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Original Article

The Application of Geographical Information System in Explaining Spatial Distribution of Low Birth Weight; a Case Study in North of Iran

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Abstract

Background: Geographical Information System is a new tool in environmental epidemiology that makes the opportunity of visualization and analysis of spatial data. The aim of this study was to determine the geographic variation of low birth weight using geographic information system in order to evaluate the efficacy of primary health care and health information system.

Methods: Low birth weight records in rural areas of Rasht district (north of Iran) were collected from the records of health care centers and health houses. Electronic map of the Rasht district was collected from National Cartographic Center. Health information was collected from health surveillance data in each village. The three layers of data were analyzed using ArcView program.

Results: The prevalence of low birth weight was 0.049. Using kernel smoothing method, three major and two minor hot spots were identified within Rasht district, mostly in northern part. Existence of health houses was found to be statistically significant in explaining low birth weight risk.

Conclusion: This research examined geographic variation of LBW in Rasht district and found hot spot places. Existing of health house was associated with higher risk of low birth weight.
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Keywords ● Low birth weight ● geographic information system ● primary health care

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Introduction

Expansion of primary health care (PHC) in Iran backs to the well established study, which conducted by Iran Ministry of Health, World Health Organization, and Tehran University in early 1970.[1] This experience provided a strong background for the PHC network and subsequent rapid growing of health services especially in rural areas through the country.[2] The core of the Iran's PHC plan was decentralization and empowering the rural areas with community health workers. Thus, health houses were founded in more than 16,000 villages nationwide. The coverage of PHC in rural areas is more than 95% today. These health houses are very active in providing family planning, maternal, and child care services. As a consequence, considerable progress has been made in health indicators during the past two decades.[3]

Despite good progress, Iran is faced with new challenges in health system. One of the crucial issues is the heterogeneity of health level indicators, i.e. inequality in access to services due to different geographical locations and socio-economic status. Another arena of debate is the effectiveness of existing information system in dealing with the emerging situations. Can the present information system with almost aggregated data determine appropriate interventions?

Health is a broad term and affected by many factors that are not within the scope of ministries of health and related organizations. In developing countries, including Iran, the communications between different organizations are not well established and they could not utilize their information appropriately. Nevertheless, it seems that using new technology such as computerization of databases and generating links between route health datasets and health related variables may improve the quality of providing services. We believe that new methods such as Geographical Information System (GIS) offer an appropriate ground to generate links between different datasets and utilize information much more effectively.

We carried out a study in north of Iran to assess the application of GIS in PHC. We aimed to link the data of low birth weight (LBW), as an important health indicator of quality of antenatal care and family planning services, to some of possible explanatory variables using GIS technology.

Methods

Setting

This study was conducted in the rural area of Rasht district. Rasht is situated in a vast plain at a distance of 30 km south to Caspian Sea in the slopes of the northern Alborz mountain range. It has Mediterranean climate with relatively high annual precipitation. There are 347 villages with about 230,000 populations. The present study was restricted to 284 villages that had at least one live birth recorded between 2000 and 2001. Forty-six villages did not have any health surveillance data and 17 villages did not have any live birth during the study period.

Electronic Maps

The electronic map of the Rasht district provided by National Cartographic Center (NCC) in UTM 84 projection and in 1:25000 scale in ArcView format. The map had information about the location of villages and their demographic and socio-economic information based on the last national census in 1996.

Health Information

The frequency of normal and LBW newborns were extracted from the records of rural health houses between 2001 and 2002.

Data Gathering and Statistical Analysis

In the first step, a link was created between the data of villages in electronic map and their LBW data. Then the frequency of LBW was added as a new layer to the Arview file. Thereafter, a density map of LBW was generated using Kernel smoothing method in Arcview program (version 3.1), with seven kilometer buffer zone to smooth the risk of LBW.

To deal with the small number of LBW newborns in many villages, we generated probability map as well. In a probability map, we mapped the statistical significance; i.e. p-values between the observed and expected number of events. This map shows the likelihood of the risk of occurring an event by chance given the risk of disease in the corresponding national or regional population.[4] For this reason, we used Poisson distribution to estimate the P values.

Using Poisson regression, the relationships between ecological factors and LBW were assessed. These factors were categorized into two parts; access to clean water and having motor vehicle as economical indicators and the general fertility rate (GFR) and having health house as health indicators. Except GFR, all other variables were binary. These relationships were analysed using STATA 8.

Results

In the 284 villages, 5987 live birth occurred between 2000 and 2001 that comprised 295 neonates with birth weight less than 2500 grams (the prevalence was 0.049, 95% CI: 0.044-0.055). Only 3.2% of villages had more than five LBW newborns. The percentage of low birth weight for general fertility rates less than 62, within 66 to 82 and more than 82 birth per 1000 women were 6.67, 9.2, and 2.55, respectively ($P<0.001$). Other predictors did not show significant association with low birth weight in univariate analysis. Table 1 illustrates the number of total birth and low birth weight newborns by variables under the study.

Using kernel smoothing method, three major and two minor hot spots were identified within Rasht district, mostly in northern part (figure 1).

Table 1: Total birth and low birth weight newborns by selected characteristics in Rasht villages, 2000-2001.

Indicators	**Total birth**	**LBW**(%)	**P value***
Having health house			
Yes	5270	259(4.9)	0.90
No	717	36(5.02)	
Access to clean water			
Yes	2285	110(4.81)	0.75
No	3702	185(4.99)	
Transportation availability			
Yes	3550	161(4.53)	0.09
No	2437	134(5.49)	
GFR**			
<66	600	40(6.67)	0.0001
66-82	1775	163(9.2)	
>82	3612	92(2.55)	

*based on chi-square test, ** General Fertility Rate per 1,000 women aged 15-44

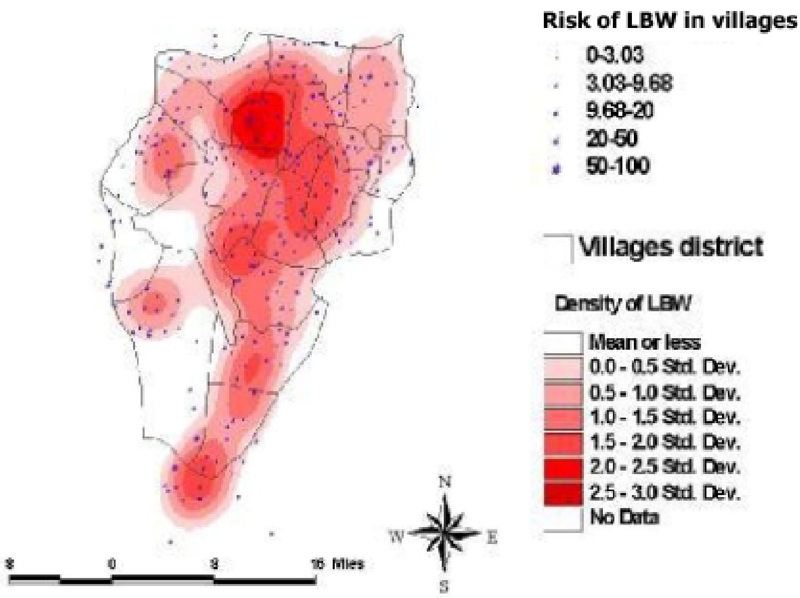

Figure 1: The density map of LBW using kernel smoothing method, polygon graduated color, superimposed by the observed LBW risk in each village, circle graduated size. LBW: Low birth weight

As probability mapping of LBW illustrates in figure 2, fewer significant hot spots were identified. In figure 2, the probability rate of low birth weight has been categorized into three levels: low (P value more than 0.05), moderate (P value less than 0.05 but greater than 0.01) and high (P value less than 0.01). Of 284 villages, five villages had high probability and 14 villages had moderate probability of low birth weight and remainder did not show significant probability of low birth weight due to small number of total birth.

The relationship between low birth weight and independent neighborhood factors was assessed using Poisson regression analysis. Table 2 presents the results of multivariate Poisson regression showing the effect of various health and economic indicators on the LBW rate at the villages' level. Existence of health house was found to be statistically significant in explaining LBW risk. The risk of LBW was greater among those villages with health house. There was no statistically significant relationship between LBW risk and other background characteristics.

Discussion

Results of the present study bring out the spatial distribution of LBW and reveal hot spot villages in rural areas of Rasht district, north of Iran. Unexpectedly, the results suggest that existing health house in a village may increase the risk of LBW.

In this study, existing a health care service was significantly associated with the risk of low birth weight. This finding may have two explanations: Firstly, better recoding system in a village with health house and the second explanation can be that some retarded fetuses in a village without health house might have aborted or still birth due to lack of access to primary care services. The former point highlighted the issue of information bias in our health information system.

Table 2: Relative risk from Poisson regression assessing the association of LBW with some health and economic indicators*

Indicator	RR	95% CI for RR		P value
Having health house				
No	1	-	-	
Yes	1.61	1.05	2.44	0.028
Access to clean water				
No	1	-	-	
Yes	0.99	0.71	1.38	0.93
Having motor vehicle				
No	-	-	-	
Yes	1.34	0.96	1.86	0.09
GFR	0.99	0.99	1.00	0.71

*Total birth as exposure variable, GFR: general fertility rate, RR: Relative risk

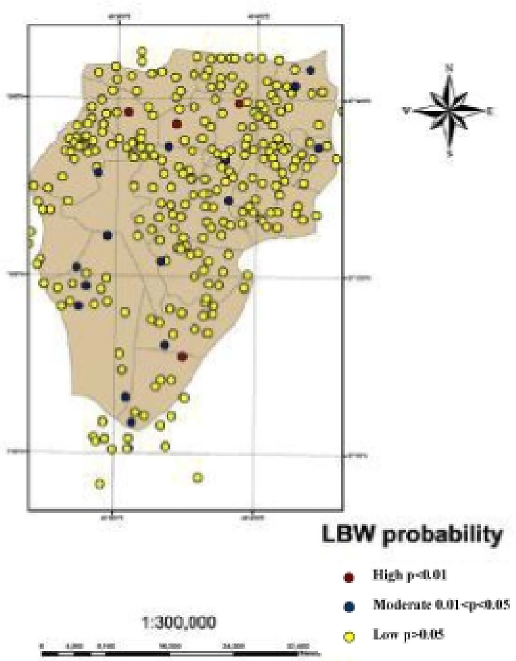

Figure 2: Probability mapping of LBW. This figure shows the likelihood of differences between observed and expected values by chance.

In univariate analysis, only GFR showed significant relationship with the rate of LBW. Since GFR directly related to the total birth and there were unequal numbers of birth in three groups of GFR, the significant association can partly be explained. But there was no relationship between the risk of LBW and adjusted GFR by total birth.

Low birth weight is a complex issue with many inter-related modifiable and non-modifiable contributing factors. Literature review identifies many interacting factors contributing to low birth weight. There are genetic and constitutional, demographic and psychosocial, obstetric, nutritional, maternal morbidity during pregnancy, toxic exposure and antenatal care as individual risk factors proven by various studies.[5] Besides, there are certainly ecologic or neighborhood factors that can influence weight at birth. Factors such as access to health care facilities and safe transportation affect all people living in a particular neighborhood independent to their educational attainment or income. On the other hand these characteristics may also directly or indirectly affect infant health.[6] These factors have a geographical distribution, therefore geographic information system could map the distribution of these factors and be used as a new tool in environmental epidemiology.[7] There are many studies trying to find the association between low birth weight with related factors such as proximity to polychlorinated biphenyls-contaminated waste site,[8] air pollution,[9] neighborhood carbon monoxide,[10] parental exposure to organic solvents,[11] maternal exposure to trichloroethylene,[12] and residence near a hazardous waste site.[13] All of these studies used multivariate modeling to account for covariates and identified pure environmental associations. But GIS technology makes the opportunity to find these associations better and provides a powerful tool for the visualization and analysis of data that may have gone unnoticed in other reports.

By using geographic information assessment, the association between birth weight and crop production patterns around mother's residences was determined.[14] However, there are limited studies that used this technology for explaining environmental association with LBW and most studies used it for explaining LBW association with socio-economic status. Nelson found an immense spatial variability of low birth weight across Kamloops that coincided with socio-economic status of residents.[15]

The present study has limitations on mapping of probable individual and neighborhood factors associated with low birth weight. PHC network, as the source of data in current study, did not provide us many individual variables. The health information of PHC network registered in vital horoscope that is the only effective tool in PHC. It covers seven arena in health including population by age and sex, households using iodine salt, birth records, family planning methods, leading causes of maternal mortality, death number by sex and age, and leading causes of death in children (less than 5 years old).

In the present study, we used only the third subject that limited to birth by sex, birth weight, and age of mother. So, the only source of maternal health information limited to these data and cannot be used for health system research. However, PHC network in Iran has reached a considerable degree of expansion, especially in rural areas, and still needs more modification. For example, the blank places that have been ignored by most health politicians are the valuable source of health information that plays a great role in health system research (HSR).

Another limitation was using census data as the source of economic characteristics. Census data are collected at 10 years intervals and they are only crude indicators of socio-economic variables for the households of a village. Moreover, socio-economic characteristics among households in a village may be completely different due to immense dispersion of homes.

In examining the spatial distribution of low birth weight in Colorado, Egbert et al. used the standard deviation method for classification of areas.[16] The advantage of this method is considering total birth for its direct relationship with low birth weight. However, this method has the limitation of having unstable rate due to small population. One way to overcome this problem is to generate probability mapping. This method is a useful way for addressing small populations. For data interpretation, two issues should be considered; Firstly, it dose not preserve the content of the original data and instead of mapping health incidence rate, it shows probability level that only connected to the rates through a statistical computation. Secondly, probability mapping tends to overemphasize the significance of the rates in areas with large populations. In the present study, most of the villages fell in low probability level due to their small populations at risk. Since an increase in the size of a population increases statistical power, for an area with a larger population, a rate that is slightly higher than the expected rate will often be statistically significance but it may not be substantively meaningful.

In conclusion, this study found hot spot places of low birth weight that can help health professionals to tailor the intervention programs to reduce the problem. It also indicated that existing health house is associated with increased risk of low birth weight.

Conflict of Interest: None declared

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