Geographic Variations in Infant Mortality

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THE HEALTH PLANNING AND RESOURCES DEVELOPMENT Act of 1974 (Public Law 93–641) provided for the establishment of more than 200 health systems agencies across the United States. One of the responsibilities of these agencies is to assemble data on the health status of residents of their areas. Although there has been a great deal of experimental work on health status indexes, the lack of uniform data across the United States has been a major impediment to the implementation of such indexes. The health status data available are still largely limited to the rather traditional measures provided by vital statistics.

It is well known that mortality data have become of limited value in recent years because of the rise in chronic illness. Selected mortality data, however, may still be a useful component of the health profile of a small area. Infant mortality in particular can serve as a useful indicator of the health of mothers and infants in an area. Our purpose is to describe geographic variations in infant mortality rates (and related measures) for a relatively recent period, 1969–73, and to determine the changes in these geographic patterns since an earlier period, 1961–65. We intend to provide a reasonably complete description of such variation so that those responsible for interpreting infant mortality in specific areas will have a useful frame of reference.

Health status is not a unidimensional concept. Even for infant mortality, at least four useful indicators are available: neonatal, postneonatal, and fetal mortality rates and low birthweight ratios. The first three indicators are direct measures of mortality at different points during gestation and infancy. The fourth, the low birthweight ratio, is a "risk factor" that is associated with high mortality. The infant and perinatal mortality rates are each composites of two of the preceding rates. These six indicators are defined in the next section.

In our analysis, we use race-specific rates instead of total rates. Since the total rate for an area is a weighted average of its race-specific rates, this total rate depends upon both the race-specific rates and the population's composition. The wide differences in race-specific rates and in the composition of populations of areas across the United States make total rates more confusing than helpful. Ideally, race would be broken into at least three categories (white, black, and other), but unfortunately the data allowed only a white-other dichotomy. Although the vast majority of the "other" category consists of blacks, in some areas, especially in the West, Indians or other groups contribute substantially to the "other" population.

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Methodological Issues

Definition of rates. We used the following definitions for the six rates under study.

- Infant mortality rate: deaths under 1 year per 1,000 live births.
- Neonatal mortality rate: deaths under 28 days per 1,000 live births.
- Postneonatal mortality rate: deaths between 28 days and 11 months per 1,000 live births. (Note that neonatal rate + postneonatal rate = infant mortality rate.)
- Low birthweight ratio: infants weighing 2,500 grams or less per 1,000 live births.
- Fetal death rate: deaths of fetuses of 20 weeks or more gestation per 1,000 live births plus fetal deaths.
- Perinatal mortality rate: deaths of fetuses of 20 weeks or more gestation plus neonatal deaths per 1,000 live births plus fetal deaths. (Note that perinatal rate = neonatal rate + fetal rate − (neonatal rate × fetal rate) ÷ 1,000.)

We recognized that a perinatal mortality rate that is defined as including deaths of fetuses of 28 weeks or more gestation and deaths of infants under 7 days is the preferred one, but data to compute that rate were not available.

Stability of rates. An area may be conceptualized as having some underlying "true" infant mortality rate (depending upon various characteristics of its population and environment). In a given year the number of infant deaths is a random variable with a certain probability distribution, which depends upon the "true" infant mortality rate for an area. If the number of births in the area is small, different mortality rates may be observed for different years. Thus, the estimated infant mortality rate for the area will be unstable and may not represent the area's true rate.

To obtain reasonably stable estimates of an area's true mortality rate, it becomes necessary to aggregate the area's experience over time. Instead of using the experience for a single year, the data for a longer period are combined (in our study, data for 5 years). This type of aggregation will obscure differences over time within the period. Thus, if an area has had a sharp drop in mortality (relative to other areas) in the preceding year, this fact will be lost; the area will be characterized by its average mortality during the period.

Even after data have been aggregated over several years, some areas will still have too few births and deaths to provide a stable rate. A criterion is needed to determine which areas have "reasonably" stable rates. By the criterion most often used, any rate based on fewer than 20 deaths is excluded. Throughout our report, the results for distributions of rates are based on areas with 20 or more deaths.

The geographic units upon which an analysis can be based are limited by the availability of data and the stability of rates. Ideally one would like to analyze small homogeneous areas with roughly the same numbers of births (and population). Unfortunately the data available are collected uniformly across the United States on a county (and town within county) basis. County populations vary from more than 7 million in Los Angeles to 64 in Yellowstone National Park; more than one-fourth of U.S. counties have fewer than 10,000 persons. In addition, the heterogeneity of populations within counties varies enormously.

Moreover, the smaller counties, although probably more homogeneous, present difficulties in terms of the stability of their rates. For example, during the years 1969–73, only 2,050 (65 percent) of the 3,141 counties in the United States had 20 or more infant deaths. Thus, greater geographic aggregation is needed for analysis. With data based on the 1950 U.S. Census, the Census Bureau and the Bureau of Agricultural Economics have delineated relatively homogeneous combinations of counties, called State economic areas—SEAs (*1*). Because of the larger population base of these areas, more stable rates can be computed for them than for counties. In fact, each of the 510 SEAs delineated had more than 20 infant deaths in the study period (although the minimum of 20 cannot be met in all instances when race-specific rates are examined).

The State economic areas were also classified as metropolitan or nonmetropolitan. The metropolitan SEAs included counties that were parts of standard metropolitan statistical areas (SMSAs) that in 1960 had a central city population of 50,000 or more and a total population of 100,000 or more. Any SMSA that crossed State lines was divided into metropolitan SEAs within each of the States concerned. The remaining SEAs were nonmetropolitan. Thus, many nonmetropolitan SEAs had an urban character. The SEA designations did not take into account changes made in the SMSA definitions since 1960 except for Brown County, Wis., which was added as a metropolitan SEA in 1970.

Components of variation. The variation in rates across geographic areas has two components. One is the variation in "true" mortality rates (the geographic component of variance). The other is the variation in the stability of rates, which we shall call binomial variation. By subtracting the binomial variance from the total variance, one can obtain an estimate of the geographic component of variance. This estimate will also be subject to binomial variation, but that variation is not great enough to affect the conclusions presented here. (For a description of the method used to subtract binomial variance from total variance, write Kleinman at tearsheet address.)

When describing variations across SEAs, a single measure like the variance (or its square root, the standard deviation) is most meanginful when the distribution of rates is approximately normal. We found that the logarithm of the observed rates followed a normal

Infant Mortality Rates for Small Areas

"Infant Mortality" by Joel C. Kleinman is the second in a series of Statistical Notes for Health Planners issued by the National Center for Health Statistics.

In the 12-page publication, Kleinman discusses the definition of terms, the value of cause-specific and race-specific rates, the sources and limitations of infant mortality data, and the relevance of the rates in planning and evaluation. How to assess the stability of the rates and the changes in them is explained in an appendix.

Effective health planning requires the use of reliable data and sound statistical methodology. The Statistical Notes for Health Planners series is designed to help health systems agencies by providing the methodology for using existing data available from Federal programs in an easily accessible and easily updated format.

Unfortunately, the amount of national information available on a small area basis is severely limited at present. The purpose of this series is not only to provide the methodology but also to encourage health planning agencies to assemble and analyze data using identical methods or recommended alternative approaches for comparable results.

Copies of "Infant Mortality" (No. 2) and "Introduction" (No. 1) in the Statistical Notes for Health Planners series can be obtained from the Scientific and Technical Information Branch, NCHS, 8-20 Parklawn Bldg., 5600 Fishers Lane, Rockville, Md. 20852.

Table 1. State economic areas with 1969–73 infant mortality rates significantly higher than U.S. average

Decile [1]	Metropolitan SEAs: Number	Metropolitan SEAs: Percent with rates significantly higher [2]	Nonmetropolitan SEAs: Number	Nonmetropolitan SEAs: Percent with rates significantly higher [2]
	Rates for whites			
9	22	81.8	32	93.8
8	23	47.8	29	86.2
7	17	11.8	30	56.7
6	24	0	34	52.9
5	18	0	30	10.0
	Rates for others			
9	16	81.3	16	75.0
8	17	29.4	16	68.8
7	16	25.0	15	73.3
6	18	16.7	14	35.7
5	15	0	16	18.8

[1] Deciles based on distribution of observed infant mortality per 1,000 live births for each State economic area (SEA) within each color and metropolitan-nonmetropolitan status category. Numbers of SEAs in each decile vary slightly because of ties.

[2] Than corresponding U.S. rate for same period—17.2 deaths per 1,000 live births for whites and 29.3 deaths per 1,000 live births for others.

distribution more closely than the rates themselves. Logarithms have two additional properties that make them useful: (*a*) the standard deviation of the distribution of logs(rates) is approximately equal to the coefficient of variation for the distribution of the rates, that is, SD(log) = SD(rates) ÷ mean (rates); (*b*) when comparing two sets of rates, the relative risk (ratio of one rate to another) is often used. In the log scale the relative risk is just the difference in logs.

Another significant issue related to binomial variation is whether a particular area's rate is higher than a standard (or perhaps than another area's rate). To determine this, we employed a significance test, using the method in Snedecor and Cochran (*2*). This method is particularly useful in designating "high risk" areas. Table 1 shows, for each decile in the geographic distribution of infant mortality rates, the proportion of SEAs with rates significantly higher than the U.S. average. Even among the areas in the highest decile (higher than 90 percent of all SEAs in their group), as many as 25 percent had rates not significantly higher than the U.S. average. As expected, the proportion with significantly high rates generally decreases as one moves down the frequency distribution.

Denominators for 1961–65 rates. The data used in this report were obtained from printouts of rates for 1961–65 and 1969–73 and numbers of live births and fetal deaths for 1969–73 provided by Margaret Pratt, senior research associate, Information Sciences Research Institute, who originally obtained them from the National Center for Health Statistics. Since the actual numbers of live births and fetal deaths for 1951–65 were not available on the printout, we estimated them as follows:

For each State, the numbers of live births and fetal deaths during 1961–65 for white and other infants were collected from published data (*3*). The ratio of the number of births in each SEA for 1969–73 to the number of births in its State was computed for each color group. These ratios were then applied to the 1961–65 State data to obtain estimates of the numbers of live births and fetal deaths for each color group in each SEA during 1961–65. We checked our estimates by comparing them with the actual rates for the United States. The results are shown in table 2. The smallness

Table 2. Specified U.S. rates, estimated and actual, for whites and others, 1961–65

Rate [1]	Rates for whites: Estimated	Rates for whites: Actual [2]	Rates for others: Estimated	Rates for others: Actual [2]
Infant mortality	22.0	22.0	40.9	41.0
Neonatal mortality	16.6	16.6	26.1	26.1
Postneonatal mortality	5.5	5.4	14.8	14.9
Low birth weight	7.1	7.1	13.5	13.5
Fetal death	13.8	13.8	26.1	26.3
Perinatal mortality	30.1	30.1	51.6	51.7

[1] Per 1,000 live births except that rates for fetal death and perinatal mortality are per 1,000 live births and fetal deaths.

[2] Source of actual rates except ratios for low birthweight is reference 3. Sources of actual low birthweight ratios are annual editions of Vital Statistics of the United States, Volume 1—Natality, for 1961–65.

Table 3. Specified rates for whites and others in metropolitan and nonmetropolitan State economic areas, 1961–65 and 1969–73

Rate [1]	Metropolitan SEAs: 1961–65	Metropolitan SEAs: 1969–73	Nonmetropolitan SEAs: 1961–65	Nonmetropolitan SEAs: 1969–73
For whites				
Infant mortality	21.3	16.5	23.1	18.1
Neonatal mortality	16.3	12.6	16.9	13.8
Postneonatal mortality	5.0	3.8	6.2	4.4
Low birth weight	7.3	6.7	7.0	6.6
Fetal death	13.8	11.5	13.7	11.8
Perinatal mortality	29.9	24.0	30.4	25.4
For others				
Infant mortality	38.0	28.2	46.4	31.8
Neonatal mortality	26.5	20.3	25.1	19.8
Postneonatal mortality	11.5	7.9	21.3	12.0
Low birth weight	14.2	13.3	12.0	12.2
Fetal death	25.9	20.1	26.6	21.5
Perinatal mortality	51.8	40.0	51.1	40.9

[1] Per 1,000 live births except that rates for fetal death and perinatal mortality are per 1,000 live births and fetal deaths.

Table 4. Geographic component of variance in specified 1961–65 and 1969–73 rates for whites and others

Rate	Metropolitan State economic areas				Nonmetropolitan State economic areas			
	1961–65		1969–73		1961–65		1969–73	
	Number	Standard deviation [1]	Number	Standard deviation [1]	Number	Standard deviation [1]	Number	Standard deviation [1]
For whites								
Infant mortality	207	.0884	207	.1041	301	.1089	302	.1168
Neonatal mortality	206	.0871	207	.1201	299	.0856	302	.1186
Postneonatal mortality	199	.1593	194	.1293	285	.2198	283	.1682
Low birth weight	207	.1047	207	.0917	303	.1381	303	.1243
Fetal death	207	.1994	207	.1745	303	.1518	302	.1485
Perinatal mortality	207	.1282	207	.1209	303	.1023	303	.1105
For others								
Infant mortality	165	.1704	164	.1662	185	.2040	154	.1966
Neonatal mortality	155	.1586	154	.2037	150	.1915	124	.2109
Postneonatal mortality	131	.3070	125	.1941	125	.2781	104	.2441
Low birth weight	197	.1822	199	.1455	243	.2347	247	.2201
Fetal death	151	.2328	149	.2134	148	.2325	138	.2023
Perinatal mortality	178	.1678	170	.1872	192	.1847	174	.2300

[1] In logarithmic scale.

of the discrepancies indicates that there are no substantial errors in the estimates.

The numbers in the numerator were estimated by multiplying the rates by their denominators. Thus, the number of SEAs with 1961–65 rates based on fewer than 20 in the numerator is also an estimate.

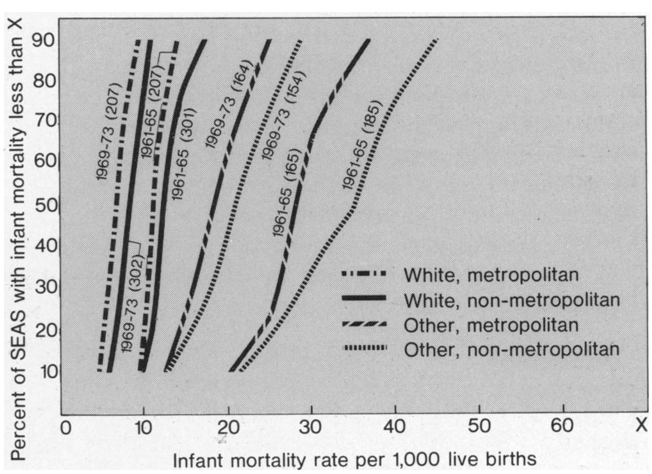
Analysis of Data

Distributions of rates for metropolitan and nonmetropolitan SEAs. Table 3 shows the average values of the rates for metropolitan and nonmetropolitan SEAs by color and period. Rates for other infants were from 50 to 150 percent higher than those for whites. The differential was greater in nonmetropolitan SEAs, but it generally diminished between 1961–65 and 1969–73. In most cases, nonmetropolitan rates were higher than metropolitan, especially for postneonatal mortality, for which nonmetropolitan rates were from 16 to 85 percent greater than the metropolitan rates. Low birthweight ratios were an exception, especially for infants other than white; for the nonmetropolitan SEAs, these ratios were 8 percent lower in the period 1969–73 and 15 percent lower in the period 1961–65.

Table 4 shows the estimated standard deviation in the logarithmic scale for each distribution of true rates. The standard deviation of the distribution of rates for other infants was always higher than that for white infants, in most cases from 50 to 100 percent higher. The standard deviations in the distributions of infant and postneonatal mortality rates and of low birthweight ratios were generally higher for nonmetropolitan SEAs than for metropolitan, although the opposite held for neonatal, fetal, and perinatal mortality rates. Comparison of the two periods also shows different patterns. Postneonatal and fetal mortality rates and low birthweight ratios exhibited greater variation in the period 1961–65, but neonatal mortality rates exhibited greater variation in the period 1969–73. The net effect on infant mortality was one of no consistent change in variation over the two periods.

Differences by period, color, and area proved even more striking when the entire frequency distributions were examined. Figure 1 shows the cumulative frequency distributions of infant mortality rates by SEA. The largest differences among the distributions were with respect to race. For both periods, the highest rates for whites were either at the same level as, or below,

Figure 1. Cumulative frequency distributions of infant mortality rates for State economic areas, by color and metropolitan status, United States, 1961–65 and 1969–73



NOTE: Numbers in parentheses indicate State economic areas upon which distribution is based (areas with 20 or more infant deaths in specified category).

Table 5. "Excess" infant mortality 1969–73 for metropolitan and nonmetropolitan State economic areas, based on two standard rates, by color

Infant mortality status [1]	White rates by standard 1 [2]	Other rates by— Standard 1 [2]	Standard 2 [3]
Total metropolitan SEAs [4] ...	207	164	164
Above standard:			
Number	80	161	70
Percent	38.6	98.2	42.7
Excess deaths:			
Number	2,541	23,854	2,551
Percent of total deaths .	1.8	29.1	4.2
Total nonmetropolitan SEAs [4]	302	156	156
Above standard:			
Number	192	149	98
Percent	63.6	95.5	62.8
Excess deaths:			
Number	7,690	13,109	3,592
Percent of total deaths .	7.7	45.4	12.5

[1] Infant mortality per 1,000 live births. State economic areas with fewer than 20 infant deaths excluded from calculation of "excess" deaths but included in total number of infant deaths.
[2] U.S. white infant mortality 1969–73 (17.2 deaths per 1,000 live births).
[3] U.S. nonwhite infant mortality 1969–73 (29.3 deaths per 1,000 live births).
[4] With 20 or more infant deaths.

the lowest rates for nonwhites. Even the 8-year interval between the periods was not sufficient to allow the nonwhite rates to catch up with the white rates: the 90th percentile for white rates in 1961–65 (that is, the rates that were exceeded by only 10 percent of the SEAs in the period 1961–65) was well below the median rates for nonwhites in the period 1969–73.

The notion of "excess" deaths is sometimes used to call attention to those areas where high infant mortality rates combine with high numbers of births (*4*). The method entails choosing a standard "acceptable" death rate and applying it to the number of births in each area. The actual number of deaths in an area is then compared with this hypothetical number, and the excess is computed. The results depend, of course, upon the standard chosen. Table 5 presents results based on two standards. The first standard is the U.S. infant mortality rate for white births during 1969–73, which was 17.2. A second standard was chosen for nonwhite births—the U.S. nonwhite infant mortality rate for 1969–73, namely, 29.3.

By the first standard, the metropolitan SEAs had many more excess deaths in the nonwhite category but fewer excess deaths in the white category. By the second criterion, used for nonwhite births, the nonmetropolitan SEAs had greater numbers of excess deaths. One reason for the difference was that 70 percent of the nonwhite births were in metropolitan SEAs. Thus, when white infant mortality was used as a standard, virtually all SEAs had nonwhite infant mortality rates in excess of the standard and, although the nonwhite infant mortality rate was greater in nonmetropolitan SEAs (31.8 versus 28.2), the greater number of births produced more excess deaths. When a race-specific standard was used, the nonmetropolitan disadvantage in the nonwhite infant mortality rate was sufficient to produce more excess infant deaths than in the metropolitan SEAs.

Along the same lines, it is of interest that although nonmetropolitan SEAs accounted for only 39 percent of the white births, their disadvantage in infant mortality rates (18.1 compared with 16.6 for metropolitan SEAs) was sufficient to produce three times as many excess deaths as the metropolitan SEAs.

Figures 2 and 3 show the location of the 75 SEAs with the highest infant mortality rates for white and nonwhite births. The maps are dominated by nonmetropolitan SEAs, wich accounted for 81 percent of the SEAs with high white infant mortality and 69 percent of the SEAs with high nonwhite mortality. The geographic patterns are somewhat different for each race (see next paragraph). White infant mortality was highest in the Mountain States and the South Central States, while high nonwhite mortality was concentrated in the South Atlantic States and the South Central States. It should be noted, however, that many SEAs were excluded from the nonwhite mortality maps because of the instability of their rates. Of course, these areas had very small nonwhite populations.

Relationships among the rates. One measure of the association among different rates is the Pearson product-moment correlation coefficient. Note that binomial variation has the effect of diminishing the correlation that may exist between an area's true rates. In this section, we discuss only the observed correlation coefficients.

Since the infant mortality rate is the sum of neonatal and postneonatal mortality rates, it correlates closely with the neonatal mortality rate. (For 1969–73, approximately 75 percent of the U.S. infant deaths occurred in the neonatal period except that nonwhite neonatal mortality in nonmetropolitan SEAs accounted for only 62 percent of the infant mortality in those SEAs.) Similarly, since the perinatal mortality rate is a function of the neonatal and fetal mortality rates, high correlations occurred among those rates (more than 0.75 in all four cases in table 6). The moderately low correlation between infant mortality rates and postneonatal mortality rates (on the order of 0.5) suggests that if infant mortality is used by itself as a problem indicator, one may overlook areas with significant postneonatal mortality. Of the 40 metropolitan SEAs with the highest white postneonatal mortality (the top 20 percent), only 18 (45 percent) were also in the top 20 percent of the corresponding distribution of white infant mortality rates.

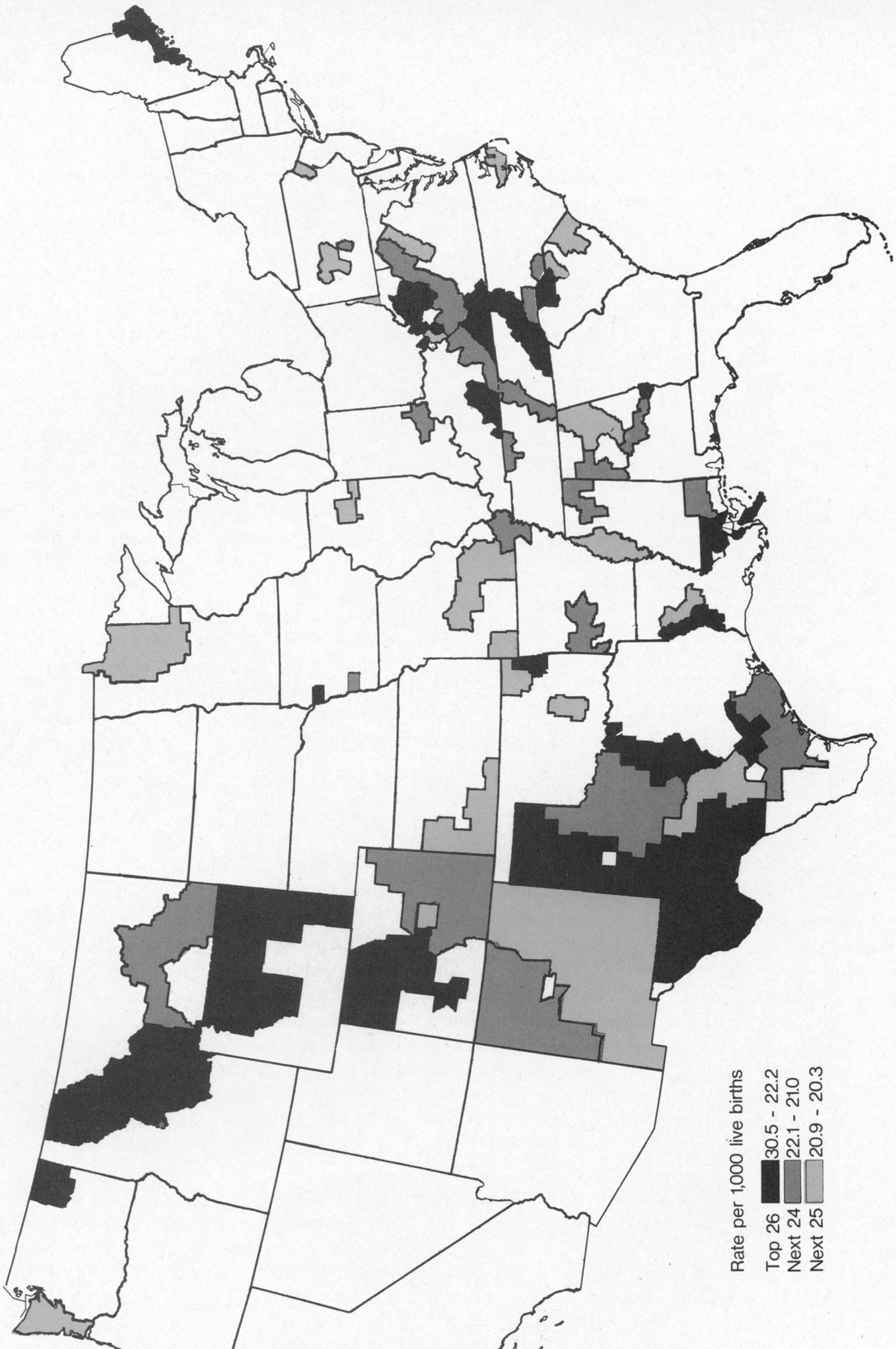


Figure 2. High mortality rates for white infants based on the 509 State economic areas with 20 or more infant deaths, United States, 1969-73

Figure 3. High mortality rates for infants other than white, based on the 318 State economic areas with 20 or more infant deaths, United States, 1969-73

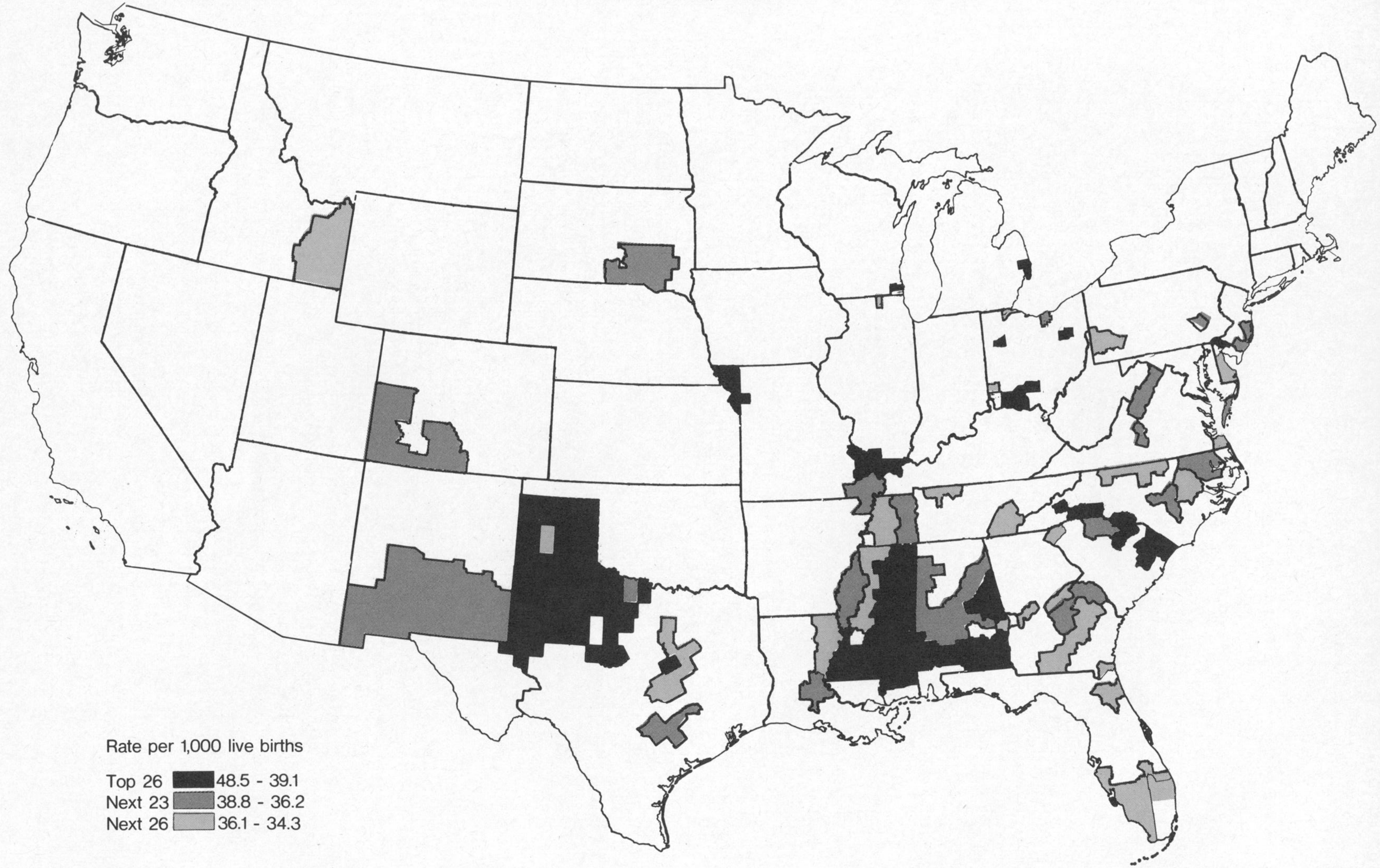


Table 6. Correlations among specified 1969–73 rates for State economic areas by color and metropolitan-nonmetropolitan status

Rate [1]	*Neonatal mortality*		*Postneonatal mortality*		*Low birth weight*		*Fetal death*		*Perinatal mortality*	
	Rates for whites in metropolitan SEAs									
Infant mortality	.937	*207*	.480	*194*	.406	*207*	.246	*207*	.694	*207*
Neonatal mortality			.144	*194*	.414	*207*	.292	*207*	.762	*207*
Postneonatal mortality					.161	*193*	—.073	*194*	.033	*194*
Low birthweight							.298	*207*	.435	*207*
Fetal death									.843	*207*
	Rates for others in metropolitan SEAs									
Infant mortality	.918	*154*	.541	*125*	.521	*164*	.370	*149*	.779	*164*
Neonatal mortality			.237	*124*	.535	*154*	.393	*148*	.822	*154*
Postneonatal mortality					.112	*125*	.142	*124*	.159	*125*
Low birthweight							.309	*149*	.484	*170*
Fetal death									.570	*173*
	Rates for whites in nonmetropolitan SEAs									
Infant mortality	.910	*302*	.630	*283*	.548	*302*	.254	*301*	.720	*302*
Neonatal mortality			.294	*283*	.485	*302*	.285	*307*	.793	*302*
Postneonatal mortality					.398	*283*	.163	*283*	.286	*283*
Low birthweight							.257	*302*	.458	*303*
Fetal death									.802	*302*
	Rates for others in nonmetropolitan SEAs									
Infant mortality	.813	*124*	.556	*104*	.441	*154*	.588	*132*	.790	*152*
Neonatal mortality			.040	*100*	.585	*124*	.584	*119*	.850	*124*
Postneonatal mortality					—.088	*104*	.237	*103*	.023	*104*
Low birthweight							.399	*138*	.570	*173*
Fetal death									.859	*138*

[1] Per 1,000 live births except that rates for fetal death and perinatal mortality are per 1,000 live births and fetal deaths.

NOTE: Italicized whole numbers to right of each correlation coefficient indicate number of State economic areas upon which correlation is based. Rates with fewer than 20 cases in numerator are omitted.

Among the remaining four rates, the only consistently high correlation coefficients were those between the neonatality mortality rate and the low birthweight ratio (between 0.41 and 0.58). In this case the coefficients for the white rates were lower than for the other rates, and the coefficients for the metropolitan SEAs were lower than those for the nonmetropolitan SEAs. The correlations between the low birthweight ratios and the fetal mortality rates were also somewhat high (0.26 to 0.40), but no clear relationship was evident.

Table 7 shows the correlations between the white and nonwhite rates. Metropolitan SEAs had higher correlations than did nonmetropolitan SEAs except for postneonatal mortality. None of the correlation coefficients were large, ranging only from 0.12 to 0.50, with most between 0.2 and 0.4. In terms of extreme rates, one can determine how many SEAs with high nonwhite infant mortality rates also had high white infant mortality rates. Using only SEAs with 20 or more nonwhite infant deaths, we found that of the 32 metropolitan SEAs in the highest quintile for nonwhite infant mor-

Table 7. Correlations of specified 1969-73 rates between color groups in metropolitan and nonmetropolitan State economic groups

Rate [1]	*Metropolitan SEAs*		*Nonmetropolitan SEAs*	
	Correlation coefficient	*Number of SEAs*	*Correlation coefficient*	*Number of SEAs*
Infant mortality	.337	*164*	.135	*154*
Neonatal mortality	.343	*154*	.235	*124*
Postneonatal mortality	.123	*125*	.323	104
Low birthweight	.309	*199*	.248	*247*
Fetal death	.601	*149*	.380	*138*
Perinatal mortality	.501	*170*	.278	*174*

[1] Per 1,000 live births except that rates for fetal death and perinatal mortality are per 1,000 live births and fetal deaths.

Table 8. Quintile rank of infant mortality rates for State economic areas, 1961–65 by 1969–73

Quintile rank 1961–65	Quintile rank 1969–73					
	Lowest 20 percent		Middle 60 percent		Highest 20 percent	
	Number	Percent	Number	Percent	Number	Percent
	Rates for whites in metropolitan SEAs					
Lowest 20 percent	17	41.5	21	51.2	3	7.3
Middle 60 percent	20	16.1	84	67.7	20	16.1
Highest 20 percent	2	4.8	18	42.9	22	52.4
	Rates for others in metropolitan SEAs					
Lowest 20 percent	18	56.3	11	34.4	3	9.4
Middle 60 percent	14	4.9	65	69.7	15	16.0
Highest 20 percent	2	6.1	18	54.5	13	39.4
	Rates for whites in nonmetropolitan SEAs					
Lowest 20 percent	25	41.7	32	53.3	3	5.0
Middle 60 percent	34	19.1	125	70.2	19	10.7
Highest 20 percent	2	3.3	28	45.2	32	51.6
	Rates for others in nonmetropolitan SEAs					
Lowest 20 percent	18	62.1	11	37.9	0	...
Middle 60 percent	14	15.4	61	67.0	16	17.6
Highest 20 percent	1	3.4	17	56.6	11	37.6

NOTE: Rates are per 1,000 live births.

tality, only 13 were also in the top quintile for white infant mortality. Whether this differential was a result of different relative socioeconomic characteristics of the white and nonwhite populations within an SEA or of differences in accessibility to health services (or other reasons) is a subject for future research.

Trends over time—1969–73 versus 1961–65. We have discussed the overall differences in infant mortality between the periods 1961–65 and 1969–73. Let us now consider how the overall decrease in infant mortality was distributed within SEAs by comparing areas in the extremes of the distributions for the two periods.

In table 8 the frequency distributions of the infant mortality rates for the two periods are compared. In all cases there was very little cross-over, that is, the SEAs that had high rates in the period 1961–65 also tended to have high rates in the period 1969–73. Omitting SEAs with fewer than 20 infant deaths in either period, we find that only 3 to 6 percent of the SEAs with infant mortality rates in the top quintile in the early period moved to the lowest quintile in the later period. Similarly, only 0 to 9 percent of the SEAs that were low in the period 1961–65 moved to the highest quintile in the period 1969–73. The decrease in infant mortality rates for the SEAs that moved from the highest quintiles in the period 1961–65 to the lowest in the period 1969–73 were all statistically significant ($P<0.01$). SEAs that moved in the opposite direction (from lowest in the years 1961–65 to highest in the years 1969–73) showed no significant change in absolute terms, although all but three showed a statistically significant ($P<0.01$) increase in their relative, infant mortality rate (that is, the race-specific infant mortality for that SEA divided by the race-specific infant mortality for all SEAs with the same metropolitan status).

The consistency of the distributions over the years is significant for two reasons. First, it gives us some additional assurance that random variation was not so great that it provided misleading characterizations of the SEAs. Second, it suggests that the sizable reduction in U.S. infant mortality over the 8 years was distributed rather evenly over the entire country. We verified this assumption by computing the proportional decrease in infant mortality rates for SEAs in each quintile of the 1961–65 distribution. Table 9 shows that although there was a tendency for SEAs in the higher quintiles in 1961–65 to have somewhat larger decreases than those in the lower quintiles, the 1969–73 rates followed their 1961–65 ranking rather closely.

Conclusions

A number of the results of our analysis deserve further comment. Although the U.S. infant mortality rate has always been lower for white infants than for others, the gap has been narrowing in recent years. Figure 1, however, illustrates dramatically the difference that still

Table 9. Changes in infant mortality rates for State economic areas between 1961–65 and 1969–73, by quintile rank of these rates for 1961–65

Quintile rank 1961–65	Number of SEAs	1961–65	1969–73	Percent decrease
	Rates for whites in metropolitan SEAs			
1	41	19.4	15.4	20.6
2	40	20.6	16.3	20.9
3	42	21.5	16.3	24.2
4	42	22.5	17.5	22.2
5	42	24.6	17.9	27.2
	Rates for others in metropolitan SEAs			
1	32	28.6	22.1	22.7
2	32	36.6	28.4	22.4
3	32	38.4	29.9	22.1
4	30	41.1	29.7	27.7
5	33	47.9	31.0	35.3
	Rates for whites in nonmetropolitan SEAs			
1	60	19.9	16.5	17.1
2	60	21.5	17.5	18.6
3	61	22.7	18.1	20.3
4	57	24.1	18.6	22.8
5	62	28.0	20.4	27.1
	Rates for others in nonmetropolitan SEAs			
1	29	30.6	25.1	18.0
2	27	39.6	28.6	27.8
3	32	44.8	33.3	25.6
4	32	49.1	33.7	31.3
5	29	55.7	35.4	36.5

NOTE: Rates are per 1,000 live births.

exists between whites and others. The highest white infant mortality rates are still below the lowest nonwhite rates. In addition, the general decrease in infant mortality has not resulted in a homogenization of areal rates. Geographic variation in the period 1969–73 was as great as in the period 1961–65 (table 4). This observation is of special concern to those who had expected that increased access to medical care as a result of such programs as the Maternal and Infant Care projects would even out such variations. Of course, this result is not an adequate assessment of the health effects of such programs; possibly the geographic variation would have increased without the additional Federal health efforts. The decrease in the variations in the postneonatal and fetal mortality rates and the increase in the variations in the neonatal mortality rates also require more careful explanation, and further research is now in progress.

Similar results were found for the differences in rates between metropolitan and nonmetropolitan areas. Although the greater variability among nonmetropolitan SEAs may have been due to their greater heteogeneity, the variation among these SEAs was the same for each period considered.

The instability of rates is especially significant to those who use these indicators in planning and evaluation. In the past, except for the work of Chiang (*5*) and Reyfitz (*6*), the random component of vital rates was not emphasized, since this component is trivial when one is dealing with large populations. However, now that vital statistics are being increasingly used as health status indicators for small areas, random error can no longer be ignored. Even with the large amount of aggregation over both time and space that was used for our study (that is, combining data for 5 years and combining counties into SEAs), the rates for a substantial portion of the areas appeared high, but they were not significantly different from the mean (table 1). To assess random variation, those using vital statistics for small areas must work with statistical tools (such as significance tests, confidence intervals, or related techniques).

Finally, the need to examine data by specific categories must be emphasized. Areas with high rates for whites do not necessarily have high rates for nonwhites (table 7), and areas ranked high by one indicator will not necessarily be ranked high by another (table 6). Such considerations unfortunately complicate the jobs of the planner and evaluator. For example, the infant mortality rate will not be a sensitive indicator of the effectiveness of programs aimed at reducing postneonatal mortality, since variation in this rate accounts for less than half of the variation in the total infant mortality rates. The data in this report point up the need to plan programs for specific high-risk groups and to use relevant indicators in evaluating the results.

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