GeoJournal
DOI 10.1007/s10708-013-9472-3

A spatial–temporal analysis of low birth weight prevalence in Georgia, USA

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Abstract Low birth weight (LBW), defined as a live birth weighing <2,500 g, is a significant public health problem in the United States, especially a few states including Georgia. Although much work has been done to study the epidemiology of LBW in various regions, the spatial–temporal patterns of LBW prevalence in Georgia remain unclear to a large degree. This paper investigates the temporal trend of LBW rates over a time span of 11 years and the spatial clusters of LBW prevalence in the state of Georgia at the county level. Comparison is also made between race and gender groups, and between county groups of different socioeconomic statuses to uncover disparities. Results showed a steady and prevalent increase of LBW rate in the state over the study period. Three counties and two county clusters with significantly higher LBW rates than the state rate were detected for 1999–2001, while one more county and two more county clusters of high LBW rates were detected for 2007–2009. More urbanized counties were found to have a relatively lower LBW rate when compared with the less urbanized ones as groups. The findings from this paper are expected to provide valuable insights to better understanding the etiology of LBW and more effective allocating prenatal health care resources in the future.

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Keywords Low birth weight · Spatial analysis · Temporal trend · Scan statistics · Disparity · Georgia

Introduction

The association between the role of low birth weight infants and a progressively greater risk of infant mortality has been well studied and reported (Robinson and Robinson 1965; Rantakallio and von Wendt 1985; Collier and Hogue 2007; Mervis et al. 1995; Msall and Tremont 2002; Wilcox and Russell 1983).When compared with infants of normal birth weight, infant mortality is reported to be six times higher for infants who are born low birth weight (LBW: <2,500 g) and more than 100 times higher for infants who are born very low birth weight (VLBW: <1,500 g) (Mathews et al. 2003). In addition, LBW is strongly associated with an elevated risk of numerous developmental abnormalities such as respiratory distress, brain hemorrhage, heart problems, and intestinal abnormalities that may impact overall quality of life of the affected infants (Jason et al. 2002). In the United States, substantial medical, political, and social efforts during

Published online: 23 January 2013

the past two decades have not resulted in an expected decrease in LBW rates. In fact, the LBW rate in the United States increased 17.0 % (7.0 to 8.2 %) from 1990 through 2009 (CDC 2012) and the rate in Georgia is among the worst in the nation and has climbed steadily since 2000, reaching 9.5 % in 2007 (GAFCAP 2012). At both the national and state levels, reported prevalence rates of LBW are well above the Healthy People 2020 intended target of 7.8 % (USDHHS 2010). These facts suggest that LBW remains a challenging public health issue in the state and in the country, and further research is necessary in order to more fully understand the epidemiology of this problem.

The primary cause of LBW, particularly VLBW is preterm delivery, occurring <37 weeks gestation. However, the exact etiology of preterm delivery remains elusive (Kiely 1994; Paneth 1995; Hillemeier et al. 2007; Adams et al. 1995). The best predictor of a VLBW delivery is a history of a previous VLBW delivery (Ensher and Clark 1994). Aside from a maternal history of previous preterm delivery, other widely studied risk factors include mother's socioeconomic status (SES), behavioral and demographic factors, environmental exposures, and neighborhood characteristics (Rogers and Dunlop 2006; Crosse et al. 1997; Aguilera et al. 2009). Furthermore, these risk factors are known to occur at both the individual-level and the neighborhood-level with complex interactions (Sellström and Bremberg 2006; O'Campo et al. 1997b).

LBW consistently demonstrates the inequity among different social and economic groups (Wilcox and Russell 1983). Evidence of associations between low SES and LBW exists across and within many countries, especially for groups with economic deprivation (Kramer et al. 2000; Rogers et al. 2000; Dunlop et al. 2011). Because of its potential importance in the elimination of poverty, reduction of health inequalities, and improvements in life quality, reduction in the prevalence of LBW is again identified as one of the reproductive health goals in the Millennium Development Goals Report by the United Nations (2012).

Significant racial disparity in LBW births has been consistently reported in the literature. After adjusting for established risk factors, observed LBW rates among non-Hispanic blacks are approximately twice greater than those observed for non-Hispanic white mothers in the United States (CDC 2012). In Georgia, the unadjusted LBW rate was 13.9 % among blacks compared to 7.9 % among whites (GDCH 2010). The comparison of the results among the previous studies also reveals that observed associations between LBW and many other risk factors have been inconsistent. For example, inadequate prenatal care has been associated with a reduced birth weight in many studies (Buka et al. 2003; Heaman et al. 2008), but insignificant associations were found in others (Bailey and Byrom 2007; Reichman and Teitler 2005; Hussaini et al. 2011).

The findings on the effects of the neighborhood-level variables are also conflicting. For instance, while one study reported that a higher risk of LBW was associated with a lower census tract-level educational attainment rate in California (Morello-Frosch et al. 2010), no significant association was found between birth weight and neighborhood-level education level in another study conducted in Massachusetts (Young et al. 2010). The complexity of LBW and its risk factors at the personal, social and spatial levels often makes the causal relationships of identified risks and responses non-stationary over space and time. Some traditional approaches with a fixed parameterization used to explore exposure–response association may not be enough to explain the spatial heterogeneity nature of these relationships. Methods that can specify explicitly spatial and temporal variations of exposure–response associations should be sought. A thorough examination of the spatial–temporal trends of LBW prevalence is a fundamental requisite in establishing baseline information for the subsequent etiologic and epidemiological research. The identification of clusters with statistically higher LBW risk can lead to the further development of specific hypotheses to explain the pattern of risk, as well as revealing important clues about disease etiology (Gatrell and Rigby 2004; Elliott 2000; Moore and Carpenter 1999; Cromley and McLafferty 2002). In practice, such LBW cluster detections are also critical for public health surveillance and healthcare resource allocations.

In epidemiological studies, various clustering indices, global or local, have been proposed and widely used (Oden 1995; Young et al. 2010; Stein et al. 1987; Luo et al. 2006; O'Campo et al.1997a). However, existing works applying spatial–temporal pattern analysis in LBW prevalence studies in Georgia have been very limited to our best knowledge. Rogers et al. (2000) completed a population-based case–control study and reported a significant association between maternal exposures to air pollution and risk for having VLBW baby. However, this study was conducted based on a small population (n = 345 mothers) in a very limited geographic area and the data were collected in the 1990s. Dunlop et al. (2011) conducted a population-based retrospective cohort study using a relatively large dataset (1994–2005) for the entire state. The study showed that from 1994–1996 to 2003–2005, the rate of recurrent VLBW increased while the rate of first VLBW decreased in Georgia. However, this study is focused on VLBW at the state level and the spatial variation of VLBW within the state was not investigated. A more recent study (Tu et al. 2012) detected the local clusters of LBW prevalence in Georgia using exploratory spatial data analysis (ESDA) methods. But this work focused on the spatial pattern with no consideration of the temporal component in the cluster analysis.

The intent of this research was thus to investigate the spatial–temporal patterns of LBW prevalence in Georgia. Temporal trends were visually and statistically examined at both the state level and county level, while spatial clusters of high LBW rates were detected using scan statistics. Analyses were performed on race and gender groups to discover disparities. The Georgia counties were also classified into four classes based on their degree of urbanization to examine the potential urban/rural disparity in LBW rates. Outcomes gleaned from this research will provide public health professionals with baseline measures of the spatial–temporal distribution of LBW in Georgia. This information will facilitate the research in etiology and epidemiology of LBW, the design of prevention and intervention activities targeted to specific geographic regions and high-risk populations, and the establishment of a best practice framework for planning health promotion program.

Data

The LBW data used to complete this study were collected from the Online Analytical Statistical Information System (OASIS) administered by the Georgia Department of Public Health (GDPH 2012). The annual rates of LBW (number of live births under 2,500 grams/number of live births ×100 %) were acquired for all the Georgia counties (n = 159) over an 11 year study period (1999–2009). Due to privacy concerns, the OASIS system does not provide rates in counties with less than five events of LBW cases of interest occurring in a single year. Excluding these masked data points, a total of 1,680 valid data records were included in our analyses and each record has four mostly related attributes: *County ID*, *Number of Births*, *Overall (unadjusted) LBW Rate*, and *Year*. Data were also segmented by race (e.g., black or white) and gender (male or female) for disparity analysis. Excel macros were written to conduct the tabular data processing programmatically. County boundary shapefiles were obtained from the U.S. Census Bureau and used for mapping and spatial cluster detection. County centroids were generated to represent county locations in cluster analyses.

Methods

Temporal analyses

The yearly overall LBW rates were plotted over the 11 year period to examine the change of LBW prevalence over time. A straight line was then fitted to the points by regressing LBW rate on year. The coefficient of determination R^2 was calculated to show the strength of the change trend. Because the overall trend tends to even off the differences between counties, an annual rate of change (ratio of year-to-year change over the prior year's value) was further calculated for each individual county between its LBW rates for every two consecutive years. The annual rates of change were then averaged for the study period as an indicator of the county's overall increase or decrease in LBW rate.

Although the plots can be used to examine the change of LBW rate over time, statistical significance of the trend is still unknown. In addition, the statewide mean rates tend to equalize the spatial variation and are dominated by populous counties. One-way ANOVA contrast tests were performed to compare the county means of LBW rate in the beginning study period (1999–2001) to those in the ending study period (2007–2009) in order to assess significant differences. The null hypothesis for this statistical test states that the means for the two groups are not significantly different. One-way ANOVA contrast tests were also performed to compare the LBW rate between black and white and between male and female births.

Spatial cluster analysis

Spatial patterns of LBW rate in Georgia were visually examined by mapping it at county level. The scan statistical method based on the discrete Poisson probability model (Kulldorff 1997) was employed in this study to detect county clusters of high LBW rates. The null hypothesis of this method signifies complete spatial randomness with each birth equally likely to be a LBW case. The alternative hypothesis is that the probability of having low weight babies within a geographic zone (e.g., a county) is higher than what would be observed outside the geographic zone. This method scans all the locations (e.g., county centroids) of the study area and uses a series of increasingly larger circular windows over each location to find a significant excess of cases. The maximum scan window size is reached until a specified percent of all births are included (Kulldorff et al. 2009). For each window, a likelihood ratio is calculated by taking into account the mean and the variance for the cases within the window and those for all the cases.

The maximum likelihood ratio over all the candidate windows is used as the test statistic and the corresponding window is treated as the most likely cluster in the current round of scan. The statistical significance of the most likely cluster is evaluated using Monte Carlo hypothesis testing (Dwass 1957). A large number (e.g., 999) of random replications of the dataset are generated under the null hypothesis of completely spatial randomness. Each randomly generated dataset is taken to calculate its maximum likelihood ratio and compare to that from the real dataset. If the maximum likelihood ratio from the real dataset is ranked high enough (e.g., top 5 %) among all the data sets, the corresponding cluster from the real dataset is believed to be statistically significant ($p = 0.05$). For more details about the method, please refer to Kulldorf (Kulldorff 1997).

The SaTScan software (http://www.satscan.org) was used to perform all the scan statistics and python programs were developed to streamline the process of reading the output from SatScan, mapping the counties or county clusters with significantly higher rates, and summarizing cluster characteristics into tables for interpretation. The programs allowed us to perform multiple experiments with different search radii more efficiently. The smallest search radius examined was set as five km, with which only one county centroid was covered. Such searches of relatively small circular areas were used employed to detect the individual counties that had higher LBW rates. The largest search radius examined was 50 % of the total births in order to find significant county clusters with unknown sizes. Both the detections of high LBW rate counties and high LBW rate county clusters in Georgia were performed for the first 3 years (1999–2001) and the last 3 years (2007–2009) of the study period, for tracking temporal changes of the spatial pattern.

Finally, Georgia counties were classified into four classes based on their level of urbanization. The first class includes the 28 counties in the Atlanta Metropolitan area and the second class includes the secondary counties covering the secondary city areas (e.g., Macon). The third class is to cover the micropolitan areas (e.g., Statesboro) while the fourth class includes the remaining rural counties. A statistical Tukey's test was performed to compare between these four classes in terms of their yearly LBW rates. The aim was to find out if there was an association between LBW rate and level of urbanization.

Results

Descriptive statistics

From 1999 to 2009, there were 1,527,831 live births in Georgia, among which 9.2 % (140,537) were LBW. By race, 64,670 (46 %) of the total LBW births were white, 67,563 (48 %) were black, and only 8,304 (6 %) of the LBW births were other races. As illustrated in Table 1, the yearly state LBW rate was considerably higher in black infants (mean = 13.7 %) as compared to either white births (mean = 7.1 %) or births of other races (mean = 8.2 %). In fact, births to black mothers were nearly twice as likely to be born LBW as white infants with a range from 12.9 % to 14.4 %. Among white and other births, the LBW range was 6.6–7.5 % and 7.4–to 8.7 %, respectively. By gender, 66,238 (47 %) of the total live births were male while 74,299 (53 %) were female. The LBW rate by gender was similar, but the proportion of LBW among males was slightly lower (12.5 %) than female births (14.9 %). Moreover, these data indicate that this trend is consistent regardless of race. Even when controlling for gender, it is evident that the racial disparity still exists with the probability of black births being approximately twice more likely to be LBW.

Table 1 Distribution of yearly state LBW rate by race and gender in Georgia (1999–2009)

	Min (%)	Max (%)	Mean (%)	SD (%)
White	6.6	7.5	7.1	0.3
Male	6.3	7.3	6.6	0.36
Female	7.2	8	7.6	0.32
Black	12.9	14.4	13.7	0.63
Male	11.6	13.1	12.5	0.55
Female	13.9	15.7	14.9	0.75
Others	7.4	8.7	8.2	0.56
Male	7	8.2	7.5	0.54
Female	7.6	10.1	8.9	0.75

Temporal trend

The temporal analysis of LBW for the entire state shows a clear trend of increasing over the study time period. The lowest rate (8.6 %) occurred at 2000 while the highest (9.6 %) was observed in 2008. As illustrated in Fig. 1, the data points follow a linear trend with little fluctuation. Furthermore, the linear regression of LBW rate on year resulted in a fairly high R^2 value of 0.89 (p value < 0.001), thus indicating a rather steady trend of increasing (slope $= 0.11$). When focused on individual counties, 132 of the 159 counties were found to have a positive average annual rate of change while only 12 counties had it to be negative (Fig. 2). It should be noted that the average annual rate of change was unknown for the remaining 15 counties due to the partial unavailability of birth data as described previously. Furthermore, average annual rates of change exceeded 20 % in three counties (Irwin, Twiggs, and Chattahoochee), and the rate of change ranged from 10 to 20 % in 25 counties. Ranging from −1 to −4 %, the rate of negative change was observed for 12 counties in Georgia.

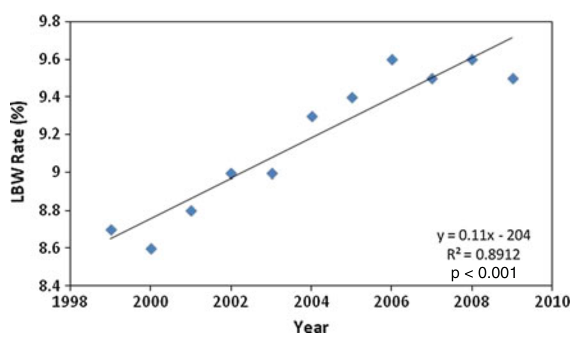

Fig. 1 Temporal variation of the overall LBW rate in Georgia (1999–2009)

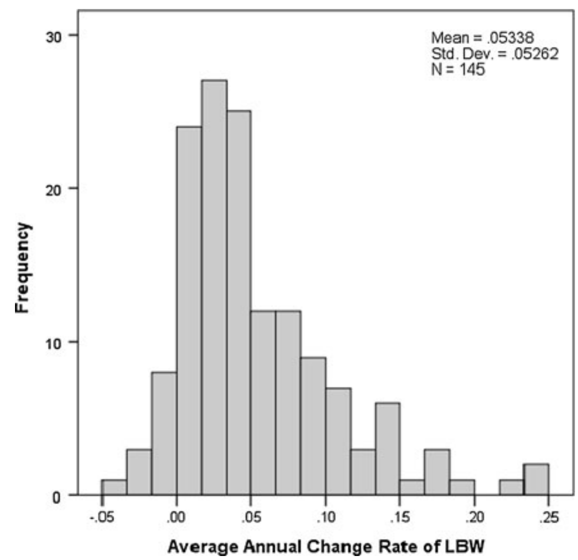

Fig. 2 Average annual change rate of LBW in Georgia (1999–2009)

When segmented by race, the LBW rate was found to increase in both black and white populations (Fig. 3). However, the trend line for black births indicates considerably more LBW births than while births, thus echoing data presented in Table 1. In addition to the noted increase, the LBW rate in black births appeared to fluctuate to a larger degree than did white births. When illustrated by gender, the trend line suggests a higher LBW rate among female as compared to male infants (Fig. 4). Although the disparity by sex did not seem to be as significant as observed for race, the increased trend is clear and deserves attention. Statistical paired comparison test confirmed that the LBW rate in black births was significantly ($p < 0.01$) higher than that in white births and the LBW rate in female births was significantly higher ($p < 0.01$) than that in male births. Moreover, one-way ANOVA contrast analysis proved that the average LBW rate in the last 3 years (2007–2009) of our study period was significantly higher than that of the first 3 years (1999–2001). Comparatively, the LBW rate in white infants seemed to increase more significantly than that of black infants, while the LBW rate in males increased more significantly than that of females (Table 2).

Table 2 One-Way ANOVA contrast analysis by race and gender in Georgia (2007–2009 compared to 1999–2001)

		F value	*P* value
Overall		11.80	0.0006
Race	Black	5.61	0.0180
	White	7.51	0.0062
Gender	Male	14.29	0.0002
	Female	8.82	0.0030

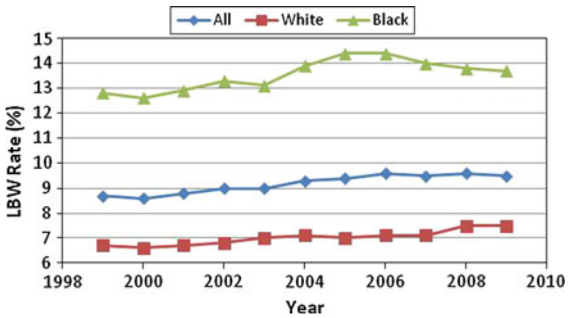

Fig. 3 Trend of LBW rate by race in Georgia (1999–2009)

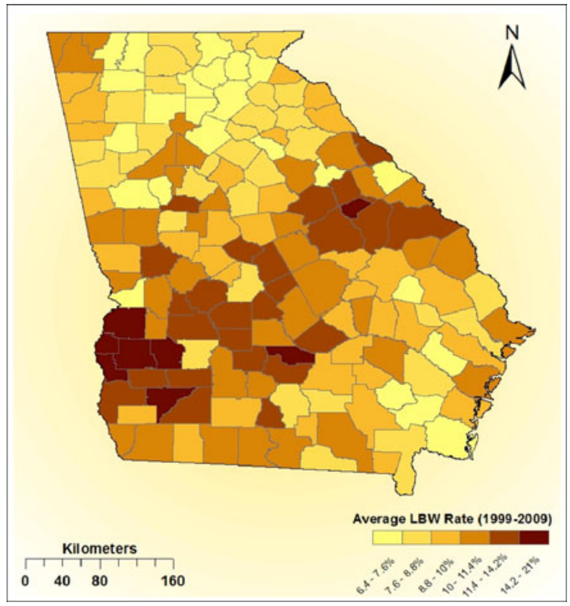

Fig. 5 County-level average of LBW rate in Georgia (1999–2009)

Distribution of high LBW rate counties

It can be seen clearly that the LBW rate varies significantly from county to county in Georgia (Fig. 5). Over the study period (1999–2009), Quitman County had the highest average LBW rate of 21 % while White County had the lowest of 6.4 %. Seven counties had their average LBW rate above 15 %. Geographically, there seem to be counties clustering with relatively higher LBW rates than others. Most of these counties lie within a stripe area stretching over from the southwest corner of the state to the middle section of its east boundary. The northeastern counties generally appeared to be relatively lower of LBW rates.

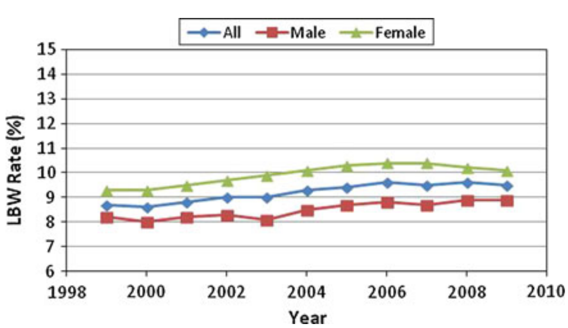

Fig. 4 Trend of LBW rate by gender in Georgia (1999–2009)

Scan statistics were performed for the two time periods in comparison (start: 1999–2001 versus end: 2007–2009), with a small search radius to focus on individual counties. Each county was therefore statistically compared to the remaining counties in the state to determine the ones with relatively higher LBW rates. Specifically, the counties with a log likelihood ratio value over 20 were identified and mapped for each time period. For 1999–2001, three counties (Bibb, Dougherty and Fulton) stood out as the most significant high LBW rate counties. These counties persisted to have a log likelihood ratio value over 20 in 2007–2009 as well (Fig. 6). In addition, the log likelihood ratio value of Spalding County increased to reach over 20 in 2007–2009. These four individual counties were statistically the highest of LBW rates at a significance level of $p < 0.0001$. It should be noted that all of them are regarded as urban counties with a total population greater than 35,000. Fulton and Spalding Counties are both part of the Atlanta metropolitan area, and Bibb County is the home county of Macon, the sixth largest city in the state by population. These three counties are geographically located in the center of state. Dougherty County is in the southwest corner of the state and is home to Albany, the eighth largest city in Georgia by population. It should also be noted that no counties in the

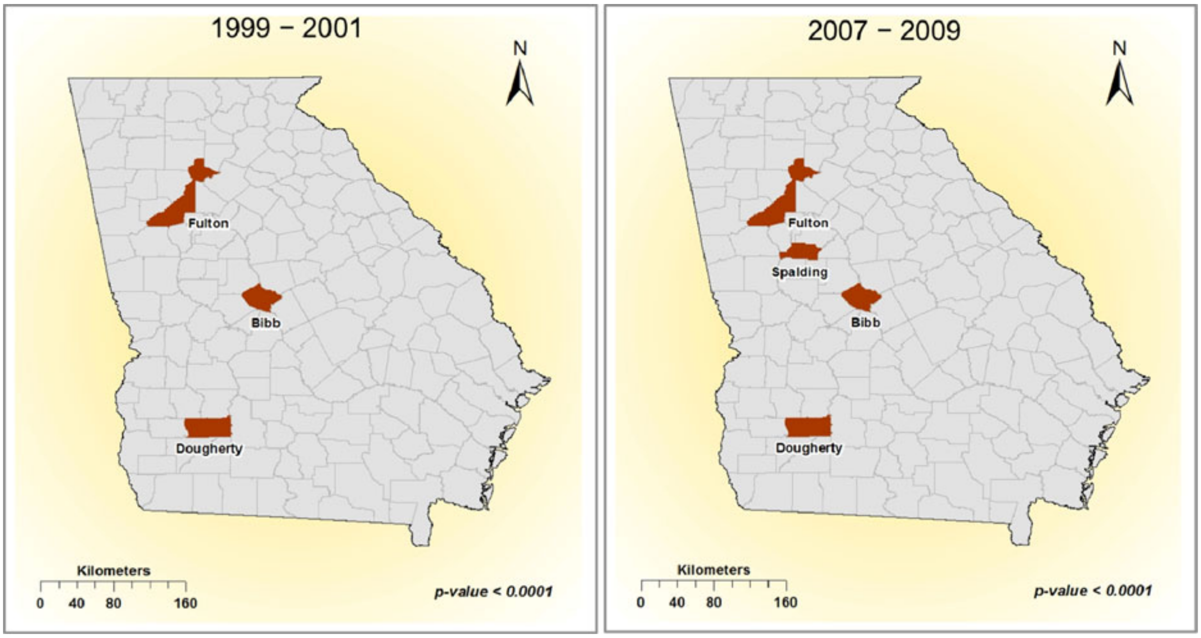

Fig. 6 Georgia counties with significantly higher rates of LBW (1999–2001 versus 2007–2009)

eastern part of the state were found to have a significantly higher level of LBW rate.

Distribution of high LBW rate county clusters

The spatial scan with a maximum search radius of 50 % of the total births resulted in two county clusters of significantly higher LBW rates for 1999–2001. The primary cluster was spatially extensive consisting of 67 counties in Southwest Georgia (Fig. 7). It was discovered that this cluster exhibited an extremely high level of significance ($p \ll 0.0001$), meaning the cluster has a very small chance of being a random result. The secondary cluster found is also highly significant ($p \ll 0.0001$) but much smaller consisting of only Fulton and Dekalb Counties. However, both of them are the principal counties in the Atlanta metropolitan area with high population density.

In comparison, four significant county clusters ($p \ll 0.0001$) were detected for 2007–2009 (Fig. 7). The primary cluster remained to be formed by a large number of counties located in the southwest of the state, although the cluster size appeared to be slightly smaller. Fulton and Dekalb Counties persisted to form the secondary cluster. The continued existence of these two clusters means that LBW has been prevalent in their member counties throughout the entire study period and close attention should be paid to these counties in order to effectively reducing LBW rate of the state. In addition, two more clusters were detected including the three counties in the northwest corner of the state and the five counties to the east as shown in Fig. 7. These five counties include Richmond County, which is the home county of Georgia's second largest city, Augusta. The presence of these two new clusters had contributed, at least partially, to the overall LBW rate increase as shown by Fig. 1. No high rate clusters were found in the northeast or southeast part of the state.

Moreover, the comparative analysis (Tukey's test) between the four county classes showed that the counties within the Atlanta Metropolitan areas and those with secondary cities (e.g., Macon) were significantly lower in LBW rate than the counties with third level cities (e.g., Statesboro) and rural counties. More specifically, the counties with secondary cities had a higher LBW rate than those within the Atlanta Metropolitan area. No significant difference was found between the latter two county classes.

Summary and discussion

It was found clear that the overall LBW rate of the State of Georgia had been increasing in both white and

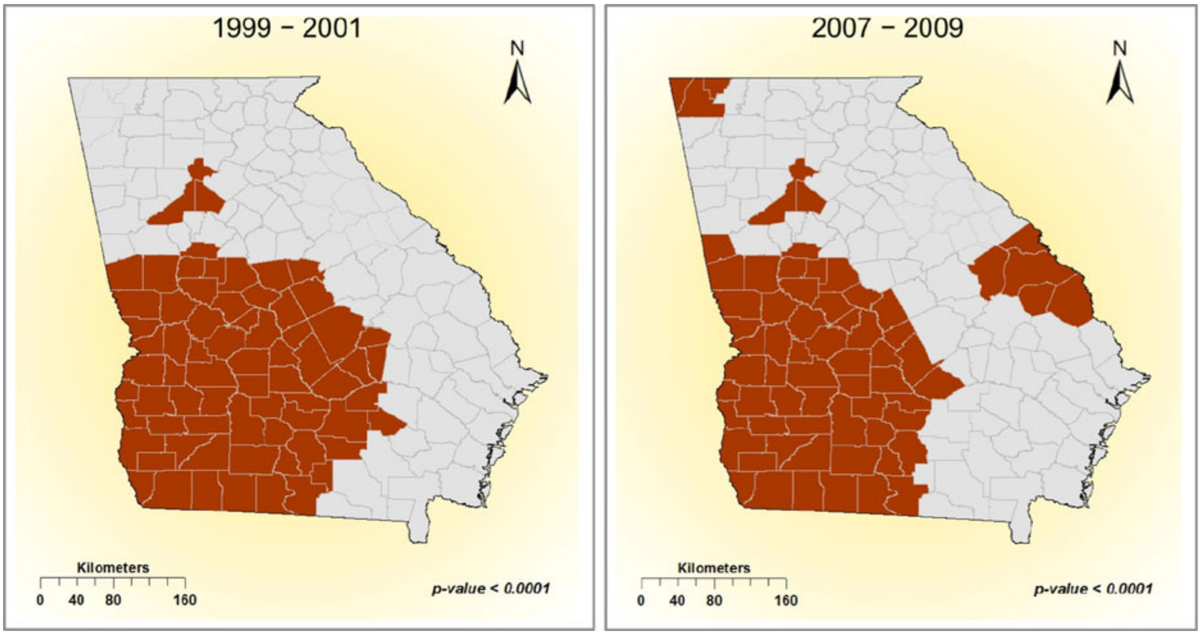

Fig. 7 Cluster of Georgia counties with significantly higher rates of LBW

black infants from 1999 to 2009, regardless of gender. The statistical analysis comparing the county rates in the first three years (1999–2001) and those in the last three years (2007–2009) suggests a significant increase that is not likely due to chance. Closer examination of the individual counties further reveals that the majority of them (at least 132 out of 159) have been trending upwards in their LBW rate. In other words, the increase of the overall rate was the result of prevalent local increases rather than of the influence of a few populous counties. The trend of increasing LBW rate found from this study is different from the trend of decreasing VLBW rate in Georgia found in Dunlop et al. (2011). This discrepancy is understandable as VLBW is strongly associated with preterm births and the decrease of VLBW is largely a result of the reduction of preterm births. In addition, this study illustrates a marked racial and geographic variability of LBW prevalence in Georgia at the county level. The average LBW rate in black infants was 93 and 67 % higher than that in white infants and other races as a group, respectively. Such black-white disparity is consistent with what is found in Dunlop et al. (2011) and Tu et al. (2012).

Geographically, three counties (Bibb, Dougherty, and Fulton) stood out as hotspot areas with the highest likelihood ratio values throughout the study period. During the same time, the LBW rate of Spalding County increased considerably making it a high LBW rate county in the end. A large number of counties in the southwestern Georgia were found to form a significant cluster of high LBW rate. Although the size and shape of this cluster changed slightly during the study period, it kept to be the most significant one among all the clusters detected. Fulton and Dekalb Counties formed the second most significant cluster throughout the study period. Two more clusters, although less significant, developed over the time span and were detected in 2007–2009 (not in 1999–2001). The scan statistical method was chosen in this study to detect spatial clusters over local spatial autocorrelation analysis because it will allow us to compare with the results found in Tu et al. (2012). The power of these two major methods in detecting spatial clusters of high LBW rates can thus be evaluated in our future research. Moreover, the LBW rate was found to be lower in the Atlanta Metropolitan counties and the secondary urban counties and higher in the third-level urban counties and the rural counties when compared as combined groups. Generally speaking, the more urbanized counties were statistically lower in overall LBW rate than the less urbanized ones.

From an epidemiological perspective, the causative relationship of this rate increases, and rate fluctuations, observed in this paper is unclear. However, it is certain that these changes are due in large part to a complex interaction that exists between lifestyle, social, economic, and environmental factors of any given community. These factors, coupled with community culture and ethnicity, influence overall risk of the population. Moreover, these characteristics are often associated with risk taking behaviors, such as smoking and alcohol consumption, as well as the ability to access quality and affordable healthcare that affects issues such as adequate prenatal care. In order to fully understand this rate increase, it would be necessary to investigate the social, economic, environmental, and lifestyle characteristics more closely in those counties where increased rates were observed. While social and economic data are available, environmental and accurate lifestyle data at the local level are relatively sparse, particularly in Georgia. This seriously hampers efforts to grasp the enormity of the problem in these communities.

This research illustrated a significantly increased rate of LBW among Black infants as compared to White infants, and these data are congruent with numerous other studies in the literature. Although the cause of LBW remains a mystery, there are documented factors that contribute significantly to increased risk including race (African American), giving birth as a teenager, multiple births (twins, etc.), and the overall health of the mother. Moreover, the health of the mother is influenced by a lower socioeconomic status, poor pregnancy nutrition, inadequate prenatal care, and complications during pregnancy. The elevated county-level rates in rural Georgia may partially be explained by the region's lower socioeconomic status (English et al. 2003; O'Campo et al. 1997a), although further research needs to be done to thoroughly understand the multi-faceted risk factors behind the racial and geographic disparities of LBW.

The research present here provides a critical first step in more clearly understanding the epidemiology of LBW and better informing the practice of public health care in the state. Multiple strategies have been used to reduce the rate of LBW in high risk areas, including novel methods focused on monitoring uterine contraction. Additionally, the success of other strategies representing a more traditional approach to prevention have also been designed and implemented. However, most efforts have been met with limited success and the challenge of solving this problem still faces public health professionals. Among the more promising strategies offered are those that have focused in large part on community education. These programs have been specifically designed to reduce individual risk taking behaviors, such as the use of drugs, alcohol, and tobacco. It appears to be the case that prenatal care is critical to reducing risk of LBW. Specifically, healthy nutritional habits and essential vitamin intake during pregnancy are essential to promote weight gain of the fetus. The spatial characteristics of LBW prevalence uncovered in this research can help develop heath initiatives including, but not limited to, educational prevention programs to target high-risk population groups and geographic regions.

It is important, however, to note that even given the challenges and limited effectiveness of health promotion efforts, success as measured by survival among preterm and LBW infants in the United States is excellent relative to other parts of the world. However, public health practitioners have been unable to accurately and strategically target primary and secondary prevention efforts due to the unavailability of local data reflecting social, economic, environmental, and lifestyle data. Sustained research efforts understanding the epidemiology of LBW, as well as a demonstrated commitment to improving population health status through collective social action, are the key to reducing health disparities and improving the quality of life among Georgia residents.

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