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Spatial pattern of phenylketonuria disease determination using geographic information system in Lorestan province from 2006 to 2016

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ABSTRACT

Introduction: Phenylketonuria (PKU) is a metabolic disorder that, if not detected and treated promptly, causes mental retardation. The use of the geographic information system (GIS) in favor of spreading the disease helps to control the disease. Therefore, the aim of this study was to determine the local pattern of the PKU disease using the GIS in Lorestan province from 2006 to 2016.

Methods: The current descriptive cross-sectional study was conducted on the patients diagnosed with PKU in Lorestan province from 2006 to 2016. The statistical population included all cases identified between April 2006 and March 2016. The ArcGIS 9.3 software was used to provide geographic maps of the incidence and frequency of the disease.

Results: The results showed that Nourabad county had the highest number of larvae with 22 (72.29%), and the most cases with PKU disease were with 2 cases (99.2%). According to GIS maps, the incidence of PKU from 2006 to 2016 was on an ascending tide. The highest incidence in these years was related to Nurabad with an average of 5.7 per 10,000 live births and the lowest incidence related to Boroujerd county with more than 0.53 per 10,000 live births.

Conclusion: According to the GIS map, Nourabad county has the highest incidence of PKU. Therefore, it is necessary to consider the majority of prevention programs for paternity screening and counseling couples, especially family marriages in the city, in order to reduce the incidence of this disease.

Introduction

Phenylketonuria is one of the most common metabolic diseases that the weakness of the phenylalanine hydroxylase disrupts the amino acid metabolism of phenylalanine and can lead to mental retardation (1). People with PKU are entirely normal at birth, but they gradually develop mental retardation and severe latency, if not diagnosed and treated appropriately, which may not be very clear in the first few months of life (2). In case of timely diagnosis of the disease and observing a diet with a phenylalanine restriction, mental retardation can be prevented in these patients. As a result, the rapid diagnosis of this disease in the first days of life is a

major and important step in countries where infants are in the process of being diagnosed and treated; however, diagnosed and treated children are rarely recognized. In some developed countries, more than 50 years have passed since the screening of the disease. After diagnosis, levels of Alanine should be monitored continuously, especially during lactation, in order to prevent complications (3). Phenylketonuria and hypothyroidism neonatal disease screening in newborns programs in Iran (4, 5). The incidence of this disease is associated with an ever-increasing phenylalanine from 1 in 3000 to 60,000, depending on the country. It is reported that the disease is low among the Irish countries and the lowest in Japan (6). The prevalence of PKU in the Caucasus is estimated at 1 in 10,000 and is different between populations and races (7). The incidence rates of this disease In China, Portugal, the United Kingdom and Brazil were 1: 11144, 1: 12037, 1: 12000, and 1: 20,000, respectively (8). The highest incidence of PKU in the world was reported from countries such as Iran and other neighboring countries. If it is about 1 in 4000 in Turkey and 1 in 3627 in Iran, it is alive (9). In Iran, according to the results of the screening of infants from 2007 to 2010, 1 in 8000, autosomal recessive disease and its increase if the marriages are closer to sympathy and there is a difference in the incidence of the disease in different regions of the country (according to the statistics). A total of 1800 people were reported in the country with PKU, out of about 81 in Lorestan province (10). Since public health and disease issues are directly related to the region's geography and always have future locations, GIS can play an important role in public health management and disease planning and the study of disease (10, 11). GIS is an applied software that can investigate the

Causative agents by providing a geographical distribution model for diseases such as PKU and showing quantitative and qualitative spatial distribution of the disease, which is to make health and prevention decisions and disease control can be very helpful (12, 13). The use of GIS is applied in two areas of health, epidemiology and health care (14). The use of GIS information is important to manage the health systems and infrastructure (15). Therefore, the aim of the current study was to determine the location of PKU disease using GIS in Lorestan province from 2006 to 2016.

Methods

Lorestan province is one of the Southwestern provinces of Iran. The province has an area of 28308 square kilometers and ranked 13th in terms of population and is one of the most populated provinces of Iran. According to Iran's statistics, in Lorestan province in 2011, it is equal to 1, 754, 243 people, accounting for 3.2 percent of Iran's population. Lorestan is bordered from the north with Hamedan and Central provinces, from the east by Isfahan province, from the south by Khuzestan, and from the west by the neighboring provinces of Kermanshah and Ilam (Figure 1). This descriptive-analytic study was conducted on patients with PKU in Lorestan province from 2006 to 2016. The community consists of all cases identified from 351164 live births between April 2006 and March 2013.The criteria for the entry of newborns as a person with PKU was to sample neonatal heel at the nearest health facility for their neonates to screen for phenylketonuria. Blood samples taken on Whatman 903 paper, the colorimetric method is screened for the presence of Phenylalanine using an ELISA.
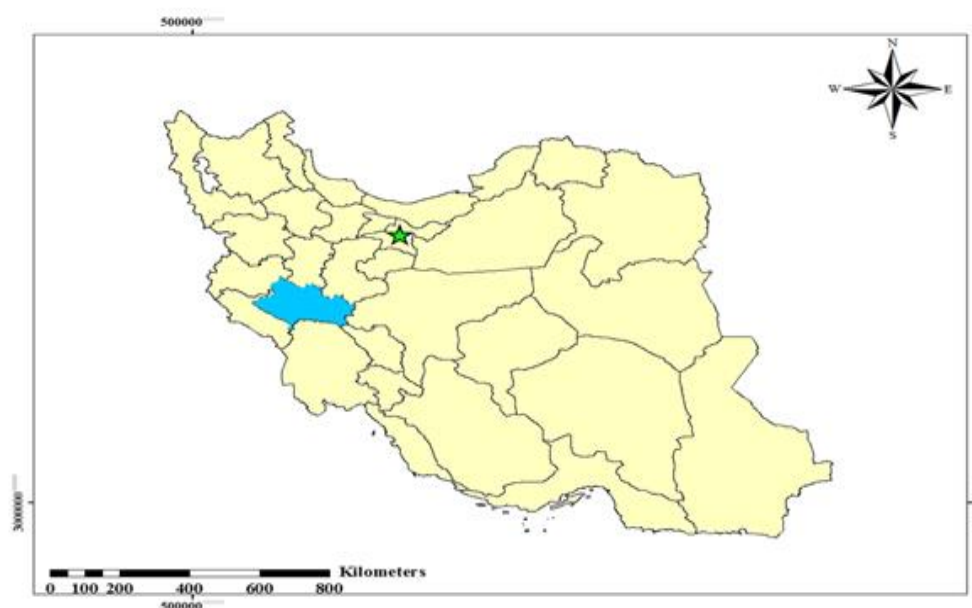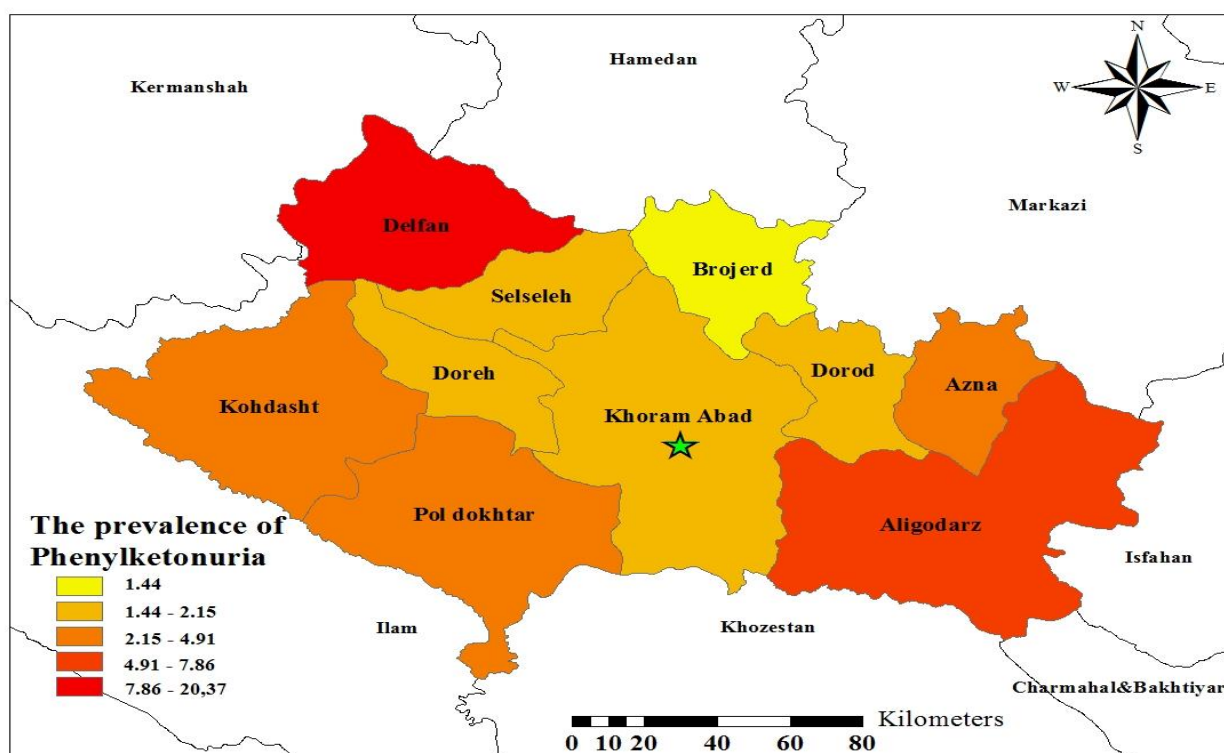

Figure 1. Consort diagram

Figure 2. Spatial distribution prevalence of PKU in Lorestan province (2006-2016)

If the levels of phenylalanine are higher than 3.9 mg / dL, the sample is suspected. Subsequently, suspected specimens were sent to Tehran University of Medical Pathology, where a High Performance Liquid chromatography (HPLC) test was used to confirm the final diagnosis. If HPLC is positively defined, the baby is considered as the definite case for PKU. Neonates with congenital genetic defects were not included (16).
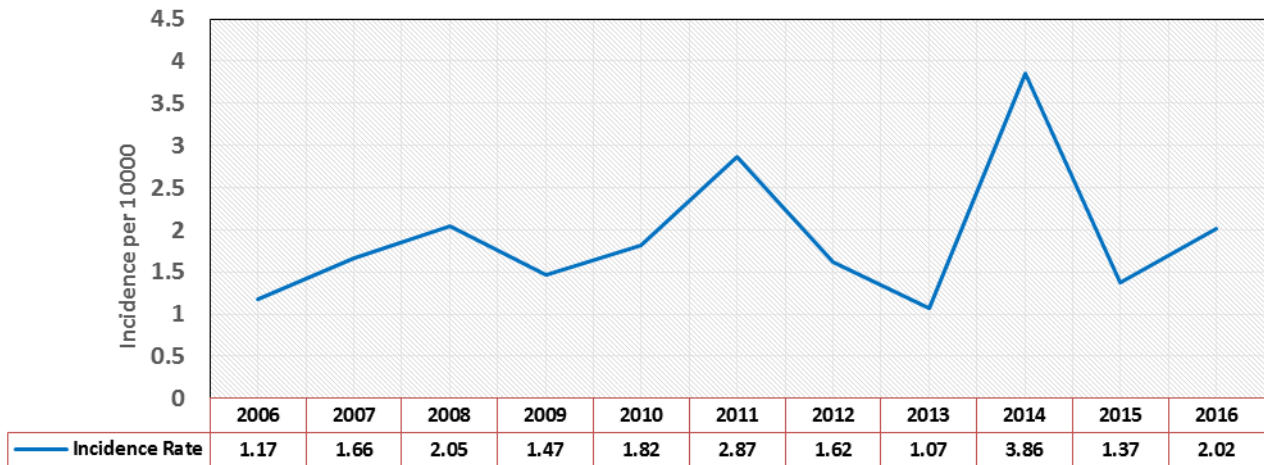
Results

Our results from 2006 to 2016 showed that, 74 cases of PKU were recorded in Lorestan province. Norabad city (Delfan) with 22 out of 74 cases (29.72% of cases) had the highest percentages and the period with three of the total of 74 cases (2.99% of cases) and Boroujerd with 2 cases had the lowest rate of PKU (Figure 2). Our study showed that in 82% of cases, PKU patients had familial marriages. In 61% of cases, neonates diagnosed with rural illness and the highest level of parental education (32% of cases) were in middle school. The results of the study showed that the incidence of PKU was increasing and decreasing from 2006 to 2016. The highest incidence in these years was related to 2014 with an incidence of 3.86 in 10,000 and the lowest incidence for 2013 with an incidence of 1.07 per 10,000 (Figure 3). The

following map shows the dispersion of PKU disease in 10,000 live births. According to the PKU incidence rate in Lorestan province, which varies from 5.7 to 0.53 per 100,000, in order to better represent this range of changes in Lorestan province. It was divided into 5 categories and was designed using the GIS software of the province's map. As it can be seen, the highest incidence rate during these years was observed in Norabad county with an incidence of 5.7 per 10,000 live births and the lowest incidence related to Borujerd county with an incidence of 0.53 per 10,000 live births (Figure 4).
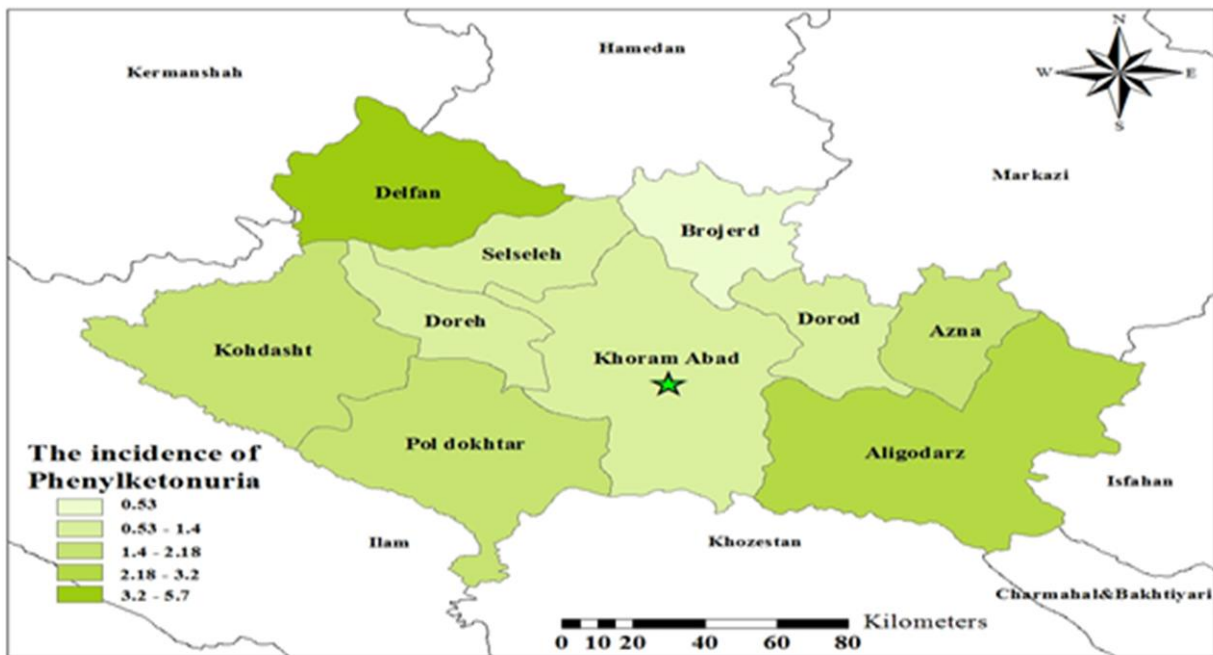
Discussion

According to the results of this study, the incidence rate of PKU in Lorestan province was fluctuated. The most frequent incidence in these years was related to 2014 with an incidence of 3.86 per 10,000 and the lowest incidence related to 2013 with an incidence of 1.07 per 10,000. Based on the maps obtained from the GIS, the highest incidence was reported in the Norabad county (5.7 per 10000 live births) and the lowest incidence was in Boroujerd county (0.53 per 10,000 live births). Phenylketonuria disease is fully curable and timely diagnosed at birth, and the child can have a completely normal life with timely treatment. Family marriages are the major cause of

Figure 3. The trend of PKU disease in Lorestan province during the period of 2006-2016

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Incidence Rate	1.17	1.66	2.05	1.47	1.82	2.87	1.62	1.07	3.86	1.37	2.02

the spread of the disease in the world (16-18). The results of our study showed that from 2006 to 2016, the highest rate recorded in Lorestan province was related to Norabad county with 22 (29.72%). The study of Sadatni Nasab *et al.* in 2014 in South Khorasan with an incidence of 0.98 per 10,000 (15), Habib *et al.* study in Fars province with an incidence of 1.6 in 10,000 (16) and a large study in Tehran with an incidence of 1.15, there were 10,000 live births(19). Studies have shown that the overall incidence of disease in Iran according to a screening program that was carried out in three medical universities of Tehran, Fars and Mazandaran from 1997 to 2010, is estimated at 1 per 8000 neonates and the incidence range varies from country to country. One person varies from 3,000 to 1 person per 60,000 people (20).

In general, various factors affect the different dispersion of PKU disease in different locations, the most important of which are inherited, genetic, race and cultural factors (21). According to the GIS map of Lorestan province, the results showed that the highest rate during these years was from Norabad county with an incidence of 5.7 per 10,000 live births and the lowest incidence related to Borujerd county with an incidence of 0.53 per 10,000 live births. High incidence of disease in the province Lorestan and especially Norabad county may be due to more familial marriages in this city. In a study by Zafar Mohtashemi *et al.*, 75% of cases of PKU had their parents married (9). Studies showed that the overall rate of family marriage in Iran was 38.6%. Considering the high prevalence of family marriages in Lorestan province, it is necessary to pay more

Figure 4. Spatial distribution incidence rate of PKU in Lorestan province (2006-2016)

attention to screening and management of PKU disease (22). Probably the reason for an increase in Norabad county is familial marriage, which is suggested that other researchers do more studies on the cause of this**.** The results of our study showed that the incidence of PKU was increasing and decreasing from 2006 to 2016. The highest rate of incidence in these years was related to 2014 with an incidence of 3.86 in 10,000 and the lowest incidence was related to the year 2013 with an incidence of 1.07 per 10,000**.** In a study performed in Fars province, from 70,477 newborns, the incidence of disease was 1 in 4698 newborns. In a study conducted in southern Iran, the incidence of illness in neonates was 1.7 in 10,000 and it was estimated as 1.5 per 10,000 cases , In a study by Pangkanon and colleagues in Thailand in 2009, the incidence rate was 0.3 per 100,000 live births (23, 24).

Conclusion

The results of our study showed that Norabad county with 22 (29.72%) patients had the highest incidence of PKU disease during these years and the incidence of PKU was fluctuated from 2006 to 2016. The highest incidence during these years was in 2014 with an incidence of 3.86 in the 10,000 cases and the lowest incidence of 2013 with an incidence of 1.07 out of 10,000. According to the results obtained from the study, phenyl ketoneuria disease is different in different regions of Lorestan province. The highest incidence rate during these years was in Norabad county with an incidence of 5.7 per 10,000 live births and the lowest incidence related to Boroujerd county with an incidence of 0.53 per 10,000 live births. Therefore, considering the highest incidence rate in Norabad county, the need for more screening programs and counseling before marriage, especially in family marriages in the city, should be considered in order to reduce the incidence of this disease**.**

Ethical disclosure

Not applicable.

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Authors' contributions

All authors contributed equally in planning and carrying out this project.

Conflict of interest

The authors declare that they have no conflict of interest.

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