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Measles Vaccinaiton in Developing Nations: A Statistical Analysis Looking at Factors That Affect Measles Vaccination Percentages

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SIT Study Abroad

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Research Question and Abstract:

Why do two developing countries in the same region have vastly different vaccination rates? What specific factors have the greatest influence on the vaccination rates in differing developing nations? This papers objective is to use a statistical model to try to determine what factors, education, healthcare system and infrastructure, play the largest role in impacting both positively the measles vaccination rate in 20 African countries. The results found only two of the six variables originally chosen to be statistically significant. These variables were the percentage of paved roads and the percentage of the GDP spent on education.

Introduction

Currently worldwide, almost 17% of all deaths in children ages 0-59 months old could be prevented by vaccinations. This percentage increases to 29% of all global deaths that could be prevented by vaccinations, if just looking at children 1-59 months old (World Health Organization, 2012a). These deaths occur from diseases such as measles, polio, hepatitis B and tetanus. Of these deaths that occur, from vaccine preventable diseases, the majority are in developing countries in Africa, South America or Asia. One disease that exemplifies this discrepancy, between the developing world and the developed world, is measles. According to the WHO, the "measles virus is highly infectious and, in the prevaccination period, >90% of individuals were infected by the age of 10 years (World Health Organization, 2009a). Furthermore, more than 95% of the annual deaths that occur from measles occur in developing nations that have poor access to healthcare (World Health Organization, 2012b). These two statistics show that the burden of the measles disease has manifested on the people living in low-income, developing nations and the developed nations have nearly eradicated measles. However, even in the developing world, there are vast differences between the vaccination rates. For example, in Chad the measles vaccination rate is 24% (World Health Organization, 20011e) while in Ghana the measles vaccination rate is 93% (World Health Organization, 20011i). The question becomes why do two developing countries in the same region have vastly different vaccination rates? What specific factors have the greatest influence on the vaccination rates in differing developing nations? This paper's objective is to use a statistical model to try to determine what factors, education, healthcare system and infrastructure, play the largest role in impacting both positively and negatively the measles vaccination rate in 20 African countries.

Many studies have been done concluding that measles has become a disease of the poor (Costa, 2003, Henao-Restrepo, 2003 and Sabin, 1991). A study in 2003 by Stein showed that 66% of the measles deaths occur in eleven of the poorest countries due to poor healthcare services (Stein, 2003). Most of the literature also agrees that measles is mostly present only in developing nations because of low levels of immunization: “The disease remains a major cause of serious disease and mortality in many developing countries. This is largely because of low vaccination coverage (Osterhaus, 1994). Expanding this argument Glass states, “it is clear that unvaccinated children have a much greater risk of infection when their local community has a low vaccination coverage (Glass, 2004). Furthermore, a study done in Portugal after they implemented a mass vaccination strategy concluded that “mass vaccination strongly suppressed the disease incidence” and that the average age of infection was higher (Gomes, 1999). A time series graph comparing global immunization percentage to number of global case of measles from 1980- 2010 shows that the two are inversely correlated (World Health Organization, 2011a). As the percentage of immunization increase from under 20% in 1980 to over 80% in 2010, the number of global cases drops from over four million, in 1980, to under five hundred thousand in 2010.

While it is clear that there is a link between immunization percentage and number of cases, it is still unclear what the best way to increase vaccination percentages is. In reviewing the literature there are a few differing opinions, or combination of ideas that could help best increase the immunization percentage in developing nations. The first is the need for improvement of the healthcare system. This includes increasing the number of well-trained healthcare personal (Nelson, 2007 and Croghan, 2006) and increasing the surveillance and record systems to ensure infants get vaccinated (Munyoro, 2003 and Cuuts, 1994). The second main improvement is to increase the education because there is a lack of knowledge both about the importance and availability of vaccinations. In some of the countries there are programs in place, however the citizens simply don’t know about the program or chose not to partake because they don’t know the benefits a vaccine can provide (Smith, 1996 and Cochran, 2000). Furthermore, providing education can help both sustain and inform the public about current programs (Gay, 2004). Increasing education would allow citizens to get the most out of their country’s current healthcare system.

The third major opinion discussed in the literature is increasing the infrastructure of countries. The argument made is that in many countries the rural population has little to no access to healthcare because they cannot simply get to the healthcare facilities (Larson, 2003, Crogan, 2006 and Rahman, 1999). In Zimbabwe, when the government implemented an Expanded Program on Immunization in 1981, it overcame the lack of infrastructure, roads, by having a small fleet of cars that would go to differing suburbs or rural villages to give the vaccinations. This method was very effective at getting vaccinations to the population despite the lack of infrastructure; the country had coverage upwards of 90% at its peak. However, by 1995 the immunization levels started to decline do to an “aging fleet of cars” (Munyoro, 2003). This example exemplifies the necessity of infrastructure in order to improve access to the available healthcare. Other authors stated that improvement in infrastructure was necessary, but it was not the need for more roads, however the need for better housing. The likelihood of an outbreak in overcrowded houses without ventilation is much higher; these are the conditions that are often seen in developing nations (Orenstien, 2006).

The literature concludes that while most agree that to eliminate measles, vaccination is the best method, the best way to increase the immunization levels in the world’s developing counties is still up for debate. Most experts believe it is best done by; either creating a more complete healthcare system, increasing education especially relating to healthcare and vaccinations or increasing the infrastructure of a nation to increase the availability of healthcare.

Methodology

Model

In order to find evidence on which factors lead to higher measles vaccination rates, the follow regression was run using the ordinary least squares method:

MV= F(C, ACW, PR, LE, HCE, HWC, EE, ALR)

Where:

MV= Percentage of 1 year olds vaccinated against measles

C= a constant

ACW= Access to clean water, measured by percentage of people who have a method to filter there water

PR= Percentage of total roads that are paved

LE= Life expectancy, measured in average years expected to live at birth if current conditions are unchanged, between men and women

HCE= Healthcare expenditure, measured in US dollars per capita per year

HWF= Healthcare workforce, measured by the number of recorded nurses, midwives and physicians for every 10,000 people

EE= Education expenditure, measured by percentage of total spending annually towards education and education improvement

ALR= Adult literacy rate, measured in percentage of literate males and females above the age of 15

These variables were chosen because they represent some aspect of the three sectors identified by the preceding literature to help improve vaccination rates: infrastructure, healthcare and education. While there is expected to be some multicollinearity, when two or more of the variables are highly correlated, these specific variables were chosen to try to create a more complete picture of each of the represented sectors and are different enough that the multicollinearity should not be too high. To represent infrastructure, access to clean water and percentage of paved roads were chosen because both help measure a countries level of infrastructure.

To represent the healthcare sector life expectancy, healthcare expenditure and healthcare workforce were chosen as the variables. Life expectancy can give a general view to the over all healthcare system because it is a common way to measure quality of life and access to basic necessities. Healthcare expenditure is used to represent the role the governement plays in improving healthcare facilities and implementing governement programs to increase the populations health. Healthcare workforce can be used to generally represent the access citizens have to healthcare in a given nation and training programs and schooling for nurses and doctors the country may have to help improve access to and quality of healthcare in the future.

To represent the education sector, government education expenditure and adult literacy rate were chosen. Education expenditure can show the role of the governement in creating access to education and can show if education is a priority for the current regime in power. Adult literacy rate, represents the quality of education, teachers' ability, and can roughly show attendance levels. A higher adult literacy rate means that more citizens attended school. The above explanatory variables were chosen because each gives a slightly different insight to the factor they are representing.

All of the explanatory variables are hypothesized to be positively correlated with the measles vaccinations percentage. Meaning that an increase in any of the explanatory variables should increase the percentage of the population that is immunized against measles.

Data (Appendix #1)

Twenty differing African countries will be used when running this regression. They were chosen from a variety of regions and half are categorized as least developed nations and half as developing nations according to the World Health Organization. The data for MV, ACW, LE, HCE, HWF were taken from the World Health Organizations country reports. The newest report for each country was used with the years ranging from 2009-2011. The data for PR was taken from the CIA WorldFact book. The data for ALR and EE were taken from the Worldbank. While sometimes figures can be misreported or bias using these sources for data, the data is as accurate as possible.

Results

Scatter Plots of Measles Vaccinations v. Explanatory Variables (Appendix #2)

Before running a regression it is important to plot all of the explanatory variables against the dependent variable, measles vaccination to make sure that a linear fit regression is appropriate for the model. All of the variables appear to have a linear relationship; none of the explanatory variables appear to have an exponential or logarithmic relationship. This means that a linear regression model is appropriate. However, the relationship between the differing explanatory variables and the percentage of measles vaccinations is not always a strong linear relationship. The relationship is especially weak for life expectancy and healthcare expenditure. However, those variables will be kept at least for the first model to see their relevance in the estimated equation. Finally, the scatter plots are important to make sure that there is not one data point that is consistently an outlier that might change to overall results. When looking at the graphs there is not one data point that is an outlier for a majority of the scatter plots, so all of the data points will be kept.

Model #1

After running the regression the following equation was estimated:

MV[t] = +0.3178 ACW[t] +0.4594 PR[t] -0.4358 LE[t] -0.011HCE[t] -0.6615 HWF[t] +1.8292 EE[t] +0.5075 ALR[t] +11.1694 + C[t]

Variable	Parameter	S.E.	T-STAT	P-VALUE
ACW[t]	0.31789	0.216871	1.465801	0.084205
PR[t]	0.459401	0.215576	2.131043	0.027227
LE[t]	-0.435858	0.600264	-0.72611	0.240847
HCE[t]	-0.010708	0.03388	-0.31605	0.378697
HWF[t]	-0.661528	0.500225	-1.322461	0.105333
EE[t]	1.82979	0.650361	2.813498	0.007824

ALR[t]	0.50875	0.211556	2.404806	0.016613
Constant	11.169458	31.837634	0.350826	0.365901

R-squared	0.805533
Adjusted R-squared	0.692094
F-TEST	7.101007
P-VALUE	0.001712

The major problem with this estimated equation is that all of the variables that represent the healthcare factors have negative coefficients. This does not make sense because increasing life expectancy, health expenditure and healthcare work force should all increase the measles vaccination percentage by increasing access.

Model #2

This regression was run without the LE explanatory variable because the scatter plots showed that there was little to no correlation between LE and MV. Furthermore, LE is such a complicated variable, that it may not accurately represent only the healthcare sector. By excluding LE, hopefully the problem with the negative coefficients from model #1 will be fixed.

The following regression was run, MV= F(C, ACW, PR, HCE, HWC, EE, ALR) with the estimated equation:

MV[t] = +0.331ACW[t] +0.3494 PR[t] -0.00701 HCE[t] -0.78238518812533 HWC[t] +1.6979 EE[t] +0.5331ALR[t] -9.249 + C

Variable	Parameter	S.E.	T-STAT	P-VALUE
ACW[t]	0.331017	0.21215	1.560296	0.071348
PR[t]	0.349442	0.150612	2.320145	0.01862

HCE[t]	-0.007067	0.032892	-0.214864	0.416604
HWC[t]	-0.782385	0.463065	-1.689581	0.057466
EE[t]	1.697932	0.613034	2.76972	0.007963
ALR[t]	0.533114	0.205044	2.599992	0.011003
Constant	-9.24898	14.655327	-0.6311	0.269457

R-squared	0.796989
Adjusted R-squared	0.703291
F-TEST	8.505967
P-Value	0.000683

This model still has the problem of the negative coefficient for both HCE and HWC.

Model #3

Given the negative coefficients of HCE and HWC, both of those explanatory variables were not included in the third regression: MV= F(C, ACW, PR, EE, ALR).

The following equation was estimated:

MV[t] = +0.1393 ACW[t] +0.3881 PR[t] +1.3515 EE[t] +0.2563ALR[t] +15.1311 + C[t]

Variable	Parameter	S.E.	T-STAT	P-VALUE
ACW[t]	0.139304	0.244004	0.570909	0.288258
PR[t]	0.388125	0.18093	2.145169	0.024359
EE[t]	1.351508	0.70865	1.907159	0.037918
ALR[t]	0.256251	0.21699	1.180932	0.128008

Constant	15.131107	14.723453	1.027687	0.160192

R-squared	0.657266
Adjusted R-squared	0.565871
F-TEST	7.191436
P-VALUE	0.001928

Of the three regressions that were run, this is the first regression where the coefficient signs were positive meaning the explanatory variables are positively correlated with the percentage of the population that received the measles vaccination which is logical.

Discussion

Analysis and Interpretation of Results

The first model produced an r-squared of 0.805 which is very high. It means that there is a strong correlation between the seven explanatory variables and the immunization coverage. With seven explanatory variables and a sample size of only twenty, the r-squared value is probably overstated. To account for the high number of variables, the adjusted r-squared is used. For this model the adjusted r-squared is 0.692, which means there is, still a strong correlation between the seven explanatory variables and the dependent variable. However, this model is flawed because of the negative coefficients on the following variables: LE, HCE and HWF. This raises concern because both the literature reviewed and theory would suggest that increasing the life expectancy, the healthcare expenditure or the number of people working the healthcare industry would increase the percentage of the population that had received the measles vaccination. To try to rid the model of these flaws a second regression was run, however this time the LE variable was removed. The LE variable was removed because the scatter plot MV v. LE showed there was little to no correlation and the life expectancy of a given country has countless variables that affect it. The variables that can impact life expectancy go beyond the healthcare system, and include living conditions, whether the country is in conflict, etc.

The second model produced a slightly lower r-squared, 0.79, but a slightly higher adjusted r-squared, 0.703. This difference in r-squared can be attributed to the fact that there is one less explanatory variable and the explanatory power of the variables is only slightly lower. However, this model is still flawed because the coefficients for HCE and HWF are still negative. As explained above the negative correlation goes against the existing literature and the theory. A final regression was run excluding HCE and HWF.

The final regression produced a much lower r-squared and adjusted r-squared, 0.657 and 0.566 respectively. This means that a correlation exists between the final four explanatory variables and measles vaccination coverage. And the model can explain about 65% of the change in immunization levels. This drop in r-squared is probably because of an omitted variable. The likelihood of an omitted variable in this final model is high because after removing LE, HCE and HWF there are no variables left that represent the healthcare sector. The results of the third regression also showed that two of the four final variables were statistically significant when tested at the 5% level, using a t-test. Since the p-values of for EE, 0.038, and PR, 0.024, are less than 0.05 level tested against, it can be inferred that those two variables are statistically significant. Since the p-values, 0.29 and 0.13 respectively, for ACW and ALR, are greater than 0.05 they are found to not be statistically significant for at the 5% level.

The coefficients of EE and PR reveal that both are positively correlated with measles vaccination, which is coherent with existing literature and theory. The values of the coefficient explain how much a one-unit change in the explanatory variable affects the dependent variable. For EE the coefficient is 1.35. This means that a one-unit change in EE, increasing the education expenditure by one percent of gross domestic product will increase the immunization percentage by 1.35% all other variables held constant. The coefficient for PR is 0.39. Similarly, this means that a one-unit in PR, increasing the number of paved roads by one percent, will intern increase the immunization coverage by 0.39%. However, it is important to not that just because an one percent change in EE has a greater affect on MV than an one percent change in PR does, it does not conclude that investing in education necessarily has greater influence than investing in roads. This is because one percent of a country's gross domestic product could be more or less than the cost to increase the percentage of paved roads by one percent. Without this data it is impossible to conclude, investment in which of this variables would be a more efficient way to increase the measles immunization percentage.

Overall, the final model broadly suggests that investment in both education and infrastructure can have an impact on increasing the measles vaccination coverage of a country's population. More specifically, given the variables tested, it shows that specific investment to increase roads and education will increases the vaccination percentage. These two variables being statistically significant makes sense because more roads allows more people in the suburbs or rural areas to have access to urban clinics and hospitals that are giving vaccinations and the more money spent on education, the more likely the citizens are going to know the importance of vaccinations.

Limitations of Results

The results found in this study have a few limitations. First, the sample size is very small, utilizing only data from twenty of the fifty-four African countries. Because of this the results are not applicable to the whole region. Second, the data collected for these variables can bias or inaccurate. When data is collected by organizations or from governments the numbers can be inflated to make the country appear better. This is specifically true with data for health and education expenditure. If a countries governement is corrupt it can be difficult to see if the money budgeted for health and education is actually being used for these purposes. Data inaccuracies or bias are always a concern with studies like this, however give the sources of the data, the data is as reputable as possible. Third, the variables used to represent the healthcare sector were removed from the model because of negative coefficients. However, theory, existing literature and common sense show that there is a direct link between the healthcare system of a given country and the percentage of the population that is vaccinated in that country. By not having the healthcare sector represented in this model is a major limitation and can be seen by the decrease in the r-squared between model #2 and model #3. Finally, the given results show that there is a positive correlation between education and measles vaccination percentage and infrastructure and measles vaccination percentage. However, these results only show the relationship between the explanatory variables and MV and do not show other possible benefits that can occur with investment in either education or additions to infrastructure. More research would have to be done to examine this other possible benefits to figure out where investment would have the greatest overall benefits to society. The results found give insight to measles vaccination, but have some limitations.

Future Studies

Future studies that could expand these results include: looking at the discrepancy between urban and rural care and the differences in availability of vaccinations and healthcare, the difference between one dose of the measles vaccination and two doses. Another possible study that more directly relates to this paper is doing the same study with a larger sample size and possible looking at another region as well such as South America or Asia. Finally, to complement these results a study that looked at differing areas of the healthcare sector would be important because both theory and literature suggest that a strong, positive correlation should exist

Conclusion

It is imperative to increase the measles vaccination percentage in many developing countries. This study shows that both increasing the levels of education and infrastructure can both positively impact the measles vaccination coverage. Increasing education can educate the public about both existing vaccination programs that may exist within a country and about the importance and benefits of being vaccinated. Increasing infrastructure would provide access to vaccination facilities to the population, that may not have an efficient, fast and easy way of getting to said facilities, therefore possible forgoing the opportunity to be vaccinated. By increasing both education and infrastructure in developing nations the measles vaccination will increase, helping to eliminate a disease that still plagues many developing nations.

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Appendices

Appendix #1

Data

Country: Algeria

MV: 77% (World Health Organization, 2011a)

ACW: 80% (World Health Organization, 2011a)

PR: 74% (CIA World Factbook, 2012a)

LE: 72 years (World Health Organization, 2011a)

HCE: $280 (World Health Organization, 2011a)

HWC: 31.6 (World Health Organization, 2011a)

EE: 2.6% (The World Bank, 2009b)

ALR: 84% (CIA World Factbook, 2012a)

Country: Angola

MV: 77% (World Health Organization, 2011b)

ACW: 48% (World Health Organization, 2011b)

PR: 10.4% (CIA World Factbook, 2012b)

LE: 52 years (World Health Organization, 2011b)

HCE: $200 (CIA World Factbook, 2012b)

HWC: 14.3 (World Health Organization, 2011b)

EE: 20.3% (CIA World Factbook, 2012b)

ALR: 70% (The World Bank, 2009a)

Country: Botswana

MV: 94% (World Health Organization, 2011c)

ACW: 92% (World Health Organization, 2011c)

PR: 35.3% (CIA World Factbook, 2012c)

LE: 61 years (World Health Organization, 2011c)

HCE: $600 (World Health Organization, 2011c)

HWC: 31.8 (World Health Organization, 2011c)

EE: 25.1 (The World Bank, 2009b)

ALR: 84 (The World Bank, 2009a)

Country: Cameroon

MV: 74% (World Health Organization, 2011d)

ACW: 70% (World Health Organization, 2011d)

PR: 12.4% (CIA World Factbook, 2012d)

LE: 51 years (World Health Organization, 2011d)

HCE: $62 (World Health Organization, 2011d)

HWC: 17.9 (World Health Organization, 2011d)

EE: 17% (The World Bank, 2009b)

ALR: 71 % (The World Bank, 2009a)

Country: Chad

MV: 23% (World Health Organization, 2011e)

ACW: 42% (World Health Organization, 2011e)

PR: 0.8% (CIA World Factbook, 2012e)

LE: 48 years (World Health Organization, 2011e)

HCE: $48 (World Health Organization, 2011e)

HWC: 3.2 (World Health Organization, 2011e)

EE: 12.6% (The World Bank, 2009b)

ALR: 34% (The World Bank, 2009a)

Country: Congo

MV: 76% (World Health Organization, 2011f)

ACW: 72% (World Health Organization, 2011f)

PR: 9.7% (CIA World Factbook, 2012f)

LE: 55 years (World Health Organization, 2011f)

HCE: $71 (World Health Organization, 2011f)

HWC: 9.2 (World Health Organization, 2011f)

EE: 12.6% (The World Bank, 2009b)
ALR: 67% (CIA World Factbook, 2012f)

Country: Democratic Republic of the Congo
MV: 76% (World Health Organization, 2011g)
ACW: 46% (World Health Organization, 2011g)
PR: 13.4% (CIA World Factbook, 2012g)
LE: 49 years (World Health Organization, 2011g)
HCE: $15 (World Health Organization, 2011g)
HWC: 6.4% (World Health Organization, 2011g)
EE: 13.2% (CIA World Factbook, 2012g)
ALR: 68% (The World Bank, 2009a)

Country: Ethiopia
MV: 75% (World Health Organization, 2011h)
ACW: 40% (World Health Organization, 2011h)
PR: 13.7% (CIA World Factbook, 2012g)
LE: 54 years (World Health Organization, 2011h)
HCE: $20 (World Health Organization, 2011h)
HWC: 2.6 (World Health Organization, 2011h)
EE: 23.3% (The World Bank, 2009b)
ALR: 30% (The World Bank, 2009a)

Country: Ghana
MV: 93% (World Health Organization, 2011i)
ACW: 81% (World Health Organization, 2011i)
PR: 29.6% (CIA World Factbook, 2012i)
LE: 60 years (World Health Organization, 2011i)
HCE: $62 (World Health Organization, 2011i)
HWC: 11.4 (World Health Organization, 2011i)
EE: 18.4% (The World Bank, 2009b)

ALR: 67% (The World Bank, 2009a)

Country: Ivory Coast
MV: 67% (World Health Organization, 2011j)
ACW: 74% (World Health Organization, 2011j)
PR: 8.1% (CIA World Factbook, 2012j)
LE: 50 years (World Health Organization, 2011j)
HCE: $52 (World Health Organization, 2011j)
HWC: 6.2 (World Health Organization, 2011j)
EE: 21.7% (The World Bank, 2009b)
ALR: 55% (The World Bank, 2009a)

Country: Kenya
MV: 74% (World Health Organization, 2011k)
ACW: 62% (World Health Organization, 2011k)
PR: 14.1% (CIA World Factbook, 2012k)
LE: 60 years (World Health Organization, 2011k)
HCE: $30 (World Health Organization, 2011k)
HWC: 13.2 (World Health Organization, 2011k)
EE: 17.2% (The World Bank, 2009b)
ALR: 87% (The World Bank, 2009a)

Country: Malawi
MV: 92% (World Health Organization, 2011l)
ACW: 78% (World Health Organization, 2011l)
PR: 45% (CIA World Factbook, 2012l)
LE: 47 years (World Health Organization, 2011l)
HCE: $18 (World Health Organization, 2011l)
HWC: 3 (World Health Organization, 2011l)
EE: 12.1% (The World Bank, 2009b)
ALR: 74% (The World Bank, 2009a)

Country: Mali

MV: 71% (World Health Organization, 2011m)

ACW: 43% (World Health Organization, 2011m)

PR: 18% (CIA World Factbook, 2012m)

LE: 53 years (World Health Organization, 2011m)

HCE: $38 (World Health Organization, 2011m)

HWC: 3.5 (World Health Organization, 2011m)

EE: 17.4% (The World Bank, 2009b)

ALR: 81% (CIA World Factbook, 2012m)

Country: Morocco

MV: 98% (World Health Organization, 2011n)

ACW: 83% (World Health Organization, 2011n)

PR: 67% (CIA World Factbook, 2012n)

LE: 73 years (World Health Organization, 2011n)

HCE: $165 (World Health Organization, 2011n)

HWC: 15.1 (World Health Organization, 2011n)

EE: 25.7% (The World Bank, 2009b)

ALR: 56% (The World Bank, 2009a)

Country: Mozambique

MV: 77% (World Health Organization, 2011o)

ACW: 45% (World Health Organization, 2011o)

PR: 20.7% (CIA World Factbook, 2012o)

LE: 49 years (World Health Organization, 2011o)

HCE: $22 (World Health Organization, 2011o)

HWC: 3.4 (World Health Organization, 2011o)

EE: 15.2% (CIA World Factbook, 2012o)

ALR: 55% (The World Bank, 2009a)

Country: Namibia

MV: 76% (World Health Organization, 2011p)

ACW: 85% (World Health Organization, 2011p)

PR: 12.8% (CIA World Factbook, 2012p)

LE: 57 years (World Health Organization, 2011p)

HCE: $245 (World Health Organization, 2011p)

HWC: 31.5 (World Health Organization, 2011p)

EE: 22.4% (The World Bank, 2009b)

ALR: 89% (The World Bank, 2009a)

Country: Somalia

MV: 24% (World Health Organization, 2011q)

ACW: 22% (World Health Organization, 2011q)

PR: 4.3% (CIA World Factbook, 2012q)

LE: 51 years (World Health Organization, 2011q)

HCE: $30 (World Health Organization, 2011q)

HWC: 1.5 (World Health Organization, 2011q)

EE: 6.3% (CIA World Factbook, 2012q)

ALR: 42% (CIA World Factbook, 2012q)

Country: South Africa

MV: 62% (World Health Organization, 2011r)

ACW: 78% (World Health Organization, 2011r)

PR: 17.3% (CIA World Factbook, 2012r)

LE: 54 years (World Health Organization, 2011r)

HCE: $450 (World Health Organization, 2011r)

HWC: 48.5 (World Health Organization, 2011r)

EE: 16.9% (The World Bank, 2009b)

ALR: 89% (The World Bank, 2009a)

Country: Sudan

MV: 82% (World Health Organization, 2011s)

ACW: 62% (World Health Organization, 2011s)

PR: 36.3% (CIA World Factbook, 2012s)

LE: 59 years (World Health Organization, 2011s)

HCE: $88 (World Health Organization, 2011s)

HWC: 11.2 (World Health Organization, 2011s)

EE: 15% (The World Bank, 2009b)

ALR: 71% (CIA World Factbook, 2012s)

Country: Zambia

MV: 85% (World Health Organization, 2011t)

ACW: 60% (World Health Organization, 2011t)

PR: 22% (CIA World Factbook, 2012t)

LE: 48 years (World Health Organization, 2011t)

HCE: $64 (World Health Organization, 2011t)

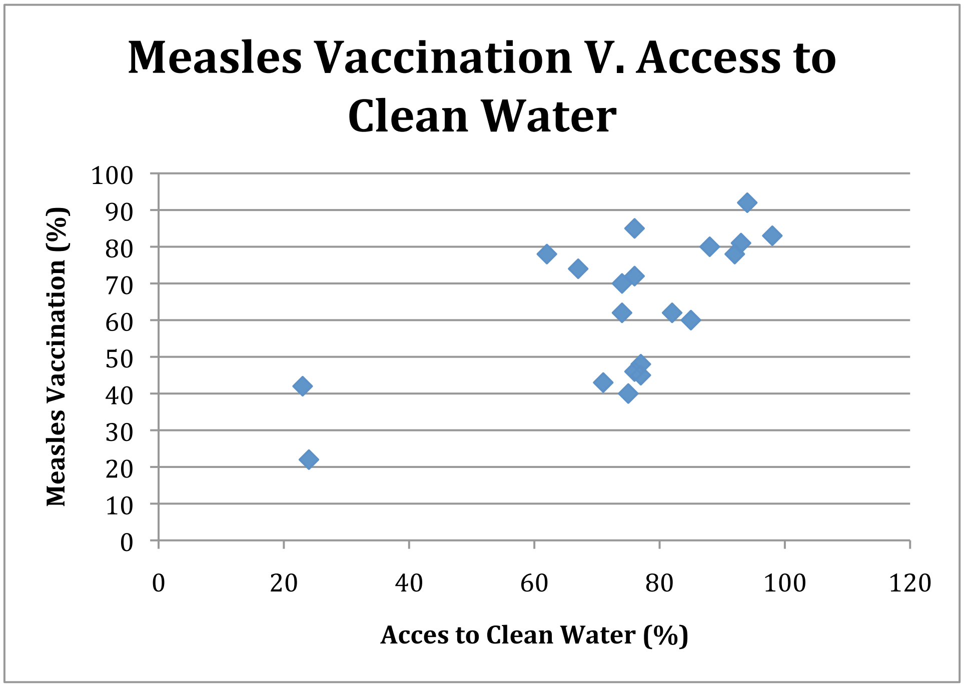
HWC: 7.7 (World Health Organization, 2011t)

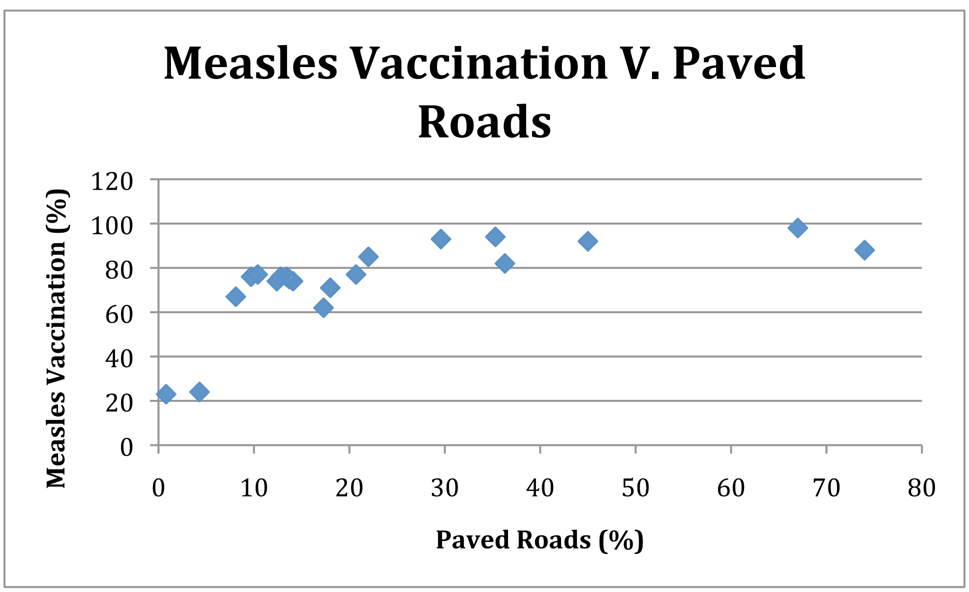
EE: 22% (The World Bank, 2009b)

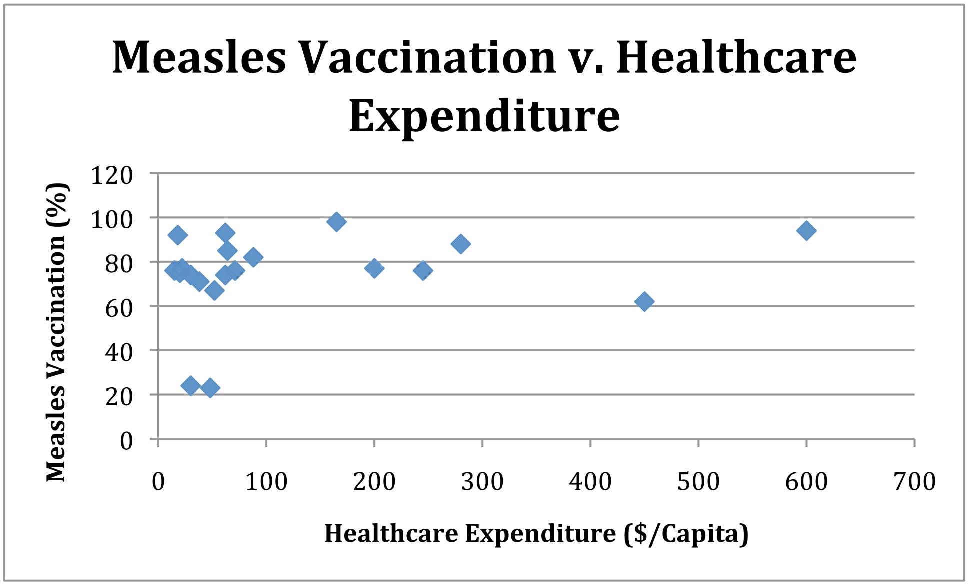
ALR: 71% (The World Bank, 2009a)

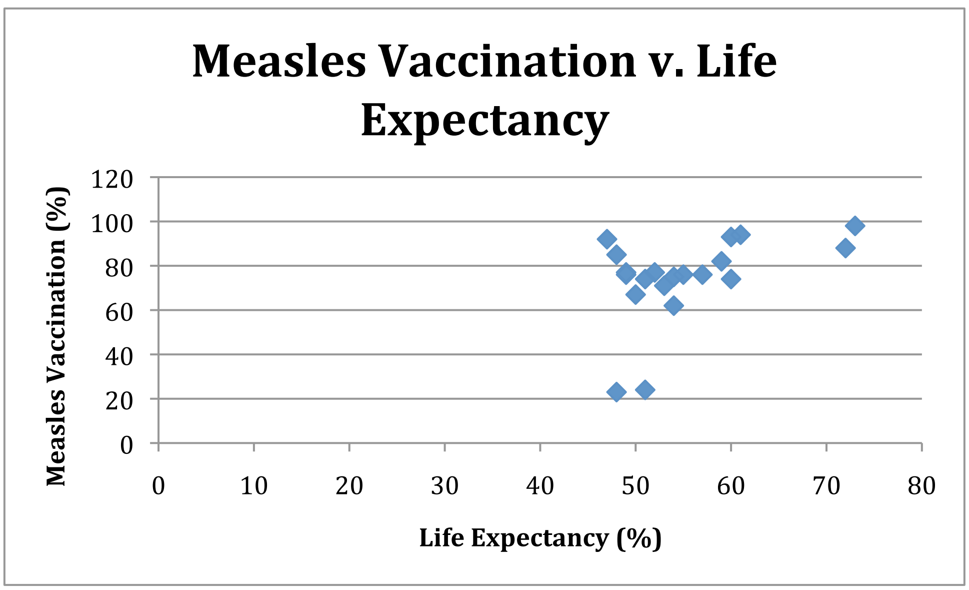
Appendix #2

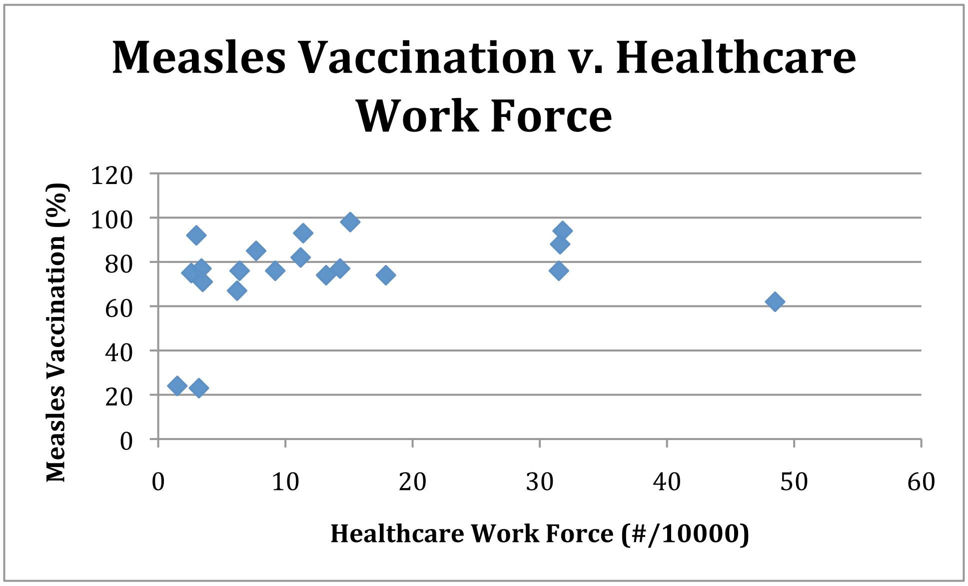
Scatter Plots



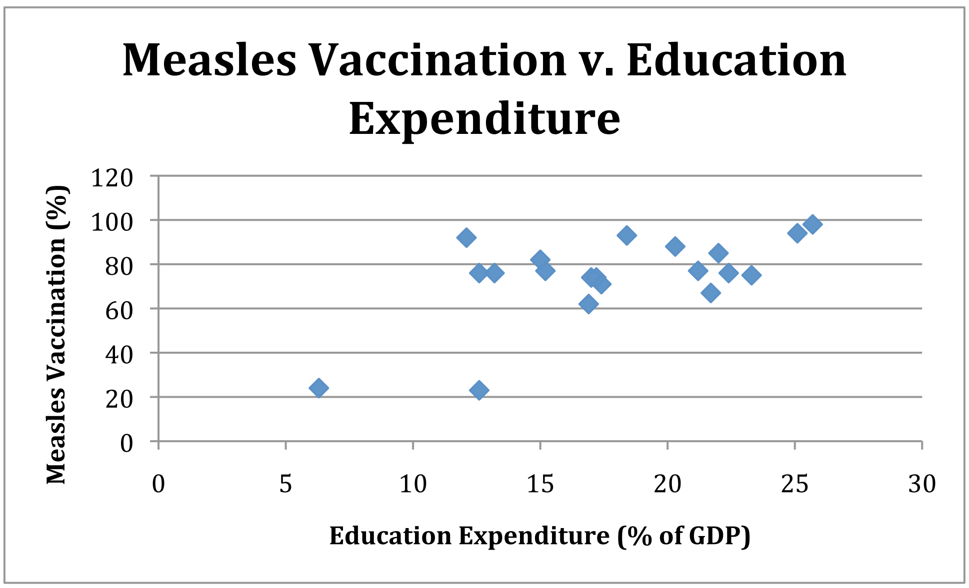


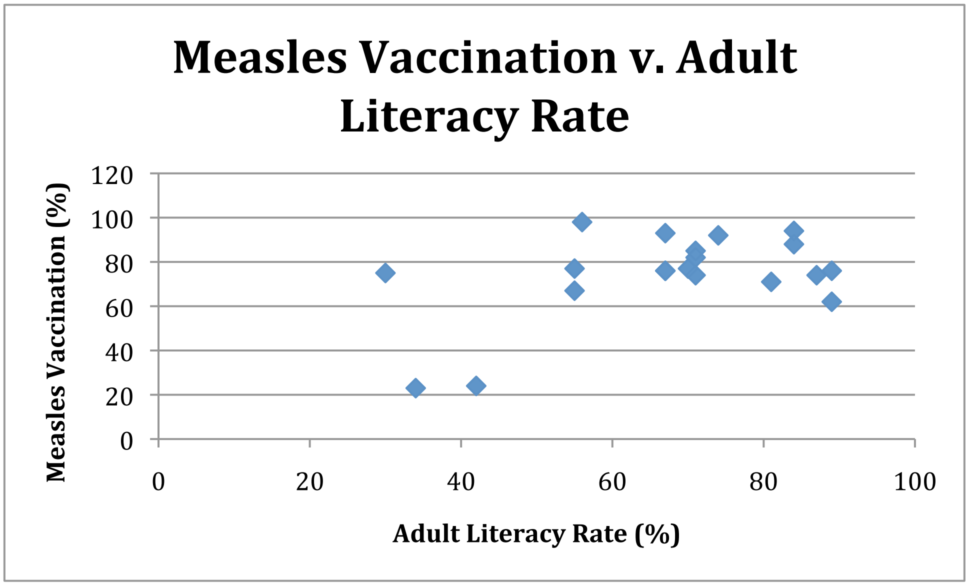

Measles Vaccination v. Healthcare Expenditure
Measles Vaccination (%)
120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
Healthcare Expenditure ($/Capita)


Measles Vaccination v. Life Expectancy
Measles Vaccination (%)
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
Life Expectancy (%)


Measles Vaccination v. Healthcare Work Force
Measles Vaccination (%)
120
100
80
60
40
20
0
0
10
20
30
40
50
60
Healthcare Work Force (#/10000)

d


Measles Vaccination v. Education Expenditure
Measles Vaccination (%)
120
100
80
60
40
20
0
0
5
10
15
20
25
30
Education Expenditure (% of GDP)


Measles Vaccination v. Adult Literacy Rate
Measles Vaccination (%)
120
100
80
60
40
20
0
0
20
40
60
80
100
Adult Literacy Rate (%)

Work Journal

Sunday April 1, 2012

- Finalized my topic: decided to specifically look at measles because it is a vaccination that has been incredible successful at preventing the disease in more developed nations. I first want to see if there is a correlation between the vaccination level and the number of cases, looking at it using a time series. This is to show that using measles vaccination is a good variable to pick for access to healthcare because vaccinations are a simple and effective way for preventative healthcare. Next using vaccination rates as a variable to represent access to healthcare, I want to look at the environment, government structure, economic status of differing countries to try to determine what variables play a greater role in access to healthcare for a given population.
- Looked at the WHO country specific data (immunization rate broken down to urban and rural, healthcare expenditure as percentage as GDP, and healthcare infrastructure data). Then organized countries based on Low or high level of GDP for the African region and European Region. Proceeded to download the country reports and immunization records for each of the 28 countries I am going to use to analyze later
- Starting looking for articles that discussed the economics (cost-benefits of immunization programs), the measles vaccination itself (its effectiveness and safeness) and barriers to healthcare in developing countries focusing on the urban/rural problems and possible solutions to these problems.

Monday April 2, 2012

- Met with Dr. Viladent. Talked over idea of project, discussed looking at the individual country's ministries of health website to further gather data (# of healthcare facilities in the country and if they have special programs to help the rural areas or to overcome other obstacles such as poor infrastructure).

- Make sure to include variable bias in the discussion section (that the variables included in model do not account for everything, economic variables don't account for inequality, and that the reported variables could be skewed by the governement, especially if it is corrupt, to make the country seem to be more developed).

Tuesday April 3, 2012 updated Friday April 27, 2012

- Emailed Pascale Wismer to get in contact with Paul-Henri Arni, ICRC Health care in Danger for an interview
- As of April 27, 2012 I have not received a response.

Thursday April 5, 2012

- Graphed a time series of the % of one year olds vaccinated to get an idea of the overall global trend.   Challenges presented: availability of vaccination percentage from long time ago. So just looked at 2002-2011

- Things to do: break time series down by region

Monday- Wednesday April 9-11, 2012

- Complied data from the internet into excel, so it will be possible to use software to run the regression. Pick the variables to use was difficult to start I am going to included: Measles vaccination, Access to clean water, Paved road percentage, life expectancy, healthcare work force, healthcare expenditure, education expenditure, and adult literacy rate, but will run multiple regressions play around with differing variables to find the best r-squared and most statistically significant variables.   I am going to run the regression using the ordinary least squares method (OLS).

Percentage of 1 year olds vaccinated against measles (MV)

Variables to represent Economy:

GDP per Capital (GDPPC) Measured in US dollars

Variables to represent Infrastructure:

Access to clean water and sanitation (ACW and ACS) measured by # of people who use improved sanitation facility and water filter

Percentage of total roads that is paved (Cia world fact book). (PR)

Variables to represent Health care sector:

Life Expectancy (LE) Measured in years

Healthcare workforce (HCW)= # of nurses, midwives and physicians for 10,000 citizens

Health expenditure (HCE) measured in US$ per capita per year

Variables to represent access to education:

Adult Literacy Rate (ALR) % of literate people ages 15 and above

EE= education expenditure percentage of GDP spent annually to improve education.

Urban population (UP) measured in a percentage

Different regression Variables to represent governement:

Dummy variable if there is a program

Corruption indices Transparency

Friday April 13th 2012

- Talked to Viladent about how many variables I was using and what the best ones to use might be. He recommends using mostly health, education and infrastructure variables. Especially healthcare and education expenditure. Corruption could be used in discussion to maybe discuss an outlier, but it could be a very biased variable and impact my results. Same with economic variables, GDP per capita does nothing to account for inequality. Finally, it was recommended that I use the put all the variables in and work my way down to a final model to see what variables create the best results.

Monday and Tuesday April 16th and 17th, 2012

- Graphed scatter plots
- Ran regressions ran into a few problems with negative coefficients with the healthcare variables, they were removed one at a time, problem persisted, so in the end removed them all and had a model that used only infrastructure and education variables. Deals with the negative coefficient problem, but makes the model more limited, however I this point I don't believe I have time to collected data on different variables and start over in the regression process. Future study?

Wednesday- Tuesday April 18th-23rd, 2012

- Write, write, write

Tuesday April, 23rd 2012

- Talked to Viladent about the specifics of citations of World Health Organization releases.

Wednesday April 24th, 2012

- Created powerpoint and hand out for presentation
- Went over results with Dr. Viladent and discussed best way to report them in the result section of my ISP

Thursday-Friday April 26th-27th 2012

- Finished up citations
- Editing ISP