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Spatial Distribution of Premature Infant Mortality in 2000-2017

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Abstract

Background

The provision, maintenance and promotion of the health of infants as a vulnerable group in health care services are a high priority, and the first step in reducing infant mortality and improving their health is undoubtedly the identification of their mortality status. We aimed to study the spatial distribution of premature infant mortality in 194 countries in 2000-2017.

Materials and Methods: In this descriptive study using reanalysis data, the data were re-analyzed. First, the infant mortality data were collected from the official website of the World Health Organization. Then, a database was created in ArcGIS 10.6 software, and the statistical tests and related maps were extracted. To this end, the Global Moran's I and Gtis-Ord-Gi spatial correlation analyses were utilized. Data was analyzed down year by year and the charts were extracted by GIS software during a period of 18 years (2000 to 2017).

Results: The results of this study demonstrated that infant mortality (0-27 days-old) followed a downward trend, but its spatial pattern was clustered (Moran's I>0, Z-score> 2.58). We analyzed 19,041,539 data about infant mortality in 2000 to 2017. This situation was concentrated as Hot Spots in the West Pacific region and part of Asia (Central, South and Southeast Asia) from 2000 to 2017 (with 90%, 95% and 99% confidence intervals). In addition, it was revealed that there were no Cold Spots between countries.

Conclusion

The results of the present study demonstrated that the total infant mortality followed a downward trend, while the Hot Spots of infant mortality were in the West Pacific region and part of Asia by 2000 and remained as Hot Spots until 2017.

Key Words: Infant, Geographic Information System, Mortality, Spatial Modeling, Premature.

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1- INTRODUCTION

Infant mortality is a key health index (1), and neonatal period (the first 27 days after birth), which is the stage at which many physiological adaptations are developed for ectopic life, is the vulnerability period, from which high rates of neonatal mortality result (2-7). Generally speaking, the rate of infant mortality is 30 cases per 1,000 live births worldwide (8), and about three-quarter of infant mortality occur in the first week of birth, and more than a quarter of them occur in the first 24 h after birth (9).

In year 2017, 32,565,478 deaths occurred in infant and 3,915 cases in Iran (10). It should be noted that, in high and middle income countries in the world, premature birth is considered a cause of death (8). However, nearly 98% of infant mortality occurs in poor countries (11). Moreover, two-third of all infant mortality occurs in 10 countries worldwide, mainly in the Asian continent (11, 12). According to the reports of the World Health Organization (WHO), about five million children under the age of five year-old were reported dead in 2016, of which 46% were due to premature birth, which is the first common cause of death among the children aged under five.

According to the World Health Organization, premature birth is defined as the situation in which babies are born alive before the completion of 37 weeks of gestation or as the period less than 259 days from the last day of the menstrual period (9). Not to mention, the complications resulting from premature birth are one of the most important direct causes of infant mortality. In this regard, the statistics indicate that premature infants account for 17.9% of the mortality rate per 1,000 live births (11). The results of previous studies indicate that premature birth is affected by various factors. For example, social factors play an important role in the risk of premature infants (12, 13), or as another example, in a meta-analysis in which 45 studies were considered, it was reported that racial/ethnic differences could increase the risk of prematurity to some extent, so that the risk rate was 13% and 9% among the African-American and white women, respectively (14). In addition, other effective factors in this respect are environmental factors and air pollution, which increase the risk of prematurity (15). However, understanding the spatial diversity of the prevalence of premature infant mortality in a spatial context causes the health and preventive interventions to be done with more appropriate planning. So, the areas in which mortality Hot Spots have been formed should be specifically examined (16). To this end, new software such as Geographic Information System (GIS) can be employed.

One of the features of this software is the ability to understand geometric patterns in space and time (17). GIS is considered a potentially powerful source for the health of societies, whose abilities are the integration of data from different sources to generate new information and its applications in intrinsic visualization, thereby leaving lasting effects on the health of people (18-20).

Given the above reasons and apart from the high costs incurred by families and the health system, the fact that premature infants are faced with many problems, including pulmonary diseases, cerebral palsy and respiratory, hearing, vision problems, and even death, it can be expressed that the identification of the Hot Spots of premature infant mortality can play a prominent role in preventing premature births. Therefore, the present research aimed to study the spatial distribution of premature infant mortality in 2000-2017.

2- MATERIALS AND METHODS

2-1. Study design and population

The statistical population of the present study consisted of 19,041,539 premature infant deaths in 2000-2017. In this descriptive study, reanalysis data on the spatial distribution of prematurity- infant mortality 0-27 days old in 194 countries was used. To commence the study, the required data were first gathered through the official website of WHO (http://apps.who.int/gho/data/view.main.ghe1002015-CH10?lang=en). The data were entered into Excel. The data provided by the WHO as an overall number for the period 2000 - 2017. It should be noted that the latest data of WHO was published in 2017.

2-2. Methods

In this descriptive study, using reanalysis data on the spatial modeling of premature infant mortality 0-27 days old in 194 countries over 2000-2017 were initially obtained from the official website of the World Health Organization (WHO). These data are available to the general public. Data was analyzed down year by year and the chart was extracted by GIS software during the period of 18 years, from 2000 to 2017. In this study Hot Spot is a statistically significant hot spot, a feature that has a high value and is surrounded by other features with high values as well. Cold Spot is a feature that has a low value and is surrounded by other features with low values as well.

2-3. Data Analyses

In this study Arc/GIS 10.6 software, a database was created and the statistical tests and related maps were extracted. To this end, the Global Moran's I (GMI) Statistic and Getis-Ord Gi (GOG) Statistic were utilized. The GIS was then used for spatial modeling. To this end, a database was first created in the Arc/Catalog environment, and the spatial tests and related maps were then extracted from Arc/Map environment. For the purpose of spatial analysis of prematurity-infant mortality 0-27 days, the GMI was used, whose value is calculated as follows (Eq. 1-1 to 1-4):

Equation 1-1:

$$I = \frac{n}{S0} \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} Wi,jZiZj}{\sum_{i=1}^{n} Z_i^2}$$

Equation 1-2:

$$S_0 = \sum_{i=1}^{n} \sum_{j=0}^{n} Wi,j$$

Equation 1-3:

$$Z_1 = \frac{1 - E[I]}{\sqrt{V[I]}}$$

Equation 1-4:

$$E[I] = -1/(n-1)$$
$$V[I] = E[I^2] - E[I]^2$$

Where,

Xi and Xj represent the variable values in the locations i and j. In addition, X shows the average of the attributes of each location, and Wij is the spatial weight of i and j. If i and j are in the neighborhood of each other, the Wij value equals one, otherwise the value equals zero. Moreover, S0 denotes the sum of all the elements. To determine the spatial distribution of Hot Spots (spatial clusters with large values), and Cold Spots (spatial clusters with low values), the GOG statistic was used (Eqs. 2-1 to 2-3):

Equation 2-1:

$$G_i^*(d) = \frac{\sum_j W_{ij}(d) x_j - W_i^* \bar{X}^*}{S^*\{[(nS^*1i) - W_i^{*2}]/(n-1)\}^{1/2}}$$

Equation 2-2:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

Equation 2-3:

$$s = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2}$$

Where,

Xj is the value for element j, Wij denotes the spatial weight between the elements and each of I and j, and finally n represents the total number of elements. Moreover, the value of this statistic ranges from ±1 to ±3 at 90%, 95% and 99% confidence levels.

3- RESULTS

In this study, premature infant mortality data, 0-27 days old, were analyzed from 2000 to 2017 worldwide. In **Figure.1**, the number and trend of prematurity-infant mortality 0-27 day-old are shown. The countries in red color had the highest rates of infant mortality, as opposed to countries in green with the lowest rates. In general, infant mortality followed a downward trend over 2000-2017, and as it can be seen, in 2000, the highest prematurity-infant mortality rates (0-27 day-old) were in India, China, Bangladesh, Pakistan, and Nigeria. However, in 2017, India, Pakistan, Bangladesh and Nigeria witnessed the highest rates in this respect.

In **Figure.1**, countries that had the highest/lowest rates of infant mortality in the world are shown. The highest premature infant mortality rates were in India, China, Bangladesh, Pakistan, and Nigeria. However, in 2017, India, Pakistan, Bangladesh and Nigeria witnessed the highest rates. The graphs showed that the overall trend of infant mortality has been declining. So, the Southeast Asian region was the highest and Europe was the lowest.

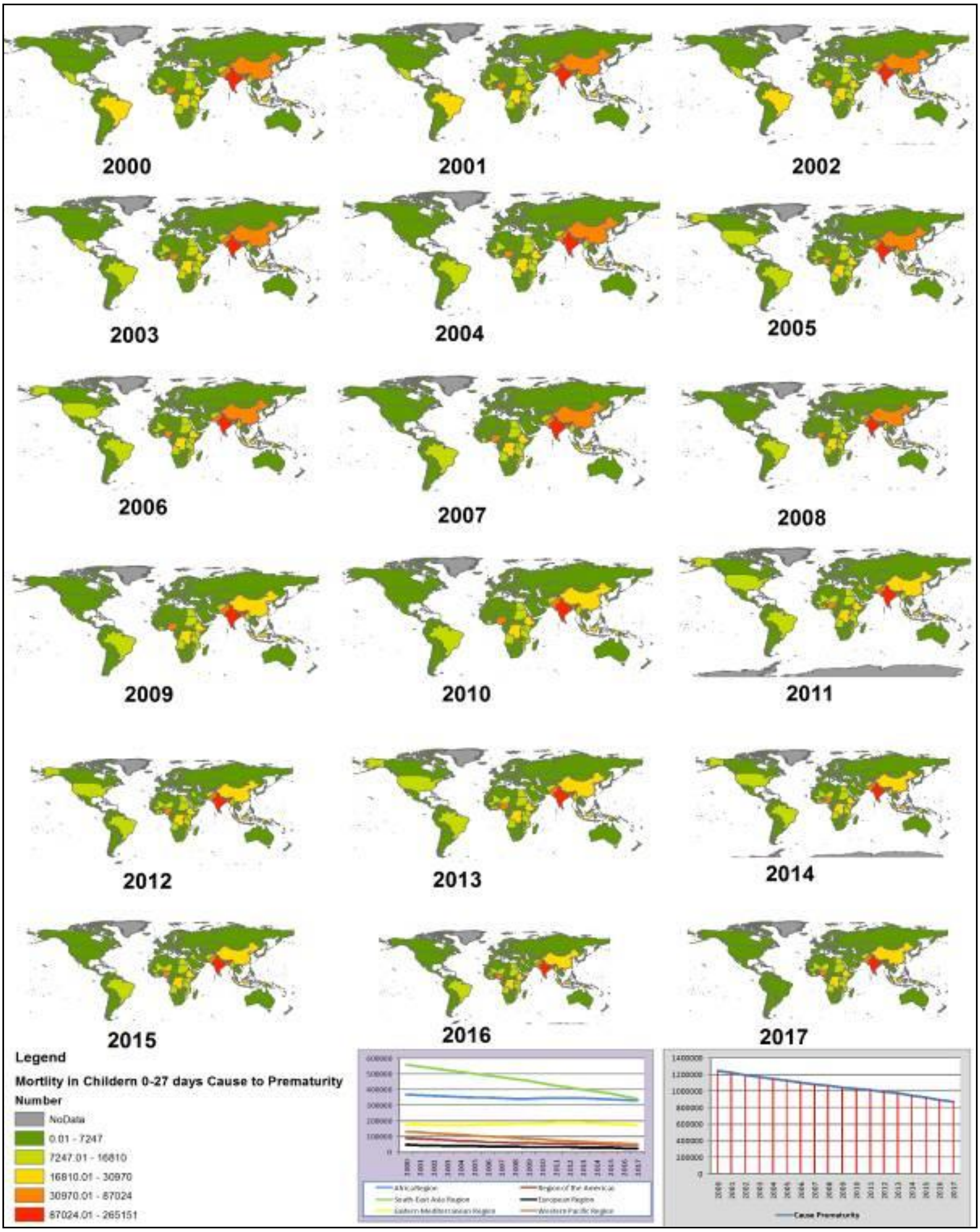

Fig.1: Mortality in children aged 0-27 day-old, caused by prematurity in 2000-2017.

According to **Figure.2**, during the period under study (18 years, from 2000 to 2017), the prematurity-infant mortality 0-27 day-old was clustered (Moran's I>0, Z-score> 2.58).

Fig.2: The Results of Moran's I Test to Identify the Clusters of Premature Infant Mortality in 2000-2017.

In above figure during the period under study infant mortality is formed in cluster form throughout the course. This means that there are countries that are the focus of child mortality. In **Figure.3**, the results of the GOG test for identifying the Hot and Cold Spots of premature infant mortality 0-27 day-old are presented at 90%, 95% and 99% confidence intervals. The results indicated that the Hot Spots of premature infant mortality were concentrated in the West Pacific region and part of Asia (Central, South and Southeast Asia) over 2000-2017 as follows: China, Thailand, Cambodia, Vietnam, Burma, India, Mongolia, Pakistan, Afghanistan, Kyrgyzstan, Uzbekistan, Turkmenistan, Kazakhstan, Oman and Iran. It should be noted that no Cold Spots were found between countries. Other findings showed that, in 2000, 24 countries were identified as Hot Spots, which remained unchanged in 2017.

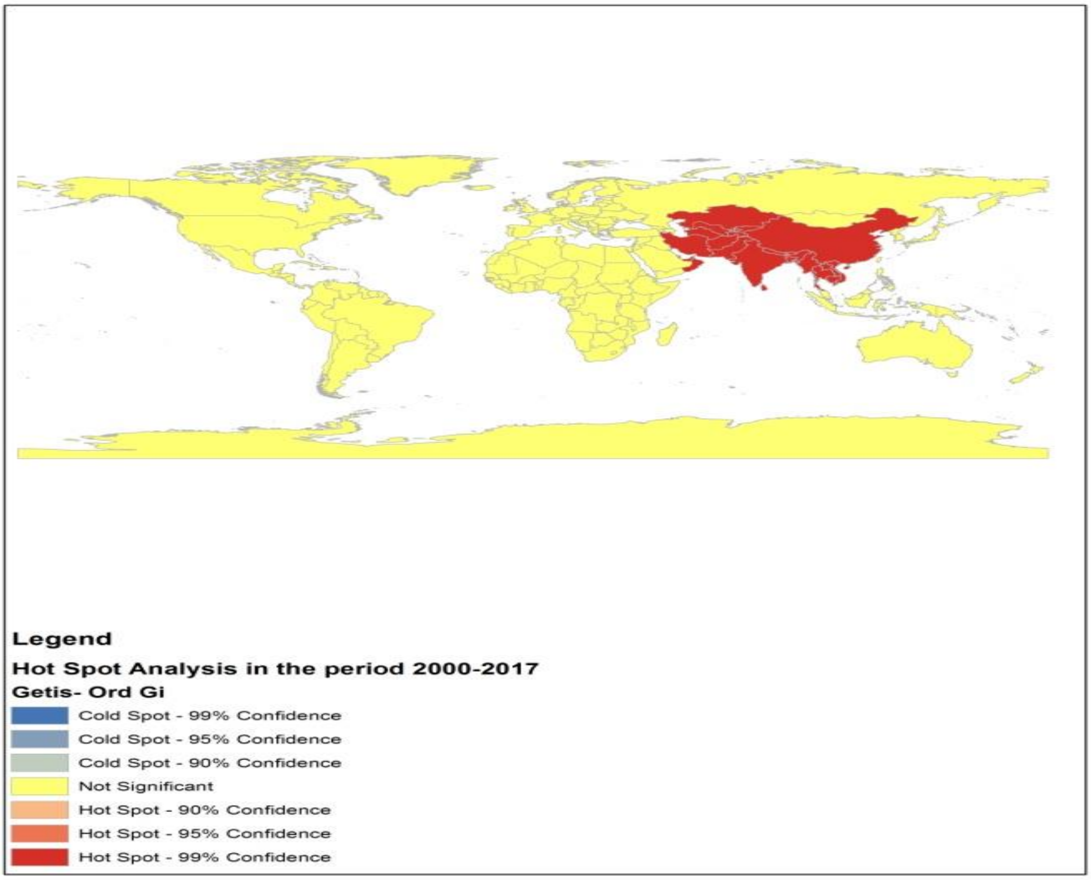

Fig. 3: The Spatial Trend of the Hot and Cold Spots of Premature Infant Mortality in 2000-2017.

In above figure, statistically significant spatial clusters of high values (Hot Spots), and low values (Cold Spots) are identified. Hot Spots have not changed in over 17 years (presented at 90%, 95% and 99% confidence intervals) (Red Color).

4- DISCUSSION

The present research aimed to study the Spatial distribution of premature infant mortality (0-27 days old) in 194 countries over 2000-2017. This situation was concentrated as Hot Spots in the West Pacific region and part of Asia (Central, South and Southeast Asia) from 2000 to 2017. According to the results of the present study, the total infant mortality followed a downward trend during the period under study. In other words, the rate of infant mortality in 2000 (124,000 deaths) dropped to 87,000 deaths in 2017, which was consistent with the results of a study conducted by Babaoğlu et al. (21), in which a decline in the number of Turkish child mortality was reported. However, in the present study, there was a decrease in the rate of infant mortality, but preterm birth is still among the first key causes of death (11), which is concurrent with the results of studies performed in Cameroon (22), Canada (23), China (24), and Japan (25). Therefore, the future health policies should be focused on sustainable development goals such as reducing child mortality to 20 cases per 1,000 live births by 2035 (26). The results of study showed that the overall trend of infant mortality has been declining. So, the Southeast Asian region was the highest and Europe was the lowest. Our findings revealed that in the 194 countries under study, the infant mortality (0-27 day-old) was clustered and there were Hot Spots in the West Pacific region and part of the Asian continent (Figure.2). This finding was concurrent with the results of studies done by Soori et al. (27), and Masho et al. (12), in which high rates were reported for infant mortality in Asia. This difference can be due to the difference in the pattern of death in the above areas with other areas in the world, and the current situation was witnessed by other countries many years ago (27). This is indicative of the fact that the continuation of the downward trend of infant mortality will become more difficult in the West Pacific region and parts of the Asian continent year by year.

More to the point, it seems that items such as maternal age (under the age of 18 and over 35) (28), low socioeconomic status (29), smoking (28), alcohol consumption (31), nutrition during pregnancy (32), infection (33), gestational diabetes (34), and repeated pregnancies (35), are effective factors in increasing the probability of preterm births. Therefore, in countries identified as Hot Spots, the factors that can play a role in reducing prematurity are as follows: improving maternal nutrition, gestational diabetes control, improved vaccination for children and mothers, providing pregnant mothers with training before and during pregnancy about taking unprescribed drugs, and lack of exposure to radiation and chemicals (27, 36). The use of spatial data in the GIS software showed that the Hot Spots of premature infant mortality (0-27 day–old) did not witness any changes over 2000-2017. In other words, the Hot Spots continue to be concentrated in the West Pacific region and part of Asia (90%, 95%, and 99% confidence intervals). The lack of changes in Hot Spots over 18 years can be due to various factors, including the spread of infant mortality in developing countries (37), global climate change (38), air and dust pollution (39), and geographical differences (40). Hence, health policymakers should pay special attention to the areas identified as Hot Spots. For instance, one of these Hot Spots is India, which has had the highest mortality rate in the last 18 years, as some studies have reported child mortality as a problem in India (41, 42). The findings were also indicative of the lack of Cold Spot formation (Figure.3). Accordingly, it seems that health policies have prevented premature infant mortality. However, there have been no signs of Cold Spot formation in 194 countries thus far, which should be taken into consideration by health organizations and health policymakers. In this study, the GIS tests were used for data analysis, whose application in health promotion studies has been stressed by researchers, such as Babaoğlu et al. (21), and Suplee et al. (43). This type of study should be carried out continuously because different results might be obtained in different countries over the years, and whose analysis can lead to the reduction of infant mortality rates.

4-1. Study Limitations

The limitations of the present study were the use of secondary data, which made it impossible for the researchers to investigate the quality of data. There were also differences in the methods for collecting information and estimates of the number of deaths in countries, which was beyond the control of researchers. In addition, due to the lack of access to specific indexes such as pregnant mothers' exposure to radiation and chemicals and the status of traffic pollution in different countries, the effects of these indexes on premature infant mortality (0-27 day-old) could not be measured. Hence, it is recommended that careful attention be paid to data registration and collection nationally and internationally, and it is suggested that health policymakers pay special attention to the countries introduced as Hot Spots in health planning. Besides, we were unable to analyzed data for 2018 and 2019, because the data was not available in the WHO website at the time of study

5- CONCLUSION

The results of the present study demonstrated that the total premature infant mortality followed a downward trend, while the Hot Spots of infant mortality were in the West Pacific region and part of Asia (Central, South and Southeast Asia) by 2000 and remaining as Hot Spots until 2017. Moreover, it was found that no Cold Spots have been formed in 194 countries thus far. In fact, this study allows the health planners and policymakers to use visual assessment, information and rapid identification of premature- infant mortality Hot Spots in GIS, rather than using the statistical tables that are difficult to understand. Therefore, the results of this research can be used in regional decisions, especially those made by global health organizations.

6- CONFLICT OF INTEREST: None.

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