

Diet, mortality and life expectancy

A cross national analysis

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Abstract. There are numerous reasons why mortality and life expectancy vary between countries. Epidemiological studies seem to indicate that dietary variations may be among them. A sample of 51 countries studied with data from the International Comparisons Project and other sources, shows that after controlling for nutrient intake, consumption of medical goods and services, income distribution, weather, and literacy, countries with more meat and poultry in their diet have lower life expectancies after age five. The results for infant mortality and child death between one and five indicate that a more animal-intensive diet may be actually be beneficial, especially if fish consumption is increased and meat and poultry consumption reduced.

It may indeed be doubted whether butcher's meat is anywhere a necessary of life. Grain and other vegetables, with the help of milk, cheese, and butter, or oil, where butter is not to be had, it is known from experience, can, without any butchers meat, afford the most plentiful, the most wholesome, the most nourishing, and the most invigorating diet.

Adam Smith, The Wealth of Nations

I. Introduction

There are a number of reasons why mortality and life expectancy vary between countries. Many have been well documented and understood. Most studies demonstrate that a good deal of these variations can be explained by differences in income and its distribution, literacy, nutrition, and health programs (Flegg 1982;

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Hobcraft et al. 1984; Pampel and Pillai 1986; Preston 1976; Primrose and Higgins 1971). However, the rapid post-war declines in mortality due largely to improvements in these variables have been replaced by lethargic progress and increasing diversity (Gwatkin 1980; Preston 1980). Caldwell (1986) provides some reasons why, emphasizing among other things the position of women and children in society, political systems, and class structure.

However, Caldwell also makes the interesting observation that nine out of ten "poor health achievers" in developing countries are Muslim or have large Muslim populations, while the superior health achievers tend to be primarily Buddhist or Hindu. One difference between Muslim and Buddhist or Hindu populations is the sharp dissimilarity in their preference for foods. Muslims tend to be meat eaters, while Buddhists and Hindus tend to be more vegetarian in their diets. Thus one question that can be asked is the extent to which the deviations in the health achievements of these populations are caused by deviations in their patterns of food consumption.

There has been some interest in this question for adult populations in high-income countries in the American bio-medical literature following a pioneering study (Kahn et al. 1984) of 27 530 members of the Seventh-Day Adventist Church of California. It looks at the association between all-cause mortality and the frequency of consumption of 28 specific foods during 1960–1980. The study finds that, after controlling for age, sex, smoking history, and history of disease, all-cause mortality shows a significant negative association with fruit and vegetable consumption, especially with green salads, and a significant positive association with meat and poultry consumption. The association with egg consumption is also positive but less significant. Cereal, fish, and milk consumption, however, have an indeterminate effect in this sample.

Another study of individual-level data from seven developed countries (Keys et al. 1981), finds that all-cause death is significantly associated with the consumption of saturated fatty acids, usually found in meats, dairy, and egg products.

These are among the very few papers that have looked at the effect of diet on adult mortality from all causes. The Seventh Day Adventists' study calls the epidemiologic literature on the subject "astonishingly limited" (Kahn et al. 1984). What has been studied in some detail is the effect of diet on the mortality of adults from very specific causes. For instance, the adverse effect of meat consumption on cardiovascular mortality has been well documented (De Bakey et al. 1986), as has the beneficial effect of increased vegetable consumption on it (Burr and Sweetnam 1982; Verlangieri et al. 1986). A vegetarian diet has been found to reduce the occurrence of diabetes (Snowdon and Phillips 1985) and to reduce the risk of certain sorts of cancer (Colditz et al. 1985; Kolonel et al. 1983; Saxon 1983), while animal fat and meat consumption has been found to increase the risk of cancers of the prostate and the breast (Kolonel et al. 1983).

On the question of the effects of diet on infant and child mortality, the consensus seems to be just the converse. The Pediatric Nutrition Handbook (1985), for instance, recommends that lactating mothers be provided with protein, iron, and calcium supplements and states that entirely vegetarian diets may adversely affect the health of mothers and infants. A study shows that augmenting the pro-

Table 1. List of countries in the sample:

Guatemala, Panama, Malawi, India, Tanzania, Sri Lanka, Madagascar, Pakistan, Kenya, Senegal, Indonesia, Bolivia, Honduras, Zambia, Philippines, Morocco, Nigeria, Zimbabwe, Peru, Ecuador, Ivory Coast, Dominican Republic, Columbia, Tunisia, Costa Rica, Republic of Korea, Spain, Brazil, Portugal, Argentina, Chile, Uruguay, Venezuela, Greece, Hong Kong, Israel, Hungary, Poland, Ireland, Italy, United Kingdom, Japan, Austria, Canada, The Netherlands, Belgium, France, United States of America, Denmark, Federal Republic of Germany.

Variable definitions, means and standard deviations:

Variable	Mean	Standard deviation
Life expectancy at birth (LE0)	64.75	10.17
Infant mortality rate (IMR)	54.55	44.98
Child death rate between 1 – 5 (ChDR)	7.17	9.26
Life expectancy at five (LE5)	64.96	6.01
Calories from vegetable products	2166.12	252.71
Calories from animal products	624.38	491.62
Share of fruits and vegetables	0.24	0.093
Share of meat and poultry	0.27	0.122
Share of fish products	0.08	0.078
Share of dairy products and eggs	0.14	0.077
Share of breads and cereals	0.27	0.142
Per capita consumption of medical goods and services (In 1980 US \$ at international prices)	217.76	219.7
Adult literacy rate (%)	75.55	24.8
Mean annual temperature (Celsius)	17.62	4.9
Mean annual precipitation (cm)	85.63	44.8
Gini coefficient	0.45	0.10

tein intake of the mother may actually reduce the risk of infant mortality (Primrose and Higgins 1971), while another determines that children with a predominantly vegetarian diet have lower physical growth than those in a reference non-vegetarian population (Dwyer et al. 1983).

It is clear that the literature is limited not only by its size but also by its scope – since most of these studies are of populations in rich countries. Almost nothing is known about the relationship between diet and mortality in LDCs. This paper attempts to fill these gaps by comparing the diet, mortality, and life expectancy in fifty-one countries, which include a mix of high-income countries, countries of the Eastern Bloc, and LDCs at aggregate levels. A complete list of countries is provided in Table 1 along with variable definitions, means, and standard deviations. The paper is organized as follows: section II describes the data and outlines the methodology, section III presents the results, and section IV concludes the paper.

II. Data and methodology

Food consumption affects the health of individuals in at least two distinct ways. The consumption of any edible good provides nutrients which are always beneficial unless consumed in very large quantities. This effect could be termed

as the *caloric* effect. However, in this paper we are attempting to identify a *compositional* effect, that is, the extent to which the consumption of a particular kind of food as a share of total food consumption affects mortality. We thus need to estimate an equation such as:

$$H = H(N, S, Z, X) \quad (1)$$

where H = health status, N = Vector of nutritional content, S = Vector of $Sh_i = Q_i / \sum_i Q_i$, Q = per capita consumption of goods, Z = vector of endogenous variables that affect health, X = vector of exogenous variables that effect health, and i indexes types of food.

Four indicators of health status representing different mortality regimes are used. The Infant Mortality Rate (IMR), the Child Death Rate between one and five (ChDR), Life expectancy at Birth (LE0), and Life Expectancy at five (LE5). IMR, ChDR and LE0 are obtained from the World Development Report (1981), which culls them from various U.N. sources, while LE5 has been calculated using a conventional formula from data on the other three indicators¹.

Nutritional content is measured by average caloric intake. Other nutrients cannot be included as separate regressors because they tend to be highly correlated with calories in this data. Proteins, for instance, have a Pearson's correlation coefficient of 0.95 with calories because the energy content of proteins is part of the caloric measure. Consequently most of the information which would be derived from including proteins as a separate regressor is captured by calories. The FAO Production Yearbook (1981), which provides the nutritional data, does not detail calories beyond those obtained from all animal (including dairy and fish) products and all vegetable products, which limits their inclusion as regressors to this level of aggregation.

Data on the per capita consumption of foods are from the International Comparisons Project (ICP)², which measures them in units of "International Prices", thus permitting their interpretation as quantities. For instance, five dollars' worth of meat in India measures valued at International Prices measures the same quantity as five dollars of meat in the United States at the same prices. The quantities of food consumed are partitioned into five groups³: fruits and vegetables; meat and poultry; breads and cereals; fish; and dairy products and eggs. These are then divided by total per capita food consumption to get shares of the food groups in total food consumption, which when included as regressors with the nutritional information are intended to capture the compositional effect of diet. However, the share of Breads & Cereals is excluded so as to be able to estimate the regression.

Other explanatory variables included are:

a) The average quantities of medical services consumed, again measured at International Prices from the ICP and treated as endogenous,

¹ $LE5 = (LE0 - 5 \cdot P5 + ((IMR/1000) \cdot 0.2 + (1.6 \cdot (P5 - P1))),$ where $P1 = 1 - (IMR/1000),$ $P5 = P1 \cdot (1 - (4 \cdot (ChDR/1000)) / (1 + (4 - 1.16) \cdot (ChDR/1000)))$.

² Information on these data, which are from 1980, is still in the process of publication, though details on similar data from 1975 for 34 countries are available (Kravis et al. 1982).

³ The definitions of the food groups are limited by the categorizations of the ICP summary data analyzed in this study.

- b) adult literacy rates, from world development reports,
- c) Gini coefficients, to capture distributional effects, gathered from different sources (Jain 1975; Lecaillon et al. 1984),
- d) average annual temperature and average annual precipitation (Pan American Airways 1970).

The last three are treated as exogenous.

Now consider the following functions:

$$H = h(P, Y, X) \quad (2)$$

$$N = n(P, Y, X) \quad (3)$$

$$Q_j = q_j(P, Y, X) \quad (4)$$

where P is a vector of relative prices, Y is per capita GDP, and j indexes all food and non-food commodities including medical goods and services. If we hypothesize the existence of a representative consumer maximizing a utility function with consumption goods and health and nutritional status as its arguments, subject to a budget constraint and a 'health production function' such as (1), then (2–4) could be characterized as demand functions.

Summing over Q_i where i indexes the food groups and then deriving the demand relations for the food shares (Sh_i), we get:

$$Sh_i = Q_i / \sum_i Q_i = q_i(P, Y, X) / \sum_i q_i(P, Y, X) = f_i(P, Y, X) \quad (5)$$

We estimate the log-linear approximations to (1)–(4) (for the consumption of medical goods and services), and (5) including the following relative prices in the price vector P : Breads and Cereals, Meat and Poultry, Fruits and Vegetables, Fish, Milk, Eggs and Cheese, Beverages, Sugar and Spices, Medical Services, Transportation, Education, Clothing, Fuel, Reading Material, and a composite price for other miscellaneous goods. To reiterate, X includes mean annual temperatures and mean annual precipitation, Gini coefficients, and the adult literacy rate.

(1) is estimated by two – stage least – squares using (2)–(5) in the first stage⁴. The results from the 2SLS regressions of (1) are presented in Table 2. The first-stage and OLS estimates are omitted for the sake of brevity, however, the OLS results tend to be similar to the 2SLS with higher levels of significance.

III. The results

Table 2 presents the results of the 2SLS estimates of (1). Beginning with the results for the life-expectancy-at-birth regression, one finds that the caloric effects

⁴ It would be interesting to estimate an equation such as $H = H(N, N_s, Z, X)$, N_s = vector of $N_i / \sum_i N_i$, which would give both the compositional and the caloric effects in nutritional units. However, nutritional data are not readily available at the required level of disaggregation in food categories and require unavailably fine categorizations in the consumption data to be accurately deduced.

Table 2. Diet, mortality and life expectancy – 2SLS estimates
(All variables are in natural logarithms, t – ratios in parentheses)

	LE0	LE5	IMR	ChDR
Intercept	0.792 (0.9)	2.135 (3.3)	14.030 (2.2)	19.967 (2.6)
Vegetable calories	0.244 (2.1)	0.169 (1.9)	-0.619 (0.7)	-0.974 (0.9)
Animal calories	0.091 (3.1)	0.061 (2.7)	-0.596 (2.7)	-0.876 (3.2)
Share fruits and vegetables	-0.021 (0.5)	0.023 (0.7)	0.075 (0.2)	0.081 (0.2)
Share meat and poultry	-0.069 (2.8)	-0.041 (2.2)	0.338 (1.8)	0.423 (1.9)
Share fish	-0.001 (0.3)	-0.009 (0.6)	-0.342 (2.1)	-0.292 (1.5)
Share dairy and egg products	-0.012 (0.3)	0.003 (0.1)	0.114 (0.4)	0.155 (0.1)
Medical goods and services	0.049 (2.7)	0.036 (2.5)	-0.238 (1.8)	-0.375 (2.3)
Literacy	0.123 (4.7)	0.024 (1.2)	-0.320 (1.6)	-0.716 (3.0)
Mean precipitation	0.009 (0.7)	1.113 (1.1)	-0.122 (1.2)	-0.142 (1.2)
Mean temperature	0.040 (1.3)	0.012 (0.8)	0.365 (1.5)	0.018 (0.1)
Gini coefficient	0.074 (1.2)	0.063 (1.4)	0.283 (0.6)	0.543 (1.0)
F – Ratio	53.7	28.1	33.7	49.29
R – Squared	0.94	0.89	0.90	0.93

from both vegetable and animal products are positive and significant⁵. Although animal calories are more significantly associated with LE0 than vegetable calories, vegetable calories yield a coefficient of 0.24 while animal calories⁶ have one of only 0.09. But given the caloric effect, the compositional variables seem to reveal a dietary pattern which indicates that an increase in the share of meats and poultry reduces LE0 at a 1% level of significance. None of the other compositional variables are significant at acceptable levels. Among the other explanatory variables, the significant relationships are with the consumption of medical goods and services, and literacy – both of which are strongly positively correlated with LE0.

However, LE0 reflects expectations over very different ages of mortality risk. The health status of infants and children below age five is affected by different causes than that of older children and adults. To sort out these regimes, it is revealing to look at the regressions for LE5, IMR and ChDR.

Life expectancies after five are again improved by both caloric effects, with animal calories having greater significance but with smaller coefficients than vegetable calories. However, the compositional effects approximate the result of the study of the Seventh-Day Adventists. An increase in the share of meat and poultry consumption reduces LE5 at a 5% level of significance. None of the other compositional effects are significant, although fruits and vegetables have a positive coefficient and eggs and dairy products, and fish have low positive and

⁵ Both consumption and mortality are measured in 1980, but life expectancy reflects the consumption from previous years as well. Hence, an assumption implicit in this regression is that average dietary patterns have not changed drastically in the last few decades.

⁶ While this specification forces the caloric effect to be monotonic, the inclusion of quadratic terms in the caloric variables was strongly rejected by an F-test, as were the inclusion of religion dummies to capture the non-dietary effects of religion on health.

negative coefficients, respectively. While it is always possible that these are spurious correlations, it is also possible that the non-nutritive liabilities of meat consumption are adverse enough that they are reflected in national mortality statistics at later ages. Knowing the strong epidemiologic evidence of the effect of meat consumption on cardio-vascular mortality, these estimates, if true, lend credence to Preston's contention that there is "consistent and compelling evidence" (Preston 1976) that a large portion of mortality variations and declines are due to cardio-vascular disease.

None of the other variables are significant, with the exception of the consumption of medical goods and services.

The results for IMR clearly reflect a different mortality regime. Calories from vegetable products are now entirely insignificant, while those from animals are significant at the 1% level. This is probably more indicative of the caloric variable's role as a proxy. Infants and children require more intensive infusions of protein, iron, and calcium for optimal health; animal calories are strongly correlated with all three, as the most common sources for these nutrients are animal (which, to reemphasize, include fish and dairy products). However, the compositional variables may be telling a story about where these nutrients ought to be coming from. The share of meat and poultry consumption increases infant mortality rates at a 10% level of significance, while fish consumption reduces them at a 5% level of significance. None of the other regressors are significant, with the exception of medical commodities and adult literacy.

Child death rates between one and five have similar associations as IMR at slightly different levels of significance, with adult literacy proving to have a very strong beneficial effect in this age group.

What all this seems to be saying is that the consumption of non-vegetarian foods may provide additional proteins and minerals essential to the health of an infant and its mother, who might be better off if they derived these nutrients from fish rather than meat and poultry. It is, however, possible, though unclear, that populations with predominantly vegetarian diets may be worse off with respect to mortality before five.

IV. Conclusion

These results indicate that there may be some truth to the proposition that some variation in the health status of populations is caused by variations in diet. Consistent with the conclusions of more carefully controlled epidemiologic studies, it is possible that a more vegetation diet at the national level is beneficial to national life expectancy after early childhood. So dietary variation among nations may be important enough that it is affecting national mortality levels; such a relation is suggested by these data despite all the errors to which they are subject.

However, before the age of five, it appears that nutrients more prevalent in animal products are important, and it is conceivable that it might be more beneficial when these are obtained from fish rather than meat and poultry.

It is, nevertheless, premature to claim causal relationships from any of the observed associations. What these data show, more than anything else, is that the

question is of interest and deserving of further analysis. The issue can never be settled without longitudinal studies at the individual level. The lack of such studies for both developed countries and LDCs clearly shows the need for more attention in this area, but efforts are hampered by a dearth of appropriate data. These studies ideally require information on the dietary habits of a sample of individuals who are then tracked for their morbidity and mortality history over a number of years.

If vegetarian diets indeed prove to be inherently more beneficial than diets with meat, then this might provide some guidelines for food subsidy programs. It would substantiate the traditional argument encouraging the consumption of vegetarian foods, that the resources required to produce a caloric equivalent of meat are far greater than those required to produce the same calories from vegetables. However, a causal relationship between diet and health might also indicate that the recent attention paid to the effects of nutrition on health (Behrman and Deolalikar 1988) may not provide the entire story, as diet may have an effect on health independent of its nutritive content.

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