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Effect of Iodized Salt Consumption on Life Expectancy

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Abstract

This paper uses WDI data provided by the World Bank to examine whether or not countries with higher percentage of households consuming Iodized Salt are expected to have a higher average life expectancy at birth. Numerous models are estimated to try correcting for any omitted variables that might be related with consumption of Iodized salt and average life expectancy. Estimates suggest that that a 1% increase in a country's households, which consume Iodized Salt leads to an increase in the average life expectancy by 0.047 years i.e. 17 days. Additionally, the effect of Iodized Salt has differing effects on countries based on income. Countries who's GDP per capita is lower than USD 755 have a downward effect of consumption of iodized salt on their life expectancy as opposed to countries whose GDP per capita is higher than USD 2 per day.

I. Introduction

Globally, Iodine deficiency affect almost 2 billion people and is the leading preventable cause of intellectual and developmental disabilities (Mc Neil 2006). Therefore, iodized salt is one of the most cost-effective measures available to improve health at just USD 0.05per person per year. However there are lots of apprehensions concerned with the use of salt. Over the past few decades lot of concerns have been raised about salt being the cause of reducing life expectancy, as it is attributed with diseased such as heart attacks and hypertensions. Furthermore, for a past few decades' policy makers have tried to regulate the amount of Salt that food manufactures put into their product. Additionally, coming from India, where the traditional Indian food is considered to very salty, I personally have been very curious to know the effect of salt on a person's life. A typical advise of any Indian parent to their children is to restrict the amount of salt in food as a way of preventing cardiovascular disease is very common. Therefore, my own life experience coupled with gathering opinions about salt and the effect of Iodine led me to empirically find the effect of consumption of Iodized Salt on average life expectancy at birth.

Therefore this research attempts to highlight the effect of consumption of iodized salt on the average life expectancy at birth. To answer the question, WDI data provided by the World Bank is used. The file contains many variables, which can be used to study the effects on a cross-country basis. Furthermore, each variable for a country is computed as a 10-year average. So for this study, I look at each country's consumption pattern of iodized salt and each country's average life expectancy for the decade of 2000's, as that is the most recent data. However, the file also contains some missing variables of some countries, mainly lower developed countries, which should be kept in mind while interpreting the obtained results.

To address the research question, a country's average life expectancy at birth, which indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life, is treated as the independent variable. The variable of interest is a country's percentage of the total households consuming iodized salt, which is treated as the dependent variable. Additionally, to control for any missing variables that might be causing any omitted variable bias, several control variables were added to the regression. These variables are – Number of Physicians (per 1000 people), Out-of-pocket health expenditure (% of private expenditure on health) and Health expenditure per capita (current US$). Also, a dummy variable is also used in one of the regression models to explore the effect of consumption of salt on life expectancy based on a country's GDP per capita. The dummy variable is termed "Poor" and it's value is 1 when a country's GDP per capita is > $755 and 0, otherwise. There is also an interaction term to show the difference in effect of salt on the basis of GDP per capita, which is generated as the product of the dummy variable, poor and salt consumption.

A lot of studies in the past have been conducted to explore the effect of consumption of salt on the effects of health, which could be referred to answer the question this research is trying to explore. For example in response to policy makers, who are trying to reduce the salt used in food industries, a study from the Journal of American Medical Association show that people with the highest sodium intake (major component of salt), have longest lives. Furthermore a research conducted at the Salt Institute actually reveals that when average life expectancy in various countries is plotted against the average salt intake in those countries, "it is clear that the higher the salt consumption, the longer the life expectancy." While this doesn't imply a causal relationship, there definitely seems to be a positive compatibility between life expectancy and salt intake. American Journal of Hypertension actually recommends that cutting the salt levels to levels recommended by the US Government can actually decrease life expectancy. Therefore a lot of past studies confirm with our hypothesis. However, it should be noted that the studies had a lot of variables to control for like heart attacks and blood pressure levels, which are not represented in this study due to the constraints of data available to us for this study. Nevertheless, the variable of interest is used in the same way.

In order to find a relationship, several regressions were conducted, by regressing number of households consuming iodized salt on average life expectancy of a country for the most recent decade i.e. 2000's. Furthermore several models were also regresses, which contained several contain variables to check for any omitted variables. Following which, the OLS obtained estimates were then tested for its statistical significance using t-tests and F-tests for joint hypothesis to explain their inclusion and relevance to the average life expectancy. The regression results were worthwhile and there does exist a positive effect of 0.0475 years for a 1% change in households consuming iodized salt on average life expectancy, while controlling for other variables, which was significant at a 10% significance level.

Also another significant effect of salt consumption was found when the GDP per capita of countries were analyzed. By regressing salt consumption along with a interaction term of GDP per capita and consumption of salt, it was estimated that effect of consumption of iodized salt was negative for countries with a GDP per capita being lower than USD755 than otherwise. This result explained the change in effect of salt between richer and poorer countries, which stood significant at 5% significance level. The models were also checked for any threats to the OLS assumptions, and any viable measure were incorporated to eliminate those concerns. For example the variance of the error terms were actually heteroskedastic in nature, which violates the OLS assumption of "Homoskedasticity." Therefore heteroskedastic robust standard errors were calculated to ensure the normal distributions of the variables.

Therefore the results obtained established a significant positive relationship between the consumption of iodized salt and the average life expectancy at birth. The rest of the paper will describe the methodology, results and future concerns in greater detail.

II. Data

In order to answer the research question, I conducted an analysis based on an average data of 2000-2010 of several countries from the WDI dataset provided. The key dependent variable used is "Average life expectancy of a country," which is measured in years. The variable of interest i.e. whose effect we are trying to determine is the "Consumption of Iodized Salt," which is measured in percentage terms as a fraction of a nation's total households. Several control variables are also included from the dataset, they are – "Number of Physicians," which is measure as a number per 1000 people; "Out-of-pocket health expenditure," measured as percentage of private expenditure on health; and "Health expenditure per capita" measured in current US$. Furthermore I also the variable “GDP per capita” measures in terms of current US$, which is used to create dummy variable.

I tried using the data for all the countries, whose data was available for the 2000 decade. The dataset did contain some missing information on the salt consumption for a lot of countries, however the data does exist for a lot of countries, which should enable us to carry out our analysis. Conversely, it should also be noted that data for some African nations are missing, which might prevent the analysis to preset a fair view of lower developed countries.

Below are the “SUMMARY STATITICS” for all the variables used from the WDI dataset:

Variable	Obs	Mean	Std. Dev.	Min	Max
lifexp	232	68.16341	10.09907	42.23126	82.18634
salt	128	60.9202	25.64786	.4	100
healthexpd	214	784.5122	1398.227	5.249868	6565.274
extexp	214	77.4513	20.13486	7.612703	100
physicians	202	1.494934	1.333874	.014	6.068667
gdp	227	11174.04	17594.8	113.9058	129300.6

III. Regression Specification

A couple of statistical models were estimated in an attempt to answer the question: Does consumption of iodized salt cause an increase in the average life expectancy of a country? I begin by summarizing some key simple ordinary least squares (OLS) estimates. The sample size for each model differs due to some missing data and the sample size is represented in the table below. The initial approach is to explain the effect of salt consumption on a country’s life expectancy. Let L_i denote i’th country’s average life expectancy in years, which is assumed to depend on a vector of observed characteristics X_i and an error term ϵ_i. Adopting a linear specification,

(1) $$L_i = X_i\beta + \epsilon_i$$

where, β is the parameter to be estimated. Section IV discusses the effect of bias because of any possible correlation between X_i and ϵ_i. The above equation is used for regression model 1-4 in Table 1 presented below. In regression model 1, X_i only has one variable i.e. the percentage of household in i’th country consuming iodized salt i.e. $Salt_i$. Thus scalar linear regression equation being,

(2) $$L_i = \beta_0 + Salt_i\,\beta_1 + \epsilon_i$$

where, β_0 is the intercept. The variable salt is the variable of interest, and β_1 being the parameter of interest representing the effect of salt consumption on life expectancy. Furthermore regression model 2-4 incorporate several control variables, adding each of the following variable consecutively. Those variables are physicians (per 1000 people) i.e. $Physicians_i$, Health expenditure per capita (current US$) i.e. $Health\ Expenditure_i$, and Out-of-pocket health expenditure (% of private expenditure on health) i.e. $Out\text{-}of\text{-}pocket\ expenditure_i$. For example, the following regression equation for Model 4 would then be,

$$(3) \qquad L_i = \beta_0 + Salt_i\,\beta_1 + Physiciancs_i\,\beta_2 + Health\ Expenditure_i\beta_3 + \ Out - of\ pocket\ expenditure_i\beta_4 + \epsilon_i$$

where, the respective β is the coefficient of each added variable. The hypothesis to address the question is that whether the coefficient of the variable of interest i.e. Salt = 0. A two-sided t-test is done and the significance of the test is presented with the presence of an asterix beside the reported coefficients. The same is carried out for all the other coefficients of the control variable. Furthermore a joint hypothesis test is the carried to test whether all the coefficients together are significant and an F statistic is used to test the significance.

My second approach was to further explore the effect of consumption of iodized salt based on a country's income. The indicator I used was GDP per capita (current US$). I created a dummy variable, $Poor_i$ that equals one if the i'th country's GDP is <$755 and zero if the i'th country's GDP is ≥$755. Furthermore I created an interaction term to assess the change in effect of salt consumption based for richer and poorer counties, SP_i , which is the product of (Salt and the dummy, Poor). The regression model 5-8 adopts a linear specification,

$$(4) \qquad L_i = X_i\beta + Poor_i\alpha + \ SP_i\gamma + \epsilon_i$$

where, α and γ are the coefficient of the dummy and interaction variable, respectively. Model 5 contains only the variable Salt in the vector X. Whereas Models 6-8 incorporate all other variables.

In the Models 6-8, I conduct two-sided t-tests for all the coefficients to test the significance of each of the variable. Additionally I also conducted joint hypothesis tests using an F-statistic to confirm the difference in effect of the consumption of salt on life expectancy based on the income level of countries. The parameters of interest in Models 6-8 were primarily α and γ as they allowed indicating the change in the effect of salt consumption.

Furthermore, the above regression models might contain some threat to internal violations as it may challenge the assumptions of OLS estimates that make them unbiased, consistent and asymptotically normally distributed. The regressions might contain some missing variables that might be correlated with the existing term; this would call for an Omitted Variable Bias, which would cause the estimated coefficients to be biased. The regression model might also have some multicollinearity between the repressors, which would also call for estimates being unbiased and inconsistent. Additionally, the estimates of standard errors are valid behind the assumption of Homoskedasticity i.e. constant variance, however given the large set of data with some missing values, this assumption might be violated, which might present misleading inference tests. Lastly, the dataset contains some missing values for a lot of underdeveloped countries. This lack of data presents sampling issues and thus the estimated effect thus couldn't be applied to the entire population of countries. Section V would discuss ways of addressing these concerns.

IV. Regression Results

TABLE 1

OLS REGRESSION ESTIMATES OF THE EFFECT OF CONSUMPTION OF IODIZED SALT ON AVERAGE LIFE EXPECTANCY AT BIRTH
(DEPENDENT VARIABLE: LIFE EXPECTANCY AT BIRTH (YEARS))

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	56.27***	53.48***	53.32***	44.12***	60.94***	49.67***	47.27***	48.51***
	(1.816)	(1.564)	(1.777)	(3.367)	(1.925)	(3.578)	(3.316)	(3.728)
Salt	0.112***	0.0765***	0.049*	0.0475*	0.0969***	0.0395	0.0745***	0.0611*
	(0.0266)	(0.0228)	(0.027)	(0.0258)	(0.0267)	(0.0247)	(0.0256)	(0.0316)
Physicians	-	4.694***	3.647***	3.089***	-	2.626***	2.595***	2.577***
		(0.534)	(0.6195)	(0.622)		(0.607)	(0.606)	(0.608)
Health Expd.	-	-	0.0207***	0.0242***	-	0.0145**	0.0150**	0.0142**
			(0.0058)	(0.00577)		(0.00617)	(0.00605)	(0.00617)
Ext. Expd.	-	-	-	0.113***	-	0.0974***	0.0965***	0.0958***
				(0.0357)		(0.0343)	(0.0342)	(0.0343)
Poor	-	-	-	-	-5.637*	-5.600***	-	-2.416
					(2.980)	(1.599)		(3.313)
SSP	-	-	-	-	-0.102**	-	0.0878***	-0.0555
					(0.0465)		(0.0243)	(0.0505)
Observations	160	152	125	117	160	117	117	117
R-squared	0.100	0.407	0.393	0.509	0.434	0.558	0.560	0.562

The regressions were estimated using WDI dataset provided. The dependent variable is the Average Life Expectancy at Birth in years, country wise. The number of observations differs in the different regressions because of some missing data. Standard errors are given in parentheses under coefficients. The individual coefficient is statistically significant at the *10% level, **5% level or ***1% significance level using a two-sided test.

The initial results presenting the relationship between salt consumption and life expectancy at birth indicate a very strong relationship between the two. The least squares regression between percentage of total households consuming iodized salt and average life expectancy at birth return the statistics in column1 of Table 1. It is based on equation (2). We find a β_1 of 0.112 significant at 1% significance level. These results come with a t-statistic of 4.19 with one degree of freedom. This yields a p-value of less 0.0001. Thus even at a 1% significance level, we can reject the null hypothesis that $\beta_1 = 0$.

Secondly, I try to explain the change in the effect of consumption of salt between richer and poorer countries based on their GDP per capita. For this, I used the regression equation (5) with only the variable salt in vector *X.* The least square regression between life expectancy, salt consumption, dummy variable and the interaction term returned the statistics in column (5). The results give us a β_1 of 0.0969 (significant at 1% level), β_2 of -5.637 (significant at 10% level) and a β_3 of -1.02 (significant at 5% level). I conduct a joint hypothesis test, with my null hypothesis being $\beta_2 = \beta_3 = 0$. I obtain a F-statistic of 46.17 with $F_{2,156}$ distribution, leading to reject the null hypothesis. Furthermore I also conduct a two-sided t-distribution of salt consumption, which gives a t-statistic of 3.63. This yields a p-value of less 0.0001. Thus even at a 1% significance level, we can reject the null hypothesis that $\beta_1 = 0$.

The regression results prove a very strong relationship between our independent variable and our variable of interest. Column 1expresses that a 1% change in the country's households consuming iodized salt will lead to an increase in the life expectancy by 0.112 years (Fig1). This results remains significant and a 95% confidence interval would be (.0589605 – .1640431) years. Column 5 explores the effect of salt based on a country's GDP per capita. It indicates that the change in effect of a 1% change in a country's households consuming iodized salt between rich and poor countries on life expectancy is of -.102 years i.e. β_3. Furthermore, it indicates that for poorer countries there is effect of $(\beta_1 + \beta_3)$ i.e. -0.0051 years as opposed to a positive effect of 0.0969 years for a 1% change in consumption of salt. These results are all statistically significant. The difference of the effect of consumption of salt for richer and poorer countries is graphically shown in Figure 2, along side.

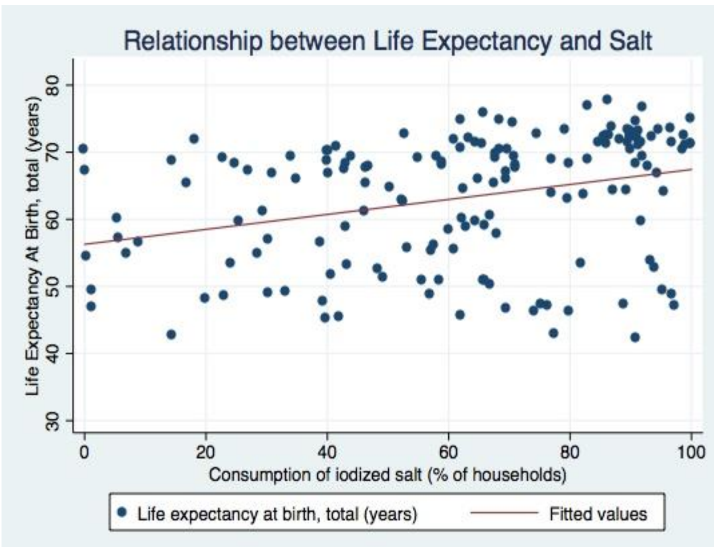
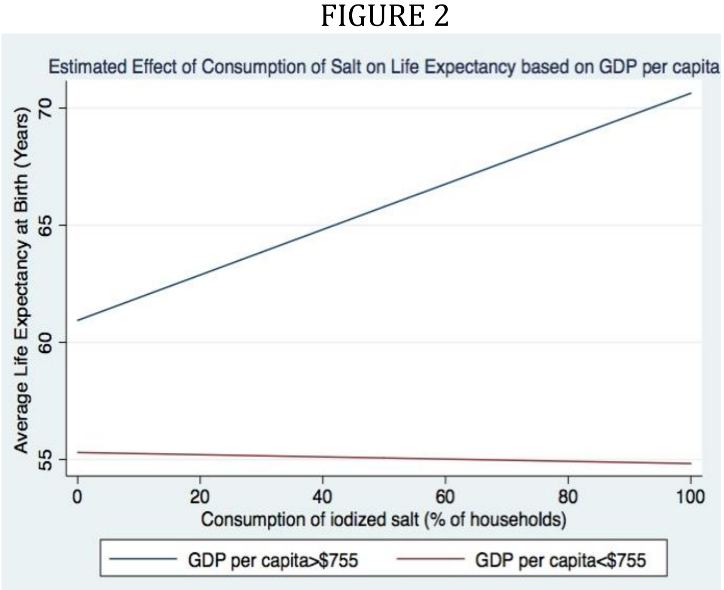


FIGURE 2



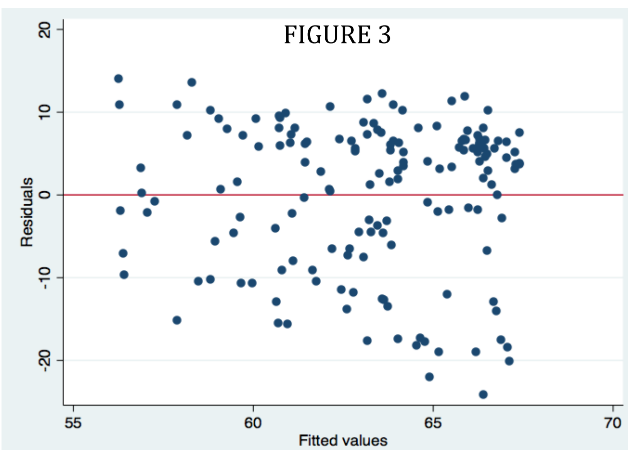
V. Robustness Analysis

Given the dataset and the initial regression, some key concerns that might violate the assumptions under which OLS estimates are invalid are omitted variable bias, heteroskedastic errors and sampling issues.

Omitted Variable Bias

This violation is of great importance with the obtained results in order to understand the relationship between consumption of salt and life expectancy. There is a high possibility that there might be some missing variables in our model that are correlated with the coefficient of our variable of interest, in this case the consumption of Iodized Salt. If such missing variables are ignored, then our estimates of the coefficient of Salt consumption will be biased and inconsistent, thereby making our estimate either an overestimate or an underestimate depending on the correlation. Therefore three control variables are included in our regression model. They include the number of physicians, health expenditure of a country and out-of-pocket i.e. private health expenditure. These variables might be correlated with the independent variable and be useful in determining the dependent variable.

Heteroskedastic Errors



The presence of heteroskedastic errors can invalidate our assumption of consistent standard errors, normal distribution and efficient estimates of our coefficients, as the default assumption of Homoskedasticity or constant variance of error terms is made. Figure 3 reveals that our standard errors are instead heteroskedastic in nature. Therefore our regression models should make us of "Robust Standard Errors" that correct for Heteroskedasticity and obtain efficient estimates.

Missing Data

There are some missing data for a couple of underdeveloped countries, which might not allow the analysis to drawn to all the countries, for the effect of salt consumption for countries whose GDP per capita is less than $755. Furthermore, a research conducted by UNICEF allows a slight possibility of biasedness in our estimate of iodized salt consumption on life expectancy for poorer countries. As per UNICEF the quality of iodized salt in some areas, like Nepal is subject to constraint because of handling, trading and storage practices of the salt, which can cause considerable loss of iodine. This loss of iodine due to handling, trading and storage practices in lower developed countries is not captured on our data, thereby making our estimates slightly biased.

Based on the above-mentioned potential violations, some attempts have been made to correct for those concerns by including omitted variables and making the regression "heteroskedastic robust." However, the concern that arises from missing data cannot be addressed due to limitation of available data.

Our initial regression (1) only included salt as the dependent variable. However in Model (2-4) (see Table 1 on Page 6), we make use of Equation (1) and respectively add a new control variable in the *X* vector to correct for omitted variable bias. Furthermore we also make use "Heteroskedastic Robust Errors." As a result we see that each time a new control variable is added in Model 2 to Model 4, our estimate of effect of salt consumption, reduces from our original estimate of 0.112 to 0.0475. Additionally, our value of R^2 also consecutively goes up from 0.1 to 0.509 indicating how the inclusion of omitted variables allow for better-predicted results. However, it should be noted that R^2 would always go up as additional regressors are added; therefore values of adjusted R^2 are reported. Also, our estimates of coefficient are statistically significant at a 10% significance level based on a two-sided t-test.

To confirm that our Regression Models do not face the threat of Omitted Variable Bias anymore after the inclusion of the three control variables, I ran an omitted-variable test i.e. "ovtest" using STATA and confirmed that the improved models have no omitted variables.

VI. Conclusion

This paper tried doing an exhaustive analysis of whether countries that have greater percentage of households consuming iodized salt have higher average life expectancy at birth or not. A variety of estimates based on internal and robustness analysis suggested that does exist a relationship between consumption of salt and life expectancy. We can predict that a 1% change in a country's total households consuming iodized salt will lead to a change of 0.0475 years or 17.33 days in a country's average life expectancy at birth as the coefficient ($\beta_1 = 0.0475$). These results are significant at a 10% significance level. Further, the R^2 statistic from Table 1 that over 50% of the cross country variation in the average life expectancy at birth within the 2000's can be explained by the modeled regression. Although it is very unlikely that single explanation can explain our independent variable, these results do prove that consumption of Iodized salt significantly explains the changes in a country's average life expectancy and debunks couple of myths around consumption of salt on health effects. The results also confirm with the results obtained by the studies conducted by American Medical Association.

Furthermore the results that explain the change in effects of the consumption of iodized salt on life expectancy based on country's GDP per capita is not a true estimate due to couple of missing variables, which are beyond the scope of this study and should be addressed in future studies. With the advancement of science and data available, it will be interesting to notice the effect of iodized salt on average life expectancy based on the food diet of people and genetic features specific to geographic regions, which will be able to affect the true effect of iodized salt. Therefore more analysis – based on time-series data and incorporation of above-mentioned missing variables – would allow policy makers to truly understand the effect of consumption of iodized salt on average life expectancy and make impactful changes affecting the administration of Sodium content in food.

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