Sudden Infant Death Syndrome and Iodine Deficiency: Geographical Evidence

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Introduction

As Barnett and Hunter (1980) pointed out, the earliest written record of sudden and unexplained infant death probably occurs in the Bible ... "and this woman's child died in the night; because she overlaid it" (1 Kings 3:19). Later references to sudden infant death, occurring during the Middle Ages, can be found on British and European gravestone inscriptions. It seems likely at least some of these fatalities were due to what is known today as the Sudden Infant Death Syndrome (SIDS) or "crib or cot death". This syndrome involves "the sudden death of any infant or young child, which is unexpected by history, and in which thorough postmortem examination fails to demonstrate an adequate cause of death" (Bergman, et al, 1970).

In the United States there are approximately 5,300 such SIDS fatalities each year. As shown in Figures 1 these cases are not geographically random (Spiers, 1980). Clearly, the death rate from SIDS, increases from East to West. In consequence, risk in the Pacific and Mountain Regions is approximately twice that of the Atlantic states. There are also major racial differences. To illustrate, SIDS in California has a rate for 1000 live births of 0.51 amongst Chinese and Japanese Americans and 5.93 amongst American Indians (Kraus and Borhani, 1972, Valdes-Dapena, 1980). These spatial and racial patterns suggest that geographical variables may play a role in the etiology of SIDS.

Method

Any attempts to identify links between SIDS and geographical factors requires environmental and medical data from the same spatial units. Since excellent data of both types is available from the United States, this was thought to be the most viable area for initial study. Even here, most environmental data have been collected by water and fisheries managers, geologists, geographers, foresters, and agriculturalists for reasons completely unrelated to human health. As a result, no synchronous environmental data-base exists. The author searched the relevant literature, therefore, and accepted for use any environmental data that had been collected since approximately 1950, most of it prior to 1970.

One excellent source of such environmental information is the *Water Atlas of the United States* (Geraghty et al, 1973). This carries a total of 122 maps providing data on an enormous range of environmental variables. From this atlas, the author obtained data on average annual precipitation, groundwater use, hardness and sodium content of finished public water supplies and the percentage of the state population drinking fluoridated water. Also used were fertilizer, DDT and phosphate application data, and information on the presence of dieldrin, lindane, cadmium, chromium, arsenic, mercury and lead in surface waters. The *Water Atlas of the United States* also included information on the use of deicing salts by state highways departments, and the withdrawal and use of water by industry and by farmers. Figures were also given for irrigated acreages. All of this information was included in the data bank used in the subsequent analyses. So too was information about the amount of farmland in each state, the harvested acreage of 59 principal crops, with additional detail concerning the number of bushels of barley, corn grain, oats, rye and all wheat produced. Data on cotton, hay, potato and tobacco production were also included (Delury, 1975). Air pollution information and other climatic data were taken from a publication by McCormick(1986).

The most comprehensive source of

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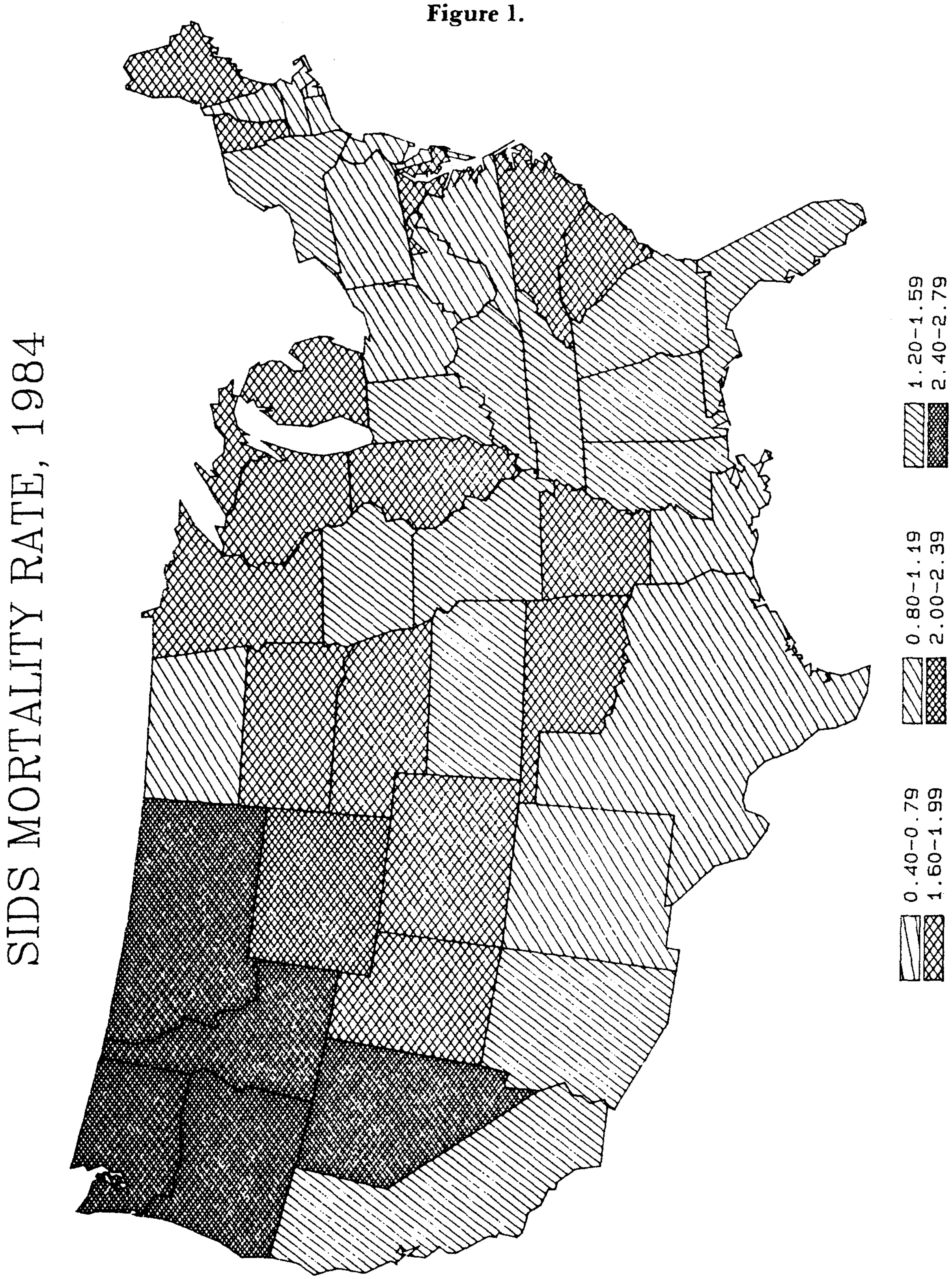
Figure 1.


SIDS MORTALITY RATE, 1984
0.40-0.79
1.60-1.99
0.80-1.19
2.00-2.39
1.20-1.59
2.40-2.79

environmental data, however, was that published by the United States Geological Survey (Shacklette et al, 1971a; 1971b; 1973; 1974). In 1961, the Geological Survey began a soil and regolith sampling program that was designed to give estimates of the range of element abundance in surficial materials, that were as unaltered as possible by human activity. These were to represent the natural geochemical environment of the United States. Samples were taken at a depth of approximately 20 centimeters below the surface from locations about 80 kilometers apart, throughout the conterminous United States, and were then analyzed to determine their mineral content. In this way, 863 sample sites were chosen. The results of the geochemical analyses for 35 elements were subsequently plotted on maps. The following soil elements were analyzed during the survey: aluminum, arsenic, barium, beryllium, boron, calcium, cerium, chromium, cobalt, copper, fluorine, gallium, iron, lanthanum, lead, lithium, magnesium, manganese, mercury, molybdenum, neodymium, nickel, niobium, phosphorus, potassium, scandium, selenium, sodium, strontium, titanium, vanadium, ytterbium, yttrium, zinc and zirconium. On the published maps, the abundance of each was represented by a symbol which indicated whether, at that site, the element level was very high, high, medium, low or very low, when compared with the geometric mean for the nation as a whole. These were used by this author to generate percentage values for each state, for each level and element. For instance, in Florida 100 percent of the samples were found to be low in barium. In contrast, in Louisiana 25 percent were very low, 8.33 percent low, while 33.33 percent contained medium levels of barium and 33.33 percent had high barium levels. There were no very high barium concentrations recorded in this state. Similar percentage values were calculated, for this study, for all 35 elements, for all conterminous states.

In summary, the environmental data base included details of a wide range of air and water pollutants, climatic data; and a variety of industrial, commercial and agricultural activities. In addition, geochemical information, which appeared to reflect, as closely as is possible, the natural chemical environment of the United States was also utilized. In total, information on 221 geographical variables was available for use in correlations with the SIDS mortality data.

Information on the magnitude of Sudden Infant Death Syndrome in the United States has been developed for the years 1983 and 1984 by the National SIDS Clearinghouse, McLean, Virginia (Booth, 1987). This data is given in the form of the rate of SIDS deaths per 1,000 live births for each state. Mortality, in 1984, for example, varied from a low of 0.40 in Rhode Island to a high of 3.41 in Alaska (Figure 1).

To test the hypothesis that these spatial variations in death rate reflected some identifiable geographical factor or factors, Pearson correlation was first used to compare the distribution patterns for the two years for which data were available. A value of $r = 0.86072$ ($p = 0.0001$) was obtained, indicating that very similar spatial patterns occurred in both 1983 and 1984. This tends to suggest that there were likely to be identifiable causal variable(s) and that spatial variations in the death rate were not simply random. Pearson correlation coefficients were then used to compare the spatial distribution of SIDS deaths for the years 1983 and 1984 with the 221 climatic, hydrological, geological, social and economic variables collected at the state level.

Results

It was found that for SIDS mortality, in 1983, the strongest positive correlation was with goitre incidence in World War I troops ($r = 0.66745$, $p = 0.0001$). Other high positive correlations were with enriched selenium soils ($r = 0.58794$, $p = 0.0001$), iodine deficient soils ($r = 0.49653$, $p = 0.0003$) and those soils that were very elevated in strontium ($r = 0.49320$, $p = 0.0004$). Other positive correlations were with soils that contained very low levels of mercury ($r = 0.48459$, $p = 0.0005$) or were very enriched in sodium ($r = 0.45428$, $p = 0.0012$).

When this procedure was repeated using SIDS mortality data from 1984, the strongest positive correlation was again with goitre incidence in World War I Troops (r= 0.74416). Other notable correlations were with soils that were very enriched in strontium (r = 0.60046), sodium (r = 0.56921), potassium (r = 0.54396), selenium (r = 0.54360) and with those that were deficient in iodine (r = 0.50129, p = 0.0003) (p = 0.0001 unless otherwise stated). The strongest negative correlation was with air pollution (r = -0.51667, p =0.0002). Stepwise multiple regression produced the following two-variable model which could explain 63.5% of the variance involved for 1983.

Sudden Infant Death Syndrome Mortality =
1.403 + (0.0419 XEnl8) - (0.00665 X PM Sr)

where:
En 18 is the incidence of goitre in troops recruited from the state during World War I and
PM Sr is the percentage of the state with soils that had moderate levels of strontium.

Repeating the procedure for 1984 yielded the following two-variable model. This could explain 73.2% of the variance. Obviously, in this particular regression, co-linearity is a problem. Nevertheless, in the one-variable model, troop goitre incidence alone (Enl8) explained 66.7% of the variance involved.

Sudden Infant Death Syndrome Mortality =
0.745 + (0.0808 X Enl8) + (0.00490 XEn21)

where:
En 18 is the incidence of goitre in troops recruited from the state during World War I and
En21 is the percentage of the soils that are deficient in iodine.

Conclusions

Numerous hypotheses have been advanced in an effort to explain Sudden Infant Death Syndrome, that is crib or cot death. These can be subdivided into at least four groups, one of which involves failure of respiratory control, a related group emphasizes sleep apnea, while a third stresses infecting agents and susceptible immunological or other defenses. The fourth suggests that one or more biochemical imbalances may be significant in the etiology of SIDS (Barnett and Hunter, 1983). The correlations presented here seem most compatible with the fourth of these hypotheses. In a paper published before this SIDS research was undertaken, the current author (Foster, 1987) suggested that dietary iodine deficiency or excess appeared to be associated with a wide range of diseases, including multiple sclerosis and cancer of the thyroid. He argued that these diseases formed a "family tree" and could be identified because all had fairly strong negative or positive spatial correlations with the incidence of goitre. He further suggested that many of these diseases were especially common in environments that were sodium enriched. Co-linearity cannot be invoked to explain this relationship since sodium enriched soils are generally found in the west and central states, while iodine tends to decline northwards (Shacklette et al, 1971).

Correlations, in and of themselves, can never establish cause. However, those presented in this article are highly suggestive of a link between SIDS and dietary iodine deficiency (and the possible exposure of infants to goitrogens in food and water) and excess sodium intake. If this is the case, racial differences in the death rate might also be partially explained, since Oriental Americans often consume iodine enriched seaweeds whilst Native Indians, frequently located on inland reservations, rarely do. If SIDS is exacerbated by sodium, then the sharp rise in the cot death rate in Scunthorpe, England that took place when drinking water was softened and its sodium content increased also becomes explicable (Robertson, 1978). Indeed, even the negative correlation in the U.S.A. between SIDS and air pollution would be consistent with this possible iodine link, since this element can be absorbed through the skin and industrial air pollution is now a significant source (Matovinovic, 1983).

It should also be noted that the soybean, used in some baby foods, is a goitrogen. Soybean milk, for example, can lower the thyroidal 131_{I} uptake and produce hypothyroidism in susceptible infants (Syk et al, 1959). It seems unlikely that excess selenium plays a role in the etiology of SIDS, since very high selenium soils tend to occur in semi-desert and desert areas where the precipitation is low and there is virtually no agricultural production or population. The possible roles of strontium and potassium in SIDS, however, required further study.

Acknowledgements

The author would like to thank his graduate research assistant, Michael John Shasko for processing large volumes of computer data; the National Sudden Infant Death Syndrome Clearinghouse, McLean Virginia for mortality data and the World Health Research Foundation, Victoria, for financial assistance.

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