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THE SOCIAL BASES OF NEONATAL AND POSTNEONATAL MORTALITY: AN ECOLOGICAL ANALYSIS OF ALBERTA, CANADA

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Résumé — La tendance descendante persistante en mortalité au Canada au vingtième siècle n'a pas été égalée par un déclin semblable en mortalité infantile. Tout en se référant aux divisions de recensement en Alberta, cette étude examine la mesure dans laquelle la mortalité ñeonatale et post-néonatale ont des rapports aux facteurs de milieu. Bien que les preuves soient mixtes, on trouve quelque appui pour soutenir l'hypothèse que la mortalité néonatale aussi bien que post-néonatale est une fonction des facteurs de milieu social.

Abstract — Canada's steady downward trend in mortality in the twentieth century has not been matched by a similar decline in infant mortality. This paper examines, by reference to census divisions in Alberta, the degree to which neonatal and postneonatal mortality are related to environmental factors. Although evidence is mixed, some support is found for the hypothesis that neonatal, as well as postneonatal mortality, is a function of social environmental factors.

Key Words — **infant mortality, neonatal mortality, exogeneous factors**

Introduction

Canada, in spite of very low levels of general mortality by world standards, continues to experience a not commensurately low rate of infant mortality. Although infant mortality rates have improved substantially over the twentieth century in comparison to some other developed countries, Canada's rates still remain relatively high. Of twenty-seven developed countries in 1975 Canada ranked only eleventh, tied with Australia (United Nations, 1977: 332-335). This compares to the United States which ranked sixteenth, tied with Belgium. In contrast to Sweden's rate of 8.6, Canada's infant mortality at 14.3 is fairly high.

Analysis of the components of infant mortality over time reveal clearly that such improvements as have been made in infant mortality over the past fifty years are attributable to control of exogeneous deaths. Over the thirty-eight year period from 1936 to 1974, deaths due to exogeneous causes or post-neonatal deaths (Statistics Canada, 1977:67) have declined precipitously. The conclusion drawn from component analyses is that infant deaths due to environmental causes are more amenable to amelioration than those due to endogenous causes.

To a large extent, research in infant mortality has conflated neonatal mortality with deaths due to endogenous causes. Infants' age at death has become a methodological short-hand for separating out causes of death. That there is some basis for this operational definition is clear. Deaths occurring within the first month of life tend to be more often associated with congenital anomalies and the circumstances of gestation and delivery than deaths occurring after the first month but within the first year of life.

It might be, however, that the conflation of neonatal mortality with endogenous causes of death obscures the degree to which the circumstances of gestation and birth as well as congenital anomalies have some relation to environmental factors. This paper addresses the question of whether neonatal mortality can be said to be a function of external environment factors. To the degree that support may be found for this hypothesis, the neatness of the accepted operational definitions of neonatal deaths as endogenous mortality and postneonatal as exogenous mortality would be called into question. As well, if support is found for the hypothesis that neonatal

mortality is to some degree a product of external factors as well as less controllable genetic and physiological factors then neonatal mortality might be seen as a more legitimate target of amelioration attempts in future.

Background

Long-standing recognition of the link between socio-economic circumstances and infant mortality, despite its declining popularity as a social indicator, has led to a considerable body of research directed toward unearthing the social correlates of infant mortality. A wide range of variables have been found to account for differentials. Characteristics of the mother such as age, parity, marital status and previous fetal loss have been found to be clearly related to infant mortality. The infant's sex and birth weight are also known to be important in infant death, with male infants weighing less than 2,500 grams having particularly high risk (Ontario Perinatal Mortality Committee, 1967). An extensive and intensive analysis of the social correlates of infant mortality throughout the world found that prematurity risks (associated with low birth weights and the leading contributor to neonatal mortality) are elevated when illegitimacy is combined with low parity and mothers under the age of twenty years (Puffer and Serrano, 1973).

Other known social correlates of infant mortality include more wide-ranging variables such as race and ethnicity, socio- economic status and type of area lived in. A basic common denominator of most infant mortality research is that race underlies differentials. The ratio between the infant mortality rates of non-whites and whites in the U.S. has been, until very recently, almost two to one (Bouvier and van der Tak, 1976:19). This longstanding differential led Newman (1971) to conclude that race, in the U.S., is the best single predictor of infant mortality. In every report of infant mortality rates in Canada which shows data by race, it is found that native Indians and Eskimos have higher rates of infant mortality than non-natives. This consistent finding has led some analysts to the conclusion that the relatively high infant mortality rate in Canada is in fact due to very high rates among native peoples. That this is not the case is demonstrated by Graham-Cumming (1966) in an analysis which shows that total infant deaths including native deaths exceeds the total excluding native deaths by only 5.4 per cent for all Canada. This is a fairly minimal contribution to overall infant mortality. Although disproportionately high, the contribution to infant mortality by native Indians is not sufficient to account for Canada's overall high rate.

The study of the relationship of socio-economic status to infant mortality has a long history extending as far back as the collection of data on infant deaths. Indeed, infant mortality is one of the oldest social indicators, a bellweather of social conditions. Whether based on father's occupation (Kessner, 1973) or educational attainment (Chase and Nelson, 1973; MacMahon *et al.*, 1972), a clear inverse relationship seems to consistently emerge between socio-economic status and infant mortality. Willie and Rothney (1962) have found that socio-economic status is such an important determinant of infant mortality that once it is controlled, similar levels of neonatal mortality are shown between whites and non-whites in the United States. In Canada, little is known about the relationship of socio-economic status to mortality since no indicator of status is published with routinely collected and tabulated data. To the extent that it can be stated that French-Canadians generally have somewhat lower status than English-Canadians, a hint of a possible relationship may be found in an Ontario Government report. French-Canadian women were found to have a high risk of prematurity and high rates of infant mortality (Ontario Perinatal Mortality Committee, 1967).

That living conditions have some bearing on infant mortality has also been clear for some time. A U-shaped relationship is apparent between level of urbanization and infant mortality. The highest rates of infant death have been found in the most isolated and the most heavily

urbanized areas in the U.S. (American Medical News, 1975). Evidence of a similar pattern is clear from Canadian data on infant mortality by Province/Territory in which the most isolated places, the two Territories in the North, always show much higher rates (Kubat and Thornton, 1974:52). However, since data are not routinely published by city size in Canada, little is known about the relationship of urban living and infant mortality.

Another set of variables known to have a relationship to levels of infant mortality include health care variables. In particular a strong relationship has emerged between prenatal care and infant mortality levels (Chase and Nelson, 1973). Availability of hospitals, physicians and general standards of health care are also known to be important in lowering infant mortality.

Data and Methods

The focus of interest here is on the degree to which environmental factors may be influential in levels of infant mortality. This aggregate level hypothesis seeks to explain the degree to which various factors in a geographical region are associated with high or low levels of infant mortality. The fact that little background data are collected on infant death certificates necessitates an aggregate level study. An individual-level study which poses questions about various environmental factors might not be able to ascertain effects any more clearly than an ecological study because of the multicausality of infant death.

The data under analysis here were collected for census divisions in the Province of Alberta, Canada. All data are routinely published by government agencies. Analysis of variability across census divisions in one province is seen as superior to analysis of inter-provincial variability in this situation since the areas are small enough to enable the indices used to be real reflections of conditions in the census division. It should be emphasized, however, that the units of analysis here are geographical units and their number is small (15). The choice of Alberta for this study is dictated by this Province's regional and ethnic diversity as well as the simultaneous presence of large cities and isolated areas which make it a suitable place for analysis of the ways in which social conditions impinge on infant mortality.

The analysis here involves a comparison of census divisions on a number of dimensions including components of infant mortality, socio-economic status, race and ethnicity, living conditions and health care availability. Some twenty-five variables are examined in a preliminary examination of census division differences, which is not reproduced here. The analysis in this paper involves submitting a selected subset of these variables to multiple regression analysis in order to assess the relative effects on neonatal and postneonatal mortality.

A Preliminary Look at Census Divisions

It seems appropriate prior to analysis of infant mortality differentials to briefly summarize historical trends in mortality and infant mortality in Alberta and Canada and to compare Alberta to the rest of Canada. Table 1 summarizes mortality trends for three time periods from 1921. The crude death rate in both Alberta and Canada during the period from 1921 to 1972 has experienced a marked decline, with Alberta's decline somewhat less pronounced than Canada's. In comparison to the rates of decline for all measures of infant mortality, however, the rate of decline of crude mortality diminishes. Postneonatal mortality for both Canada and Alberta shows the most pronounced decline. Neonatal mortality shows somewhat less of a decline in Alberta. Even the rate of decline for perinatal mortality which includes fetal deaths is impressive for both Alberta and Canada. Clearly Canada has made great strides since 1921 in improving the chances of survival of infants. In 1972, although overall infant mortality in Alberta was comparable to that for all of Canada, Alberta's neonatal mortality rate was somewhat higher than Canada's. For postneonatal and perinatal mortality, however, Alberta's rates were somewhat lower than the rest of the country.

TABLE 1. MORTALITY AND INFANT MORTALITY RATES ALBERTA AND CANADA: 1921, 1941, 1972

	1921	1941	1972	%Change 1921-72
Crude Death Rate				
Alberta	8.4	8.0	6.5	-22.6%
Canada	10.6	10.0	7.3	-31.1
Infant Mortality				
Alberta	84.0	51.0	17.5	-79.2
Canada	88.1	60.0	17.1	-80.6
Neonatal Mortality[1]				
Alberta	44.0	28.0	12.4	-71.8
Canada	--	31.0	11.9	--
Postneonatal Mortality[2]				
Alberta	58.1	--	5.0	-91.4
Canada	64.0	30.0	5.2	-91.9
Perinatal Mortality[3]				
Alberta	52.2	--	18.6	-64.4
Canada	65.0	48.0	19.1	-70.6

[1]Neonatal mortality is defined as deaths occurring from birth through the first 28 days of life per 1,000 live births.

[2]Postneonatal mortality is defined as deaths occurring to infants between four weeks and one year of age.

[3]Perinatal mortality is defined as fetal deaths (deaths occurring after 20 weeks gestation) plus neonatal deaths.

Source: 1921 rates: Dominion Bureau of Statistics, Vital Statistics, p. xv.
1941 rates (except for perinatal mortality): Dominion Bureau of Statistics, 1941, p. 22, Table 8.
1941 Perinatal rate: Perspective Canada, 1974, p. 40 Table 39.
1972 Data: Statistics Canada, Vital Statistics, 1972, Preliminary Report, Table 2, p. 7.

Enormous variability in infant mortality rates across census divisions was apparent from a first look at the data. Patterns of neonatal mortality did not clearly parallel patterns of infant mortality, suggesting that neonatal mortality may not necessarily be the chief determinant of levels of infant mortality. High neonatal mortality rates seemed generally associated with high births rates while low neonatal rates were associated with low birth rates and death rates. Across census divisions, postneonatal mortality showed somewhat greater variability than neonatal mortality. Higher rates of overall infant mortality and neonatal mortality tended to occur in census divisions with lower proportions of labour force age population in the labour force and with lower proportions of managerial and professional workers. Postneonatal mortality also

tended to be associated with the latter variable. Higher infant mortality, measured in three ways, was associated with non-urban living and with a lower proportion of deaths due to degenerative diseases. No association emerged between infant mortality levels and proportions native, British or Catholic; nor did an association occur between infant mortality and low income. Most health care variables were not found to be associated with levels of infant mortality. The exception to this is that high overall infant mortality, neonatal mortality and postneonatal mortality was associated with higher ratios of population to physician.

Correlation and Regression Analysis

Bivariate correlation coefficients between neonatal and post-neonatal mortality, respectively, and each of the variables under analysis are presented in Table 2. The variable most highly correlated with neonatal mortality across census divisions is the health care variable, proportion of births in hospital. As might be expected, this variable is negatively correlated with neonatal mortality. Age-standardized birth rate and population to hospital bed ratio, are shown to be less highly correlated with the former being positively correlated, as might be expected, but with hospital bed ratio negatively correlated, an unexpected result. Uncorrelated with neonatal mortality are per cent native, low income and illegitimacy.

The variable most highly correlated with postneonatal mortality is per cent of births which are illegitimate, in the expected positive direction. This is closely followed by age-standardized death rate, also positively correlated. Other variables found to be correlated with postneonatal mortality include per cent Catholic, positively, per cent deaths due to degenerative diseases, negatively, as expected, per cent native, positively and per cent without schooling, positively. A number of variables are found to have no correlation with postneonatal mortality including age-standardized birth rate, low income, higher education, per cent urban and population to hospital bed ratio.

A difference calculus of variables seems to be related to the two components of infant mortality. For neonatal mortality, birth related variables provide the central components, either proportion of births in hospital or the standardized birth rate. This appears, at least at first, to lend some credence to the notion that neonatal mortality may be an acceptable operationalized index of endogenous deaths. Further support for this is provided by the finding that variables relating to external circumstances such as proportion native, low income levels and rates of illegitimacy are found to be uncorrelated with neonatal mortality. For postneonatal mortality, the nexus of variables is clearly related to the social environment. Illegitimacy, general rates of mortality, levels of control of infectious disease, proportion native and population without schooling all point to this conclusion. A number of other environmental factors, however, such as low income, high education and urbanism seem to have no relationship to levels of postneonatal mortality.

In an attempt to gain further insight into the relative impact of exogenous factors on neonatal and on postneonatal mortality, multiple regression analysis is undertaken for each infant mortality component separately. Only variables found in the correlation analyses to be important are included here. This approach circumvents the problems inherent in employing too many independent variables when the sample size is small. Tables 3 through 6 present standardized regression coefficents for regression equations done separately for neonatal and postneonatal mortality. In Tables 3 through 5 the same variables are used for both measures of infant mortality. In Table 6 those variables found to be most important in explaining variance for each measure, from analyses not reproduced here, are examined. Standard errors of estimate (S.E.E) tend to be high because of the small number of variables included.

Variables in the two regression equations, for which significant indicators are shown in Table 3, include two generally considered endogenous variables, the age-standardized birth rate

TABLE 2. CORRELATION COEFFICIENTS (PEARSON'S r) FOR NEONATAL AND POSTNEONATAL MORTALITY AND SELECTED VARIABLES, ALBERTA'S CENSUS DIVISIONS

	Neonatal Mortality	Postneonatal Mortality
Age-standardized Death Rate	.07	.60
Age-standardized Birth Rate	.47	.02
Percent Native	-.07	.47
Percent British	.36	-.27
Percent Catholic	-.05	.56
Percent Adults in Labour Force	.32	-.38
Percent Labour Force Managerial-Professional	-.18	-.23
Percent Males Earning less than $4,000	.00	.14
Percent Without Schooling	.05	.41
Percent With University	-.29	-.10
Percent Deaths due to Cancer/Cardiovascular	.31	-.50
Percent Urban	-.29	-.02
Population (per 1,000) Charged With Crime	-.24	-.26
Percent Births Illegitimate	-.08	.65
Percent Deaths in Hospital	-.12	-.18
Percent Births in Hospital	-.71	-.17
Population/ Physician Ratio	.14	.17
Population/ Hospital Bed Ratio	-.43	-.02

and percentage of births which occur in hospital and two exogenous variables, per cent of the population which is native and the age-standardized death rate. The later, although not significant in neonatal mortality is of major importance in postneonatal mortality and thus is included in the comparative analysis. By submitting the same variables to a regression analysis separately for neonatal and postneonatal mortality, the relative impact of the same factors in each dimension of infant mortality can be assessed. The percentage of births in hospital is found to explain one-half of the variance in neonatal mortality across census division. Not surprisingly this variable has a negative relationship to level of neonatal mortality. Per cent native, a clearly exogenous variable adds 23 per cent more to explained variance in neonatal mortality. The remaining two variables, age-standardized birth rate (endogenous) and age-standardized death rate (exogenous) add very little more. Turning to postneonatal mortality, exogenous variables prevail as age-standardized death rate explains 36 per cent of the variance, with per cent native adding about 7 per cent more. From this regression analysis, support seems to emerge for the long-held notion that postneonatal mortality is roughly equivalent to mortality attributable to

TABLE 3. STANDARDIZED REGRESSION COEFFICIENTS WITH SELECTED ENDOGENOUS AND EXOGENOUS VARIABLES AS INDEPENDENT VARIABLES AND WITH NEONATAL MORTALITY AND POSTNEONATAL MORTALITY AS DEPENDENT VARIABLES

Neonatal Mortality:	BETA	R^2	R^2 Change
Percent births in hospital	-0.816	.504	.504
Percent native	-0.702	.733	.230
Age-standardized birth rate	0.338	.782	.049
Age-standardized death rate	0.124	.795	.012
S.E.E.[1] 2.38			

Postneonatal Mortality:	BETA	R^2	R^2 Change
Age-standardized death rate	0.455	.365	.365
Percent native	0.438	.434	.069
Age-standardized birth rate	-0.251	.477	.043
Percent births in hospital	not statistically significant		
S.E.E. 3.67			

[1]S.E.E. is standard error of estimate which tend to be high because of the small number of variables included.

exogeneous factors. However, it appears that neonatal mortality, although largely associated with endogenous causes of deaths, also has some exogenous component.

In Tables 4 and 5, only exogenous factors are included in the separate regression equations for neonatal and postneonatal mortality. From Table 4, it is apparent that for these selected exogenous variables, postneonatal mortality is more fully explained than neonatal mortality. While 54 per cent of the variance across census divisions for postneonatal mortality is explained by percent births illegitimate, deaths due to degenerative diseases and low income earners, only 10 per cent of the variance in neonatal mortality is explained by these variables. In Table 5, a different constellation of exogenous variables is analyzed. Here, per cent adults in the labour force, urbanization and educational levels explain somewhat more of the variance in neonatal mortality than in postneonatal mortality. From this analysis, then, it would seem that considerable support is found for the hypothesis that neonatal mortality, as well as postneonatal mortality, is to some degree at least, a function of social environmental factors as well as endogenous factors.

TABLE 4. STANDARDIZED REGRESSION COEFFICIENTS WITH SELECTED EXOGENOUS VARIABLES AS INDEPENDENT VARIABLES AND WITH NEONATAL AND POSTNEONATAL MORTALITY AS DEPENDENT VARIABLES

Neonatal Mortality:

	BETA	R^2	R^2 Change
Percent deaths due to cancer and cardiovascular	0.350	.093	.093
Percent males earning less than $4,000	0.104	.101	.007
Percent births illegitimate	0.051	.103	.002
S.E.E. 4.76			

Postneonatal Mortality:

	BETA	R^2	R^2 Change
Percent births illegitimate	0.590	.423	.423
Percent deaths due to cancer and cardiovascular	-0.265	.518	.095
Percent males earning less than $4,000	0.163	.540	.023
S.E.E. 3.45			

TABLE 5. STANDARDIZED REGRESSION COEFFICIENTS WITH SELECTED EXOGENOUS VARIABLES AS INDEPENDENT VARIABLES AND NEONATAL MORTALITY AND POSTNEONATAL MORTALITY AS DEPENDENT VARIABLES

Neonatal Mortality:

	BETA	R^2	R^2 Change
Percent adults in labour force	0.478	.100	.100
Percent population urban	-0.401	.267	.167
Percent population with no schooling	0.100	.274	.008
S.E.E. 4.29			

Postneonatal Mortality:

	BETA	R^2	R^2 Change
Percent population with no schooling	0.363	.165	.165
Percent adults in labour force	-0.284	.216	.051
Percent population urban	0.201	.249	.201
S.E.E. 4.41			

Table 6 presents regression equations for those variables found useful in explaining variance in neonatal and postneonatal mortality respectively in previous analyses not reproduced here. Over 50 per cent of the variance in neonatal mortality across census divisions in Alberta is explained by the three variables: hospital births, population to physician ratio and age-standardized birth rate. Not surprisingly, the former two variables are negatively related while birth rate is positively related. It would seem, then, that some component of neonatal mortality is exogenous. The three variables illegitimate births, deaths due to degenerative diseases and age-standardized death rate explain over 60 per cent of the variance in postneonatal mortality across census divisions. The major component of postneonatal mortality seems to be exogenous factors.

TABLE 6. STANDARDIZED REGRESSION COEFFICIENTS WITH SELECTED VARIABLES OF EXPLANATORY IMPORTANCE AS INDEPENDENT VARIABLES AND NEONATAL MORTALITY AND POSTNEONATAL MORTALITY AS DEPENDENT VARIABLES

Neonatal Mortality:

	BETA	R^2	R^2 Change
Percent births in hospital	-0.696	.504	.504
Population/physician ratio	-0.162	.518	.014
Age-standardized birth rate	0.116	.526	.007
S.E.E. 3.47			

Postneonatal Mortality:

	BETA	R^2	R^2 Change
Percent births illegitimate	0.247	.423	.423
Percent deaths due to cancer and cardiovascular	-0.391	.518	.095
Age-standardized death rate	0.408	.604	.087
S.E.E. 3.20			

Discussion and Conclusion

This paper has sought to understand the degree to which components of infant mortality are related to social environmental factors. An analysis of census divisions within the Province of Alberta reveals that very different constellations of variables affect neonatal and postneonatal mortality. Some limited support is found for the hypothesis that neonatal mortality differentials across regions may be attributable in part to differentials in social environmental factors. Clear evidence is found to support the notion that postneonatal mortality is to a large degree a product of social environmental conditions.

From a reading of the infant mortality literature it is clear that neonatal mortality is seen as the result of endogenous factors and therefore not so amenable to improvement as postneonatal mortality which is seen as the product of exogenous factors. An examination of census divisions in Alberta reveals that lower rates of postneonatal mortality are associated generally with lower birth rates and death rates. This lends some support to the notion that postneonatal mortality is associated with generally higher levels of living and socio-economic development. Higher rates of neonatal mortality are associated with higher birth rates but bear no particular relationship to death rates. This may suggest, in support of the infant mortality literature, that neonatal mortality is in large part a function of endogenous factors, perhaps closely allied with birth-related factors. The finding that neonatal mortality, at least in the initial examination, bears little relationship to general levels of mortality seems to lend this notion further credence.

Other findings from the correlation and regression analyses, however, suggest that both neonatal and postneonatal mortality are products of environmental factors. High rates of neonatal mortality, for example, are found to be associated with lower proportions in the labour force and lower proportions in managerial and professional occupations. High rates of postneonatal mortality are found also to be associated with lower proportions of managerial and professional workers. Although hospital births explain a considerable portion of the variance in neonatal mortality across census divisions in the regression analysis, other variables of importance such as population/physician ratio are suggestive of environmental considerations. Postneonatal mortality is clearly found to be a product of environmental factors with variables such as illegitimacy, control of infectious diseases, educational levels and labour force participation emerging as important.

Although evidence from this analysis of one province's census divisions is far from definitive, some support is found for the hypothesis that neonatal mortality, as well as postneonatal mortality, is related to social environment. It must be borne in mind, of course, that this analysis does not consider whether the relationship of social environment and neonatal mortality is direct or indirect or both. Given that some evidence is found to support the hypothesis under consideration, future research might be directed to close examination of causes of death and times of infant death in order to better understand how best to ameliorate neonatal mortality. The simple assumption that neonatal mortality essentially is the "untouchable" component of infant mortality or directly equivalent to endogenous deaths may no longer be sufficient.

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