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## ASSOCIATIONS BETWEEN NUTRITION AND MORTALITY IN SIX HEALTH SERVICE AREAS OF NORTH CAROLINA

(An Indirect Study)

In recent years, considerable attention has been given to studies relating disease processes to various elements of human consumption. These studies have experimentally implicated a number of products including cyclamates, food dye and saccharin. In addition, various studies have related basic foodstuffs to disease processes; for example, the high cholesterol content of eggs has been implicated as a factor in cardiovascular disease. Still other recent reports point to the role of diet in various forms of cancer.

A recent PHSB study (1) suggests that occupational distribution contributes significantly to the explanation of death from acute myocardial infarction, lung cancer and prostatic cancer; in addition, that income is explanatory for lung cancer; education for colon-rectum cancer; and elevation for acute myocardial infarction and prostatic cancer. The question is, what do these variables represent. . . . Is diet an important factor?

Fortunately, North Carolina is in the position of having conducted a survey that provides dietary data for a representative sample of the household population (2,3). Although that survey was conducted seven years ago, and time and circumstance have undoubtedly modified eating behavior to some extent, we believe the data are still useful indicators of the relative dietary habits of different areas of the state and, in any event, that they afford us the unique opportunity to examine associations between prior dietary practice and current mortality in North Carolina.

The present study uses correlation analysis to examine dietary factors that might be affecting age-race-sex-adjusted mortality in the state's six health service areas (HSA's), these being the smallest areas for which survey data are available. In these analyses, intercorrelations among per capita income, a contrived elevation variable and nutrition factors are also examined. Although the previously cited study (1) and other investigations tend to support the hypothesis of a protective effect of altitude upon heart function, dietary factors may be the protective agent in North Carolina.

## METHODS AND MATERIALS

### Dietary Data

The North Carolina Nutrition Survey (NCNS) was originally designed to provide dietary data for only three regions of the state--the East, the Piedmont, and the West (2). However, in terms of the number of households for which dietary data were obtained, each of the HSA's appears sufficiently represented to allow for the post-stratification used in this paper. Table 1 compares the percentage distributions of responding survey households and household members to the corresponding distributions obtained in the April 1970 Census.

Details concerning the survey design and procedures have been reported (2). Briefly, the data were collected by trained nutritionist-interviewers from an adult household member who had responsibility for meal preparation. This person was asked

Table 1

Percentage Distributions of North Carolina Households and Household Members by Health Service Area

| | Households | | Household Members | |
|---|---|---|---|---|
| | 1970 Census Enumeration (4) | 1970 Sample Survey* | 1970 Census Enumeration (5) | 1970 Sample Survey* |
| Total Number | 1,509,564 | 1,160 | 4,893,113 | 3,885 |
| Health Service Area | | | | |
| I Western | 17.8 | 17.8 | 17.3 | 16.1 |
| II Piedmont | 20.1 | 23.4 | 19.6 | 21.0 |
| III Southern Piedmont | 17.8 | 12.5 | 17.4 | 12.4 |
| IV Capital | 13.2 | 11.0 | 13.0 | 10.9 |
| V Cardinal | 13.9 | 19.1 | 14.6 | 21.0 |
| VI Eastern Carolina | 17.3 | 16.2 | 18.0 | 18.7 |

*Based on households providing complete dietary data. This excludes nearly 12% of the original sample of 1,315 households.

to recall all foods consumed from the home food supply on the day prior to interview with food models being used to help respondents recall the amounts of foods consumed. A computer program was then used to convert food model specifications into gram amounts and caloric and nutrient values.

Dietary data used in the present study are described below. These data are specific for households located in each HSA and may be obtained by contacting the Public Health Statistics Branch.

- Data items are the per person per meal grams of food consumed from each of 20 food groups. Details concerning the food items included in each food group are available (3,6).
- Data items are the per person per meal amounts of 17 nutrients consumed in survey households. In the case of water, it should be noted that this represents the water content of foods and mixed beverages and does not include plain drinking water.
- The survey data file provides information concerning the "adequacy" of caloric and nutrient intakes as related to age-sex-weight-specific daily standards described in a published report (2). Data items presently used are the percentages of households meeting less than 50% of their standard for calories and each of 8 nutrients ("low" intakes) and the percentages of households meeting 200 percent or more of each standard ("high" intakes). In the determination of these percentages, standards were adjusted for meals eaten from other than the home source (2).
- Data items are the percentages of total calories derived from protein, fats and carbohydrates. Factors used to convert grams to calories were 4, 9 and 4 respectively (e.g., each gram of protein is equivalent to 4 calories).
- Each household diet was rated optimal, adequate or inadequate according to published criteria (2). The data are used here as the percentage of household diets in each diet rating category.
- Data items are the percentages of persons failing to eat the A.M., noon and P.M. meals.

## Mortality Data

Rates used in these analyses are the 1973-75 average annual death rates, adjusted for age, race and sex (7) and specific for the disease entities described on the next page. Other causes of death were not studied due to the fact that death rates are presently computed only for underlying causes of death, and for many diseases, the "incidence at death" is known to be much higher. For example, hypertension, arteriosclerosis and diabetes are considered "associated" conditions far more often than they are considered an underlying cause. Since our primary interest is in the determinants of disease rather than the determinants of underlying causes of death per se, analysis based soley on underlying frequencies would not be appropriate. We also did not study causes for which the 3-year rates appear to fluctuate randomly over time.

Causes listed below were deemed amenable to study on the basis that (i) the underlying frequencies are thought to closely represent the incidence at death and (ii) correlations between the 1968-70 and 1973-75 HSA death rates are statistically significant suggesting the presence of some causative agent that may invite intervention. In the case of acute myocardial infarction, the latter condition was met only when HSA IV was eliminated; hence, results for that cause are based on data for five rather than six HSA's. This concession was allowed because of special interest in intercorrelations among elevation, nutrition factors and myocardial infarction.

| Cause | ICDA Codes (8) |
|---|---|
| Acute Myocardial Infarction | 410 |
| Colon and Rectum Cancer | 153,154 |
| Pancreatic Cancer | 157 |
| Trachea, Bronchus and Lung Cancer | 162 |
| Cancer of the Cervix Uteri | 180 |
| Prostatic Cancer | 185 |

## Income and Elevation Data

Clearly, food utilization practices reflect many facets of living including economic power and culturally conditioned lifestyles; hence our need to be aware of these associations when assessing apparent associations between nutrition factors and mortality.

Per capita income (9) is used in these analyses because NCNS results indicate that food utilization is more a linear function of income than of homemaker's education (2,3). We chose per capita income as a general descriptor that is highly correlated with other income variables.

The elevation variable presently used is the population-weighted average of the elevations of all county seats located in each HSA.

## Correlation Analysis

Two statistical tests—Pearson's product-moment correlation procedure and Spearman's nonparametric procedure—were used in these analyses (10). While results are probably stronger when both tests indicate a statistically significant correlation, the reader should be aware that we are dealing here with a small number of observations (HSA's) such that a single pair of values can make a lot of difference to the value of r (Pearson's coefficient) or $r_s$ (Spearman's coefficient). Hence, results are only suggestive, not conclusive, and in any event, they should not be taken to imply cause-and-effect relationships. Rather, the correlation coefficients merely indicate the degree and direction in which two variables change together as described in the next section.

# RESULTS

Table 2 shows statistically significant coefficients for correlations between mortality rates and each of the nutrition factors, income and elevation respectively, and Table 3 displays significant coefficients for correlations between nutrition factors and income and elevation respectively. In these tables, the sign of the coefficient (r or $r_s$) indicates the direction of the association between variables; for example, Table 2 shows that increases in acute myocardial infarction are associated with increases in egg consumption and decreases in the use of non-confection desserts. The closer the value of r or $r_s$ to 1.00 or to -1.00, the greater the association between a pair of variables.

Mindful of the fact that evaluation of present results must be left to the nutrition community, remarks given below merely highlight these results while pointing up other evidence of relationships between disease and various socio-environmental factors. Here, frequent reference is made to the diet and mortality experiences of the Japanese because (i) nutrition conditions in Japan are documented and (ii) mortality patterns in Japan appear to vary markedly in some instances from those observed in the United States (11). In this regard, it should be noted that the Japanese diet is being increasingly influenced by western culture; thus, the future of that country's mortality patterns will be of great interest.

- Present results support other evidence of a positive association between death from cardiovascular disease (acute myocardial infarction) and consumption of eggs. Here, Japan's experience seems particularly notable since that country has one of the world's lowest recorded heart disease rates, calculated in 1965 at less than one-fourth the U.S. and N.C. rates. The low rate is associated with a Japanese diet that is low (but increasing) in cholesterol. (11)
- The high negative correlation between myocardial infarction and use of desserts was not expected but may be explained in part by the fact that dessert consumption is positively associated with income and use of citrus fruits while being negatively associated with use of eggs. Also, confection-type desserts are not included here but in a separate sugar/sweets group. Again referring to Japan, the Japanese enjoy and use sweet foodstuffs, but theirs have a low sugar content compared to western confections (11).
- As before (1), elevation appears protective against death from myocardial infarction, but this result may be confounded by the effects of various dietary factors as well as climatic and other elevation-related factors. The previous study (1) also suggests that water zinc may be a positive correlate of myocardial infarction death in North Carolina, but a mechanism for any such action is unknown and levels of water zinc appear well within established limits in this state.
- Colon-rectum cancer is shown to be positively associated with intakes of beef and negatively associated with intakes of flour/cereal products. Intakes of protein and niacin and the incidence of high-niacin diets are also positive correlates. Although these results may reflect income-related factors other than diet per se, they are consistent with a low incidence of colon cancer in Japan where diets are extremely high in carbohydrates and low in all animal products except fish (11). The previous study (1) suggests that colon cancer mortality in North Carolina is positively associated with education and with water manganese; also, death from this cause appears more frequent among divorced nonwhite males (12).
- Little is known of the causal aspects of pancreatic cancer, but the increasing trend in mortality suggests that exposure to etiologic factors has increased (13) or that more accurate diagnoses are being made. Present results show a positive association with three intercorrelated variables, i.e., the incidence of high-niacin and high-vitamin C diets and income. Pancreatic cancer is also shown to be negatively associated with the incidence of low-protein and low-thiamine diets. Previous findings (12) indicate that in North Carolina higher pancreatic cancer death rates occur among divorced and widowed persons.
- Lung cancer mortality is shown to be associated with elevation and several related dietary factors, but previous findings (1) suggest that elevation is unimportant while income (a negative correlate) and occupation distribution are highly important when these factors are considered against each other and various other social and environmental conditions. Other studies (13) have found an inverse relationship between lung cancer and educational class, and in North Carolina, divorced males of both races appear particularly disposed to lung cancer mortality (12).
- Present results support other evidence of an inverse relationship between cervical cancer and socio-economic class (12,13). Sexual activity has been implicated (13); diet may or may not be an important factor.
- Findings for associations between prostatic cancer and consumption of protein and thiamine are consistent with reports of a higher frequency of prostatic cancer among Japanese Americans than among Japanese in Japan (13); the Japanese diet traditionally includes mostly vegetable protein and is low in thiamine relative to dietary standards in the U.S. (11,2). Other studies indicate a higher northern than southern frequency for U.S. whites and nonwhites and a higher frequency among professional workers, relatives of prostatic cancer decedents, and widowed and married men, especially nonwhites (12,13). In North Carolina, elevation-related factors may be important (1).

- In addition to the correlation analyses reported above, the several death rates were correlated with an "apparent" per capita dollar sale of distilled spirits (see reference 7, page 204). Since these sales involve tourists and other non-residents of an HSA, they are only gross indicators of alcohol consumption; however, the correlation with cirrhosis of the liver was moderately high (r = .74) such that results for other causes may have meaning. Among the causes presently studied, highest correlations were observed for lung cancer (r = .68), colon-rectum cancer (r = .50) and prostatic cancer ($r_s$ = .49). The sale of distilled spirits was also a moderate negative correlate of elevation (r = -.63). None of these correlations was statistically significant.

Table 2

Significant Pearson Coefficients (r) and Spearman Coefficients ($r_s$) for Correlations Between Mortality Rates and Nutrition Factors, Elevation and Per Capita Income Respectively

North Carolina Health Service Areas

| | Cause of Death | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrition Factors | Myocardial Infarction† | | Colon-Rectum Cancer | | Pancreatic Cancer | | Lung Cancer | | Cervical Cancer | | Prostatic Cancer | |
| | r | $r_s$ | r | $r_s$ | r | $r_s$ | r | $r_s$ | r | $r_s$ | r | $r_s$ |
| *Per Person Per Meal Grams* | | | | | | | | | | | | |
| Dairy Products | | | | | | | -.80 | | | | | |
| Beef | | | .84* | .83* | | | | | | | | |
| Pork | | | | | | | .74 | | | | | |
| Sausage/Luncheon Meats | | | | | | | .75 | | | | | |
| Eggs | .81 | .80 | | | | | | | .78 | .83* | | |
| Legumes/Nuts | | | -.75 | | | | | | | | | |
| Citrus Fruits/Tomatoes | | -.90* | | | | | | -.77 | -.75 | | | |
| White Potatoes | | -.70 | | | | | | | | | | |
| Fruits/Vegetables, n.e.c.# | | -.70 | | | | | -.84* | | | | | |
| Homemade Self-rising Biscuits | | .80 | | | | | | | | | | |
| Other Flour/Cereal Products | | | -.94** | -.83* | -.75 | -.77 | | | | | | |
| Desserts (non-confection) | -.96** | -.90* | | | | | | | | -.83* | | |
| Soups/Sauces | | -.70 | | | | | | | | | | |
| *Per Person Per Meal Nutrients* | | | | | | | | | | | | |
| Calories | | | | .83* | | .77 | | | | | | |
| Protein | | | .85* | .83* | | .77 | | | | -.77 | .76 | .77 |
| Calcium | | -.70 | | | | | -.83* | -.77 | | | | |
| Iron | | -.80 | | | | | | | | | .80 | |
| Potassium | -.91* | -1.00** | | | | | -.82* | -.83* | | | | |
| Vitamin A Value | | | | | | | | | | | .74 | |
| Thiamine | | .72 | | | -.80 | | | | | .75 | | |
| Riboflavin | -.87 | -.80 | | | | | | | | | | |
| Preformed Niacin | | | .92** | .83* | | .77 | | | -.84* | -.77 | | .77 |
| Vitamin C | | -.70 | | | | | | | -.97** | -1.00** | | |
| Water | | -.70 | | | | | -.87* | | | | | |
| Ash | | -.80 | | | | | | | | | | |
| *Percent Households with Low Intake of:* | | | | | | | | | | | | |
| Calories | | | | | | | | .77 | | | | |
| Protein | | | | | -.87* | -.83* | | | | | | -.89* |
| Thiamine | | | | | -.82* | -.78 | | | | | -.90* | -.84* |
| Riboflavin | | | | | -.74 | | | | | | | |
| Preformed Niacin | | -.70 | | | | | | | | | | |
| Iron | | | | | | | -.77 | | | | | |
| Vitamin A Value | .91* | .80 | | | | | | | .76 | .77 | | |
| Calcium | | .70 | | | | | .78 | | | | | |
| Vitamin C | | | | | | -.77 | | | .90* | .77 | | |
| *Percent Households with High Intake of:* | | | | | | | | | | | | |
| Protein | | | .74 | | | | | | | | | |
| Riboflavin | -.85 | -1.00** | | | | | -.92** | -.83* | | | | |
| Preformed Niacin | | | .95** | .83* | .74 | .77 | | | -.88* | -.77 | | |
| Iron | -.87 | -.80 | | | | | | | | | | |
| Calcium | | | | | | | -.73 | | | | | |
| Vitamin C | | -.70 | .76 | | .78 | .77 | | | -.88* | -.94** | .73 | |
| *Percent Household Diets Rated:* | | | | | | | | | | | | |
| Optimal | | -.70 | .74 | | | | | | -.98** | -1.00** | | |
| Adequate | | -.90* | | | | | -.77 | -.77 | | | | |
| Inadequate | | .90* | | | | | .75 | .77 | .83* | | | |
| *Percent Failure to Eat:* | | | | | | | | | | | | |
| A.M. Meal | | .90* | | | | | | | | | | |
| Noon Meal | | .70 | | | | | | | | | | |
| *Percent Calories from Protein* | | | | | | | | | | | .89* | .77 |
| Elevation | -.83 | -.90* | | | | | -.80 | -.89* | | | | |
| Per Capita Income | | -.70 | .85* | | .81 | .77 | | | -.95** | -.94** | | |

† HSA IV not included in these correlations.

# Fruits/Vegetables, not elsewhere classified, i.e., excludes citrus fruits, tomatoes, high vitamin A fruits/vegetables and white potatoes.

no superscript p < .10, two-tailed test.
* p < .05, two-tailed test.
** p < .01, two-tailed test.

## CONCLUSION

Although the preceding dietary findings may reflect the effects of other factors, perhaps they still should not be dismissed lightly for the following reason. Many processed foods have added nutrients, including niacin, thiamine and others. For some of these products, levels of the nutrients are regulated by Federal standards, but for many products, there are no regulations (14). And even for those products subject to regulation, one must wonder if the standards have been in effect long enough to reliably discern the long-term effects. We note, for example, that enrichment of wheat products was initiated during World War II (15) and enrichment laws for other grain products are considerably younger (16).

Table 3

Significant Pearson Coefficients (r) and Spearman Coefficients ($r_s$) for Correlations Between Nutrition Factors and Income and Elevation Respectively

Six North Carolina Health Service Areas

| Nutrition Factors Correlated with Per Capita Income | r | $r_s$ |
|---|---|---|
| Per Meal Intake of Desserts | | .77 |
| Per Meal Intake of Citrus Fruits/Tomatoes | .74 | |
| Per Meal Intake of Mixed Foods | | .83* |
| Per Meal Intake of Thiamine | | -.84* |
| Per Meal Intake of Preformed Niacin | .83* | |
| Per Meal Intake of Vitamin C | .91* | .94** |
| Percent Households with Optimal Diet | .95** | .94** |
| Percent Households with Inadequate Diet | -.78 | |
| Percent Households with Low Iron Intake | | .77 |
| Percent Households with Low Vitamin C Intake | -.88* | -.83* |
| Percent Households with High Preformed Niacin Intake | .95** | .89* |
| Percent Households with High Vitamin C Intake | .97** | 1.00** |
| **Nutrition Factors Correlated with Elevation** | | |
| Per Meal Intake of Citrus Fruits/Tomatoes | | .77 |
| Per Meal Intake of Fruits/Vegetables n.e.c. | .80 | |
| Per Meal Intake of Fiber Carbohydrates | .84* | |
| Per Meal Intake of Calcium | .78 | .77 |
| Per Meal Intake of Potassium | .94** | .89* |
| Per Meal Intake of Thiamine | | -.75 |
| Per Meal Intake of Ash | .88* | .77 |
| Percent Households with Low Calcium Intake | | -.83* |
| Percent Households with Low Vitamin A Value Intake | -.79 | |
| Percent Households with High Riboflavin Intake | .89* | .89* |
| Percent Households with High Iron Intake | .79 | |
| Percent Households with High Calcium Intake | .80 | |
| Percent Households with Adequate Diet | .88* | .94** |
| Percent Households with Inadequate Diet | -.76 | -.94** |
| Percent Persons Failing to Eat A.M. Meal | | -.89* |

no superscript $p < .10$, two-tailed test.
* $p < .05$, two-tailed test.
** $p < .01$, two-tailed test.

Note: Persons desiring coefficients for correlations among the nutrition factors may contact the Public Health Statistics Branch.

One final word concerns indicators of nutritional status which have not been studied here. These include the use of sugar vs. starch carbohydrates, animal vs. vegetable protein and saturated vs. unsaturated fats. While the NCNS statistical file does not identify these constituents, it does identify specific food items such that, with the aid of nutritionists, we might estimate the needed parameters in order to perform corresponding analyses. Some present results point to a need for these more detailed analyses; for example, contrary to expectation, correlations between dietary fat and the diseases studied here were not significant, but correlations involving saturated vs. unsaturated fats may be quite different.

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