

## Determinants of Life Expectancy: A Cross - Country Analysis

K. Yavari \*

M. Mehrnoosh

### Abstract

This paper analyzes the effects of socio-economic factors on life expectancy. Using multiple regression analysis, the paper shows that there is a positive strong correlation between life expectancy as an independent variable and per capita income, health expenditures, literacy rate and daily calorie intake. Also, it shows that there is a negative strong correlation between life expectancy and number of people per doctor. Using dummy variables, the paper shows that there exist some unrecognized or recognized but not quantifiable factors which affect life expectancy in African countries. Finally the paper concludes that human development requires an increasing investment in the socio-economic sectors.

**Keywords:** Life Expectancy, Cross-Country, Social Indicators

### I- Introduction

"Wealth is evidently not the good we are seeking, for it is merely useful and for the sake of some- thing else." Aristotle

People are the real wealth of a nation. The basic objective of development is to create an enabling environment for people to enjoy long, healthy and

- 
- 1- Corresponding Author- Associate Professor of Economics, TMU, and Vice President, Research, ITSIR.
  - 2- Ph.D Student, Al-Zahra University, and Director of Marketing and Market Research, ITSIR.

creative lives. This may appear to be a simple truth. But it is often forgotten in the immediate concern with the accumulation of commodities and financial wealth. Life expectancy is the key indicator of human development. It is influenced by both physical magnitudes such as income and other human development indicators such as education, health and nutrition. A satisfactory level of income is necessary to ensure high level of life expectancy. However this is not a sufficient condition to ensure desirable level of life expectancy. Many fast-growing developing countries are discovering that their high GNP growth rates have failed to reduce the socioeconomic deprivation of substantial sections of their population. At the same time, some low-income countries have demonstrated that it is possible to achieve high levels of human development if they skillfully use the available means to expand basic human capabilities.

The purpose of this paper is to show that the way income is spent by policy makers is more significant in influencing life expectancy than income per se. This purpose seems very simple. However it has remarkable policy implications for policy makers especially in developing countries. The rest of the paper consists of four sections. In section II, we just review the literature, and compare different models. Section III introduces a new model based on reasonable justifications and the observed facts. Section IV provides the empirical results and the policy implications induced by the estimated coefficients. Finally, section V gives a summary and conclusion.

## **II- Review of Literature**

Before reviewing the cross-sectional studies of the determinants of life expectancy, it is necessary to give two warnings. Firstly, there is a very little specific theory on the socioeconomic determinants of life expectancy as opposed to biological theories about causes of it. Secondly, the data on life-expectancy are not routinely generated by vital registration systems in developing countries.

The lack of theory pertaining to the socioeconomic determinants of life expectancy manifests itself in the literature by a lack of agreement on what variables should be used in empirical estimation. The specification of the functions to be reviewed here varies wild. The only consensus is that income is positively related to life expectancy. Beyond this, there has been considerable variation in the functional relationship assumed in the studies reviewed.

Samuel Preston (1976) contributed a number of studies which attempt to evaluate the relative importance of income and variations in income in determining the levels and fluctuations in the level of life expectancy. His basic conclusion is that at any point in time, life expectancy and income per capita are very closely related, but that over time changes in income have been rather unimportant since World War II in determining changes in life expectancy.

Isemnam (1979) used simple specification of the relationship between life expectancy and per capita income. The estimated regression found by Isemnam was:

$$\ln(e) = 3.263 + 0.123\ln(y) \quad R^2 = 0.65$$

(39.47)      (10.19)

Income has the expected sign and is statistically significant.

Susan Cochrane (1980) analyzed comparatively the relationship between income and life expectancy. Table.1 summarizes the results she got for the different periods. Examining Table 1 we see that between the 1930s and 1940s and 1960s and 1970s the amount of variation in life expectancy explained by income levels (as measured by  $R^2$ ) has fallen. Cochrane generalized Preston's statement (1976) saying that between the 1930s and the 1970s there had not been any progressive disassociation between income and life expectancy. She added that there has certainly been no increasing association between the variables in this sense.

**Table 1: Estimation of  $\ln(e) = a + b\ln(y)$  for Various Time Periods**

Date of sample	a	b(t)	$R^2$
1930	2.69	.213(12.45)	.81
1940	2.47	.242(10.68)	.79
1963	3.17	.153(11.58)	.70
1970	3.06	.158(17.06)	.71
1975	3.26	.123(10.19)	.65

Source: World Bank Working Paper No. 405 1980

Contrary to the theory that income has become more important, there appears to have been a very substantial reduction in the elasticity of life



expectancy with respect to income as measured by  $b$ . Table .1 indicates that the elasticities have declined from over 0.2 in the 1930s and 1940s to less than 0.16 in the 1960s and 1970s. Table.1 basically means that in the more recent periods a given percentage increases in life expectancy came to be associated with substantially large percentage increases in income. This could be interpreted as a manifestation of diminishing returns.

Many researchers tried to explain the variation of life expectancy by incorporating some other socioeconomic variables, besides per capita income. Som (1981) has presented correlation coefficients for a number of socioeconomic and health indicators for life expectancy at birth using data from 70 developing and 25 developed countries in the mid-1970s. He found that there is high correlation between literacy rate and life expectancy. Caloric consumption was also significant in this sense.

Another study of the relationship between life expectancy, socioeconomic variables, and health inputs has been completed as part of the World Bank's research on basic needs. In a study of 86 developing countries in the mid-1970s Norman Hicks (1979) found the correlation of variables with life expectancy quite significant. Hick's results which were restricted to developing countries were in sharp contrast to those of Som with respect to calories per capita and income per capita. Income per capita was much more important in Som's sample, which included developed and developing countries (0.92 versus 0.52); while in the case of calories per capita Som found them to be much less important than did Hicks (0.26 versus .71). These differences may well reflect the fact that in developing countries income is less appropriate measure than it is in developed countries since fewer goods consumed by the household pass through the market in the former.

In his 1976 NBER paper, Preston estimated regression equations for life expectancy in 1970 using in addition to per capita income, daily caloric consumption and literacy. The result of his regression is as follows (t values are given in parentheses):

$$e = -17.1464 + 4.2488 \text{Ln}(y) + 0.2086 (\text{lit}) + 0.317 \text{Ln}(\text{cal})$$

(6.51)            (9.84)            (0.23)

$R^2 = 0.86$      $R^2 = 0.858$              $N = 120$

Where:

$e$  = life expectancy

$\ln(y)$  = log of per capita income

$\text{lit}$  = literacy rate

$\ln(\text{cal})$  = log of caloric consumption

Preston's results show that all variables have the expected sign, but that the coefficient of daily caloric intake (measured as a deviation from 1500) does not approach statistical significance. But the log of income and literacy are highly significant in both periods. In terms of their relative importance literacy has a higher elasticity than income. The coefficients indicate that a percent increase in the proportion literature is associated with a gain in life expectancy of approximately two years and that a 10 percent gain in national income by itself increases life expectancy by approximately one-half-year (Preston, 1986, p. 19)

Isenman (1979) has estimated an equation similar to Preston's but using the natural log of literacy and life expectancy. The results are as follows:

$$\ln(e) = 2.83 + 0.065\ln(y) + 0.199\ln(\text{lit}) \quad R^2 = 0.88$$

(45.3)    (7.27)    (10.69)

He concluded that literacy has a higher t-value than income and the R for life expectancy increases from 0.65 to 0.88 with its inclusion. These two different studies show that literacy is the most important variable in the multivariate analysis of life expectancy which includes measures of per capita income.

### III. A New Specification

Development economists often refer to two critical problems accompanying economic analysis of the human aspects of development. The first problem relates to the determination of the set of economic variables which are relevant in explaining the variations of some other economic variables. Although this problem exists in all economic development analyses it becomes more complicated in analyzing human aspects of economic development.

The second problem relates to the choice of functional form. This problem is not as critical as the first one. However, it manifests itself once the set of



relevant explanatory variables determined. I should refer to a third problem which is empirically critical in the analysis of human indicators in a cross-sectional framework. The third problem is the lack of data especially regarding human indicators in developing countries. All these problems together with many others have resulted in insufficient empirical work on human development in comparison with other branches of economics.

In this section we analyze the effects of per capita income and some human indicators such as nutrition, education and health on the variations of life expectancy in a cross-sectional framework. The reason that I have chosen cross-sectional framework is that life expectancy as the key indicator of human development shows very high degree of persistence over time. In other words it takes a long time to change the level of life expectancy within a country. However, it varies very much across countries. Therefore cross-sectional analysis of life expectancy is very informative. Panel data analysis of life expectancy might seem more useful. However, due to the data problem I mentioned earlier, this type of analysis is not tractable at least for a big number of developing countries.

I got all the data necessary for this cross-sectional analysis of life expectancy from World Bank Publications. 89 countries have been chosen, 33 from Africa, 17 from Asia, 19 from Latin America, and 20 from the rest of the world including European countries, United States and Canada. I will later explain the specific way in which data have been collected. Our specific model is the following:

$$LE = B_1 + B_2(PCGNP) + B_3(HE) + B_4(ALR) + B_5(DCS) + B_6(TPPD) + u \quad (1)$$

Where:

LE = life expectancy at birth

PCGNP = per capita GNP

HE = health expenditure (% of GNP)

ALR = adult literacy rate

DCS = daily calorie supply of food (% of requirement)

TPPD = thousands of people per doctor

U = stochastic term

This model is perfectly linear. We will see in section IV that this model provides remarkable empirical results.

I should emphasize that the linear specification here does not imply that all nonlinear specifications have been neglected. After testing all types of nonlinear specifications, I found that a perfect linearity approximated reality better than any other functional form. In addition, perfect linearity makes the economic interpretation of empirical results much more convenient.

Although there are not perfect theoretical justifications for all included explanatory variables, economic literature indicates the influence of education, nutrition and health on life expectancy of people. To enjoy long healthy and creative lives people do need a satisfactory method of nutrition. As Human Development Report (1990) shows rapid advances in health and nutrition are highly correlated with life expectancy. It is not needed to mention that education is really important for any society in this modern world. Educated people have more information about factors which affect their lives. Our goal is to find the best representatives of these human indicators as explanatory variables which affect life expectancy subject to the restrictions imposed on our analyses by data.

As I said earlier per capita income is the most widely discussed socioeconomic determinant of life expectancy, primarily because it is considered a summary of the ability of an economy to meet the needs of its citizens. I have chosen health expenditure (% of GNP), adult literacy rate and daily calorie supply of food (% of requirement) as the best representatives of health education and nutrition respectively. Thousands of people per doctor can be a representative of the effects of both health and population distribution in terms of medical facilities.

As I said earlier, data for human development indicators are not reported regularly. For this reason I have chosen year 1986 for the economic variables. Due to the lack of data in 1986 for two explanatory variables; adult literacy rate and thousands of people per doctor, I have alternatively used 1984 and 1985 data for thousands of people per doctor and adult literacy rate respectively. This specific choice of data is indeed reasonable because the number of doctors in 1984 has definitely an effect on health in 1986. Similarly adult literacy rate in 1985 is not irrelevant approximation. In addition and more importantly, these two explanatory variables will not change significantly during one or two years and show high degree of persistence over time. Finally I should say that I did not have any specific purpose in choosing different number of countries from

different continents. I have tried to include all countries in the world. But lack of data was the only restriction on this choice.

#### IV. Empirical Results

Table 2 shows the empirical results provided by basic model (1)

**Table 2: Estimation of Model (1)**

Independent Variables	Estimated Coefficients	Estimated Elasticities	Standard Errors of Elasticities	t-values
PCGNP	0.30	0.017	0.007	2.4
HE	0.50	0.019	0.01	1.7
ALR	0.20	0.22	0.02	9.0
DCS	0.14	0.24	0.05	4.4
TPPD	-0.16	-0.02	0.005	3.8
Constant	32.4			9.8

$R^2 = 0.88$

\* scaled by 1000

Table 2 shows that all the coefficients of model (1) have expected signs. It is clear that per capita income is still necessary to obtain a satisfactory level of life expectancy. A very important message of Table 2 is that the elasticity of life expectancy with respect to income is very consistent with conclusions of earlier studies (Table 1) that per capita income has a declining positive effect on life expectancy over time.

Table 2 also shows that adult literacy rate has more significant influence on the level of life expectancy than any other socioeconomic variable. This result is consistent with previous empirical results obtained regarding the significance of education effect on the level of life expectancy. The implication is that economic policies towards raising the level of education horizontally and vertically within developing countries are very promising in raising standard living of people. As expected daily calorie supply of food is highly correlated with the level of life expectancy. More interestingly Table 2 shows that for a given number of doctors population growth has negative effect on the level of life expectancy.



Although the message of Table 2 is very simple it provides outstanding policy implications for policy makers especially in developing countries. A very intuitive policy implication is that with only moderate per capita income, an active policy towards satisfactory distribution pattern of medical facilities, improvement in education and population growth control can ensure a satisfactory level of life expectancy. Quite contrary undesirable economic policies even with high per capita income might lead to reduction of social welfare and the level of life expectancy. Some moderate income countries such as Taiwan and Korea pursued desirable policies towards health, education and nutrition and got satisfactory results. Whereas many high income countries have low levels of life expectancy. This fact shows that high per capita income is necessary but not sufficient to ensure high level of life expectancy.

## V. Regional Analysis

There are certainly immeasurable factors which affect the level of life expectancy across countries. Customs, religion, colour, race, political environment and many other facts differ from region to region and from continent to continent. Western countries have their own customs which certainly differ from Asian's customs. For example, in addition to differences in quality and quantity of food consumed by different nations there are also differences between the times that they consume. For example, people in some Asian countries like to have dinner at 10 pm which might not be good for their health. There are also many other differences between different nations that will influence the level of life expectancy across countries.

Using dummy variables we can test for different versions of regional analysis. After testing different versions of regional models the only version that I found statistically very significant is the following:

$$LE = B_1 + B_2(PCGNP) + B_3(HE) + B_4(ALR) + B_5(DCS) + B_6(TPPD) + B_7(D_A) + u \quad (2)$$

Where  $D_A$  indicates intercept dummy for Africa and it is meant that regardless of the socio-economic factors, living in Africa or in the rest of the world does matter by itself. Estimated coefficients and the other relevant statistics are shown in Table 3.

**Table.3 Estimation of Model (3)**

Explanatory Variables	Estimated Coefficients	t-values	Estimated Elasticities	Standard Errors of Elasticities
PCGNP	0.28*	2.3	0.016	0.007
HE	0.5	2.0	0.019	0.009
ALR	0.16	7.5	0.17	0.20
DCS	0.13	4.5	0.22	0.05
TPPD	-0.12	-3.2	-0.016	0.005
D <sub>A</sub>	-3.9	-4.2	-0.02	0.005
Constant	37	11.5		

$R^2 = 0.90$

\* Scaled by 1000

Economic interpretation of Table .3 is similar to that of Table 2. Table 3 shows that the coefficient of dummy variable  $D_A$  is very significant. This implies that living in Africa or in the rest of the world really matters in terms of the effect on the level of life expectancy.

There is a second version of regional analysis which might be interesting. It might be appropriate to consider a separate model for each continent in the world. Table .4 shows separate estimated models for Africa, Asia, Latin America and the rest of the world including European countries United States and Canada.

**Table 4: Estimated Models for Africa, Asia, Latin America and the Rest of the World (T-values are in parentheses)**

Coefficients of Independent Variables							
Regions	Constant	PCGNP	HE	ALR	DCS	TPPD	SSR
Africa	26 (4.8)	0.02 (0.02)	0.6 (0.8)	0.1 (3.9)	0.2 (4.2)	-0.07 (-1.4)	283
Asia	43 (3.8)	0.6 (1.2)	0.7 (0.5)	0.2 (4.0)	0.02 (0.2)	-0.2 (-1.6)	148
Latin America	48.5 (4.8)	0.4 (0.5)	0.5 (0.9)	0.1 (1.0)	0.7 (0.9)	-0.8 (-.8)	184
The Rest	68 (6.0)	0.08 (0.8)	0.1 (-0.3)	0.1 (1.1)	-0.04 (-1.1)	-1.1 (-0.5)	26

Comparing Table 2 with Table 4, the former is the restricted model and the latter is the unrestricted model. Considering a separate model for each continent as a null hypothesis we can use Chow Test to decide which table approximates the real world. Calculated Chow statistic is approximately 2.0 which imply that the null hypothesis is rejected.

## **VI. Conclusion**

There is no general agreement among economists on which economic variables and functional forms should be used to explain the variations of the level of life expectancy across countries. Historically different models have been used by researchers to illustrate the true relationship, if any, between the level of life expectancy and other economic variables such as per capita income and some human development indicators such as education, nutrition and health subject to the data restrictions and insufficient theoretical justifications. Human development indicators such as life expectancy and literacy rate show high degree of persistence over a long period of time. Therefore, cross-sectional analyses of human development indicators are much more informative than time series analyses. One important message of all empirical studies is that as societies develop socially and economically over time more information becomes available that helps to predict the changes in the level of life expectancy.

There is a perfect agreement among all researchers that per capita income is still a key determinant of life expectancy because it represents the ability of an economy to design social and economic policies to improve standard living of people. However, it appears from empirical studies and social planners' experiences that the role of per capita income determining the level of life expectancy is diminishing over time. However, it is apparent that the way in which income is spent by social planners is becoming very significant in affecting the level of life expectancy across countries. While many high income countries are still suffering low level of life expectancy many moderate income countries reached a satisfactory level of life expectancy by just paying sufficient attention to human development indicators such as education, nutrition, and health.



The present paper confirmed previous empirical results that expenditure on human development indicators will affect the level of life expectancy. In addition, it pointed out that with a minor change in specification of econometric models we can get better results. It also showed that there are immeasurable facts that might affect the level of life expectancy across countries.

## References

1. Cochrane, Susan, Donald J.O, Hara and Joanne Leslie, "The Effect of Education on Health" *World Bank Staff Working Paper* No. 405, PP. 22-43 July 1980.
2. Hicks Norman, "Economic Growth and Human Resources" *World Bank Staff Working Paper* No. 408 July 1980.
3. Isenman Paul, "The Relationship of Basic Needs Growth, Income Distribution and Employment: The Case of Sri Lanka." Policy Planning and Program Review Department, *World Bank*, March 1979.
4. Preston, S.H. "Causes and Consequences of Mortality Declines in Less Developed Countries during the 20th Century." Edited by R.A. Easterlin. *Population and Economic Changes in Less Developed Countries*, NBER Conference, Philadelphia, Chicago: University of Chicago Press, 1976.
5. Som, R.K. "Effects of Economic, Social and Demographic Factors on Fertility and Mortality Levels: Inter country Studies." *Population Bulletin of the United Nations*, No. 9, PP.12-20 New York, 1977.
6. United Nations, "*Human Development Report*" Chapters 1 and 2, 1990.
7. World Bank, "*World Development Report*" 1986.