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Socio-Economic Correlates of Life Expectancy at Birth
-The Case of Developing Countries-

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I. Introduction

One of the major goals of every human society has been to reduce morbidity and mortality of its population to the maximum feasible extent. Despite efforts directed towards achieving the above goal, not all people enjoy a long life:mortality differentials exist within, as well as, between countries.

The reasons for these mortality differentials well reside in the fact that social groups that exist in a society or between societies form differential background against which the biological processes that lead to illness and death, operate. Thus, although at the individual level, death is determined biologically, at the collective level this biological concept is to be articulated within the social context. In other words, in the process of searching for the determinants of mortality, attention must be paid to socio-economic and environmental characteristics that directly affect an individual's health and are often found to be differentially distributed across social groups. The idea does not negate the existence of biological determinants but reasons that these determinants are themselves subject to transformation under varying social causes.

The decline of mortality in the developing countries since 1950 led to the belief that the influence of socio-economic factors on mortality had been brought to the

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level of insignificance and that the gap between the mortality levels of the developing and developed countries could be reduced substantially by the socialization of health services. The idea that followed was that the health was merely matter of medicine-an optimistic prediction that was not confirmed by the subsequent course of events. Life expectancy has lengthened but the social differences remained.

For example, Behm and Rosero (1977) in their study of mortality in the first two years of life for Ecuador found a 48 percent higher mortality risk in rural areas then in urban areas. A greater risk of mortality for rural population compared to their urban counterparts has also been reported by several other researchers (Ortega and Rincon, 1975 ; Gaisie, 1976 ; Rizgalla, 1977 ; World Health Organization, 1976). The larger urban centers are usually the centers of political and economic power and a great part of the resources and social services of the public sector, including medical services, is concentrated in them. Benefits are distributed unequally among the social classes : rural populations who need more medical care, receive less care indeed.

Carvalho (1977) observed in Brazil that the expectation of life of the lower-income group is about 12 years less than for the higher-income group. Several other researchers also reported negative relationship between income and mortality (Duleep, 1986 ; Araki and Murata, 1986 ; Jain, 1984 ; Lerner and Stutz, 1977). Winkelstein(1972) observed in his study of stomach cancer data in Buffalo that the male death rate was more than three times higher in the lowest economic level census tracts than in the highest level. Education has also been found to have a depressant effect on mortality (Preston, 1978 ; Rizgalla, 1977 ; Arriaga and Hobbs, 1982 ; Trussel and Hammerslough, 1983 ; Amin, 1988 ; Gajanayake, 1988). Households having toilet facilities were found to experience lower infant mortality rates (Alam and Cleland, 1981 ; Conning and Marckwardt, 1982 ; Chidambaram et al., 1985).

The studies cited above, although in no way exhaustive, show the widespread concern of the researchers about the socio-economic determinants of mortality. The importance derives primarily from the policy point of view. The fact that the developing countries do differ considerably within themselves in mortality levels, as well as in socio-economic development provides reasons for studying mortality in these countries.

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Moreover, the relevant data are available for many developing countries. The rationale guiding this research is that the socio-economic, health, and environmental factors do exert independent as well as joint influences to change the mortality level. The aim of this paper is to identify these factors and their relative contribution towards the variations in mortality level across a number of developing countries for which the relevant data are available.

II. Methods and Findings

Data and Variables

The data analyzed in this paper have been taken from Family Planning and Child Survival : 100 Developing Countries (Ross et. al., 1988) compiled by the Center for Population and Family Health, Columbia University, New York, as well as from the 1987 World Population Data Sheet (Population Reference Bureau, 1987).

The dependent variable is the life expectancy at birth(LEB), defined as the average number of years to be lived by a cohort subjected from beginning to end to the series of probabilities of dying. The LEB has been extensively used as a convenient summary measure of mortality in a population. This single index is readily interpretable and condenses the information in a full mortality schedule considerably. As such, its use for summarizing mortality levels has been advocated in recent years (Pollard, 1988). The explanatory variables considered in the study are the population per square kilometer (DENSITY), dependency ratio, i. e., the ratio of the dependent population (aged 0~4, and 65+) to the economically active population (aged 15~64) (DEPRA-TIO), per capita daily calories (CALORIE), male and female literacy rates i.e., percent of population 15 years old and over who can read and write (MALELIT, FEMALLIT), per capita gross national product(GNP), per capita energy use (ENERGY), percent of the total population living in urban areas (URBAN), percent of population with access to safe water supply(SWATER), population per hospital bed (PPHBED), population per physician (PPPHYS), number of oral rehydration solution packets used per 100 diarrhea episodes (ORALSOL), and family planning program effort score based on four components : policy and stage setting, service, record keeping and eva-

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luation, availability and accessibility (FPSCORE). Ross et al. (1988) and Population Reference Bureau(1987) discussed these variables in more details.

The choice of the explanatory variables has been guided by their expected relationships with LEB as well as by data availability. The final analysis was based on 50 observations for which values were available for all fourteen variables.

Table 1 presents the means and standard deviations for the dependent as well as for the explanatory variables. The LEB has an average value of 56 years varying

Table 1. Means and Standard Deviations for Life Expectancy at Birth, and the Thirteen Explanatory Variables : 50 Developing Countries.

Variable Description (Name)	Mean	Standard Deviation
Life Expectancy at Birth(LEB)	55.980	8.639
Population Density(DENSITY)	147.930	376.970
Dependency Ratio(DEPRATIO)	87.500	12.173
Per Capita Daily Calories(CALORIE)	2,302.980	392.486
Male Literacy Rate(MALELIT)	68.040	20.480
Female Literacy Rate(FEMALLIT)	51.440	26.815
Gross National Product(GNP)	796.304	895.908
Per Capita Energy Use(ENERGY)	12.149	21.989
Percent of the Total Population Living in Urban Areas(URBAN)	34.280	17.838
Percent of Population with Access to Safe Water Supply(SWATER)	46.240	23.723
Population per Hospital Bed(PPHBED)	922.180	1,041.986
Population per Physician(PPPHYS)	11,390.600	11,718.343
Number of Oral Rehydration Solution Packets Used per 100 Diarrhea Episodes(ORALSOL)	31.900	32.782
Family Planning Program Effort Score(FPSCORE)	35.142	25.473

from lows of 35 years in Sierra Leone, and 43 years in both Central African Republic, and Chad to highs of 70 in both Sri Lanka, and Trinidad and Tobago. We expect positive relationships between the GNP, ENERGY, URBAN, FEMALLIT, MALELIT, SWATER, CALORIE, ORALSOL, and PPSCORE variables and the LEB while we hypothesize negative relationships between the DENSITY, DEPRATIO, PHBED, and PPPHYS variables and the LEB.

Among the explanatory variables, GNP and ENERGY variables are highly correlated (0.95), and so are the variables male literacy rate, and female literacy rate(0.88) (Correlation matrix not shown here). To avoid the problem of multicollinearity which is associated with unstable estimated regression coefficients, the variables energy and male literacy rate have not been included in the regression model.

Since an examination of only the simple correlations might fail to take into account the relationship of an independent variable with all other independent variable(Lewis- Beck, 1980) each independent variable (excluding those deleted before) has been regressed on all the other independent variables to see whether there can be any further problem of multicollinearity. None of the R^2s from these equations is near unity, indicating that multicollinearity is no longer a problem for the slope estimates in the multiple regression model.

Further analysis has, therefore, been based on the variables LEB(Response, Y), DENSITY(X_1), DEPRATIO(X_2), CALORIE(X_3), FEMALLIT(X_4), GNP(X_5), URBAN(X_6), SWATER(X_7), PPHBED(X_8), PPPHYS(X_9), ORALSOL(X_{10}), and FPSCORE(X_{11}).

The results of fitting the model

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11}$$

(where β's are the regression coefficients) connecting the LEB and the eleven explanatory variables, are shown in table 2.

The table shows that some of the t's are significant and that the value of R^2 is quite large(0.79). This does not, however, imply a good fit (Anscombe, 1973), nor that the model assumptions have not been violated (Chatterjee, and Price, 1977). To this end, the standardized residuals have been plotted against the fitted values. The graph did not show any systematic pattern of variation and almost all the standardized residuals fell beteen +2 and -2. The residuals are next plotted against the

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Table 2. Unstandardized and Standardized Coefficients of Regression of Life Expectancy at Birth on the Eleven Explanatory Variables.

Variables	Unstandardized Coefficients	T Value	PR>T	Standardized Coefficients
INTERCEPT	26.51745904	2.51	0.0171	—
DENSITY(X_1)	0.00061772	0.33	0.7467	0.0269538
DEPRATIO(X_2)	0.05154709	0.68	0.4984	0.0726335
CALORIE(X_3)	0.00550855	2.24	0.0320	0.2502614
FEMALLIT(X_4)	0.10696374	3.02	0.0048	0.3320096
GNP(X_5)	0.00026470	0.25	0.8059	0.0274507
URBAN(X_6)	0.02665599	0.44	0.6608	0.0550396
SWATER(X_7)	0.07226935	1.52	0.1385	0.1984540
PPHBED(X_8)	−0.0000480	−0.06	0.9535	−0.0057894
PPPHYS(X_9)	−0.00011218	−1.02	0.3134	−0.1520576
ORALSOL(X_{10})	0.00014258	0.01	0.9948	0.0005407
FPSCORE(X_{11})	0.09577522	2.32	0.0267	0.2824032
N=50		R^2=0.793173		S=4.47424

explanatory variables. These plots also did not show any trends. Neither did they detect the presence of any outliers. Consequently, there is no evidence for model misspecification or for serious violations of model assumptions.

The high value of R^2 indicates that fluctuations in the eleven explanatory variables are responsible for over 79 percent of the variation in the life expectancy at birth. This reflects the adequacy of the explanatory variables as well as the accuracy of the equation. The F test of the model has also shown a very high significance of the equation. The fitted equation is

LIFE EXPECTANCY AT BIRTH=26.51745904+0.00061772DENSITY

+0.05154709DEPRATIO+0.00550855CALORIE

+0.10696374FEMALLIT +0.00026470GNP

$$+0.02665599URBAN+0.07226935SWATER$$
$$-0.000048PPHBED-0.00011218PPPHYS$$
$$+0.00014258ORALSOL+0.09577522FPSCORE.$$

Out of the eleven explanatory variables, only three -- female literacy rate, family planning program effort, and per capital daily carlories --- are significantly related to the life expectancy at birth. The slope estimates show that an increase of per capita daily calories by 100 is associated with over 5 years increase in the life expectancy at birth, an increase of female literacy rate by ten percent is associated with an increase of 1.1 years in the life expectancy at birth, and an increase in the family planning program score by 10 is associated with an increase of almost one year in the life expectancy at birth, in each case holding the linear effects of all other variables constant. These results do not contradict our expectations.

In order to evaluate the relative importance of the explanatory variables in determining the life expectancy at birth, the standardized coefficients are examined (table 2). The table shows that the female literacy rate has the highest contribution in determining the life expectancy at birth. A one standard deviation increase in the female literacy rate is associated with over .33 standard deviation increase in the life expectancy at birth, on the average, with all other explanatory variables held constant. Family planning program effort, and per capita daily calories rank second and third respectively in determining the life expectancy at birth. A one standard deviiation increases in the family planning program score is associated, on the average, with .28 standard deviation increase in the life expectancy at birth, and a one standard deviation increase in the per capita daily calories does induce, on the average, a .25 standard deviation increase in the life expectancy at birth. We conclude that the impact of female literacy rate, as measured in standard deviation units, is the largest in raising the life expectancy at birth.

III. Summary and Conclusions

Although the recent decades have witnessed marked declines in mortality rates in the developing countries, they are still at higher levels than in the developed countries.

In addition, social differences of mortality did not disappear. Indeed class differentials of mortality have risen in some cases (Antonovsky, 1981). Although at the individual level disease and subsequent death are principally biological, at the collective level socio-economic factors appear as more dominant determinants of mortality. It is, therefore, important that these factors be analyzed so as to identify their relative weights necessary for ascertaining prioriting while formulating policies to improve the people's level of living.

In this paper the cross-national variation in life expectancy at birth has been analyzed using multiple regression technique with national data for 50 developing countries. The explanatory variables used are population density, dependency ratio, per capita daily calories, female literacy rate, gross national product, percent of population living in urban areas, percent of population with access to safe water supply, population per hospital bed, population per physician, number of oral rehydration solution packets used per 100 diarrhea episodes, and family planning program effort score based on four components : policy and stage setting, service, record keeping and evaluation, and availability and accessibility.

The analysis shows that out of eleven explanatory variables only three -- female literacy rate, family planning program effort, and per capita daily calories -- are significantly related to the life expectancy at birth. An examination of the unstandardized coefficients shows that an increase of per capita daily calories by 100, an increase of female literacy rate by ten percent, and increase of family planning program effort score by 10 are associated with increases respectively of .5 years, 1.1 years, and almost one year in the life expectancy at birth. The standardized coefficients have been examined to assess the relative importance of the explanatory variables in determining the life expectancy at birth. The female literacy rate has the highest impact on the life expectancy followed by family planning program effort, and per capita daily calories in that order.

This study has a number of policy implications. The high female literacy rate is the most important contributor to the increase in the expectation of life, probably because of its depressant effect on the infant mortality rate -- the rate which is an integral part of the life expectancy at birth. High rates of infant mortality have been

found to be very important reason for lower life expectancy in Brazil(Imof, 1987). It is highly likely that the low female literacy rate contributes to increase the infant mortality rate, that, in turn, depresses the life expectancy at birth. Education, especially maternal education has been found to be one of the most significant factors that depresses infant mortality (Preston 1978 ; Behm, 1981 ; Arriaga and Hobbs, 1982 ; Trussel and Hammerslough, 1983 ; Jain, 1984 ; Hobcraft et al., 1984 ; Chidambaram et at., 1985 ; Cramer, 1987 ; Amin, 1988 ; Gajanayake, 1988). Caldwell (1977) found that maternal education was the single best predictor of infant mortality in Nigeria. Increasing the level of female literacy may be a prerequisite for the reduction of infant mortality to a significant level. Schooling the people, especially women, in respect of childcare, hygiene, and first aid, should substantially reduce infant mortality, which will eventually boost the life expectancy at birth. The next most important contributor to the life expectancy at birth is the family planning program effort. It is expected that the higher is the program effort, the lower is the fertility. The adverse consequences of excessively high fertility on child health and mortality seldom need to be established. Wray(1971) accumulated a good deal of evidence on how large family size is associated with low per capita expenditure on food, treatment and maternal care, which, in turn, leads to high infant mortality, that, as we mentioned before, contributes to depress the life expectancy at birth.

The other variable significantly related to the expectation of life is the per capita daily calories. Calorie supply measures not only the nutritional status but also gives a broad outline of differences in food availability. In the developing countries large segment of population are poverty-stricken and the daily per capita calorie supply as percent of requirement mostly varies between 80 and 100. The prospect of increasing the expectation of life in these countries depends on the egalitarian distribution of the benefits of socio-economic development among the population. Hernandez(1974) observed in has Mexican data analysis that the explosive economic growth that occurred during the period 1958-1971 favoured only an already previleged sector of the population who began to consume greater quantities of meat, milk, and other products, while the agricultural working class remained more or less in the same situation. Thus, lack of adequate calorie consumption by a significant portion of the population is

the result of poverty which is itself the product mainly of the non-egalitarian distribution of the benefits of socio-economic development. To ensure that the economic growth goes hand in hand with an even distribution of its benefits so that all segments of population receive at least adequate foods should be the major aim of all government policies. The International Labour Organization (Behm, 1981) estimated that in 1973 about 43 percent of the Latin American population (approximately 110 million) lived in "serious conditions of poverty" and about 35 percent could not afford even a minimum balanced diet. These are pointers to the non-egalitarian social policies that produce differences in the levels of living of various social sectors which, in turn, influence the occurrence of sickness and death. There is, therefore, a need in the developing countries to express development goals in terms of progressive reduction in infant mortality through maternal education, and by limiting family size through family planning efforts, and eventual elimination of malnutrition from the proverty-stricken people, to achieve the goal of bringing down the mortality level at its minimun.

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Socio-Economic Correlates of Life Expectancy at Birth
—The Case of Developing Countries—

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In this paper, the effects of socio-economic and health services related variables on life expectancy at birth have been examined. National data for 50 developing countries obtained from the "Family Planning and Child Survival : 100 Developing Countries" compiled by the Center for Population and Family Health, Columbia University, and from the 1987 World Population Data Sheet, have been used in this analysis. The multiple regression technique has been employed to identify the variables significantly associated with the life expectancy at birth.

The thirteen variables that were chosen initially as explanatory variables are energy consumption per capita, male literacy rate, famale literacy rate, per capita gross national product, population density, dependency ratio, per capita daily calories, percent of total population living in urban areas, percent of population with access to safe water supply, population per hospital bed, population per physician, number of oral rehydration solution packets used per 100 diarrhea episodes, and family planning program effort score. Among these the first two variables were dropped from the analysis as they posed threats of multicollinearity problem. The rest eleven variables were considered finally for inclusion in the regression model. Only female literacy rate, family planning program effort, and per capita daily calories are significantly associated with life expectancy at birth. The female literacy rate has the largest contribution in lowering the life expectancy at birth followed by family planning program effort, and per capita daily calories. Policy implications are discussed.

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