Bitlis**, **Diyarbakır**, **Gaziantep**, Kars, **Mardin**, **Muş**, Siirt, Şanlıurfa, Şırnak, Van
	Low-Low	Bolu, Çankırı, Çorum, Karabük, Kocaeli, Kırıkkale
2014	**High-High**	**Adıyaman**, Ağrı, **Batman**, **Bitlis**, **Diyarbakır**, **Gaziantep**, **Mardin**, **Muş**, Siirt, Şanlıurfa, Şırnak, Van
	Low-Low	Aydın, Bilecik, Bolu, Bursa, Çankırı, Düzce, Eskişehir, Karabük, Manisa, Sakarya, Tekirdağ, Zonguldak
2015	**High-High**	**Adıyaman**, Ağrı, **Batman**, **Bitlis**, **Diyarbakır**, **Gaziantep**, Hakkari, **Mardin**, **Muş**, Siirt, Şırnak, Van
	Low-Low	Ankara, Bolu, Çanakkale, Çankırı, Edirne, Karabük, Kastamonu, Kırklareli, Tekirdağ, Zonguldak
2016	**High-High**	**Adıyaman**, Ağrı, **Batman**, **Bitlis**, **Diyarbakır**, **Gaziantep**, **Mardin**, **Muş**, Siirt, Şanlıurfa, Şırnak, Van
	Low-Low	Çanakkale, Çankırı, Tekirdağ

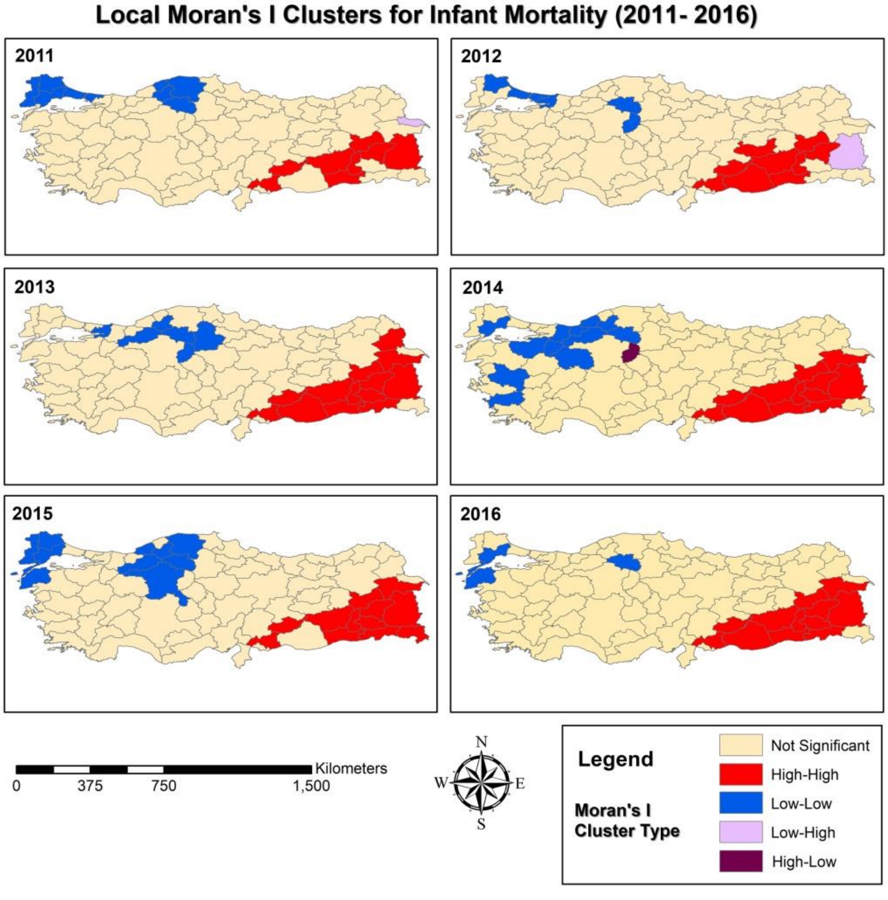

Figure 4. Statistically significant clusters for infant mortality identified by local Moran's I statistics between 2011 and 2016

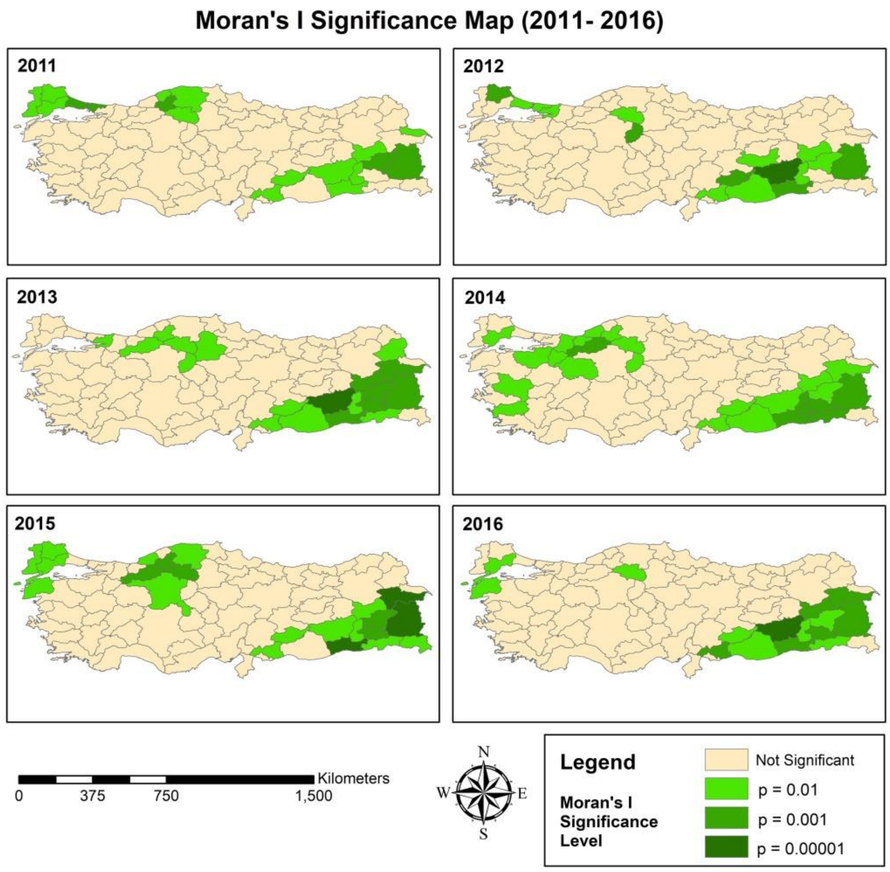

Figure 5. The locations with significant local Moran's I statistics in different shades of green (the corresponding p values are given in the legend)

Table 3. Correlation coefficients between the variables and infant mortality rates

Variable	Year					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
V_1	-0.496**	-0.450**	-0.586**	-0.672**	-0.728**	-0.654**
V_2	-0.286**	-0.245*	-0.373**	-0.453**	-0.598**	-0.492**
V_3	NDA	-0.297**	-0.539**	-0.604**	-0.529**	-0.250*
V_4	NDA	0.231*	0.379**	0.414**	0.377**	0.381**
V_5	NDA	0.255*	0.201	0.353**	0.337**	0.292**
V_6	NDA	0.267*	0.253*	0.116	0.081	0.044
V_7	-0.594**	-0.523**	-0.580**	-0.694**	-0.698**	-0.610**
V_8	0.316**	0.172	0.235*	NDA	NDA	NDA

V_1: Average age of marriage for women, V_2: Average age of first marriage for women, V_3: Net schooling rates of female in secondary education, V_4: Number of women aged 15-49 per midwife, V_5: Number of persons per physician, V_6: Number of persons per family medicine unit, V_7: Gross domestic product by economic activity, V_8: Unemployment rate,
*: Correlation is significant at the 0.05 level, **: Correlation is significant at the 0.01 level, NDA: No data available.

Table 3 presents the correlation coefficients between the variables and infant mortality rates in Turkey, based on the data from the period between 2011 and 2016. The findings of the correlation test indicate that the average age of marriage for women, the average age of first marriage for women, the net schooling rates of females in secondary education, and GDP are significantly negatively correlated with infant mortality rates in each year. Conversely, the number of women aged 15-49 per midwife and infant mortality rates are found to be significantly positively correlated. Although there is a positive relationship between the number of persons per physician, unemployment rates, the number of persons per family medicine unit, and infant mortality rates, the relationship is not found to be statistically significant in some years.

4. DISCUSSION AND CONCLUSIONS

Although the infant mortality rate results from a small portion of the population, which is not considered representative, and non-fatal health outcomes are not taken into consideration, infant mortality is found to be strongly associated with factors such as economic development, general living conditions, social welfare, and environmental quality, which affect the health of populations (Reidpath & Allotey, 2003). In the related literature, the factors associated with infant mortality include deficiencies in the practice of family medicine, the inadequacy of health services related to the neonatal period (Nesanır & Özcebe, 2011), low birth weight, number and quality of follow-ups in the gestation period (Bodur et al., 2009), birth order, and maternal demographic characteristics such as education level and age (Hacettepe University Institute of Population Studies, 2014). Lack of education and information, inadequate maternal and new-born care, limited access to nutritive and staple foods, poor environmental health conditions, inadequate health services, poverty, social exclusion, and gender discrimination have also all been shown to be causes of infant mortality (United Nations Children's Fund (UNICEF), 2008). For all these factors, space is a direct or indirect determining factor. Thus, it is valuable to assess and plan the health services of higher mortality hot spots.

In the current study intending to demonstrate the spatial differences related to infant mortality in Turkey between 2011 and 2016, provincial statistics were used, and the spatial distribution of infant mortality was depicted employing spatial statistical techniques. A total of 7,834,196 live births and 85,196 infant mortalities occurred in Turkey between 2011 and 2016. Every year, therefore, nearly one in 100 children who were born alive died before reaching their first year of life. During these years, the infant mortality risk in 16 provinces in Turkey was found to be higher than the country average. Fifteen of these provinces are located in South-eastern Anatolia and Eastern Anatolia regions. According to the health statistics in 2011 – 2016 submitted by the Republic of Turkey, Ministry of Health’s General Directorate of Health Research (Republic of Turkey's Ministry of Health, 2019), the average number of follow-ups per infant and the average number of follow-ups per puerperant in nine of these provinces in the South-eastern Anatolia region were below the country average.

The negative conditions associated with infant mortality in the South-eastern Anatolia and Eastern Anatolia regions have been revealed in many studies in the literature. In a study published by the State Planning Organisation in 2003, for example, it was shown that South-eastern Anatolia and Eastern Anatolia regions were in the last two ranks in terms of socio-economic development, which was determined by means of social and economic variables (Dinçer, Özaslan, & Kavasoğlu, 2003). In the study utilising the number of physicians, dentists, pharmacies, and hospital beds per 10,000 persons and the infant mortality rate, it was demonstrated that South-eastern Anatolia and Eastern Anatolia regions were in the last two ranks in terms of health sector development. Similarly, in a socio-economic development ranking survey presented by the Republic of Turkey's Ministry of Development (2013), the provinces were sub-divided into six based on the provincial development index, and it was determined that all provinces which were in the sixth, namely, the last, rank were located in the South-eastern Anatolia and Eastern Anatolia regions. Moreover, Bahcesehir University Strategic Researches Centre (2009) conducted a study regarding potable water, which may be an indicator of health conditions. They found in the examination of the investment expenditures for municipal drinking water and water treatment plants that the locations with the lowest expenditure ratios were in the South-eastern Anatolia and Eastern Anatolia regions. Another result obtained from the study was related to gross domestic product per capita, which is considered to be responsible for many problems. In this regard, these two regions are disadvantaged compared with the other regions. Poverty has also been shown to be the cause of infant mortality in many studies in the literature (Eryurt & Koç, 2009; Nersesian et al., 1985). Finally, another factor responsible for the increase in the infant mortality rate is early marriage. Child marriages can result in decreased education levels and poverty or vice-versa (Boran et al., 2013). When the provinces in Turkey were examined in terms of the share of child marriages among total marriages, high rates were found in Turkey between 2015 and 2016 in the provinces with infant mortality rates which were higher than the country average and showed clustering within high–high relationships over the last six years (Turkish Statistical Institute, 2019b).

When the results of spatial autocorrelation analysis were examined, global Moran's I results indicated a statistically significant clustering for infant mortality, even for rough rates. All global Moran's I statistics were positive and indicated a clustering for similar values consisting of low or high infant mortality rates. It is thus suggested that the provinces with similar infant mortality rates are spatially close to each other. Cluster maps, obtained using spatial empirical Bayes smoothing, which provides a better understanding of low population locations and eliminates the effect of population differences, showed that the clusters in the southern part of the country are considered to be hot spots.

After completing the spatial analysis, we investigated the relationship between infant mortality rate and variables including age, education, healthcare, and economic factors. One of the reported results for the correlation test is the strong relationship between infant mortality rate and marriage age, education, number of midwives, and GDP, that is also commonly observed in some studies (Metintas et al., 2010; Yılmaz, 2019; Boran et al., 2013; Baird, Friedman, & Schady, 2011; Kotsadam, Lind, & Modalsli, 2018; David, Lawrence, & Murungaru, 2018; Bora, Lutz, & Raushan, 2018). Although Cesur et al. (2017) indicated the positive effect of family health units on infant mortality, in this study, a statistically significant relationship between the two variables was observed only in the period between 2011 and 2012.

There are several limitations to our study. Firstly, data was gathered at the provincial level. Secondly, the current study is not a cause-effect study due to the lack of recorded data at the country level. It is hoped, therefore, that more mechanisms will be revealed by further studies applying different spatial statistical methods in the years ahead.

It is important to determine the other associated factors in the provinces with high infant mortality rates found in this study and to develop an understanding of what can be done to prevent infant mortality in the future. In South-eastern Anatolia and Eastern Anatolia regions, it is necessary to produce and implement policies with the scope of reducing the infant mortality rate. Moreover, infant mortality awareness in the general public can be increased in simple ways, such as using popular social media tools. In this context, it is recommended that short videos and animations posted on social media channels should be made.

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