Per Capita GDP, Health Expenditures, and the Income Elasticity of Demand for Health Care in Developing Nations

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Using Word Bank's World Development Indicators data for 130 developing countries and linear and logarithm regression models, this study tests the functional relationship between Per Capita GDP and Per Capita Health Expenditures. Results suggest that health care is neither a luxury nor a necessity for this entire set of countries. However, for nations with an annual per capita GDP less than 2,500 PPP constant 2000 US$, and for countries with GDP per capita over 7,000 PPP constant 2000 US$, medical care is a necessity. Health care is a luxury in developing nations with annual GDP per capita between 2,501 and 7,000 PPP constant 2000 US$.

INTRODUCTION

Advancements in medical care technology during the last half century have increased life expectancy in some advanced industrialized nations such as Canada, France, Japan, Norway, Sweden and Switzerland above 80 years of age and reduced the infant mortality rate before the fifth year of life, to less than 6 for every 1,000 live births in the world's wealthiest countries. In contrast, the life expectancy in the developing countries such as Zambia, and Zimbabwe, most adversely affected by the AIDS epidemic, is below 30. Moreover, for every 1,000 live births in the least developed nations, 148 children do not survive past the age of five. [World Development Indicators, 2005].

Disparities in health outcomes across countries reflect, among others, differences in expenditures on health care. Within this context, this paper seeks to identify some of the causes for the differences in health care spending and in health outcomes across a sample of 130 non-industrial developing nations (LDCs.) Using 2004 data from the World Bank's *World Development Indicators,* this study tests the hypotheses of functional relationships between health expenditures per capita and Gross Domestic Product per capita, and between life expectancy as well as infant mortality rates and both, per capital health expenditures and per capita GDP. Additionally, this paper seeks to estimate the income (GDP) elasticity of demand for medical care in order to ascertain whether health care is a luxury or a necessity in the non-industrialized developing nations.

If, in fact, spending on health care is a policy variable, another important question that this study seeks to address is the extent to which such policy variable is effective in inducing better health outcomes as, measured by criteria such as life expectancy and infant mortality rates in developing countries. While it may be logical to assume that growth in Real Gross Domestic Product may indeed result in increases in expenditures on health care and in improvements in health outcomes in LDCs, it may also be possible that neither economic growth nor increased spending on medical care lead to improvements in the health status of peoples in developing countries. This could be the case if additional medical care resources in

LDCs were allocated towards newer and sophisticated technologies or medical procedures for the benefit principally of the upper income groups. This could lead to inefficient allocation of scarce medical care resources since, arguably, the incremental health outcome benefit of resources so allocated may be lower that the associated marginal cost, or lower than the marginal benefit of allocating those same resources towards more basic medical care, such as preventative vaccinations, basic dental care, improved diet and sanitary conditions of lower income strata in those developing nations.

A review of the relevant literature follows this introduction, and two regression models, one in linear form and the other in logarithmic form are specified in Part II. Cross-section data on health expenditures per capita, GDP per capita, life expectancy, and infant mortality rates for the sample of 130 non-industrial developing countries serve as the basis for the empirical section of the study, presented in part III, along with the discussion of the results. The conclusions close out this paper.

REVIEW OF THE LITERATURE

International comparisons of expenditures on health care date back to the 1970s with the pioneering work of Kleimann and Newhouse. Using industrialized countries' data for the early 1960s, Kleimann [1974] first demonstrated the existence of a direct relationship between aggregate health care spending per capita and per capita income through a simple linear regression model. Based also on a linear regression model and with 1970s data for thirteen developed nations, Newhouse [1977] also established a positive relationship between these two variables and, additionally, found medical care in those countries to be a luxury good since their income elasticity of demand for health care exceeded one. Both authors converted the data from the respective countries' currencies to US dollars using current years' rates of exchange. Maxwell [1981] used average exchange rates for the 1977 calendar year and concluded that Germany, Sweden and the United States led the world in health care expenditures per capita.

Parkin, McGuire, and Yule [1987] adjusted for the inadequacy of exchange rates in reflecting relative purchasing power across countries by using Purchasing Power Parities for their international comparisons of health care spending in eighteen OECD countries. Contrary to Newhouse's earlier conclusion, they found health care to be a necessity rather than a luxury. Gerdtham, Anderson, Sogaard, Jonsson [1988]; and Culyer [1989] have subsequently also established a close linear relationship between heath care spending and income per capita for OECD countries. Culyer also concluded that, although variations GDP per capita explained between 87% and 92% of the variations in medical spending per capita, other relevant variables such as the type of system to deliver and fund health care are also significant factors in accounting for variations in health care expenditures.

Since nominal exchange rates may not reflect price differentials across countries, the use of nominal rates of exchange in the conversion of data to US dollars, for international comparisons, does not provide an appropriate yardstick for such cross-country comparisons. Specifically, current rates of exchange tend to underestimate spending on health care in countries whose prices and cost of living are lower relative to those in the United States and result in overestimates of such expenditures in nations whose prices and cost of living are higher than those in the United States. More recent studies have used what has now become the standard practice by researchers analyzing international economic or financial statistics-- using purchasing power parity rates of exchange in converting figures in local currencies to US dollars. In more recent studies by Poullier [1989,] Schieber [1990,] and Schieber, Poullier, and Greenwald [1992,] similar conclusions were reached regarding the direct relationship between per capita health care spending and per capita income, using purchasing power parity rates of exchange to convert foreign currency data into US dollars. Phelps [2002] utilized a regression model in natural logarithmic form to validate the relationship between the two variables mentioned above and to estimate the income elasticity of demand for health care in industrialized countries. He also concluded that the model specified in logarithmic form offers a better fit to the data.

Reinhardt, Hussey, and Anderson [2002] focused on the growth in per capita health care spending and found that high health care spending countries exhibit lower growth rates in such expenditures. Through a regression in logarithmic form they estimated that the GDP elasticity of demand for health care

spending in OECD countries in 1999 was 1.32, suggesting that health care in these nations is a "superior or luxury good" since a given percentage change in income generates a proportionately greater change in health care spending. In another study the same authors analyzed growth rates in per capita real health care expenditures and per capita real GDP during the 1991 to 2001 period and found that the growth rate in the former variable exceed the growth rate in the later in all but five of the thirty OECD countries included in their study. They attributed the relatively higher health care spending growth rates in the United States to stronger US GDP performance and to its complex and fragmented third-party medical care payment system [Reinhardt, Hussey, and Anderson 2004]. Phelps [2003] used data for 2000 for twenty one high-income countries to test the relationship between health care spending and health outcomes and also between GDP per capita and health outcomes. He found a negative but relatively weak correlation (R^2 value of 0.35) between mortality rates and per capita income, and also an inverse although weaker correlation (R^2 value of .21) between mortality rates and per capita spending on health care.

Benavides [2007] also corroborated the direct relationship between per capita health care expenditures and per capita GDP through linear as well as through logarithmic regression models using 2004 data for a group of twenty four upper income industrialized countries and twenty four developing economies of Latin America and the Caribbean. He concluded that health care is a luxury in the former but a necessity in the latter group of nations. Benavides also did not find a strong correlation between GDP per capita or health expenditures per capita and the health outcome measures of life expectancy and infant mortality rates in the industrialized countries and suggested that further improvements in the health condition of peoples in these affluent countries are more likely to result from changes in qualitative variables such as life styles, diet, physical activity levels, and others.

On the other hand, given the low correlation between health care spending or GDP and health outcome variables in the developing countries of the Latin America and Caribbean region, Benavides also concluded that neither GDP growth nor increases in health care spending alone would improve the health status of residents in these developing countries unless these were accompanied by additional expenditures in other areas such as infrastructure development and education, particularly in the rural regions of these countries.

All the studies reviewed above suggest that, despite wide differences in country size, population, ethnicity, delivery system for health care services, governmental institutions, and climatic and geographic characteristics, income per capita is the primary determinant of medical care spending per capita in high income countries

Specification of Model

Two models, one a simple linear regression model and another one specified in logarithmic form are employed to test the well established relationship between per capita expenditures in health care and per capita income as well as the relationship between medical expenditures per person and health outcomes represented by life expectancies and infant mortality rates; and also between income per capita and each of these two health outcome variables. The 130 non-industrial, developing nations in Africa, Asia, Eastern Europe, Latin America and the Caribbean, for which full data was available from the World Bank's 2005 *World Development Indicators*, provide the basis for the empirical analysis that follows this section.

The two models are specified as follows:

Model I
Health Expenditures per capita in
    Purchasing Power Parity 2000 US\$ = Bo + B1 (GDP / capita PPP constant 2000 US\$)
    To adjust for cross country differences in price levels, data for the dependent and independent variables is converted to real 2000 US\$ using purchasing power parity exchange rates. The B1 coefficient is hypothesized to have a positive sign reflecting the expected direct relationship between the two variables in question.

The extent to which health care expenditures or income determine health outcomes is tested using the linear regression model specified below. The B2 coefficients are hypothesized to have a positive sign to reflect the expectation that greater levels of medical spending per person or higher levels of income are associated with higher longevity. The B3 coefficients are hypothesized to have a negative sign to reflect the expectation that greater levels of medical spending per person or higher levels of income are associated with lower infant mortalities.

Life Expectancy = Bo + B2 (Health Exp. / capita in PPP constant US 2000 US$)
Life Expectancy = Bo + B2 (Per capita GDP in PPP constant US$)
Infant mortality = Bo − B3 (Health Exp. / capita in PPP constant 2000 US$)
Infant mortality = Bo − B3 (Per capita GDP in PPP constant US$)

Model II

To acknowledge the possibility that there might be a non-linear relationship between the variables in question; an alternative logarithmic regression model is specified as follows:

Log N Health Exp. per capita in PPP constant 2000 US$ = Bo + B1 (Log N GDP/capita PPP constant 2000 US$)

The B1 coefficient is hypothesized to have a positive sign reflecting the expected direct relationship between the dependent and independent variables. Additionally, the B1 coefficient of the regression of per capita health expenditures in logarithmic as a function of the per capita GDP in logarithmic form provides a approximate estimate of the income elasticity of demand for health care, which represents the percentage change in health care spending resulting from a given percentage change in income or GDP, Reinhardt, Hussey, and Anderson [2002, p. 172]

For the life expectancy health outcome as the dependent variable, the B2 coefficients in the logarithmic model below are hypothesized to have a positive sign to reflect the expectation that greater levels of medical spending per person or higher levels of income are associated with higher longevity. For the infant mortality rates health outcomes as the dependent variable, the B3 coefficients are hypothesized to have a negative sign to reflect the expectation that greater levels of medical spending per person or higher levels of income are associated with lower infant mortalities.

Log Life Expectancy = Bo + B2 (Log Health Exp. /capita in PPP constant US 2000 US$)
Log Life Expectancy = Bo + B2 (Log Per capita GDP in PPP constant 2000 US$)
Log Infant mortality = Bo − B3 (Log Health Exp. / capita in PPP constant 2000 US$)
Log Infant mortality = Bo − B3 (Log Per capita GDP in PPP constant US$)

Empirical Results

Various regression were run using 2005 *World Development Indicators* data on per capita health expenditures and GDP per capita for 2004, both in purchasing power parity (PPP) 2000 US$, along with their respective natural logarithm values for the 130 nations in this study.

Hypothesis I

Per capita expenditures on health care and per capita income (GDP) are directly related for the group on nations under study. This hypothesis is tested first via Model I, the simple linear regression model described above. The results are summarized in Table 1 below. Since there is a strong and statistically significant direct relationship between per capita expenditures on health care and per capita income (GDP) in the linear regressions model, the first hypothesis is validated.

TABLE 1
PER CAPITA HEALTH EXPENDITURES AS A FUNCTION OF PER CAPITA GDP
REGRESSION RESULTS FOR 131 NON-INDUSTRIAL/DEVELOPING COUNTRIES

Dependent Variable	Independent Variable	R^2	Regression Constant	Beta 1 Coeff.	t Stat**	F Stat***
Health $/capita *	GDP / capita*	0. 700	24.55 (0.14)	0.053	17.34	300.8
Log N Health $ / capita*	Log N GDP / capita*	0.866	-3.44	1.06	28.89	835.1

  * Data for 2004, in Purchasing Power Parity constant 2000 US$.
 ** Critical t value at 0.05 level = 1.65.
*** Critical F value at 0.05 level = 3.92

When regressions are run using cross-section data, heteroscedasticity may be present if the error terms or regression residuals are correlated with the independent variable. If this is the case to obtain unbiased results the regression would have to be run with transformed data.

Based on White's test[1], [Ramanathan, 1992] heteroscedasticity was found present in the simple regression (per capita health spending as a function of per capita GDP) but not in the logarithmic form regression model. To adjust for heteroscedasticty, if present, data in the simple linear regression in question was transformed by dividing each observation by the standard deviation of the residuals. The only change in the results of the regression with the transformed data was in the value of the regression constant (intercept of the function) which is included in parenthesis under the regression constant column for the first regression in Table 1 above. The independent variable (per capita GDP) beta coefficient, R-square, t and F statistics remained unchanged

Since there is a strong and statistically significant direct relationship between per capita expenditures on health care and per capita income (GDP) in the non-linear regression, the first hypothesis is also validated with data expressed in natural logarithmic form. Additionally, based on higher R-squared values, the logarithmic form model does appear to provide a better fit for the data in this study. A more formal test of the superiority or inferiority of the logarithmic versus the linear model, which uses the Box-Cox power transformation, is beyond the scope of this paper.

Another advantage of the logarithmic model is that the B1 coefficients represent a very close approximation of the income elasticity of demand for health care. The 1.06 income elasticity of demand for heath care estimate, which is not statistically different from 1.00, for this group of 130 non-industrial / developing nations indicates that health care is neither a superior or luxury good nor a necessity in these countries as a group. In other words, a given percentage change in income (a 10% increase in per capita GDP) generates a substantially proportionately equal change (a 10.6 % increase) in the demand for medical care spending. This result is important in light of the earlier findings by Newhouse [1977] and Reinhardt, Hussey, and Anderson [2002] that medical care is a clearly a luxury good in the industrialized OECD nations. On the other hand this result is contrasts with findings by Benavides [2007] of a 0.95 income elasticity of demand for heath care estimate for the Latin American and Caribbean countries, suggesting that health care is a necessity, rather than a luxury good, in these relatively lower income, lesser developed nations of the New World. In other words, a given percentage change in income (a 10% increase in per capita GDP) generates a proportionally smaller change (a 9.5 % increase) in the demand for medical care spending in the Latin American and Caribbean nations.

Given the significant differences in the 2004 GDP per capital levels of the countries included in this study (from Malawi's 592 PPP constant 2000 US$ to Kuwait's 22,248 PPP constant 2000 US$), data was grouped into four income categories, identified in column 1 of Table 2 below, to examine the extent to

which GDP levels affect the estimation of the income elasticity of demand for health care. Colum 2 shows the number of countries included in each category. Column 3 shows the coefficient of determination (R^2 value) of regressions whose dependent variable is health care spending per capita in logarithmic form; and whose independent variable is GDP per capita also expressed in logarithmic form. The estimate of the income elasticity of demand for health care is the B1 coefficient which is listed in column 4 of Table 2 below. Columns 4 and 5 show the computed t and F statistics respectively with their critical values at the 0.05 level of significance listed in parenthesis.

The regressions whose results are summarized in Table 2 below were also run with the transformed data in order to pre-empt the possibility of biased results that would occur if heteroscedaticity were present. The only difference in the regressions' output was in the regression constant or intercept. Specifically, none of the results included in Table 2 above differed from their original values after running the regressions with the transformation of the data.

As indicated on column 3 on the table below, the estimated income elasticity of demand for medical care in nations whose GDP per capita is below 1,100; or between 1,101 and 2,500 purchasing power parity constant 2000 US dollars, is less than 1. This suggests that for these two groups of nation's health care is a necessity since a given percentage decrease in income would result in a proportionately smaller decrease in health care demand.

Given the income elasticity of demand for medical care (1.245) for the group of forty nine medium income non-industrial / developing nations included in this study, whose PPP per capita GDP in constant 2000 US$ is between 2,501 and 7,000, health care is a luxury since a given increase in income (say 10%) would result in a proportionately greater increase in medical care consumption (12.45%.)

TABLE 2
INCOME ELASTICITY OF DEMAND ESTIMATES FOR VARIOUS GDP/CAPITA RANGES

Per capita GDP Range*	Number of Nations	R^2	B 1 Coeff. (income elasticity)	t Stat	F Stat
591<GDP/cap<1,100	20	0.245	0.971	2.42 (1.734)	5.85 (4.41)
1,101<GDP/cap<2,500	29	0.173	0.929	2.37 (1.703)	5.65 (4.21)
2,501<GDP/cap<7,000	49	0.459	1.245	6.30 (1.676)	39.8 (4.03)
7,001<GDP/cap<22,250	33	0.175	0.545	2.56 (1.691)	6.57 (4.14)

*Per capita GDP for 2004 in PPP constant 2000 US$

This may reflect that consumers in this middle - income developing countries may be spending increasing amounts of funds in non-basic, more optional types of medical care services. More paradoxical, however, is the very low income elasticity of demand for medical care (0.545) in the relatively more affluent group of nations whose per capita GDP exceeds 7,001 PPP constant 2000 US$ indicating that, in these nations, health care is clearly a necessity. The collective income elasticity of demand for this set of thirty three nations indicates that a given percentage decrease in income (say 10%) would trigger a proportionately much smaller decrease in the demand for medical care. This may suggest that consumers in these relatively more affluent developing countries have already become accustomed to obtaining medical services beyond the basic level so that the more optional types of medical care have already become a necessity for these consumers and they would not be willing to reduce their consumption by as much despite a decrease in their incomes.

Hypothesis II

The second hypothesis to be tested refers to the expected direct relationship between life expectancy and health expenditures per capita as well as between life expectancy and GDP per capita; and also to the expected inverse relationship between infant mortality rates and health spending per person as well as between infant mortalities and GPD per capita for the group on nations in this study. Due to data limitations for 2004, the health outcomes hypotheses are tested using data for 2,000 for the 130 nations. As in the hypothesis I tests, per person medical spending and GDP figures are expressed in purchasing power parity constant 2,000 US$. Through the linear and logarithmic regression models specified in the model specification section above, the hypothesis of a correlation between income or health care spending and health outcomes is tested.

As was the case with the regressions whose results are reported in Table 2 above, the regressions reported on Table 3 were also run with the transformed data to pre-empt the possibility of biased results due to the presence of heteroscedasticity (see note 1) and no differences in the results were found with the exception of changes in the regression constant or intercepts of the functions.

TABLE 3
HEALTH OUTCOME REGRESSION RESULTS FOR NON-INDUSTRIALIZED,
DEVELOPING COUNTRIES

Dependent Variable	Independent Variable	R^2	Constant Term	Beta 1 Coeff.	t Stat*	F Stat**
Life .Expectancy	Health $ / capita	0.326	55.94	0.025	7.87	61.9
Life Expectancy	GDP / capita	0.354	54.91	0.0016	8.38	70.19
< 1 Mortality***	Health $ / capita	0.403	76.33	-0.092	-9.30	86.46
< 1 Mortality***	GDP / capita	0.423	79.65	-0.006	-9.69	93.88
< 5 Mortality***	Health $ / capita	0.361	116.47	-0.151	-8.50	72.25
< 5 Mortality***	GDP / capita	0.377	121.85	-0.0096	-8.81	77.58
Log Life Expt.	Log Health $/cap.	0.471	3.45	0.131	10.68	114.14
Log Life Expt.	Log GDP / cap.	0.511	2.85	0.157	11.56	133.7
Log <1 Mort.	Log Health $/cap.	0.674	7.02	-0.666	-16.27	264.8
Log <1 Mort.	Log GDP / cap.	0.695	9.92	-0.778	-17.09	292.2
Log < 5Mort.	Log Health $/cap.	0.686	7.82	-0.769	-16.73	279.9
Log < 5 Mort.	Log GDP / cap.	0.708	11.17	-0.899	-17.63	310.8

*Critical t value at the 5% level of significance = + or − 1.65.
**Critical F value at the 5% level of significance = 3.92.
*** The under one and under five infant mortality rates are measured in terms of the
   number of children who die before age one or age five, respectively, for every 1,000
   live births.

All of the regressions above are statistically significant and so are the coefficients of the independent variables, thereby validating hypothesis II. Specifically, as postulated there is a direct relationship between per capita GDP growth and life expectancy as well as between health expenditures per capita and life expectancy in the sample on 130 non-industrial, developing nations studied. Secondly, the analysis also supports the hypothesis that higher levels of per capita GDP and/or per capita expenditures on medical care reduce both, the under one and the under five years of age infant mortality rates in these nations.

Additionally, given the noticeably higher coefficients of determination (R^2 values) of the logarithmic regressions ranging from 47% to 70%, versus those for the linear regressions, ranging from 32% to 42%; the logarithmic model appears to fit the health outcomes data better. This may indicate that increases in per person income and/or in per capita medical care spending result in exponentially or, at least, proportionately higher improvements in the health status of peoples in the non-industrialized/developing world—very large increases in health expenditures in these nations may not be necessary to generate noticeable improvements in health conditions in these countries. These same R^2 values also indicate that there is room for other contributing variables such as, for example, infrastructure development, improved sanitary conditions, and enhanced access to education, to better the health conditions to residents in these nations.

CONCLUSIONS

Our finding show that for the 130 non-industrialized / developing countries in our study, despite differences in the level of economic development, structure of the heath delivery system, political institutions, climatic, cultural, and demographic variables, the key determinant of health care spending per person is the level of income or GDP per capita. Additionally, our results suggest that health care is neither a luxury nor a necessity for these nations as the estimated income elasticity of demand for the entire set of countries is not statistically different from 1.00. However, for nations with an annual per capita GDP of less than 2,500 PPP constant 2000 US$, as well as for the more affluent nations whose GDP per capita exceeds 7,000 PPP constant 2000 US$, medical care is a necessity. On the other hand, health care is a luxury good in the middle-income non-industrial developing nations whose annual GDP capita is between 2,501 and 7,000 PPP constant 2000 US$.

Furthermore, additional medical spending or increases in income do translate into longer lives and lower infant mortality rates in the non-industrialized / developing world. Further gains in these health outcomes in these nations, however, would be enhanced by allocating additional health care resources according to the principle of marginal cost versus marginal benefit and would need to be complemented by additional spending on education and infrastructure investment in rural and/or more impoverished areas in order to generate further improvements in life expectancy and infant mortality rates.

ENDNOTES

1. Heteroscedasticity occurs when the error terms or regression residuals are correlated with the independent variable and may arise when running regression using cross-section data. White's test for heteroscedasticity entails regressing the squared residuals of the regression in question against the independent variable plus the independent variable squared. The test statistic (TR^2) is obtained by multiplying the number of observations (T) times the unadjusted coefficient of determination (R^2). Homoscedasticity is rejected and heteroscedasticity is present if the TR^2 statistic exceeds the chi-square value at the given level of significance, usually 0.05, and with degrees of freedom equal to the number of independent variables, two in this case.

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