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A Spatial Temporal Analysis of Infant Mortality in the Midwest Industrial Belt: 1940 and 2000

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A SPATIAL TEMPORAL ANALYSIS OF INFANT MORTALITY IN THE MIDWEST INDUSTRIAL BELT: 1940 AND 2000

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A SPATIAL AND TEMPORAL ANALYSIS OF INFANT MORTALITY IN THE MIDWEST INDUSTRIAL BELT: 1940 and 2000

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This study compares and analyzes the spatial patterns of infant mortality (IM) for 1940 and 2000 using county-level socio-economic variables in the Industrial Belt, assesses the changes in IM as an indicator of the living standards for the population over time and space, and explains the changes. The region was delineated using 1940 employment data. OLS, spatial regression, and exploratory spatial data analysis were used on IM (the dependent variable) and socio-economic variables to study the standard of living in the region. Some important factors were statistically significant in the various models including: minority population, levels of industrialization, and urbanization and poverty. When contrasted with the nation, the region had a higher standard of living in 1940 verses 2000 yet lacks uniformity at the county level across space and time. Several clusters of high and low IM rates were identified. Future research in these areas may shed more light on IM and the quality of life in the region.

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CHAPTER I

INTRODUCTION

The relative quality of life in a society is reflected in a variety of indicators such as access to health care, education, sanitation, diet and lifestyle. The number of infant deaths (deaths of children before their first birthday) often reflects a population's living standards. A society where women are educated, have access to health care and clean water, and able to afford nutritious food usually experiences lower infant mortality rates (Suwal, 2001). For this reason previous research that focuses on general health and well being of a society often uses infant mortality rates as an important statistical indicator. Infant mortality "provides a useful illustration of the dynamic interaction of underlying social forces" (Gortmaker and Wise, 1997 pg. 1).

Infant mortality rates are calculated as the number of deaths of children under the age of 1 year per one thousand births. During the mid to late 1800s, a "war" was declared on infant deaths via better sanitation, health standards, and pasteurization of milk (Meckle, 1990; Brosco, 1999). This "war" included an expansion of public health services and social welfare workers along with the increased efforts by doctors to lower both infant mortality rates and maternal deaths (MMWR, 1999). As a result of these efforts the United States experienced an impressive decrease in the infant mortality rate during the 20th century (Lerner, 1963). In 1915, the death rate was 149.7 deaths for every 1000 live births (Meckle, 1963). In 1940 the rate dropped to 73.8 and by 1997 the rate dropped to 7.2 deaths (MMWR, 2002). When compared to other countries, the United States ranked 28 out of 38 of countries in a report of nations who state infant mortality to the World Health Organization in 1998 (March of Dimes, 2002). Hong Kong, Sweden, Japan, Norway, and Finland were the five countries with the lowest rates.

Today, the United States faces two issues. The US infant mortality rate is considerably higher than many other highly developed wealthy countries and its infant mortality is far from being uniform across the country. There are places and segments of the population that continue to experience high infant mortality rates (Singh and Yu, 1993), suggesting more efforts are required to assure the health and well being of today's babies.

There are important spatial variations in the nation's infant mortality rates. In both 1940 and 2000, the southern and southwestern states experienced some of the highest infant mortality rates by county across the country (Shapiro et al, 1968). Variations also exist based on a range of demographic variables. Several studies show infant mortality rates are different among the different races that make up the nations population (see Hummer et al 1999, and Singh and Yu, 1993). Differences in infant mortality rates between blacks and whites in the United States increased from 2.1 in 1983 to 2.4 in 1991 (Carmichael and Iyasu, 1998). These two important issues have raised concerns within the health, social and governmental professions. Questions revolve around the importance of poverty, race, personal behavior, and government intervention as these factors are related to infant mortality rates (Meckel, 1990). In 1940, the leading cause of infant mortality was reported to be infections in the digestive tract (Shapiro et al., 1968). Today the leading causes of infant mortality are birth defects, low birth weight, sudden infant death syndrome and maternal pregnancy complications (March of Dimes, 2002). The purpose of this thesis is to investigate the relationships among infant mortality and a variety of socioeconomic indications identified in existing literature and to determine if these relationships have changed for the 1940 and 2000 census years. What aspects of the society in the manufacturing belt in 1940 and in 2000 have an impact on infant deaths? What has changed in the six decades in regards to infant mortality and the quality of life in the region? These are some of the questions this study sets out to answer.

CHAPTER II

THE RESEARCH

The Research Question

This study examines the spatial pattern of infant mortality in the traditional Industrial Belt of the upper midwest United States for the years 1940 and 2000 using county-level socio-economic variables. Again, the purpose of the study is to identify the spatial patterns for each time period, assess the changes in infant mortality as an indicator of the living standards of the population over time and space, and study the relationship between infant mortality and other socio-economic census variables. Listed below are the specific research questions this thesis will address:

1) What are the spatial patterns of infant mortality in 1940 and 2000?

2) What are the socio-economic determinants of infant mortality in 1940 and in 2000?

3) What are the determinants of change in the spatial patterns between 1940 and 2000?

The Region

The first stage of the research involves defining the region. Geographers have long partitioned the world and its many places into myriad types of regions. The partitioning of the world can reflect nationalism, governmental delineation or areas of research (Haggett, 2001). Standard practice in geography has been to identify three types of regions: 1) formal – based on shared characteristics in the culture, economy or natural system; 2) functional – based on an organized node or center and 3) vernacular – based on the perception of people (Rubenstein, 1999). Significant to this study, regions without distinct or obvious borders such as the industrial belt are subject to a variety of delineations based on different criteria.

The Industrial Belt is a formal region defined by a high concentration of manufacturing and manufacturing employment but is represented in geographic publications with some variability with respect to the precise locations incorporated in the macroregion. For example, Rubenstein (1999) represents the major industrial region of North America as five subsets around 1) Milwaukee to Chicago and onto Detroit, 2) Cleveland to Pittsburgh, 3) Toronto to Buffalo, 4) Boston and 5) New York to Baltimore. de Blij (1977) depicts the Industrial Belt as one large region that stretches from Minneapolis south to St. Louis east to Baltimore and north to Montreal.

After a review of several maps, I concluded that for greater accuracy in my further statistical analysis, a homogeneous contiguous region based on socio-economic characteristics needed to be quantitatively constructed based on selected county-level variables that represent a high concentration of manufacturing employment in 1940. The region building exercise is explained in Chapter IV.

The Time Frame

Nineteen-forty represents an important break in history of the United States. The nation was recovering from the Great Depression, yet the economic boom and social impacts of World War II and its aftermath had not yet taken place. It also marks a time of great reductions in certain infant health diseases. Between 1940 and 1955, infectious and parasitic diseases were reduced by 86%, indigestive diseases experienced a 75% reduction and respiratory diseases were lowered by 50% (Lerner and Anderson, 1963). The use of antibiotics had yet to make its impact on the medical scene as penicillin was first used in 1943 (Lerner and Anderson, 1963).

By the end of the 20th century, the nation had experienced another World War along with several smaller armed conflicts, and great achievements in medicine and technology (Kaledin, 2000). During the entire 20th century, the country experienced a significant decline in infant mortality. Research studies report a rapid decline in the first half of the century and then the slowing down and leveling off during the 1950s (Shapiro et al., 1968). The most important factors in explaining this dramatic drop prior to the 1930s include “declining fertility”, “better nutrition” and a “rising standard of living” (Meckel, 1990, pg. 2). After the 1930s, these same factors along with “improved quality and availability of medical care” were also cited as important (Meckel, 1990, pg. 2). After the 1950s the drastic decrease in infant mortality in the United States leveled off with only a few scattered years of small increases (Shapiro et al., 1968).

CHAPTER III

INFANT MORTALITY

The Socio-economic Variables

There are logical associations between infant mortality and a range of socio-economic factors. Several studies (Hertz et al., 1994; Tresserras et al., 1992; CDC, 2003) have shown the importance of economic factors with respect to the variations in infant mortality. These factors include, but are not limited to variations in Gross National Product, growth in the labor force, per capita gross domestic product and income equality. Hertzman (2001) analyzed the relationship between mortality and a range of economic factors for an international analysis of gross domestic product per capita. His research indicates the association between wealth and life expectancy is strong in poorer countries, but becomes less so as the nation becomes wealthier. His analysis of infant mortality and the use of income inequality across the 50 states and 10 Canadian provinces indicates that death rates do correlate with income inequality in the US and Canada at the state/province level.

Other important socio-economic factors include education, race and class. Brooks (1975) used the median number of school years completed as a surrogate for education, the percent of white-collar workers as a surrogate for class and the percentage of blacks as a race variable compared locational variations in infant mortality at the state level. One interesting finding in Brooks' (1975) research was the increasingly positive association between infant mortality and the percentage of black population between the years 1938 and 1968. Other researchers also found an association between high infant mortality and race (Schoendorf et al., 1992 and Bird, 1995).

Infant Mortality and Scale of Analysis

The scale of analysis is an important issue when designing research of this type. For example, large scale or global studies could result in different conclusions in comparison to national or regional studies. Hertz et al. (1994) compared the significance of economic and social factors for 66 countries. Their results suggest that economic indicators are less reliable in predicting the infant mortality rate than health status measures at the international level. This finding is supported by Tresserras et al. (1992). In this study, researchers looked at 103 countries and the association of infant mortality with both per capita income and adult illiteracy. The results indicated that while adult illiteracy was found to be a "good predictor" for infant mortality, per capita income was not.

A greater number of meso-scale studies, (national-level) contrast with the limited number of large-scale research projects. Most studies of infant mortality have been conducted at the national level (Schoendorf et al., 1992; Bird and Bauman, 1995; MMWR, 1999; Kleinman, 1986). Many of these national studies focused on infant mortality rate and its relationship to gender, race, education, family income and causes of death for children in the United States. There are "substantial differences across sex, race/ethnicity and socioeconomic groups" for infant mortality rates across America (Singh and Yu, 1996, pg. 511). Interestingly, Singh and Yu (1996) found that male black children have a higher mortality rate so that both race and gender are important considerations. Furthermore, as many previously cited studies have shown, socioeconomic status is a major factor in childhood mortality.

Numerous studies conducted at smaller scale (regional/state or urban area), have typically used similar factors as those for large area projects. Vazquez-Virzoso et al. (1993) studied infant mortality in 17 autonomous communities in Spain. This study looked at the different communities to identify "disadvantaged areas" within Spain using infant mortality as the indicator. Results indicated certain autonomous communities continue to experience spatial differences that play an important role in infant mortality. Andes and Davis (1995) discussed using geographic information systems (GIS) and related databases at the state level and concluded that this method is a feasible technique to analyze infant mortality rates at this scale.

As indicated in the previously cited studies, the relationship between socio-economic measures and infant mortality can be influenced by the scale of the research. A researcher needs to consider scale since it is evident that size of the study area can affect the results. This problem is referred to as the Modifiable – Areal - Unit Problem where different study size areas can impact the outcome of the statistical analysis (Openshaw, 1983, Robinson, 1998).

Despite variations in the unit size, much of this previously cited research associating socio-economic conditions and infant mortality do report associations among the characteristics of the population and the standard of living for the study region. The current research will be employ county level data for the region often referred to as the Industrial Belt of the Midwest United States. Although there are a host of social, economic, cultural and environmental factors affecting infant mortality, due to the limitations of data available for 1940 at the county level, this research will focus exclusively on socio-economic factors available at this time. In general, then, this thesis seeks to identify the relationship between these socio-economic factors and infant mortality for 1940 and

2000. In addition, changes in a variety of these socio-economic factors will then be used to explain change in infant mortality between 1940 and 2000.

CHAPTER IV

DATA AND METHODOLOGY

The Traditional United States Industrial Belt

Often, employment data has been used, along with per capita and industrial output, to delineate industrial regions and distinguish them from other places (Wheeler, 1998). Secondary data on employment by industry at the county-level has been used to delineate the region based on the characteristics for 1940. Employment by industry data for 1940 has been obtained from Regional Employment by Industry published by the U.S. Bureau of Economic Analysis (1975). Appendix 1 displays the employment variables used for region building.

The location quotient (LQ) was used to identify employment and concentration by comparing the total of employed in each economic sector, the total employment for each county and the national employment for each sector and the national total (Robinson, 1998). Following Robinson (1998) the general equation for the LQ is:

$$LQ = \frac{c_x/t}{N_x/T}$$

Where c_x is the number employed in each economic sector in 1940 for the county and t is the total employed in the county, N_x is the national employed in each economic sector in 1940 and T is the total national employment.

An LQ greater than 1 indicates a higher than average degree of concentration in that economic sector for a given county; a value less than 1 indicates a low concentration and a 1 indicates the distribution is the same as the national average (Robinson, 1998).

Initially, a GIS was developed to map each LQ variable in order to visually inspect and determine which variables exhibited a spatial pattern. Based on this assessment and the LQ values, only six variables were kept for further analysis: forestry and fishing, mining, total manufacturing, lumber and paper production, machinery, and motor-vehicles and motor-vehicle equipment. Once these variables were identified, "Average Linkage Cluster Analysis" was applied to these six variables in order to determine if counties "belonged" to the industrial belt. Average linkage clustering uses the average distance between observations within two groups as the measure of distance between two groups (Cytel, 2001). In this analysis counties were assigned to one of two groups: industrial counties and non-industrial counties. Based on the six variables listed above, the cluster analysis assigned more than 500 counties in the six states of Michigan, Ohio, Indiana, Illinois, Wisconsin and Pennsylvania to the "industrial" group. The non-industrial counties were eliminated.

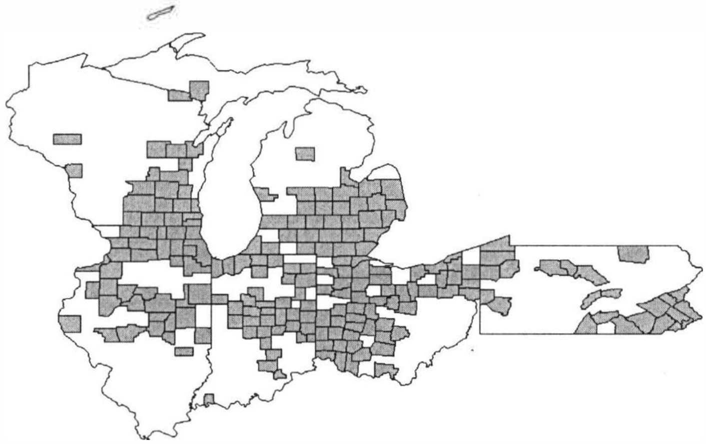

Figure 1: Initial Region

As displayed in Figure 1, the initial region had some "holes" and "outlying counties". In an effort to create a discrete region with no gaps or outliers, additional steps needed to be taken.

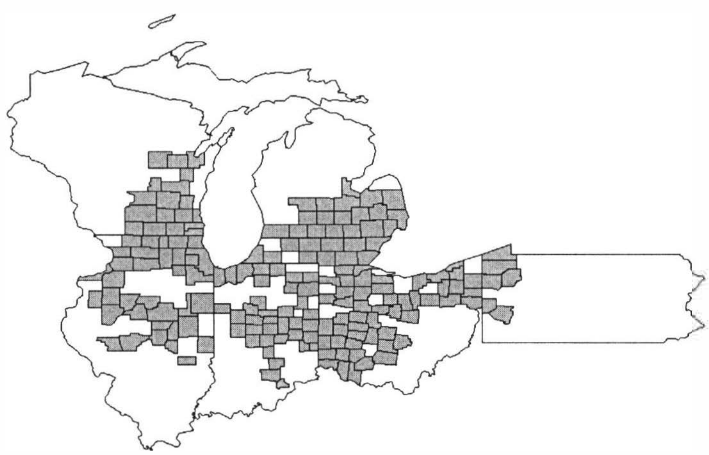

Figure 2: Region Without Outliers

The counties representing the eastern Pennsylvania area and other scattered counties not connected to the main region were eliminated to create a contiguous region (see Figure 2).

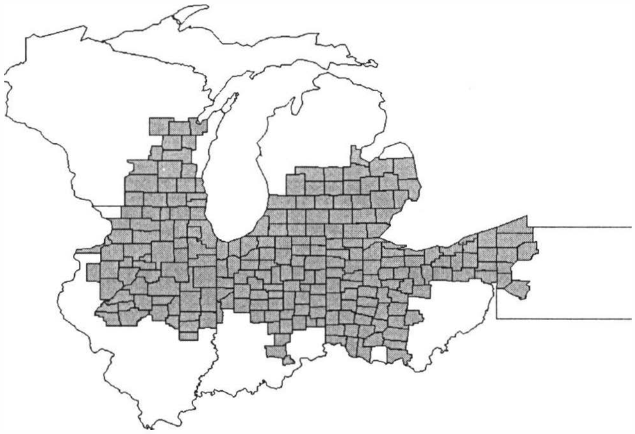

Figure 3: Final Region

In addition to including the counties which were identified as manufacturing counties through the cluster analysis, a one-mile buffer was created to include all the "non-manufacturing" counties that were inside the initial region. This step was justified because although these counties had lower levels of manufacturing surrounding manufacturing counties would have a strong influence. The counties on the outside edge of the region initially included in the buffer were individually eliminated during the analysis.

As shown in Figure 3, the end result of these steps was a contiguous region for the northern manufacturing belt of the US. The region shown in Figure 3 is very similar to the other publications (de

Souza, 1990; de Blij, 1977). A list of the counties included in the manufacturing belt is located in appendix 2.

Infant Mortality Data

The infant mortality data for each county within the region was obtained from the National Vital Statistics. A three-year average of 1938, 1939 and 1940 was used for the 1940 analysis (Vital Statistics, 1938, 1939; 1940). A three-year average of 1998, 1999 and 2000 was used for the 2000 analyses (Bureau of Health Information, 2003; Bureau of Health Statistics and Research, 2003; Illinois Department of Public Health, 2003; Indiana State Department of Health, 2003; Michigan Resident Death, Birth and Fetal Deaths Files and Occurrence, 2003; Ohio Department of Health, 2003). Three year averaging was done to minimize the possible wide fluctuations of infant mortality rates in counties with low populations or particular extreme events in 1940.

The socio-economic variables for statistical analysis were obtained from the 1940 United States Census and the 2000 United States Census. The variable for 1940 include: the LQs of a variety of industrial sectors, the percentage of males and females who have completed high school, population unemployed, urbanized, rural and minority population, and the natural log of the population. The variables for 2000 include: the

LQs of a variety of industrial sectors, medium income, percentage of nonfarm population, percentage of females at the childbearing age, percentage of male and females with a high school diploma, percent unemployment, percentage of households with no income, percentage of poverty, and percentage of minority population, and natural log of the population. These variables were chosen with two criteria: past literature supports the use of such variables for indicators of infant mortality and each variable could be used for both the time frame and as a comparison between 1940 and 2000.

Descriptive Statistics

Descriptive statistics were completed for each time period to identify the basic features of the data and to provide simple summaries about the data used in this study (see Table 1). The mean or average number of infant deaths for 1940 was 39.6 deaths per 1000 live births. The 2000 mean was 6.8 showing a dramatic overall drop in infant mortality between 1940 and 2000. Standard deviations are an absolute measure showing the dispersion of data about the mean. Large standard deviations indicate a wider dispersion in the data, whereas small standard deviations indicate a small dispersion.

Table 1: Descriptive Statistics

	Average 1940	*Index 1940*	*Average 2000*	*Index 2000*
Mean	39.698	0.815	6.828	0.975
Median	39	0.800	7.05	1.007
Standard Deviation	8.242	0.169	2.176	0.310
Range	71.833	1.475	14.033	2.004
Minimum	11.5	0.236	0	0
Maximum	83.333	1.711	14.033	2.00
Number	231	231	231	231

The 1940 standard deviation of 8.2 is larger than that of 2000 when the figure dropped to 2.1. The range within the data also depicts this wider dispersion in 1940 when the range was 71 in 1940 but dropped to 14 in 2000.

Since the standard deviation is an absolute measurement of variation and the means are very different, an alternative measurement which can be used is the coefficient of variation (CV). The coefficient of variation measures the spread of a set of data as a proportion of its mean; it is a relative measure of dispersion (Becker, 1995). In general the CV is equal to the standard deviation divided by the mean. The CV for 1940 is 4.81 and the CV for 2000 is 3.13. Consequently, by all of these measures, 1940 has a larger variability in the infant mortality or a greater spread in the rates compared to 2000 for the 231 counties in the sample.

The extreme drop in infant mortality causes methodological difficulties in comparing the two time periods. To overcome these problems, the average for each county was divided by the national average for that time period providing an index for comparison. The national average of infant mortality for 1940 was 48.7 deaths per 1000 live births. The use of an index allows for a comparison of each county with what was happening throughout the region and the nation as a whole despite the large differences in absolute values for the two years. By 2000, the national average of infant mortality had dropped to 7.0. The formula used for calculating each index is:

$$Index = AVc / Avn.$$

Where AVc represents the average for each county
AVn represents the national average for each time period.

If the infant mortality of a county is the same as the national average the index will be 1. Descriptive statistics were also performed on the indices. The mean index for 1940 is 0.81 and for 2000 is 0.97. The index exposes an interesting finding; the difference in the indices indicates that average infant mortality for the manufacturing belt in 1940 was substantially lower than the national average. However, in 2000 the infant mortality was almost equal to the national average. This suggests that the standard of living in this region (as measured by infant mortality rates) – despite the overall drop in the infant mortality – actually decreased between 1940 and 2000 when comparing the national average to the regional rate.

For this analysis, the standard deviation of the indices gives a clearer picture of the dispersion of the data (see Table 1). The standard deviation for 2000 is much higher (0.31) than the deviation for 1940 (0.169). The dispersion from the national average in 2000 is wider than the dispersion for 1940. Consequently, when compared to the national average, there is a greater within-region variation in infant mortality in 2000 than in 1940. More counties in 2000 displayed either higher or lower levels than the national average. In 1940, however more counties were generally closer to the national average. The range of the index for each time period also confirms the greater variability. In 1940 the range for the index is 1.47 and the range for 2000 is 2.0.

As displayed in Figures 4 and 5, averages for both time periods were mapped using equal interval categories of Low, Medium and High. In 1940, a large majority of the counties fall into the moderate category.

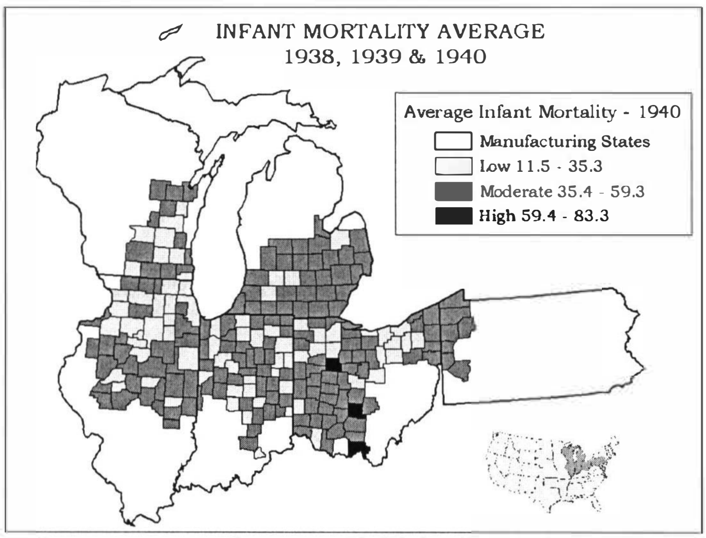

Figure 4: 1940 Average

Only three counties display high infant mortality rates in 1940. There are several clusters of low rates around Cleveland and Bowling Green Ohio, Kalamazoo, Michigan, and Chicago, Illinois. The map for 2000 (see Figure 5) reveals that many more counties fall into the high infant mortality category, with fewer scattered counties with low infant mortality.

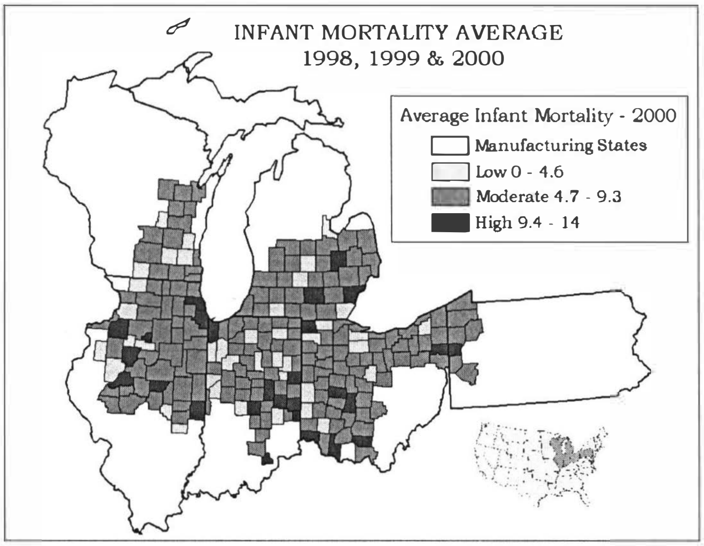

Figure 5: 2000 Average

There are more clusters of counties in 1940 that had a comparatively low infant mortality rate and very few counties with a high rate. In 2000 many more counties can be seen in the "high" category for infant mortality with many fewer counties having a low infant mortality rate.

Statistical Analysis

To gain a greater understanding the variations in the rates for both time periods and the six decade change further analysis was completed. The first step in the analysis is to examine the change in the indices for the two time periods.

First, exploratory spatial data analysis was performed by constructing a scatter plot of the indices for each county for each time period (see Figure 6). The scatter plot displays the indices for 1940 on the horizontal axis and the indices for 2000 on the vertical axis. Counties with a higher than average value for both time frames are considered “high-high”. The remaining relationships are “high-low” for the clusters in the lower right quadrant, “low-high” for the clusters in the upper left quadrant, and “low-low” for the lower left quadrant. The “high-high” and “low-low” quadrants represent a positive temporal autocorrelation, while the other two quadrants represent a negative relationship. This graphic may take some time to understand, but it clearly shows that the most common and scenario is that many locations which once had low infant mortality now have values higher then the national mean in 2000.

Further visual inspection of the scatter plot shows that the majority of the counties in 1940 were low compared to the national average (Low/Low) and either remained low or became relatively high when compared to the national average (Low/High). There are only seven counties that had a high infant mortality rate in 1940 and dropped to low in 2000. There are several counties that displayed a low infant mortality rate in 1940 yet had a high infant mortality rate in 2000 when compared to the national average. Of those with the greatest change, most counties' infant mortality rates increased when compared to the national average.

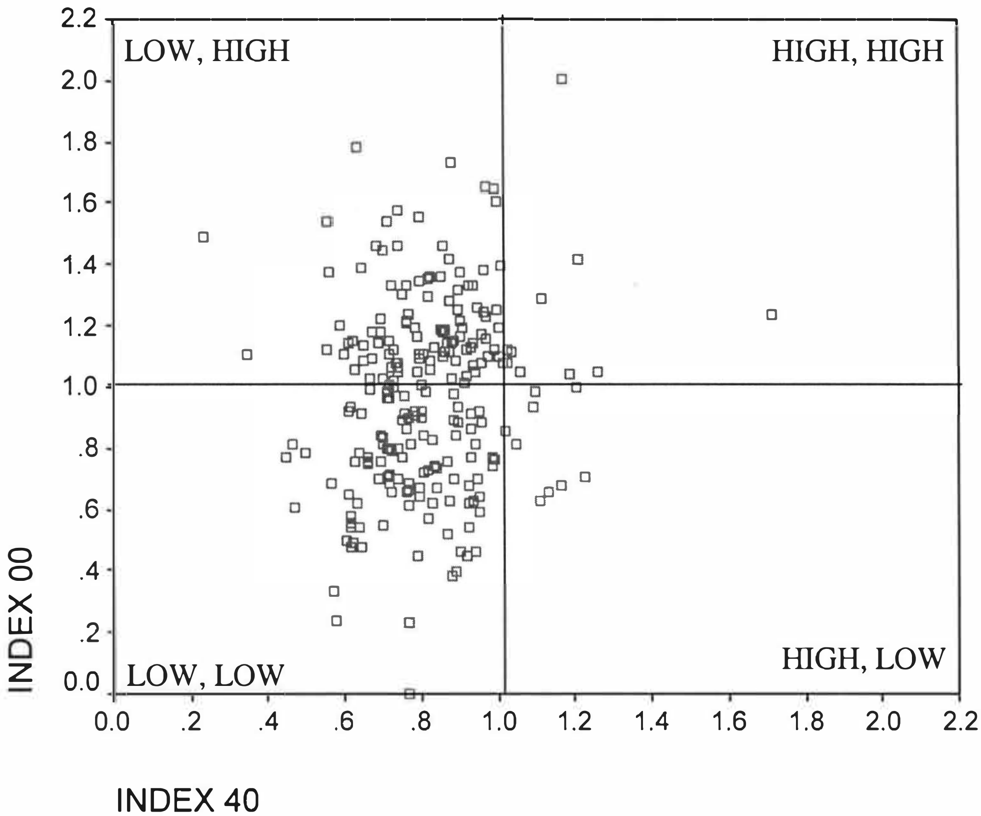

Figure 6: Scatter Plot of Indices

The scatter plot indicates that most of the 230 counties in the region had a lower than national average infant mortality rate in 1940 and that most either experienced stability between 1940 and 2000 or saw an increase in infant mortality in comparison to the national average. Of the counties that were higher than the national average in 1940, very few experienced an improvement with a lower than the national average infant mortality for 2000. Again, there are important implications to this finding which are best illustrated with some examples.

An example of a county that was high in 1940 and remained high in 2000 is Pike County, Ohio (located on the border with Kentucky). Pike County's infant mortality rate in 1940 was 58.8 and it dropped to 9.9. Yet when compared to the national index Pike County's 1940 index was 1.20 (1.2 times the national mean) but in 2000 it was 1.41.

Bay County, Michigan (a county located in the southern peninsula that borders Saginaw Bay) reported a higher than average infant mortality in 1940 and by 2000 dropped substantially relative to the national average. The average infant mortality rate in Bay County in 1940 was 55.0. By 2000, it had dropped to 4.58. The index for Bay County, Michigan in 1940 was 1.13 and in 2000 was 0.654. This could indicate that the living standard in Bay County was lower than the rest of the nation in 1940 but by 2000 the living standard had improved to make it better off than the rest of the country. Another possible reason is that the county was very rural in 1940 and by 2000 it was peri-urban or suburban.

Marshall County, Illinois (located in the rural area west southwest of Chicago) had comparatively low infant mortality rates in 1940 and in 2000, 27.8 and 2.3 respectively. As a consequence, Marshall County had an index of 0.570 for 1940 and 0.324 for 2000. This county represents a county that was better off in 1940 compared to the nation and actually improved even more, visa-versa the other counties, in 2000.

Putnam County is just north of Marshall, Illinois. This county's infant mortality was fairly low in 1940 but then increased significantly in 2000 compared to the national average. Putnam County's average infant mortality rate for 1940 was 11.5 and in 2000 it was 10.4. Its indices were 0.236 and 1.49 for 1940 and 2000 respectively. Based on the indices of infant mortality, Putnam County had a slightly better standard of living compared to the nation in 1940 but by 2000 it had dropped.

Lists of the top 20 highest and lowest indices for infant mortality for each time frame were completed (see appendix 3 and appendix 4). In reviewing appendix 3, it is interesting to note that of the counties with the lowest (better than national average) infant mortality, as measure by my index, Michigan has only one county on the list for 1940 (Barry) and no counties on the 2000 list. Of the remaining counties for 1940, eight were located in Illinois, five in Indiana, and three in both Ohio and Wisconsin. By 2000 the list of the 20 lowest indices showed Illinois dropped to five while Indiana increased to eight and Ohio increased to four. Wisconsin remained the same. This indicates that Michigan counties were either close to the national average or slightly higher in their infant mortality rates. Illinois and Indiana had the greatest amount of change while Ohio and Wisconsin remained fairly stable in the number of counties that were slightly lower than the national average in their infant mortality. Pennsylvania did not have any counties on either list of the lowest indices.

For the counties with the highest indices (higher than the national average) for either time periods again, Pennsylvania had no counties on the list, however neither did Wisconsin (see appendix 4). Ohio had the largest number of counties (12) in 1940 with infant mortality rates higher than the national average. Of the remaining eight counties, four were located in Michigan, and two were located in Ohio and in Indiana. Ohio experienced a dramatic drop in the number of counties on the top 20 list by 2000 (6) where Michigan only dropped down by one having three counties on the list. Indiana and Illinois both experienced an increase in the number of counties that were on the top 20 of the highest infant mortality rates by indices from two counties up to six in Indiana and five in Illinois. Pennsylvania only had seven counties included in this region yet the results of the listings indicate that the counties included were close to the national average during both time frames. Ohio's dramatic drop of counties on the highest indices reflects an improvement over time when compared to the national average. Overall these results indicate the lack of uniformity in infant mortality across space and time.

The next step was to assess whether the change in the indices for the two time periods is statistically significant. My null hypothesis was that the infant mortality indices of 1940 are the same as the infant mortality indices of 2000. My alternate hypothesis was that the indices of 1940 are less than the infant mortality indices of 2000. Due to the large sample size (n = 231) I was able to assume that these data are normally distributed. A histogram was created for each time frame (see Figure 7 and 8). A slight skew can be seen for both time frames but the large data set allows an analysis to be done using a one tailed paired t-test assuming a normal distribution.

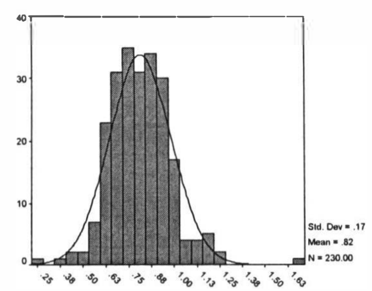

Figure 7: Histogram of 1940 Indices

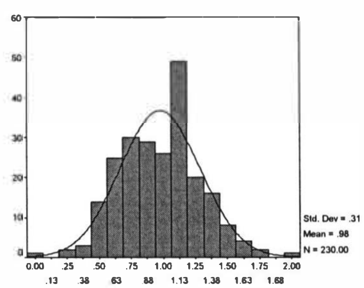

Figure 8: Histogram of 2000 Indices

This analysis was done using the indices for each of the 231 counties for both 1940 and 2000. To test my hypothesis, the t-test was completed using a 0.05 significance level (confidence level of 0.95). The critical value of the t-stat for this analysis was -1.65. The resulting t-value was –7.312, which is less than the t-critical of –1.65. The probability of getting this result by chance was substantially less than one percent. The null hypothesis may be rejected. Therefore, I concluded that the infant mortality index for 1940 was not equal to the infant mortality index for 2000.

After the examination of the indices, the next step was to make an initial evaluation of the change in infant mortality from 1940 to 2000. This was done by calculating the Z-scores for each time period. The general equation for the Z-score is:

$$\text{Z-score} = \frac{(IMRc - \overline{IMR})}{s}$$

Where IMRc is the infant mortality for each county and $\overline{IMR}$ is the mean for the region and s is the standard deviation for the region.

A positive Z-score indicates infant mortality has decreased in relation to the mean (0) and a negative Z-score indicates the opposite.

The equation for the change from 1940 to 2000 is:

$$Z_{change} = Z_{1940} - Z_{2000}$$

Changes in infant mortality are shown on Figure 9 and range from a 4.46 to -5.07, with a standard deviation of 1.31. Scioto, Ohio had the highest positive change indicating that Scioto's infant mortality had the greatest relative improvement in infant mortality between 1940 and 2000. Putnam, Illinios had the greatest decline indicating that Putnam's infant mortality had the least improvement in infant mortality between 1940 and 2000.

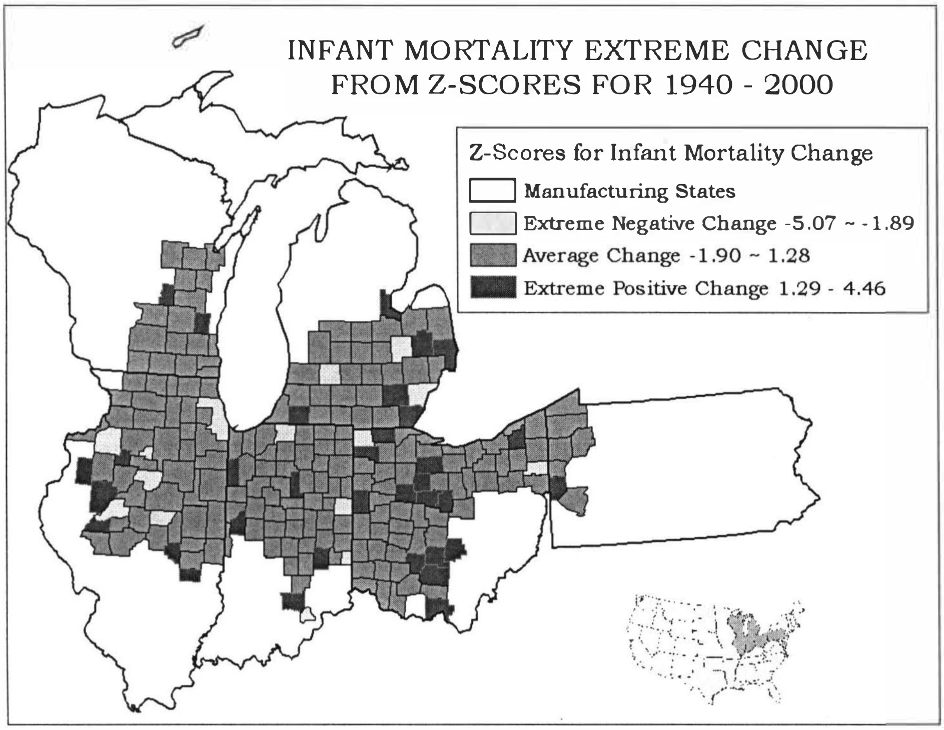

Figure 9: Extreme Change

Figure 9 displays the extreme change in infant mortality using the changes in infant mortality as measured by the Z-scores between 1940 and 2000. Two small clusters of extreme positive change can be seen in Ohio. One centers around Marion County and also includes Hardin, Union, Seneca, Wyandot and Marrow Counties. The other cluster centers around Pickaway County and includes Ross, Fayette and

Fairfield Counties. Three of the most highly urbanized areas within the region experienced extreme negative change - Chicago, Illinois; Detroit, Michigan; and Flint, Michigan.

Regression Analysis

In 1940, the Midwest Industrial Belt included a large concentration of relatively well educated, industrial workers who lived in or very near the cities (de Souza, 1990). The time period captures a generally good standard of living prior to the intense suburbanization, white flight and inner city decay of the late 20th century. Therefore, the counties that were highly urbanized with large populations employed in manufacturing are expected to have a higher standard of living compared to the rural, poor farming communities of the non-manufacturing counties. Even with the wealth of the time, only 56 percent of the deliveries occurred in the hospital and only nine percent of the population had third-party hospital insurance (Dawley, 2003).

To determine the relationship between infant mortality and socio-economic variables at the county level, Ordinary Least Squares (OLS) regression models were calculated for each time period as well as a third model which could measure the relationship between changes in infant mortality and socio-economic for the change between 1940 and 2000.

The dependent variable is the three year average of infant mortality for each county in 1940 and in 2000. The independent variables are the socio-economic variables at the county level from the United States Census. Location quotients give an indication of the concentration of manufacturing industries compared to the region as a whole. For the regression models the LQs were calculated as:

$$LQ = \frac{c_x / t}{R_x / T}$$

Where c_x is the number employed in each economic sector for the county and t is the total employed in the county, R_x is the regional employed in each economic sector and T is the total regional employment.

For all the regression models an F-test is used to analyze the explanatory power of the overall regression model with the dependent variable and the independent variables. The socio-economic variables include issues such as poverty, minority population, education, urbanization and economic specialization. My null hypothesis was that there is not a significant linear relationship between infant mortality and the socio-economic variables. My alternate hypothesis was that there is a significant linear relationship. I used a t-test for the regression model on each individual variable to determine statistical significance. The confidence level for the overall regression model was 0.90, which means that the significance level (α) equaled 0.10. The coefficient of determination (adjusted R squared) is the percentage of the variation in infant mortality explained by the variation of the individual variables as a group. The approximate cutoff for the retention of variables for each final model was $\alpha = 0.10$. This meant that variables with a result above 0.10 were dropped from further analysis. The OLS models were completed in two steps. In the first step the calculation utilized all the variables and the second step saw the models calculated again using only the retained significant variables.

The 1940 Model

My hypothesis was that for 1940 there will be a significant negative relationship with infant mortality and the location quotients in the economic sectors of: mining, construction, manufacturing, food, lumber and paper, machinery, vehicle and vehicle equipment, transportation except vehicle, wholesale trade, other manufacturing, total transportation, communication, total wholesale and retail trade, finance insurance and real estate, total services, total government, manufacturing establishments and manufacturing employment. In addition to the economic sectors, I hypothesized that the percentage of males over 25 with a high school diploma, percentage of females over 25 with a high school diploma, and the percentage urban population will also have a significant negative relationship. The urbanized areas with large manufacturing sectors represent the more affluent population and would be expected to have a lower infant mortality. I expected a significant positive relationship with infant mortality and unemployment, agricultural production, percent farm population, and percentage of the population self reporting as minority. These variables represented non-urban areas or the population in the lower income brackets which I expected to have a higher infant mortality rate.

As the results in Table 2 on page 36, the initial model includes all the independent variables. The final analysis included only the statistically significant variables. As shown in Table 2, the initial analysis explained 16.9 percent of the variation in infant mortality. Based on the associated F-test, the overall model was statistically significantly. The first model showed that there is a statistically significant relationship between infant mortality and the LQ for total manufacturing employment, percent females over 25 with a high school diploma, LQ food production employment, total percentage minority, LQ communication employment, and percentage urban. This model did not find the other variables to be statistically significant and therefore they were not retained for the final model.

The final OLS model (see Table 2) is statistically significant, but now only explains 12.1 percent of the variation in infant mortality for 1940. Although the model explains a limited amount of the variation in infant mortality, all the variables but one take on the expected sign and are individually statistically significant. Based on tolerance, no large degree of correlation is found among the independent variables (smallest tolerance is 0.349). The standardized coefficient exhibits the strength or weakness of the relationship between the variable and infant mortality. If the relationship is positive this indicates that as the variable increases, infant mortality increases; a negative relationship indicates that as the variable increases infant mortality decreases. The unstandardized coefficient displays the amount of change in infant mortality for each unit of change in the independent variable. From the 1940 model, urbanization has the strongest relationship with infant mortality and is positive. For one percentage of increase in the percentage of urbanization, infant mortality increases by 0.149. Manufacturing employment has the second strongest relationship, which is negative, and for each unit of increase in the manufacturing sector infant mortality decreases by 5.81. Food production employment, communication employment and females with a high school diploma have a negative relationship and for each unit of increase, infant mortality decreases by 1.45, 5.42 and 0.718 respectively. In addition, the percent minority has a weak positive relationship. For each unit of increase in the minority population, infant mortality increases by 0.709.

All the variables except the percentage of the county's population that is urban display the expected relationship with infant mortality. It was not expected that as the level of urbanization increases the infant mortality would increase but the increase is a very small amount.

Table 2: Models for 1940

Variable	OLS Model 1 ß		OLS Model 2 ß		Spatial Error Model ß	
Constant	84.324	(82.064)	49.209	(3.241)	47.278	(3.367)
LQ total agriculture	-4.277	(6.669)				
LQ mining	-.380	(.424)				
LQ construction	2.449	(4.482)				
LQ total manufact.	-32.113	(26.348)	-5.815 **	(2.271)	-3.900 *	(2.352)
LQ food production	-1.334 *	(1.012)	-1.454 **	(715)	-1.108 *	(0.681)
LQ lumber production	.212	(.502)				
LQ machinery	2.071*	(1.396)				
LQ vehicle equipment	1.407	(1.123)				
LQ transportation.	-.120	(.369)				
LQ other manufact.	2.097	(2.855)				
LQ total transport	1.074	(6.128)				
LQ communication	-5.733 **	(3.022)	-5.424 **	(2.436)	-2.979	(2.360)
LQT wholesale retail	-10.342	(18.519)				
LQ wholesale trade	2.068E-02	(3.803)				
LQ finance insurance	-1.808	(4.783)				
LQ total services	1.079	(14.627)				
LQ total government	-2.273	(2.638)				
% male 25+ HS grad	5.015	(98.182)				
% female 25+ HS grad	-110.892 *	(76.788)	-71.822 **	(28.106)	-73.56 **	(30.219)
% unemployed	70.122	(86.383)				
LN agric. products	-1.526	(1.643)				
LN population 1940	.657	(2.165)				
PCT farm population	9.460	(17.388)				
PCT urban	9.513E-02*	(.070)	.149 **	(.036)	0.127 **	(0.034)
LN manufact. estab.	-4.065 **	(1.704)				
LN manufact. empl.	4.305 **	(1.229)				
Total minority pop.	55.682 **	(26.086)	70.955 **	(24.685)	52.156 **	(24.144)
λ					0.061**	(0.016)
F-statistic	2.725		6.258			
Adjusted R^2	.169		.121			
Psuedo R^2					0.138	

Note: Dependent Variable in all models is Infant Mortality Rate, 1940. Standard errors are shown in parenthesis. * indicates statistical significance at α =0.10; ** indicates statistical significance at α = 0.05.

In general, the variables of food production, manufacturing, and communication represent the counties with a higher industrial base, which creates a population with a higher income and more education and often better access to health care. The negative relationship between the percent of educated females and the percent of minorities with infant mortality is as expected.

As stated in Chapter One, previous research has indicated that race and education have an important role on the rates of infant mortality. A county with higher concentrations of minority populations would likely have social concerns, such as lower income and education levels, less access to health care and poorer diets, and therefore would possibly have higher infant mortality.

The last test done on the 1940 data was to check for spatial autocorrelation (see Table 2). An OLS regression model assumed that the observations were independent and therefore did not take into account the possibility of interaction between counties. Yet, political boundaries at the county level do not stop people from traveling back and forth and infant mortality rate in one county may be related to the infant mortality rate in adjoining counties.

To determine if spatial autocorrelation was present, exploratory spatial data analysis was initially conducted by mapping the residuals from the final OLS regression model (see Figure 10). Residuals are the expected infant mortality for each county from the regression model subtracted from the actual (or observed) infant mortality for each county. If a county's actual infant mortality is lower than the expected value, the residual will have a negative number. On Figure 10, this is categorized as "overestimated" and represents those counties that have a higher living standard but not the commesuratly lower to infant mortality that the regression model anticipated. Several large clusters of counties can be seen where infant mortality was highly overestimated by the OLS model.

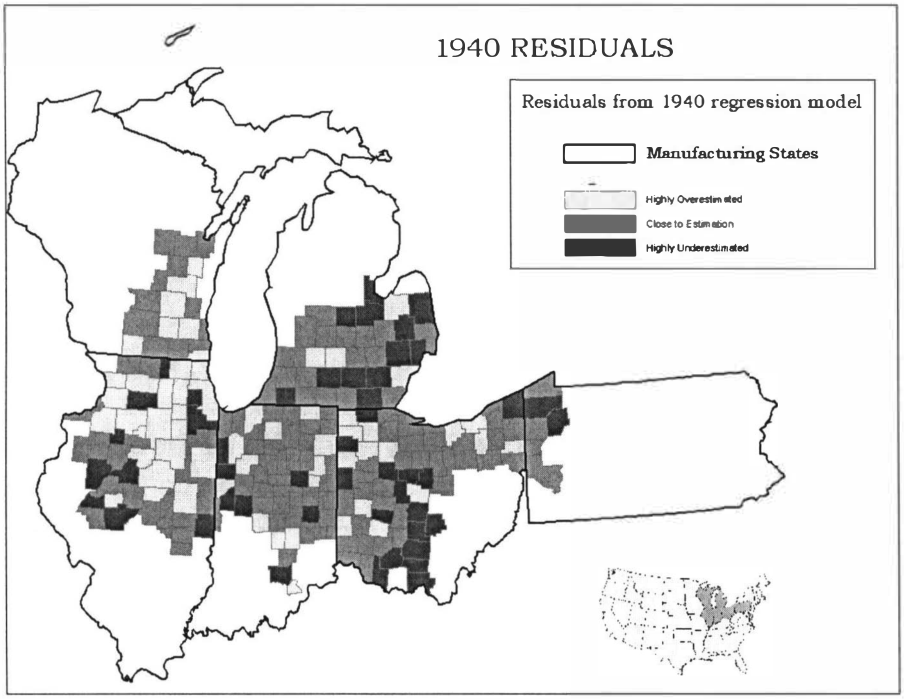

Figure 10: 1940 Residuals

These counties center around the urbanized areas of Chicago, Milwaukee, Detroit, Cleveland, Lansing, Champaign and Gary/South Bend. These urbanized counties have lower infant mortality rates than what the model expected.

Counties where infant mortality was highly underestimated by the OLS model are shown in black on Figure 10. One large cluster is found in southern Ohio representing the rural counties on the edge of the study region bordering counties that are next to West Virginia and Kentucky. There are several smaller clusters in Michigan. These counties had an actual infant mortality rate that was much higher than what the model predicted. In regards to infant deaths, positive residuals indicate that these counties were not as well off in their standard of living.

To assess the possible presence of spatial autocorrelation among the residuals of the infant mortality rates at the county level in the manufacturing belt, a Moran's I test was calculated, and the results were plotted (see Figure 11). Moran's I is an exploratory spatial data analysis test using a weighted coefficient to quantify spatial autocorrelation. Numerically, it runs from a negative 1 to a positive 1. Values close to 0 indicate randomness in the patterns while values towards the extremes reflect a non-random pattern in the data.

Stated another way, values close to 1 indicate strong spatial pattern with negative numbers representing a negative spatial autocorrelation and a positive number representing a positive spatial autocorrelation (clustering).

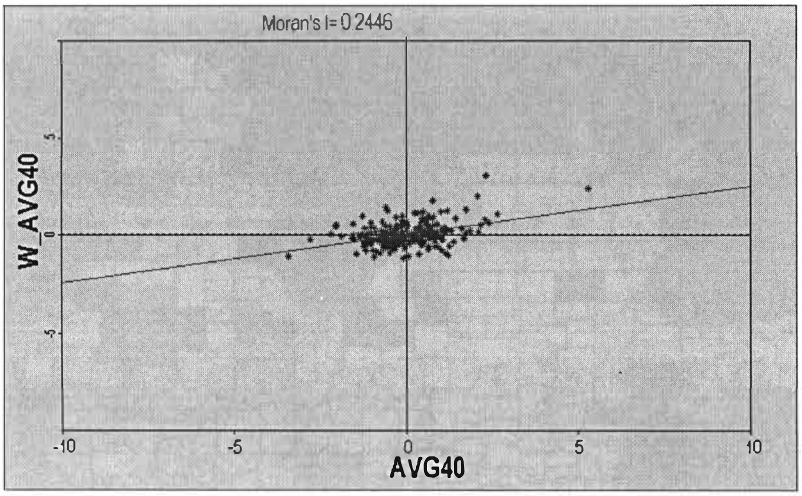

Figure 11: 1940 Moran's I

In real world geographic analysis, positive spatial autocorrelation is quite common yet a negative spatial autocorrelation is very rare (Anselin, 1999). The 1940 weighted average infant mortality rates for each county's neighbor is on the vertical axis and the average rate for each county is on the horizontal axis. Counties with a high-high are found in the upper right quadrant, low-high in the upper left, low-low in the lower left and high-low in the lower right quadrant. The Moran's I for 1940 is 0.244 indicating there is moderately strong positive spatial autocorrelation among the counties.

A LISA (local indicators of spatial autocorrelation) map was also generated to visualize the statistically significant hot spots or clusters of counties using local indicators of spatial autocorrelation (Anselin, 1999)

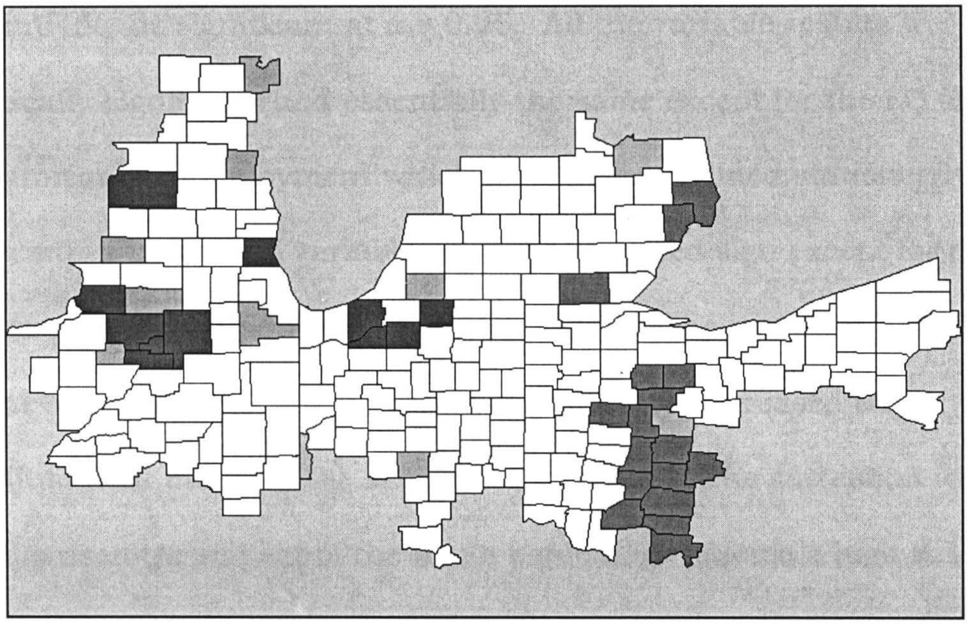

Figure 12: LISA Clusters - 1940

The Moran's I test is a global indicator of spatial autocorrelation. LISA statistics serve to identify smaller local clusters of spatial autocorrelation within sub-portions of the dataset. Two large clusters can be seen (see Figure 12). One "hot spot" in the southern portion of Ohio consists of counties with high rates. A "cold spot" centered in Illinois around Bureau, Illinois is a cluster of low rates.

To correct the OLS model for spatial autocorrelation, a spatial error regression model was performed. The spatial autocorrelation parameter (λ) was used to measure the influence infant mortality in a given county has on adjacent counties. As shown in Table 2, the overall model was strongly statistically significant and explains 13.8 percent of the variation in infant mortality. The spatial autocorrelation parameter was also statistically significant at $\alpha = 0.05$. All the variable results were statistically significant and essentially the same except for the LQ of communications employment which no longer remained statistically significant. Further, all variables had the expected sign except for the percentage of urban population. In addition, all the variables except the percent of females that are high school graduates decreased slightly after the adjustment made by the spatial errors model. The correction for the model caused the impact of the mean percentage of female high school graduate for each county on infant mortality to increase a very small amount.

The 2000 Model

In the last few decades leading up to 2000, the region experienced sluggish growth, high rates of unemployment, and loss of many major industrial plants (Bluestone and Bennett, 1982). The major industries, such as steel and automobile production, moved numerous plants out of the region to the southern states and later out of the country (Clawson and Fisher, 1998). There were towns and cities that experienced near bankruptcy including Detroit, Cleveland and “a host of smaller municipalities throughout the industrial Midwest” (Bluestone and Bennett, 1982). By 2000, urbanized areas of the great Midwestern industrial region no longer represented the wealthy but rather harbored the very poor and unskilled. As a consequence, the region experienced higher infant mortality rates compared to the nation as a whole (Schneider, 1995). Despite the economic slowdown, 70 percent of the nation had private health insurance (PAHO, 2002) and 99 percent of baby deliveries were in hospitals (NCHS, 1999).

For 2000, my hypothesis is that there will be a significant negative relationship with infant mortality and indices of specialization in agriculture and median income of 1999. Both of these variables represent a population that is experiencing greater wealth and are further from the inner city and therefore would have better health care and lower infant mortality rates. I also expect a negative relationship with infant mortality and the percentage of males that are a high school graduate and percentage of females that are a high school graduate. This is expected due to previous research that indicates that as education levels increase infant mortality decreases. I expect a significant positive relationship with infant mortality and percent of non farm population, unemployment, percentage of households with no income, percentage of total poverty population, percentage of minority population, and the indices of industrial concentration: construction employment, manufacturing employment. These variables represent urban population by percentage of nonfarm population or by the presence of manufacturing or populations of lower income which previous research has indicated as having positive relationships with infant mortality. I also expect that an increase in the general population or in the percentage of females at the childbearing age will have a significant positive relationship with infant mortality.

As shown in Table 3, the initial model explains 12.9 percent of the variation between infant mortality and the socio-economic variables introduced above. Based on the F-statistic (3.116), the overall model is statistically significant. The initial model shows that there is a significant relationship between infant mortality and agriculture, percentage of households with no income in each county, the percentage the county population which self reports as minorities and the percentage of females between the ages 15 – 44. Only the variables statistically significant were retained for further analysis.

A final model was run using only the statistically significant variables (see Table 3). This model is also statistically significant and now explains 16.3 percent of the variation. Again, the model explains a limited amount of the variation in infant mortality but all the variables take the expected sign and are statistically significant. Based on tolerance, no large degree of correlation is found among the individual variables (smallest tolerance is 0.521).

Table 3: Models for 2000

Variable	OLS Model 1 ß		OLS Model 2 ß	
Constant	-2.330	(8.020)	-1.094	(2.988)
LN population	.117	(.319)		
PCT non farm population	.912	(1.157)		
PCT female 15 - 44	19.716*	(17.562)	18.946**	(2.988)
PCT male HS grad	-1.661	(11.696)		
PCT female HS grad	1.011	(11.496)		
PCT unemployed	-11.247	(28.175)		
Medium income 19999	-6.918E-06	(.000)		
PCT households no income	17.264**	(9.663)	16.905**	(4.175)
PCT total poverty	4.694	(4.346)		
PCT minority	17.422**	(8.191)	19.266**	(4.966)
LQ agriculture	-.128*	(.089)	-8.530E-02**	(.061)
LQ mining	-3.611E-02	(.043)		
LQ construction	7.420E-02	(.392)		
LQ manufacturing	5.648E-02	(.204)		
LQ trade	-8.182E-02	(.472)		
LQ total other	4.943E-02	(.389)		
F	3.116		12.124	
Adjusted R^2	.129		.163	

Note: Dependent Variable in all models is Infant Mortality Rate, 1940. Standard errors are shown in parenthesis. * indicates statistical significance at α =0.10; ** indicates statistical significance at α = 0.05.

Based on the standardized coefficients, the percent of households with no income has the strongest relationship with infant mortality and is positive. For each unit increase, infant mortality increases by 0.169. The minority population has the second strongest positive relationship. For each unit increase in the minority population, infant mortality increases by 0.192. The percent of females has a weak, positive relationship with infant mortality. For each unit increase, infant mortality increases by 0.189. The LQ of agriculture has a weak negative relationship with an extremely small decrease in infant mortality as it increases by one unit. The variables that represent the socio-economic level for the county, percentage minority and percentage of households with no income, had the expected positive relationship in 2000. The LQ of agriculture represents the counties that are less urbanized, possibly sub-urbanization or urban farms and has the expected negative relationship. A possible explanation for the results associated with these counties is the lack of inner city poverty concerns, which would allow for lower infant mortality rates.

The final test completed on the 2000 data was to check for spatial autocorrelation. The Moran's I statistic was calculated (0.058) and is not statistically significant. Consequently, no additional models were run.

Change Between 1940 and 2000 Model

The Industrial Belt experienced a shift in the living standards of the population between 1940 and 2000. For example, in 1940, the Social Security Act appropriated funds to states for maternity and newborn care on the basis of its rural community due to lack of health services outside the cities. However, by 1963, the Social Security Act was allocating its funds to slum areas of the core cities. (Shapiro et al, 1968) The region also experienced a change in the lifestyle of teen women; the national birth rate for unmarried teenagers was 7 per 1000 in 1940 and increased to 44 per 1000 in 1990. (Ventura, 1999)

Based on these changes, my hypothesis is that there will be a significant negative relationship with the change in infant mortality by county and the change in mining and manufacturing at the same scale.

I expect a significant positive relationship with change in infant mortality and any changes in the percentage of minorities or overall population growth at the county level as well. The presence of manufacturing or mining employment still represents some wealth for the local population and therefore increase in industry would impact the county with a lower infant mortality rate. Counties that experienced an increase in population and an increase in the minority population would, in turn, experience a higher infant mortality rate.

As shown in Table 4, the overall model explains only 4.5 percent of the variation between change in infant mortality and the socio-economic variables. However, again, the overall model is statistically significant (based on F-test). The initial model shows that there is no significant relationship between a change in infant mortality from 1940 to 2000 by county and the change in the LQ of manufacturing. Consequently a second model was run using only the remaining variables (see Table 4). This model explains 4.3 percent of the variation between change in infant mortality and the socio-economic variables and is statistically significant. Again, this model explains a very small amount of the variation, but the signs for each variable are as expected and they are statistically significant.

Of the three variables, two have a weak, positive relationship with infant mortality change in minorities and change in population. As each increases by 1 unit, infant mortality increases by 0.296 and 2.79, respectively. The last variable, change in mining, has a weak, negative relationship. As the change in the LQ of mining increases the change in infant mortality decreases by 0.194. In general, the change in the minority population and the natural log of the population represent the more urbanized counties, which would have the higher infant mortality.

The final test done on change in infant mortality from 1940 to 2000 was to check for spatial autocorrelation (see Table 4). The residuals of the final OLS regression model were mapped (see Figure 13).

Table 4: Models of Change

	OLS Model 1		OLS Model 2		Spatial Error Model	
Variable	ß		ß		ß	
Constant	34.879	(.825)	34.601	(.794)	34.908	(0.945)
Change in LQ mining	-.255**	(.133)	-.194*	(.124)	-0.144	(0.124)
Change in percent minority	25.819*	(16.731)	29.6**	(16.460)	24.330*	(16.085)
Change in LN population	2.870**	(.310)	2.799**	(.993)	3.042**	(1.018)
Change in LQ manufacturing	.381	(17.562)				
λ					0.055**	(0.017)
F	3.699		4.421			
Adjusted R^2	.045		.043			
Psuedo R^2					0.0541	

Note: Dependent Variable in all models is Infant Mortality Rate, 1940. Standard errors are shown in parenthesis.
* indicates statistical significance at α =0.10; ** indicates statistical significance at α = 0.05.

Several large clusters (black) of counties with highly underestimated infant mortality rates can be seen in Michigan around the thumb area, and in southern Ohio and southwestern Illinois. The change in infant mortality in these counties was higher then the expected, which indicates that they are counties that, with respect to infant mortality, have a lower standard of living. Counties of highly overestimated rates (light gray) can also be seen. In regard to infant mortality, these counties have a higher standard of living.

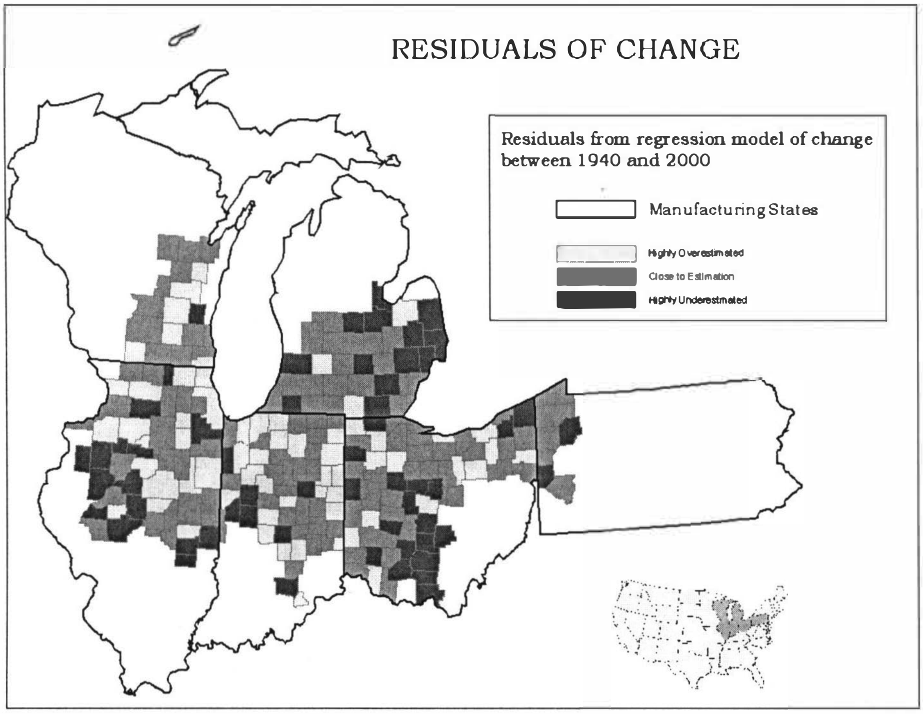

Figure 13: Residuals of Change

In order to assess the possible presence of spatial autocorrelation, a Moran's I test was calculated and plotted (see Figure 14). The Moran's I statistic for the Change model is 0.1801, indicating there is moderate positive spatial autocorrelation among residuals for the counties.

As with the case for 1940, a LISA map was also generated to visualize statistically significant "hot spots" (see Figure 15). Two very similar clusters to the 1940 map can be seen on the change map.

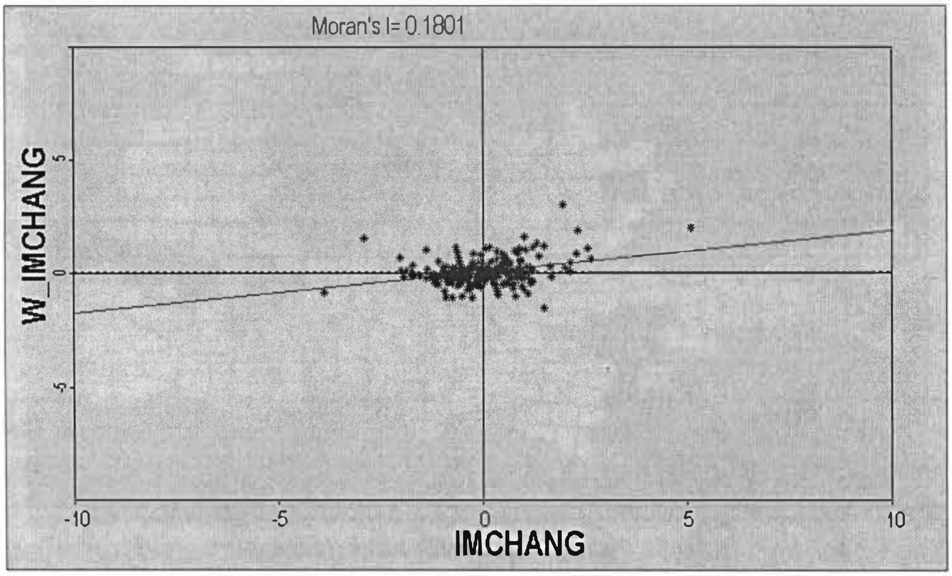

Figure 14: Moran's I of Change

The "hot spot" counties of high rates are found in the southern portion of Ohio, the thumb of Michigan. There was also a "cold spot" of low rates in Illinois.

To correct the OLS model for spatial autocorrelation, a spatial error regression model was generated (see Table 4). The spatial autocorrelation parameter (λ) was used to measure the influence infant mortality in a given county has on adjacent counties. The overall model remains statistically significant and explains 5.41 percent of the variation in infant mortality. The spatial autocorrelation parameter was also statistically significant at α = 0.05. Two variables, change in the percent of minority population and the change in the natural log of the population remained statistically significant. The variable that did not remain statistically significant was the change in LQ in mining.

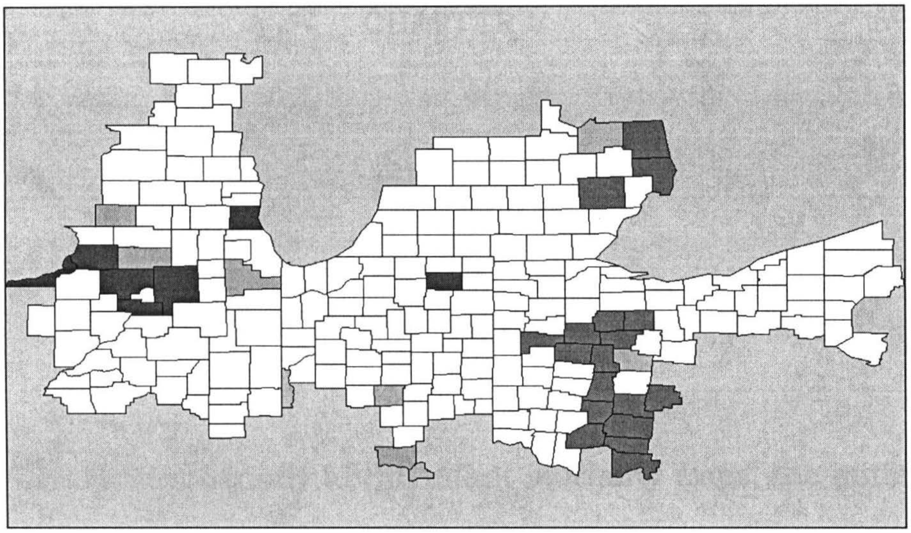

Figure 15: LISA Clusters of Change

All the variables displayed the expected signs. The correction the model made on the variables was very slight. The adjustment resulted in a slight decrease in the variable change in the percent of minority so that its impact on infant mortality decreased ever so slightly. The adjustment on the variable change in LN population resulted in a small increase.

CHAPTER V

RESULTS

Conclusion and Discussion

When looking strictly at the infant mortality rates, the initial focus may be on the extreme drop in infant mortality from 1940 to 2000. The average rate for infant mortality in 1940 was 39.6/1000; 39 babies died for every 1000 live births. By 2000 the average rate dropped to 6.8/1000.

However, the drop in infant mortality does not tell the entire story. Comparing the average infant mortality in the manufacturing belt with the national average shows that despite the very high mortality rates in 1940 the region was actually significantly healthier then other regions of the country for the same time period with an index of 0.81. By 2000, the index was 0.97 or almost the same as the national average. This may indicate that the population compared to the rest of the nation had a higher standard of living in 1940 than in 2000. In addition, the standard deviation of index from the national average in 1940 was 0.16 and in 2000 was 0.31. The greater variability in the rates in 2000 reflects the spatial and temporal inconsistencies discussed in the previous chapters.

The majority of the counties in 1940 reported lower than average infant mortality compared to the national average (see Figure 4). These counties either remained comparatively low or experienced a decline in the health and welfare of the population thus recording an increase in the indices. When compared to the nation, by 2000, the counties within the region had either declined in their standards of living or possibly the country caught up to the region's better quality of life.

In 1940, the region had primarily a white, educated, wealthy, urban-dwelling population. This especially holds true when compared to the rest of the nation. The minority population in the region was 4.6 percent in 1940 and in the nation it was 10.1 percent (Bureau of the Census, 1940). The percent of men and women who had a high school diploma or 4 years of college in the region was 12.2 percent while for the nation this was only 10.5 percent (Bureau of the Census, 1940). Manufacturing and urbanization represented wealth for a county in 1940. The region was more urbanized than the nation (75 percent versus 56 percent) and had more employed in manufacturing (9.3 percent versus 6.0 percent) (Bureau of the Census, 1940). The per capita income for the five major states of the region was $663 per year and for the nation $595 (Bureau of the Census, 1940).

Although the 1940 regression model only explains about 12 percent of the variation in infant mortality, several important socio-economic factors were identified. According to the model, counties that had a higher concentration of minorities experienced higher infant mortality rates. There are also some data issues related to this finding. In 1940, the population was divided into white, black or other by the census and therefore the variable "percent minority" represented the black and "other" community. A possible explanation for this positive relationship could be that this sector of the population often represents people who have less access to education thereby their income to be lower. This was a time the country was still highly segregated and this could have impacted their education and job opportunities and their access to health care.

Counties with a greater specialization in manufacturing, food production or communication employment experienced lower infant mortality rates. These are the counties that had a population that was wealthier and more educated which would have a negative relationship with infant mortality. Counties with a larger percentage of females with a high school diploma also reported lower infant mortality rates. In 1940 a high school diploma had a greater value than in 2000. Many studies show that education is one of the most important factors impacting infant mortality.

What was unexpected in the study was the relationship between urbanization measured as percentage of the population and infant mortality. According to this model, in 1940 as urbanization increased, so did infant mortality. Several explanations could account for this. While most counties that experienced specialization in manufacturing had a population that was better off (as reflected in infant mortality rates), the heavily urbanized areas may display or experience factors that counteract the wealth via the manufacturing. These counties could also have experienced greater amounts of poverty due to immigration and possibly the remaining effects of the Great Depression. In 2000, the region remained a predominantly white, educated, urban-dwelling population. The region had a 20.9 percentage minority population compared to 24.9 percent in the nation (Bureau of the Census, 2000). Both were very urbanized with the region at 83.6 percent and the nation at 79 percent of the population (Bureau of the Census, 2000). The region remained slightly more educated than the nation as measured by the proportion of the population which completed high school and four years of college (30.1 percent versus 28.6 percent), yet no longer does the region have more employed in manufacturing with both at 9.6 percent (Bureau of the Census, 2000). The region no longer is wealthier than the nation as whole; the per capita income for the region was $29,437, while the nation was $29,760 (Bureau of the Census, 2000).

By 2000, urbanization no longer represents wealth for a county due several factors including inner city decay. Further, a high school diploma no longer represents an acceptable education as a college degree has become the standard. Although the 2000 regression model explains only 16.3 percent of the variation in infant mortality, as with the previous model, several important socio-economic factors remain significant. According to the model, counties with large populations of women of child-bearing age, households with no income and minorities experienced higher infant mortality rates. These counties could be experiencing the impact of inner city decay, white flight and deindustrialization. The several variables related to agriculture in the model reflected a negative relationship with infant mortality; counties with more agriculture had lower infant mortality. The presence of agriculture could represent suburban or peri-urban counties. The population living in these suburban areas could possibly represent the wealthier communities that can move out from the city.

The region and nation experienced several changes over the 60 year period covered in this study. Both the nation and the region increased in minority population, yet the region experienced a greater increase (from 4.6 percent to 20.9 percent) (Bureau of the Census, 1949; 2000). Both the nation and the region experienced an increase in urbanization, yet the nation had the largest increase (from 56 percent to 79 percent) (Bureau of the Census, 1949; 2000). The region's per capita income dropped when compared to the nation; in 1940 it was 111 percent of the national average and by 2000 it had dropped to 99 percent (Bureau of the Census, 1949; 2000).

The results of the model examining change between 1940 and 2000 were disappointing. The model only explains 5.3 percent of the variation in infant mortality. One limiting factor for this research was finding compatible variables from the 1940; 2000 data. Therefore calculating the change was a challenge. Despite this disappointment, there were some variables that help to explain the changes in the counties between these two time periods. The change in the percent minority and the change in the natural log of population remained significant in all three models. Counties that reported increases in their population and also experienced an increase in the percent of minorities had a higher infant mortality rate. The only negative relationship is with the LQ of mining which did not remain statistically significant after the correction for spatial autocorrelation for the change model.

Two of the counties discussed in the previous section are discussed here for further clarity. Bay County, Michigan had a high infant mortality index for 1940. We may assume the living standard was low when compared to the nation in regards to infant mortality. Yet in 2000 the county had a higher standard of living than the nation. Bay County maintained a very low percentage of minority population from 1940 to 2000 (0.3 percent versus 5.2 percent) compared to the region

(4.6 percent versus 21 percent) (Bureau of the Census, 1949; 2000). Although Bay County had a very low percentage of minorities in 1940, beyond race, there were many other factors that could explain the high index. In 1940, only 7.6 percent of Bay County's population had a high school diploma and/or 4 years of college, considerably lower to the regions average of 12 percent (Bureau of the Census, 1949; 2000). It was less urbanized than the region (64 percent versus 75 percent), which usually represented higher living standards for 1940 (Bureau of the Census, 1949; 2000). Only 7.9 percent of the population was employed in manufacturing compared to the 9.3 percent for the region (Bureau of the Census, 1949; 2000). In 2000, several factors could explain the significant drop in infant mortality compared to the nation. The percent of minority population remained very low in 2000 (5.2 percent versus 21 percent) for the region (Bureau of the Census, 1949; 2000). The county's educated population increased from 7.6 percent to 31.4 percent, higher than the region of the mean in 2000 (30 percent) (Bureau of the Census, 1949; 2000). Although the county is highly urbanized, it is less urbanized than the region as a whole (70.8 percent versus 84 percent) and has fewer persons employed in manufacturing (8.6 percent versus 9.6 percent) (Bureau of the Census, 1949; 2000). Bay County is a good example for the study. In actuality the significant factors identified by the models in this study and how they impact infant mortality and reflect the quality of life for the population hold true.

For the case studies, another example of change is Putnam County, Illinois. Putnam County had a low infant mortality index for 1940 (0.236). That is, the counties living standards were better when compared to the nation in regards to infant mortality. Yet in 2000, the county's strong standard of living was below that of the entire nation (1.49). Putnam had an increase in its minority population from 1940 to 2000 (0.2 percent to 2.37 percent) (Bureau of the Census, 1949; 2000). Yet for both time periods were well below the regional average (4.6 percent in 1940, 21 percent in 2000) (Bureau of the Census, 1949; 2000). The educated adult population (high school and 4 years of college) was well below the region's average in 1940 (7.2 percent) and only slightly above the region (31 percent) in 2000 (Bureau of the Census, 1949; 2000). Putnam was completely rural (0 percent urban) in both 1940 and 2000 (Bureau of the Census, 1949; 2000). It also had no manufacturing employment recorded for 1940, yet reflecting a national trend had a large percentage of the population employed in industry in 2000 (10.5 percent) (Bureau of the Census, 1949; 2000). The county's population increased only slightly from 5289 in 1940 to 6286 in 2000 (Bureau of the Census, 1949; 2000). Putnam is an example of a county that experienced stagnation over the past six decades with a resulting impact on infant mortality rates.

Overall, infant mortality has dropped considerably in the past 60 years. However, a closer examination shows that despite the impressive decline, it can be argued that the region as a whole and many individual counties are not experiencing the higher of standard of living relative to the nation as in 1940. Consistent with previous research, this study's examination of the infant mortality rates in the Midwest Industrial Belt demonstrated the importance of several aspects of public health and demographic impacts. The concentration of minority population and urbanization and the level of education and poverty within the county have an important role in understanding infant mortality and the quality of life for the population. The Midwest Industrial Belt, much like the nation, lacks uniformity across the counties and clusters can be found of both high and low infant mortality rates.

Possible Future Research

Several factors not included in this study have in previous research shown to be important factors for infant mortality. Factors include the age of mother and the lifestyle of the mother (Meckel, 1990). The United States is expected to experience an increase in foreign – born populations and in minority populations in the next century (Hummer et al, 1999). This research and past research (see Chapter One) has shown the importance of race and its impact on infant mortality. Any future research should include race in its methodology. As noted by past research (Brosco, 1999; Bird, 1995) other important variables include child health care and available health insurance. This study, based on county level data and faced with the constraints associated with the 1940 data, was not able to incorporate these important factors to the models.

Both LISA cluster maps (see Map 11 and Map 15) from 1940 and the change between 1940 and 2000 depicted two large clusters and one small cluster. One cluster of high infant mortality rates can be seen in the southern portion of Ohio and another smaller cluster is in the thumb area of Michigan. A large cluster of low infant mortality rates can be seen in Illinois. Research done within these cluster areas based on the factors discussed in the previous chapters may provide more insight related to the variations in infant mortality rates in the Midwest Industrial Belt. Future research that includes each decade from 1940 to 2000 may provide a clearer picture as these values and conditions change overtime.

APPENDIX ONE

VARIABLES FOR REGION BUILDING

Economic Sectors for Building a Region
Source: Regional Employment by Industry, 1940 – 1970 U.S. Department of Commerce
Total employment
Agriculture and Ag Services
Forestry & Fisheries
Mining
Contract Construction
Food & kindred products
Textile mill products
Apparel & other textile products
Lumber, wood products and furniture
Printing, publishing and allied inds
Chemicals and allied products
Machinery - except electrical
Machinery - Electrical mchy, equip & supplies
Motor Vehicles and motor vehicle equip
Transport. Equip. except motor vehicle
Paper and allied products
Petroleum refining & related industry
Primary metals industry
Fabricated manufacturing
Railroad & Railway Express
Trucking and Warehouse
Transportation - other
Communications
Electric, Gas, Water & Sanitary Services
Wholesale Trade
Food & Dairy Products stores
Eating and Drinking Places
Other Retail Trade
Finance, Insurance and Real Estate
Lodging, Places and other pers. serv.
Business and repair services
Entertainment and recreation services
Private households
Professional services
Public Administration
Federal Military

APPENDIX TWO

COUNTIES WITHIN THE REGION

COUNTY	STATE
Boone	Illinois
Bureau	Illinois
Carroll	Illinois
Cass	Illinois
Champaign	Illinois
Coles	Illinois
Cook	Illinois
Cumberland	Illinois
De Kalb	Illinois
De Witt	Illinois
Douglas	Illinois
Du Page	Illinois
Edgar	Illinois
Ford	Illinois
Fulton	Illinois
Grundy	Illinois
Henry	Illinois
Iroquois	Illinois
Kane	Illinois
Kankakee	Illinois
Kendall	Illinois
Knox	Illinois
La Salle	Illinois
Lake	Illinois
Lee	Illinois
Livingston	Illinois
Logan	Illinois
Macon	Illinois
Marshall	Illinois
Mason	Illinois
McHenry	Illinois
McLean	Illinois
Menard	Illinois
Morgan	Illinois
Moultrie	Illinois
Ogle	Illinois
Peoria	Illinois
Piatt	Illinois
Putnam	Illinois
Rock Island	Illinois
Sangamon	Illinois
Stark	Illinois
Stephenson	Illinois

Vermilion	Illinois
Warren	Illinois
Whiteside	Illinois
Will	Illinois
Winnebago	Illinois
Woodford	Illinois
Adams	Indiana
Allen	Indiana
Bartholomew	Indiana
Benton	Indiana
Blackford	Indiana
Boone	Indiana
Carroll	Indiana
Cass	Indiana
Clinton	Indiana
De Kalb	Indiana
Delaware	Indiana
Elkhart	Indiana
Fayette	Indiana
Fountain	Indiana
Fulton	Indiana
Grant	Indiana
Hamilton	Indiana
Hancock	Indiana
Hendricks	Indiana
Henry	Indiana
Howard	Indiana
Huntington	Indiana
Jackson	Indiana
Jasper	Indiana
Jay	Indiana
Johnson	Indiana
Kosciusko	Indiana
La Porte	Indiana
Lagrange	Indiana
Lake	Indiana
Madison	Indiana
Marion	Indiana
Marshall	Indiana
Miami	Indiana
Montgomery	Indiana
Newton	Indiana
Noble	Indiana

APPENDIX 2 CONTINUED

Tazewell	Illinois
Pulaski	Indiana
Randolph	Indiana
Rush	Indiana
Scott	Indiana
Shelby	Indiana
St. Joseph	Indiana
Starke	Indiana
Steuben	Indiana
Tippecanoe	Indiana
Tipton	Indiana
Union	Indiana
Vermillion	Indiana
Wabash	Indiana
Warren	Indiana
Wayne	Indiana
Wells	Indiana
White	Indiana
Whitley	Indiana
Allegan	Michigan
Barry	Michigan
Bay	Michigan
Berrien	Michigan
Branch	Michigan
Calhoun	Michigan
Cass	Michigan
Clinton	Michigan
Eaton	Michigan
Genesee	Michigan
Gratiot	Michigan
Hillsdale	Michigan
Ingham	Michigan
Ionia	Michigan
Jackson	Michigan
Kalamazoo	Michigan
Kent	Michigan
Lapeer	Michigan
Lenawee	Michigan
Livingston	Michigan
Macomb	Michigan
Monroe	Michigan
Montcalm	Michigan
Oakland	Michigan
Saginaw	Michigan

Porter	Indiana
Shiawassee	Michigan
St. Clair	Michigan
St. Joseph	Michigan
Tuscola	Michigan
Van Buren	Michigan
Washtenaw	Michigan
Wayne	Michigan
Allen	Ohio
Ashland	Ohio
Ashtabula	Ohio
Auglaize	Ohio
Brown	Ohio
Butler	Ohio
Champaign	Ohio
Clark	Ohio
Clermont	Ohio
Clinton	Ohio
Columbiana	Ohio
Crawford	Ohio
Cuyahoga	Ohio
Darke	Ohio
Defiance	Ohio
Delaware	Ohio
Erie	Ohio
Fairfield	Ohio
Fayette	Ohio
Franklin	Ohio
Fulton	Ohio
Geauga	Ohio
Greene	Ohio
Hamilton	Ohio
Hancock	Ohio
Hardin	Ohio
Henry	Ohio
Highland	Ohio
Huron	Ohio
Knox	Ohio
Lake	Ohio
Logan	Ohio
Lorain	Ohio
Lucas	Ohio
Madison	Ohio
Mahoning	Ohio

APPENDIX 2: CONTINUED

Sanilac	Michigan
Medina	Ohio
Mercer	Ohio
Miami	Ohio
Montgomery	Ohio
Morrow	Ohio
Ottawa	Ohio
Paulding	Ohio
Pickaway	Ohio
Pike	Ohio
Portage	Ohio
Preble	Ohio
Putnam	Ohio
Richland	Ohio
Ross	Ohio
Sandusky	Ohio
Scioto	Ohio
Seneca	Ohio
Shelby	Ohio
Stark	Ohio
Summit	Ohio
Trumbull	Ohio
Union	Ohio
Van Wert	Ohio
Warren	Ohio
Wayne	Ohio
Williams	Ohio
Wood	Ohio
Wyandot	Ohio
Allegheny	Pennsylvania
Beaver	Pennsylvania
Crawford	Pennsylvania
Erie	Pennsylvania
Lawrence	Pennsylvania
Mercer	Pennsylvania
Venango	Pennsylvania

Marion	Ohio
Brown	Wisconsin
Calumet	Wisconsin
Columbia	Wisconsin
Dane	Wisconsin
Dodge	Wisconsin
Fond Du Lac	Wisconsin
Green	Wisconsin
Green Lake	Wisconsin
Jefferson	Wisconsin
Kenosha	Wisconsin
Milwaukee	Wisconsin
Outagamie	Wisconsin
Racine	Wisconsin
Rock	Wisconsin
Walworth	Wisconsin
Washington	Wisconsin
Waukesha	Wisconsin
Waupaca	Wisconsin
Winnebago	Wisconsin

APPENDIX THREE

LOWEST 20 COUNTIES OF INDICES FOR EACH PERIOD

STATE	COUNTY	Index 40
IL	GRUNDY	0.56263
IL	HENRY	0.55715
IL	KENDALL	0.60849
IL	MARSHALL	0.57084
IL	MASON	0.55373
IL	OGLE	0.49897
IL	PUTNAM	0.23614
IL	WOODFORD	0.55305
IN	BLACKFORD	0.57837
IN	HENDRICKS	0.47296
IN	JOHNSON	0.46543
IN	STJOSEPH	0.34497
IN	WELLS	0.61328
MI	BARRY	0.58864
OH	CLERMONT	0.60917
OH	DELAWARE	0.60164
OH	PREBLE	0.61328
WI	CALUMET	0.44901
WI	GREEN	0.60301
WI	WAUKESHA	0.61191

STATE	COUNTY	Index 00
IL	CUMBERLAND	0.38095
IL	MARSHALL	0.32857
IL	MOULTRIE	0.23333
IL	WARREN	0.44762
IL	WHITESIDE	0.54762
IN	BLACKFORD	0.23810
IN	JASPER	0.48571
IN	MARSHALL	0.55714
IN	NEWTON	0.45714
IN	RUSH	0.39524
IN	WARREN	0.47619
IN	WELLS	0.53810
IN	WHITE	0.53810
OH	DEFIANCE	0.44286
OH	MORROW	0.46190
OH	PREBLE	0.47619
OH	SENECA	0.51905
WI	GREEN	0.49841
WI	GREENLAKE	0.00000
WI	WASHINGTON	0.54139

APPENDIX FOUR

HIGHEST 20 COUNTIES OF INDICES FOR EACH PERIOD

STATE	COUNTY	Index 40
IL	EDGAR	1.17248
IL	LEE	1.02327
IN	FOUNTAIN	1.10815
IN	JACKSON	1.04791
MI	BAY	1.13073
MI	LAPEER	1.18412
MI	STCLAIR	1.02122
MI	WASHTENAW	1.09103
OH	ASHTABULA	1.01164
OH	CLARK	1.03628
OH	HARDIN	1.22587
OH	HIGHLAND	1.11294
OH	MARION	1.20534
OH	MERCER	1.09925
OH	PAULDING	1.02669
OH	PICKAWAY	1.26215
OH	PIKE	1.20739
OH	ROSS	1.16632
OH	SCIOTO	1.71116
OH	UNION	1.05749

STATE	COUNTY	Index 00
IL	COOK	1.39048
IL	DEWITT	1.44286
IL	EDGAR	2.00476
IL	MASON	1.53810
IL	PUTNAM	1.49048
IN	HENRY	1.60476
IN	JAY	1.46190
IN	MADISON	1.41429
IN	MARION	1.39524
IN	SCOTT	1.53810
IN	UNION	1.78095
MI	GENESEE	1.73218
MI	JACKSON	1.64507
MI	WAYNE	1.55057
OH	BROWN	1.65714
OH	CHAMPAIGN	1.38095
OH	HAMILTON	1.45714
OH	MAHONING	1.57143
OH	PIKE	1.41429
OH	WILLIAMS	1.45714

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