The Effect of National Healthcare Expenditure on Life Expectancy

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Abstract

Our analysis seeks to examine whether or not there is a relationship between healthcare expenditure and national life expectancy in order to gain perspective on how to efficiently increase the quality of health in a state. In addition to healthcare expenditure, we also used percent government expenditure, concentration of doctors in an area, and literacy rate as independent variables. Our data shows that there is no significant correlation between healthcare spending and life expectancy in developing countries, but it does exist in developed countries. We speculate that in developing countries, it is not the quantity spent but the quality of expenditure that impacts healthcare. In developed countries, spending may be more efficient and thus more effective. However, our results alone are not evidence enough, and further research is recommended.

I. Introduction

Healthcare is arguably the most severe development issue facing our world today. States all around the globe are crippled by the onset of infectious disease and other preventable health issues. They are unable to focus their attention fully on other development issues such as education and economic sustainability because they have to first address the more pressing, immediate needs of their citizens. Global progress and the pursuit of international development simply won't be possible without improved access to and availability of healthcare. In addressing this issue, it is important to understand what policies and programs are most effective and efficient in improving healthcare.

In our paper, we examine the relationship between healthcare spending and life expectancy. The foundation of economics lies in the allocation of scarce resources. Thus we expect that if a state is spending money on a good or service, it is allocating itself a necessary resource. Because of this, we would assume that, logically, healthcare expenditure would result in some kind of health benefit. Thus, we expect an increase in healthcare expenditure to indicate a higher quality of health, quantified in our model through the use of life expectancy. Examining this relationship is important because it will allow for a greater understanding of the effectiveness of government spending on health.

II. Literature Reviews

In a study conducted by Day, Pearce, and Dorling, life expectancy was compared to a range of health system indicators within and between clusters of countries. 12 clusters of countries were identified with average life expectancy of each cluster ranging from 81.5 years (cluster 1) to 37.7 years (cluster 12). Unsurprisingly, the three highest ranked clusters were dominated by Western European countries, US, UK, Canada, Australia and Japan, while the four lowest ranked clusters were constructed by different combinations of African countries. On a per capita basis, worldwide health spending was concentrated within the three highest life expectancy clusters; in other words, health spending was concentrated in the developed world.

Health system indicators for workforce, hospital beds, access to medicines and vaccinations clearly corresponded with life expectancy of each cluster. The study concluded that there are considerable inequalities in life expectancy and healthcare, which was evident when comparing clusters grouped by their health outcomes. Specifically, it demonstrates the inequitable distribution of health care where those with the greatest need are afforded the least amount of care (Day,Pearce, and Dorling, 2008).

The study by Day, Pearce, and Dorling concluded that quality and availability of healthcare is higher in places where life expectancy is higher. Because this link exists it may be beneficial to ask: how much does spending alone affect the quality of healthcare? This question is examined in a study analyzing health system performance. In this study, there is a specific focus on spending and the resulting outcomes in the quality of care; data from the Organization for Economic Cooperation and Development (OECD) us used.

Keeping the quality of healthcare provided in mind, the study shows that health has improved dramatically since the 1970's in all of the countries of the OECD. Since then, OECD countries have collectively spent more on health per person; however, the gains in health as well as the spending levels vary tremendously across countries. Quality of care is relatively high in some cases, especially in terms of vaccination rates. In other areas, such as cancer rate survival, most countries are making slow progress, with much more room for improvement. Finally, in other areas, such as in-patient care, there is a wide discrepancy in quality. In general, it was not found that more health care expenditure translated to an equal increase in quality of healthcare provided (Kelley,2007).

The relationship between expenditure and healthcare quality can be tested for in several ways. In another study, the relationship between avoidable mortality and healthcare spending in 14 western countries was examined. Using changes in national health expenditures as an input measure, or independent variable, they measured the changes in avoidable mortality, which they defined as a situation in which “timely and effective health care could prevent mortality even after the condition had developed.” What the study found is that there is a negative relationship between healthcare spending and avoidable mortality, even after factors such as unemployment, education, and time varying determinants were controlled for

In general, countries with an above average increase in health spending experienced an above average decline in avoidable mortality. However the study also noted that although there is certainly a negative relationship between the two factors, there are some limits regarding how to interpret the findings. For example, increased spending may have created other welfare gains that were not accounted for in the study. This may have had an additional effect on mortality, and thus, the precise efficiency of the healthcare system is not given by the study.

In short, even after accounting for confounding factors, the study concluded there is a negative relationship between health care spending and avoidable mortality. There is little room to extrapolate further based on these findings alone, however, the study does indicate several other areas that could be researched further (Heijink, Koolman, and Westert, 2013)

Overall, the findings in the literature suggest that there will not be a positive relationship between healthcare expenditure and life expectancy. Although this literature exists, our paper is unique in that it examines 181 developed and developing nations and examines, though not exclusively, the relationship between just health expenditure life expectancy. We seek to further literature on the effectiveness of government spending on healthcare to see if it is the most efficient way of improving healthcare.

III. Data

We have chosen life expectancy as a general indicator of health for a country. Life expectancy is a statistic widely available for most countries, ensuring there will be more than sufficient data for this analysis. The life expectancy statistic used is the life expectancy at birth, or the number of years that a newborn could be expected to live on average. This statistic accounts for mortality across all age groups, and includes factors like infant mortality and infectious disease rates.

One independent variable chosen was total per capita expenditure on health, including government and private spending. We would expect that countries that spend more on health care would have a longer life expectancy. Per capita expenditure was chosen to measure total health care spending while accounting for variance in population between countries.

The second independent variable chosen was per capita GDP. We expect that countries with a higher GDP would have a longer life expectancy. Again, the per capita metric was used to account for variance in population. We also expect that per capita GDP and per capita health expenditure would be positively correlated because beyond the basic necessities, health spending is induced spending. Thus, countries with a higher income level can afford to spend more on health. Also, countries with a higher per capita GDP would probably have a better standard of living, which would affect life expectancy. This effect could mistakenly be attributed to health expenditure if GDP was omitted

A third variable measured what percent of health spending was done by the government. This statistic was considered to see whether higher public or private spending correlated with health. On one hand, if percent government spending correlates positively with life expectancy, it may indicate that health care provided through the government is more efficient. However, if the correlation is negative, it may indicate that it is better to put individuals in charge of their own health spending.

The fourth independent variable used is literacy rate. Literacy rate is used as an indicator of the level of education in a country. We expect literacy rate to be positively correlated with life expectancy. A higher literacy rate indicates the population is better educated. A better educated population is likely to be better informed about their health, and should contribute to a higher life expectancy.

The last variable considered is density of physicians, measured as the number of doctors per 1000 population. This statistic is used to provide a measurement of health care availability in a country. A higher density of physicians indicated more easily accessible health care, and should correlate with a higher life expectancy.

Regression models were done first using all countries in the sample. Additionally, the regressions were redone using only most developed countries, and only least developed countries. This was done to see if there was any noticeable difference in the trends for the two countries. The World Bank groups countries based on their income: low-income, lower-middle-income, upper-middle income, and high-income.   The sample group for the most developed countries was taken to be the group of high income countries. The sample group for the least developed countries was taken to be the group of low-income countries.

Health expenditure, life expectancy, percent government spending, and physician density were collected from the World Health Organization's Global Health Observatory Data Repository. The World Health Organization collects data on a wide range of global health indicators, including life expectancy and health care spending. Life expectancy is determined from mortality data collected from civil registrations or population censuses. Per capita total expenditure and percent government expenditure on health comes from national health accounts. For countries without an updated national health account, data is obtained from publicly-available reports or in-country technical contacts. Expenditure is measured in Purchasing Power Parities (PPP) to allow comparison across different countries. Physician density is determined based on health workforce data collected by the WHO.

Per capita GDP and literacy rate data was obtained from the World Bank. The World Bank collects data on a wide range of development indicators. The per capita GDP used in this analysis is measured in current US dollars. Literacy rate is measured as the percent of people aged 15 and above that can read and write. As far as possible, data from 2011 was used. If 2011 data was unavailable, the closest statistic from 2008-2011 was used.

In our analysis, we used data from 181 countries. All countries that the World Health Organization had data available for were used in the sample. Countries from a variety of regions worldwide were represented to obtain a wide spread of data. The following table contains summary statistics for all the variables used in the regression models.

	Life Expectancy (years)	Health Expenditure (PPP)	Per Capita (USD)	Government Expenditure (%)	Literacy Rate (%)	Doctor Density
Number of Observation	181	181	181	181	118	172
Average	70.2	1109.0	14245.7	757.5	84.1	1.49
Standard Error	9.141	1468.9	22349.1	1102.9	17.7	1.43
Max	83	8607.9	163025.9	5794.5	99.8	7.06
Min	47	17.0	245.6	7.9	25.3	0.008

In a preliminary analysis, health expenditure and GDP appeared to trend exponentially with life expectancy, as seen in Figures 1 and 2.

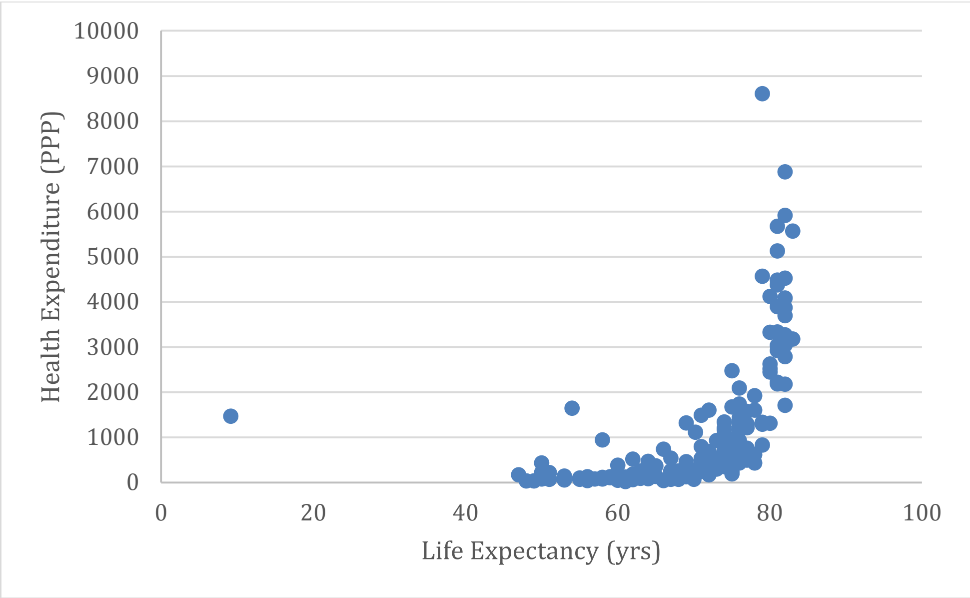

Figure 1. Health Expenditure vs. Life Expectancy

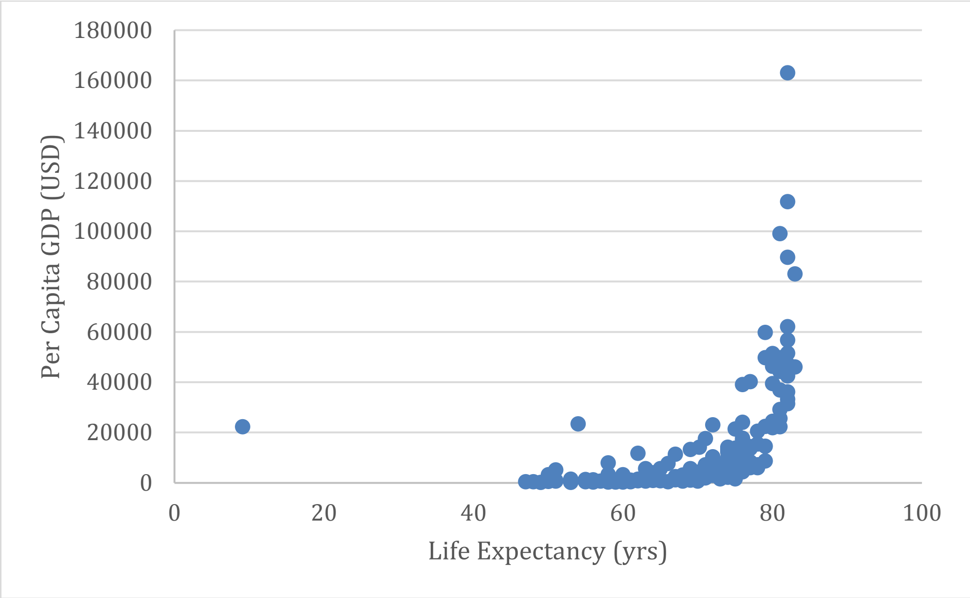

Figure 2. Per Capita GDP vs. Life Expectancy

For this reason, the regression was done with the natural log of both variables.

The first Gauss Markov Assumption is that the model is linear in parameters. Looking at the model we have selected, we can say that the first assumption is met. The second assumption is random sampling. The World Health Organization collects data on every country when possible. It is likely that countries missing data are less developed, with shorter life expectancies. However, the World Health Organization does its best to obtain data on all countries, and for the purpose of this paper we will assume random sampling. The correlation between each independent variable was checked to determine if there was any perfect collinearity.

	lnhealth	lngdp	percGov	litrate	docden~y
lnhealth	1.0000				
lngdp	0.9245	1.0000			
percGov	0.3991	0.4658	1.0000		
litrate	0.7544	0.7169	0.3682	1.0000	
docdensity	0.6152	0.5537	0.2569	0.6560	1.0000

Although there is no perfect collinearity between the independent variables, there is a high correlation between lnhealth and lngdp (R^2 = 0.92). This correlation may affect the results of the multiple regression model. For this reason, lnhealth and lngdp were not included in the same multiple regression models.

The fourth assumption is zero conditional mean, which states that the error value u has an expected value of zero given any value of the independent variables. Assumption five states that error u has the same variance given any value of the independent variable(s). Although there is no way to be completely certain that both of these assumptions have been met, measures such as estimating a multivariate model, have been taken to further reduce the likelihood of biasedness in our model.

IV. Results

STATA was used first to do a simple regression between life expectancy and per capita health expenditure. The resulting correlation was

$$LExp = 36.60 + 5.43 * \ln(HealthExp)$$

There is a positive relationship between health expenditure and life expectancy. The R^2 value for the regression is 0.66, indicating a fairly good correlation. The β_1 value for this model measures the elasticity of life expectancy with respect to health expenditure.

The simple regression models were also done looking solely at most developed and least developed countries.

Statistical Inference – Table

	Simple Regression, All Countries	Simple Regression, Most Developed	Simple Regression, Least Developed	Multiple 1, All Countries	Multiple 1, Most Developed	Multiple 1, Least Developed	Multiple 2, All Countries
Constant	36.60*** (19.83)	50.85*** (11.64)	55.13*** (7.60)	35.31*** (10.33)	41.92* (1.74)	56.03*** (8.61)	30.52*** (8.12)
lnHealth	5.43*** (18.65)	3.64*** (6.60)	0.61 (0.38)	2.68*** (3.65)	7.73*** (4.11)	-2.14 (-1.26)	
lnGDP							2.72*** (4.50)
percGov				2.12 (0.67)	0 (-0.47)	7.16 (1.18)	-0.04 (-0.01)
litrate				0.18 (3.61)	-0.21 (-0.88)	0.09 (1.15)	0.17 (0.05)
docdensity				0.94* (1.76)	-0.04 (0.44)	20.67*** (3.56)	1.05 (0.51)
R^2	0.66	0.51	0.003	0.61	0.74	0.38	0.63

*Indicates significance at 10% level, **5% level, ***1% level

To test our hypothesis, we constructed both simple and multiple regression models. In both scenarios, we conducted a test using all countries, a test with a grouping of the "most developed countries", and a test with a grouping of the "least developed countries."

STATA was used first used to conduct a simple regression between life expectancy and per capita health expenditure for all countries. The resulting correlation was:

$$LExp = 36.60 + 5.43 * \ln(HealthExp)$$

There is a clear positive relationship between health expenditure and life expectancy. The β_1 value for this model measures the elasticity of life expectancy with respect to health expenditure. The coefficient is 5.43 indicating that a one-unit increase in health expenditure would result in a 5.43 unit increase in life expectancy. The R^2 value for the regression is 0.66, signifying that 66% of the variance in life expectancy can be predicted from health expenditure in this model. It is also important to note that the t-statistic for health expenditure is 18.65, denoting statistical significance at the 1% level. Thus, it can be noted that our simple regression model for all countries shows a significant positive correlation between health expenditure and life expectancy.

The simple regression models were also tested using solely the "most developed" and "least developed" country groupings; however, these relationships were not nearly as strong. The resulting correlation for the "most developed countries" is as follows:

$$LExp = 50.85 + 3.64 * \ln(HealthExp)$$

The resulting simple regression model for the "least developed countries" is as follows:

$$LExp = 55.13 + 0.61 * \ln(HealthExp)$$

When comparing the two models it is clear that the simple regression model applies differently to "most developed" and "least developed" countries. For MDC, the health expenditure coefficient is 3.64 with a t-statistic of 6.60. This indicates that the positive relationship between health expenditure and life expectancy is statistically significant at the 1% level. However, for the LDC model the coefficient is only 0.61 demonstrating a weak, positive relationship between the two variables. Furthermore, the t-statistic for the LDC is only 0.38 indicating that it is statistically insignificant at even the 10% level. The R^2 value is 0.003- an extremely weak correlation. This signifies that only 0.3% of the variation in life expectancy can be explained by health expenditure in the LDC model. It is extremely interesting to note that the simple regression holds true for the models with the groupings of all countries and the groupings of all developed countries. However, for the grouping with the least developed countries, the model cannot explain the relationship between life expectancy and health expenditure. This is very different than what we had originally hypothesized. If anything, we predicted a stronger correlation between the two variables for LDC, as any slight increase in health expenditure would improve the overall quality of health care. Reasons for this difference may include the inefficiency in health care spending in LDCs. The health care expenditure variable constitutes both private and public spending; however, the lack of correlation perhaps shows the misallocation of these resources. In many LDCs, corruption is rampant and the importance given to health care spending is fairly low. Thus, the incapability of the model to explain the relationship between health care spending and quality of health care given leads us to believe that the spending is not efficient or effective.

STATA was then used to conduct a multiple regression test between life expectancy and the following independent variables: per capita expenditure on health, per capita GDP, percent government spending on health care, literacy rate, and density of physicians. Due to the high collinearity between GDP and healthcare expenditure (0.9245), we conducted two multiple regression tests- one with each of the two variables. Again, we conducted three groupings of tests- one with all of the countries, one with the "most developed countries," and one with the "least developed countries."

The resulting correlation for the 1st multiple regression model between all countries is as follows:

$$LExp = 35.32 + 2.68\ln(HealthExp) + 2.12percGov + 0.18litrate + 0.94docdensity$$

There is a clear positive relationship between life expectancy and healthcare expenditure and percent government spending on healthcare. There is a weaker, yet still positive relationship between life expectancy and literacy rate of the population and density of physicians in the population. As expected, health care expenditure is a strong and statistically significant variable at the 1% level. Physician density is also statistically significant at the 10% level indicating that a one-unit increase in physician density would result in a 0.94 increase in life expectancy. The other two variables, percent government spending and literacy rate, are not significant on any of the three levels. However, when removed and tested for joint significance, the variables proved to be statistically significant at the 5% level. It is also important to note the R^2 value of 0.61. This demonstrates that this model can explain 61% of the variation in life expectancy. Additionally, the p-value associated with our F-statistic (0.0000) is extremely small. This indicates that our group of independent variables, when used together, reliably predicts the dependent variable and is thus jointly significant. This multiple regression model indicates that healthcare expenditure, percent government spending, literacy rate, and physician density all have a positive relationship with life expectancy and are collectively significant. This conclusion is in line with what we had hypothesized. We believed that a country's expenditure on healthcare, its percent government spending on healthcare, its literacy rate, and density of physicians per capita would all have a positive correlation with average life expectancy.

We then conducted a 2nd multiple regression test between life expectancy and the independent variables; however, GDP was used in this model instead of healthcare expenditure. The resulting correlation is as follows:

$$LExp = 30.52 + 2.72\ln(GDP) - 0.04percGov + 0.17litrate + 1.05docdensity$$

Interestingly enough, this model varies from the previous one. There is a statistically significant positive relationship between life expectancy and per capita GDP of a country proving that a one percent increase in the GDP would lead to a 2.72 percent increase in life expectancy. However, the other independent variables tested in this model are not statistically significant. There appears to be a very slight negative correlation between percent government spending on healthcare and life expectancy. This can be attributed to the fact that private spending on healthcare might have a more significant impact on quality of healthcare provided as it is specifically and purposefully allocated by individuals. The coefficients for literacy rate and physician density seem to be on par with the results of the 1st multiple regression model, indicating similar positive relations with life expectancy. It is worth noting that the R^2 value is 0.63 and that the p-value associated with the F-statistic is again 0.0000. Thus, this group of independent variables in the model is jointly significant.

This multiple regression model was then tested using the “most developed” and “least developed” country groupings; however, these relationships indicated varying results. The resulting correlation for the “most developed countries” is as follows:

$$LExp = 41.92 + 7.73\ln(HealthExp) + 0percGov - 0.21litrate - 0.04docdensity$$

The resulting multiple regression model for the “least developed countries” is as follows:

$$LExp = 56.03 - 2.14\ln(HealthExp) + 7.16percGov - 0.09litrate + 20.67docdensity$$

When comparing the two models it is clear that the multiple regressions had drastically different results on the two groupings. For the MDC, healthcare expenditure is clearly positively correlated with life expectancy and statistically significant at the 1% level. The rest of the variables tested for the MDC model are statistically insignificant. Yet, it might be worth noting the extremely low correlation coefficients for percent government spending, literacy rate, and density of physicians, which we did not originally anticipate. This phenomena might be can potentially be attributed to the fact that the countries in this grouping are all of a comparable development level already indicating high life expectancy levels, literacy rates and physician density. Thus, this model cannot stipulate a high correlation between life expectancy and these other two variables.

Comparably, for the LDCs, healthcare expenditure is actually *negatively* correlated with life expectancy but is statistically insignificant- much like the simple regression model for LDC. It appears that an increase in expenditure does not necessarily translate to an increase in the overall quality of health in the country. This can perhaps again be attributed to the inefficient allocation of healthcare spending in those countries. The only statistically significant variable in the LDC model is physician density. The coefficient for this variable 20.67 indicating that a one unit increase in physician density leads to a 20.67 unit increase in life expectancy. This variable is also statistically significant at the 1% level demonstrating that this variable is very strongly and positively correlated with quality of healthcare received. This denotes that access to healthcare is very impactful in terms of increasing the quality of health in the country.

It is also important to note the R^2 values for the two models. For the MDC, the R^2 value is 0.74 while the R^2 value is only 0.38 for the LDC. This indicates that the model for MDC explains the variation in life expectancy more effectively than does the LDC model. Additionally, both of the F-statistic values for the MDC and LDC models are significant at the 5% level implying that the independent variables used are jointly significant.

It is also important to touch on the robustness of our various models. Our analysis was structured so that we could quantitatively assess the effect of healthcare spending on quality of healthcare provided. Life expectancy was the variable used to assess this, yet we understand the inadequacy of the variable to fully capture the quality of health service provided in a country given that lifespan is not solely determined by that factor. We attempted to maximize the effectiveness of our model by:

a) Ensuring random sampling of the data used.
b) Avoiding multicollinearity by utilizing two separate multiple regression models to isolate the effect of healthcare expenditure by a country and a country's GDP, since they were so highly correlated to each other.
c) Diminishing omitted variable bias by including a variety of applicable variables in our research.
d) Testing our models in three different groupings (all countries, "most developed," "least developed") in order to truly differentiate and analyze the effect of the variables in scenarios where average expected life expectancy, GDP, etc. could be kept relatively comparable

V. Conclusions

Health is one of the most critical development issues facing the world today. Thus, our research sought to determine whether there is an effect of healthcare expenditure on life expectancy. We hypothesized that there would be a positive correlation between healthcare expenditure and life expectancy, indicating that an increase in spending would increase life expectancy. However, we found that an increase in spending is only positively significant in developed countries. In developing countries, it is healthcare spending is an insignificant variable on life expectancy. The lack of significance of healthcare spending on life expectancy in developing countries may indicate that in these places, money is not allocated effectively towards health spending. Merely increasing spending does not guarantee that there is any kind of improvement in healthcare.

Additionally, when the multiple regression for least developed countries was run, the only statistically significant variable is *docdensity*, which was significant at the 1% level. This variable specifically may indicate that, in developing countries, access to healthcare is a large issue. Infrastructure is less established and the process of reaching an available doctor is more complicated than it is in the developed world. The importance of having a doctor nearby becomes more significant. This may also indicate other areas for possible research on healthcare effectiveness.

In the future, it may be beneficial further explore the effect of *docdensity* on life expectancy; it also may be useful to build a model with variables pertinent to *docdensity*. Based on our findings, it may be beneficial to more carefully examine variables that directly affect the quality of healthcare rather than focusing on spending. This would help assess how relevant this variable is to the health in a country and what kinds of policy and/or research recommendations would be needed at that point.

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Appendix

Appendix A. STATA Regression Outputs

Model 1. Simple Regression, All Countries

```
regress lexp lnhealth
```

Source	SS	df	MS
Model	9928.28112	1	9928.28112
Residual	5111.15534	179	28.5539404
Total	15039.4365	180	83.5524248

Number of obs =	181
F(1, 179) =	347.70
Prob > F =	0.0000
R-squared =	0.6601
Adj R-squared =	0.6583
Root MSE =	5.3436

lexp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnhealth	5.427763	.291083	18.65	0.000	4.853368	6.002159
_cons	36.5956	1.845636	19.83	0.000	32.95359	40.2376

Model 2: Simple Regression, Most Developed

```
regress lexp lnhealth
```

Source	SS	df	MS
Model	155.999724	1	155.999724
Residual	150.636639	42	3.58658665
Total	306.636364	43	7.13107822

Number of obs =	44
F(1, 42) =	43.50
Prob > F =	0.0000
R-squared =	0.5087
Adj R-squared =	0.4970
Root MSE =	1.8938

lexp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnhealth	3.642928	.552369	6.60	0.000	2.528202	4.757653
_cons	50.84844	4.367498	11.64	0.000	42.03448	59.66241

Model 3: Simple Regression, Least Developed

```
regress lexp lnhealth
```

Source	SS	df	MS
Model	4.92323242	1	4.92323242
Residual	1422.93723	41	34.7057862
Total	1427.86047	42	33.9966777

Number of obs =	43
F(1, 41) =	0.14
Prob > F =	0.7084
R-squared =	0.0034
Adj R-squared =	-0.0209
Root MSE =	5.8912

lexp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnhealth	.6075366	1.613051	0.38	0.708	-2.650087	3.86516
_cons	55.12715	7.251254	7.60	0.000	40.48295	69.77136

Model 4: Multiple Regression, All Countries

```
regress lexp lnhealth percGov litrate docdensity
```

Source	SS	df	MS
Model	5484.96742	4	1371.24185
Residual	3470.55013	109	31.8399094
Total	8955.51754	113	79.2523676

Number of obs =	114
F(4, 109) =	43.07
Prob > F =	0.0000
R-squared =	0.6125
Adj R-squared =	0.5982
Root MSE =	5.6427

lexp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnhealth	2.681739	.7357271	3.65	0.000	1.223552	4.139926
percGov	2.123853	3.174603	0.67	0.505	-4.168108	8.415813
litrate	.1794157	.0496425	3.61	0.000	.0810259	.2778055
docdensity	.9443695	.5372011	1.76	0.082	-.1203456	2.009085
_cons	35.31352	3.417376	10.33	0.000	28.54039	42.08665

Model 5: Multiple Regression, Most Develooped

```
regress lexp lnhealth percGov docdensity
```

Source	SS	df	MS
Model	158.83063	3	52.9435433
Residual	147.805734	40	3.69514334
Total	306.636364	43	7.13107822

Number of obs	= 44
F(3, 40)	= 14.33
Prob > F	= 0.0000
R-squared	= 0.5180
Adj R-squared	= 0.4818
Root MSE	= 1.9223

lexp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnhealth	3.688904	.5631429	6.55	0.000	2.55075	4.827059
percGov	-1.849876	2.285859	-0.81	0.423	-6.46977	2.770017
docdensity	.0745887	.2195837	0.34	0.736	-.3692066	.518384
_cons	51.62014	4.64616	11.11	0.000	42.2299	61.01038

Model 6: Least Developed

```
regress lexp lnhealth percGov litrate docdensity
```

Source	SS	df	MS
Model	430.058891	4	107.514723
Residual	711.618528	26	27.3699434
Total	1141.67742	30	38.055914

Number of obs	= 31
F(4, 26)	= 3.93
Prob > F	= 0.0126
R-squared	= 0.3767
Adj R-squared	= 0.2808
Root MSE	= 5.2316

lexp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnhealth	-2.14499	1.701504	-1.26	0.219	-5.642482	1.352501
percGov	7.1595	6.06059	1.18	0.248	-5.29822	19.61722
litrate	.0856254	.0745749	1.15	0.261	-.0676655	.2389163
docdensity	20.67319	5.813236	3.56	0.001	8.723908	32.62246
_cons	56.02886	8.616208	6.50	0.000	38.31799	73.73973

Model 7: Multiple Regression with GDP

```
regress lexp lngdp percGov litrate docdensity
```

Source	SS	df	MS
Model	5672.89771	4	1418.22443
Residual	3282.61983	109	30.1157783
Total	8955.51754	113	79.2523676

Number of obs =	114
F(4, 109) =	47.09
Prob > F =	0.0000
R-squared =	0.6335
Adj R-squared =	0.6200
Root MSE =	5.4878

lexp	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lngdp	2.716426	.6030987	4.50	0.000	1.521104	3.911748
percGov	-.0409824	3.184237	-0.01	0.990	-6.352037	6.270072
litrate	.1704444	.04696	3.63	0.000	.0773712	.2635175
docdensity	1.051998	.5133192	2.05	0.043	.0346161	2.06938
_cons	30.52233	3.758641	8.12	0.000	23.07283	37.97183

Appendix B. Raw Data

Country	Life Expectancy	ln(Health Expenditure)	ln(GDP)	% Gov Spending	Literacy Rate	Physician Density
Japan	83	8.062839	10.73932	0.800053		2.14
Lesotho	50	5.388067	7.126015	0.740744	75.8002	0.05
Norway	81	8.643607	11.50432	0.856427		
Lao People's Democratic Republic	68	4.355939	7.143388	0.492943		0.187
Liberia	59	4.722242	5.932055	0.315958		0.014
Saudi Arabia	76	6.803905	10.09064	0.689314	87.15616	0.939
Poland	76	7.260312	9.501671	0.712251	99.73019	2.068
Turkmenistan	63	5.525652	8.652518	0.607608	99.60858	
Kenya	60	4.344844	6.684563	0.395563		0.181
Ecuador	76	6.422938	8.524217	0.410078	91.5869	1.69
Armenia	71	5.519619	8.137901	0.358419	99.56817	2.845
Pakistan	67	4.239166	7.101619	0.270224	54.89264	0.813
Kiribati	67	5.53934	7.459082	0.800126		0.38
Netherlands	81	8.541408	10.81661	0.856648		
United Kingdom	80	8.108223	10.58414	0.826991		2.765
Iran (Islamic Republic of)	73	6.834281	8.826965	0.397327	85.01877	0.89
Yemen	64	5.027033	7.216215	0.20888	65.26195	0.197
Albania	74	6.33718	8.320955	0.448496	96.8453	1.113
Egypt	73	5.73541	7.997187	0.404728	72.04785	2.83
Ukraine	71	6.268187	8.181862	0.516966	99.71874	3.517
Saint Kitts and Nevis	74	6.508859	9.487848	0.558609		1.167
Qatar	82	7.44261	11.4046	0.786088	96.2837	2.757

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Montenegro	76	7.133751	8.889233	0.669831	98.45932	2.026
Oman	72	6.529375	10.04901	0.808123	86.939	2.048
Rwanda	60	4.902605	6.345929	0.567291	65.85227	0.056
Thailand	74	5.867289	8.554897	0.754621		0.298
Paraguay	75	6.266194	8.283173	0.385625	93.87092	1.11
Guinea	55	4.207822	6.118102	0.273471	25.30774	0.1
Lebanon	74	6.828485	9.121305	0.255047		3.54
Nicaragua	73	5.689142	7.397392	0.542822		0.37
Luxembourg	82	8.835805	11.62458	0.842695		2.779
United Arab Emirates	76	7.457107	10.5728	0.743893		1.93
Sudan	62	5.190454	7.337977	0.283932	71.93777	0.28
Ghana	64	4.499921	7.374021	0.560938	71.49708	0.085
Tunisia	76	6.370175	8.378008	0.550774	79.13058	1.222
Peru	77	6.206898	8.718036	0.561271		0.92
Nigeria	53	4.937706	7.310753	0.366942	51.07766	0.395
Sri Lanka	75	5.254156	7.950147	0.446488	91.18136	0.492
Fiji	70	5.209541	8.372095	0.681493		0.43
Monaco	82	8.684942	12.00166	0.885625		7.056
Guinea-Bissau	50	4.303119	6.389954	0.268362	55.27518	0.07
Malta	80	7.801064	9.997151	0.639858		3.226
Panama	77	7.157549	9.032717	0.674893	94.09412	1.5
Morocco	72	5.715579	8.020963	0.343491	67.08416	0.62
Gambia	58	4.540312	6.249497	0.54044	51.10727	0.107
Sao Tome and Principe	63	5.100232	7.211887	0.332256	69.53638	0.49
Nepal	68	4.224349	6.55704	0.393092	57.3691	0.21

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Malaysia	74	6.423979	9.216128	0.551749	93.11788	1.198
Kazakhstan	67	6.279665	9.337553	0.579337	99.73241	3.84
Ethiopia	60	3.950474	5.814139	0.577367		0.025
Honduras	74	5.859789	7.72385	0.481306	85.12331	0.372
Maldives	77	6.632871	8.777642	0.444225		1.595
Namibia	65	5.899349	8.64685	0.570669		0.374
Mexico	75	6.845986	9.181681	0.494479	93.51998	1.96
Palau	72	7.377509	9.243011	0.747462		1.38
Equatorial Guinea	54	7.404103	10.06362	0.662424	94.22589	0.3
Kyrgyzstan	69	5.079539	7.024718	0.596764	99.2414	2.469
Haiti	63	4.540312	6.596066	0.437047		0.25
Gabon	62	6.243254	9.373191	0.534488	88.98886	0.29
Mozambique	53	4.169297	6.236956	0.417195	50.58381	0.03
Papua New Guinea	63	4.746843	7.477174	0.790227	62.42167	0.05
New Zealand	81	8.017195	10.51648	0.83221		2.74
Lithuania	74	7.198191	9.557356	0.713443	99.70355	3.641
Kuwait	80	7.176767	10.84928	0.821712	93.9062	1.793
Latvia	74	7.07215	9.535145	0.584552	99.78424	2.899
Mauritius	74	6.735721	9.076597	0.402601	88.84715	1.06
Jamaica	75	5.970139	8.5795	0.541347	87.04274	0.411
Niger	56	3.671733	5.961847	0.551373		0.019
Eritrea	61	2.832625	6.085734	0.487934	68.93744	0.05
Indonesia	69	4.843321	8.152323	0.341398	92.8119	0.204
Mali	51	4.293742	6.605526	0.45426	33.44121	0.083
Congo	58	4.68804	8.135656	0.671852		0.095

Guyana	63	5.43973	8.088884	0.791171	84.99401	0.214
Austria	81	8.407731	10.80647	0.75593		4.862
Uzbekistan	68	5.244178	7.342605	0.513882	99.43299	2.539
Bhutan	67	5.464764	7.829605	0.838752		0.074
Belarus	71	6.676403	8.822427	0.70669	99.61706	3.756
Grenada	74	6.533673	8.957571	0.484242		0.663
Micronesia (Federated States of)	69	6.134482	8.006418	0.907822		0.18
Democratic Republic of the Congo	49	3.468544	5.503634	0.337488		0.11
Marshall Islands	60	5.949314	8.086945	0.832721		0.44
India	65	4.949611	7.335413	0.31002		0.65
Madagascar	66	3.677566	6.125138	0.6311	64.4809	0.161
Guatemala	69	5.811081	8.084159	0.354602	75.85726	0.932
Azerbaijan	71	6.25983	8.880421	0.214631	99.75984	3.379
Israel	82	7.683353	10.41181	0.615054		3.108
Mongolia	68	5.523459	8.064984	0.573174	97.35589	2.763
Mauritania	59	4.859192	7.051047	0.605647	58.61391	0.13
Italy	82	8.048641	10.49537	0.772455	98.97965	3.802
Ireland	81	8.267071	10.80656	0.704196		
Iceland	82	8.090598	10.69264	0.803817		3.456
El Salvador	72	6.145408	8.215695	0.633045	84.49272	1.596
Côte d'Ivoire	56	4.786575	7.124125	0.266161	56.86751	
Malawi	58	4.343676	5.896169	0.734251	61.30972	0.019
Bangladesh	70	4.208714	6.595636	0.365839	57.73479	0.356
Germany	81	8.382843	10.69908	0.758543		3.689

Bahrain	79	6.716135	10.0198	0.710303	94.55679	1.489
Cuba	78	6.063413	8.708016	0.946817	99.83425	6.72
France	82	8.315195	10.65777	0.767406		3.381
Dominican Republic	73	6.271121	8.611167	0.4933	90.10627	1.88
Cabo Verde	72	5.145691	8.243138	0.750772	84.93627	0.295
South Africa	58	6.848536	8.980025	0.476966	92.98314	0.758
Central African Republic	48	3.430756	6.212165	0.519417	56.613	0.048
Saint Vincent and the Grenadines	74	6.27809	8.746917	0.81737		0.525
Vanuatu	72	5.250492	8.087067	0.878842	83.22246	0.12
Solomon Islands	70	5.560143	7.384563	0.947934		0.22
Georgia	72	6.335072	8.077003	0.221149	99.73247	4.243
Dominica	74	6.61153	8.821812	0.720529		1.59
Swaziland	50	6.071915	8.093886	0.694194	87.8443	0.17
Greece	81	7.978664	10.15155	0.61194	97.3018	
Saint Lucia	75	6.51452	8.856992	0.482982		0.473
Tonga	72	5.502767	8.305514	0.835677		0.56
Turkey	76	7.056623	9.269066	0.749449	94.10609	1.711
Portugal	80	7.8726	10.02187	0.64054	95.43412	
Tuvalu	64	6.150155	8.292461	0.998912		1.09
Cameroon	53	4.851405	7.093984	0.311054	71.2905	0.077
Suriname	72	6.293197	9.016295	0.531763	94.67575	0.911
Sierra Leone	47	5.107399	6.216652	0.179981	43.2831	0.022
Togo	56	4.383276	6.344706	0.522347	60.40995	0.053
Chad	51	4.181745	6.914055	0.271228	35.39147	0.037
Samoa	73	5.772438	8.12028	0.889518	98.83078	0.48

Switzerland	83	8.624117	11.32764	0.654162		4.082
Burkina Faso	56	4.396299	6.476857	0.502649		0.047
Benin	57	4.311202	6.614612	0.532537		0.059
Brazil	74	6.949598	9.439544	0.457434	90.37918	1.76
Senegal	61	4.774913	6.987732	0.583122	49.69513	0.059
Cambodia	65	4.90483	6.778083	0.22447	73.90002	0.227
Chile	79	7.164101	9.582773	0.46954	98.55367	1.03
Seychelles	74	6.897068	9.416481	0.920657	91.83646	1.51
Republic of Korea	81	7.687397	10.0163	0.573259		2.02
Estonia	76	7.196245	9.729667	0.788851	99.79689	3.343
Sweden	82	8.260883	10.9465	0.809353		3.868
Singapore	82	7.932707	10.76359	0.310198	95.85733	1.921
Tajikistan	68	4.908086	6.727001	0.295686	99.70706	1.899
Afghanistan	60	3.921379	6.419961	0.155934		0.194
Costa Rica	79	7.192791	9.066566	0.700935	96.25802	1.32
Burundi	53	3.958525	5.509041	0.32646	86.94787	0.03
Czech Republic	78	7.561564	9.932084	0.835057		3.708
Canada	82	8.416258	10.85039	0.70413		2.069
China	76	6.069074	8.602883	0.558897	95.12447	1.456
Finland	81	8.111376	10.79208	0.747869		
Denmark	79	8.425896	11.00025	0.851589		
Colombia	78	6.42631	8.874709	0.748483	93.58054	1.47
Philippines	69	5.127648	7.765387	0.333294	95.4201	1.153
The former Yugoslav Republic of Macedonia	75	6.671273	8.509526	0.614036	97.3752	2.624
Botswana	66	6.598591	8.948637	0.608084	85.09085	0.336
Timor-Leste	64	4.407451	6.86645	0.714965	58.3089	0.1

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Bulgaria	74	6.969781	8.893798	0.553116	98.35245	3.76
Belize	74	6.055284	8.459737	0.664673		0.828
Jordan	74	6.224202	8.448045	0.67741	95.90445	2.558
Brunei Darussalam	77	7.166621	10.60272	0.850501	95.447	1.36
Spain	82	8.019869	10.35687	0.735946	97.74889	3.961
Serbia	74	7.086086	8.693513	0.621534	98.01291	2.114
Bahamas	75	7.81326	9.97536	0.467823		2.818
Bosnia and Herzegovina	76	6.833872	8.466757	0.680441	98.00262	1.694
Cyprus	81	7.705753	10.28215	0.432657	98.67843	2.753
Bolivia (Plurinational State of)	67	5.5225	7.749154	0.707744	91.16782	1.22
Croatia	77	7.360912	9.57739	0.847343	98.8807	2.715
Iraq	69	5.909495	8.645869	0.806849	78.48049	0.607
Angola	51	5.368683	8.548543	0.615342	70.36242	0.166
Slovenia	80	7.831566	10.10554	0.727953	99.69498	2.542
Algeria	73	5.923212	8.570087	0.807553		1.207
Slovakia	76	7.643914	9.784727	0.637598		3
Barbados	78	7.377959	9.64881	0.640247		1.811
Australia	82	8.213802	11.03692	0.685143		3.851
Russian Federation	69	7.182595	9.494318	0.59721	99.68427	4.309
United States of America	79	9.060433	10.81685	0.459369		2.42
Republic of Moldova	71	5.954671	7.585849	0.455842	98.97083	3.643
United Republic of Tanzania	59	4.676653	6.273622	0.395215	67.8007	0.008
Venezuela (Bolivarian Republic of)	75	6.490966	9.280611	0.366967	95.51199	1.94
Hungary	75	7.420136	9.531252	0.647646	99.04719	3.408
Uruguay	77	7.098144	9.526896	0.676024	98.07271	3.736
Uganda	56	4.851874	6.17089	0.26301	73.2118	0.117

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Comoros	62	4.073461	6.770436	0.578285	75.53978	0.15
Romania	74	6.804038	9.090916	0.802281	97.70193	2.385
Trinidad and Tobago	71	7.305087	9.78057	0.529065	98.83491	1.175
Viet Nam	75	5.444277	7.341501	0.403535	93.35947	1.224
Belgium	80	8.323361	10.74553	0.75945		3.782
Argentina	76	7.268014	9.301239	0.606431	97.85877	3.155
Antigua and Barbuda	75	6.864169	9.427076	0.681621	98.95	0.17
Zambia	55	4.598347	7.250324	0.597865		0.066