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Quality Control and Improvement

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***Abstract*— The aim of this project is to analyze the healthcare of countries with low resources/financing to understand how factors like sanitation, GDP, literacy rate, life expectancy etc affect the health of people; by looking into the cases of malaria, tuberculosis and cancer. The point is to establish how the above factors influence these diseases. We will set our own control limits (the limits we believe encompass an ideal system) by using Denmark, one of the countries with the best healthcare resources in the world, as a benchmark. We will analyze the data we obtain from the Gapminder.org, against our control limits we wish to meet, do a regression analysis and also suggest possible recommendations for improvement in these low healthcare resource countries.**

***Index Terms*— healthcare, literacy rate .**

I. Introduction

Index	Countries	Tuberculosis/100,000	Malaria/100,000	Cancer Cases	Access to Sanitary Facilities	Literacy Rate	Life Expectancy
1	Bangladesh	227	232	67	56	61.5	67.5
2	Cuba4	25		77	91	99.7	75
3	Egypt	15	0.0391	69	95	75.2	70.1
4	Haiti	200	347	60	17	60.7	60.3
5	India4	167	155	62	34	72.1	62.9
6	Indonesia	399	580	68	54	93.9	68.9
7	Kenya	246	21800	57	32	78	58.4
8	Lesotho	852		47	26	79.4	49.7
9	Malawi	227	31000	47	51	65.8	29.6
10	Mali	58	8540	52	22	38.7	57.4
11	Mauritus	22		71	89	90.6	74.6
12	Myanmar	369	982	62	76	93.1	64
13	Nepal	158	560	60	31	64.7	67.8
14	Pakistan	270	78	63	48	56.4	62.7
15	Papua New Guinea	471	27000	57	45	64.2	58
16	Somalia	274	583	55	23		52.2
17	Sudan	94	5930	65	26	75.9	64.9
18	Uganda	161	42800	52	34	73.9	54.9

Figure 1: Countries and their factors

Above, we have the data from Gapminder.org, which we will analyze and set control limits on, to see how the data performs against the standards we aim to meet.

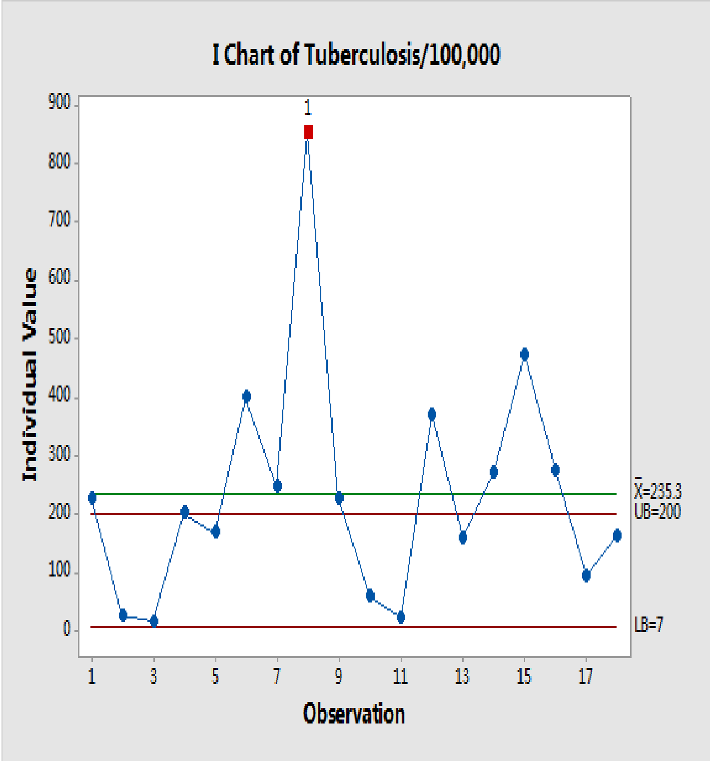

Figure 2: Control chart of tuberculosis/100,000 for each country vs control limits we have set

In the chart above, we set control limits LCL 7 (DENMARK) UCL (estimate of 200). We set Denmark to be our LB because this is one of the lowest reported rates in the world and so it is our LB because this is what we are willing to accept. We chose 200 as the UCL because experts aim to have 20% reduction in tuberculosis cases by the year 2020, thus we chose our UCL of 200 (200/100,000) cases. By analyzing the data, we see that the average no of tuberculosis cases/100,000 is much above the upper bounds we have set. We also see that we have many out of control points that correspond to the countries Bangladesh, Haiti, Indonesia, Kenya, Lesotho, Malawi, Myanmar, Pakistan, Papua Guinea, and Somalia (numbers correspond to the Figure 1) as they are much above the UB. This tells us tuberculosis cases are above the standard we aim to reach and we need to suggest recommendations to bring these numbers down.

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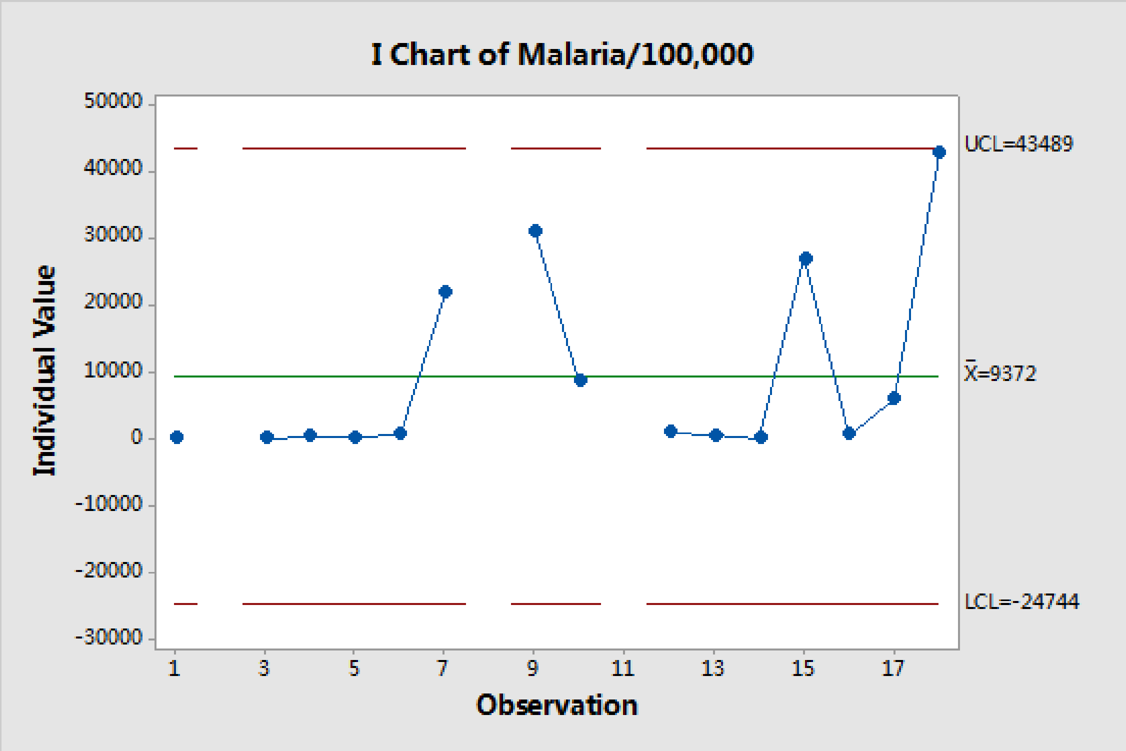

Figure 3: Control chart of malaria/100,000 for each country vs control limits we have set

In the chart above, we didn't set any control limits, because we couldn't find any reported data for Denmark. As such, all data set falls within Minitab calculated standards.

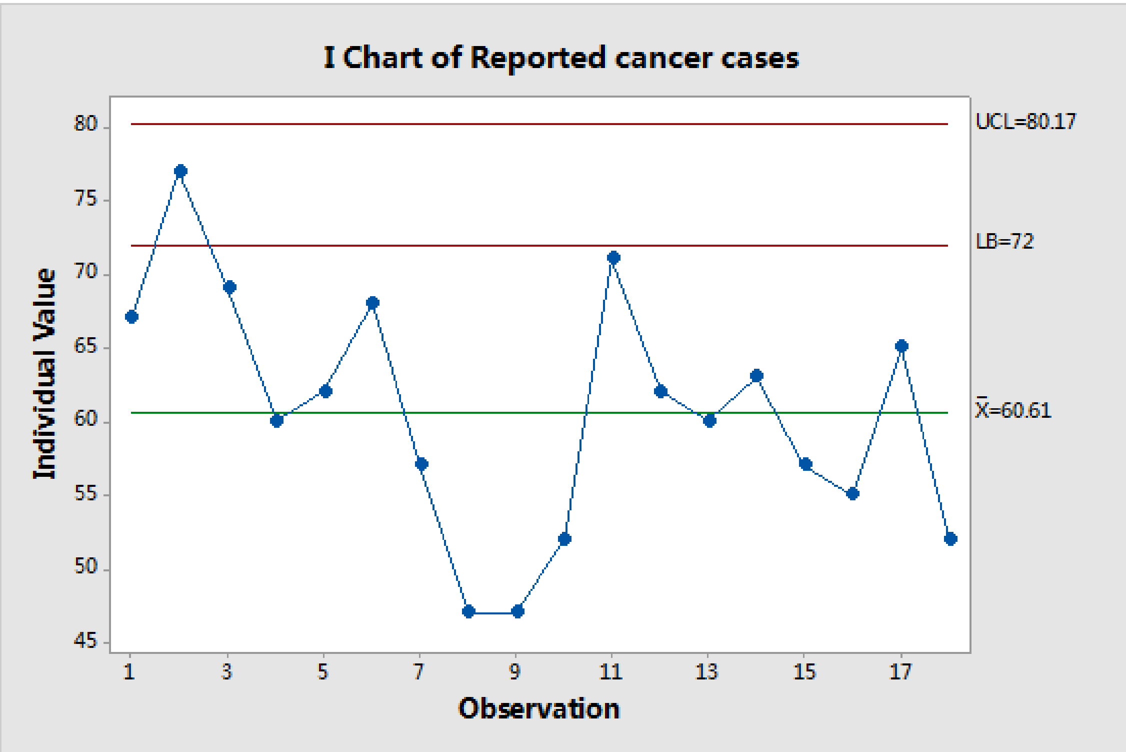

Figure 4: Control chart of cancer cases for each country vs control limits we have set

In the chart above, we set control limits LCL 72 (DENMARK) UCL blank. We set Denmark to be our LB because this is one of the lowest reported rates in the world and so it is our LB because this is what we are willing to accept. We chose to leave our UCL blank and work by Minitab calculation because there is no direct way to combat cancer, people just get diagnosed for various reasons, so we can't set an upper bound. In fact, we wish to have as many as possible reported cases because this tells us the healthcare in the country is more effective, given people are coming in and the data is being documented. By analyzing the data, we see that the average no of cancer cases is below the lower bounds we have set. Thus, cancer cases are being underreported. We also see that we have many out of control points that correspond to all of the countries besides Cuba (numbers correspond to the Figure 1) as they all fall below the LB we have set. This tells us cancer cases are being underreported in many countries and we need to suggest recommendation to encourage reporting and documentation of this disease.

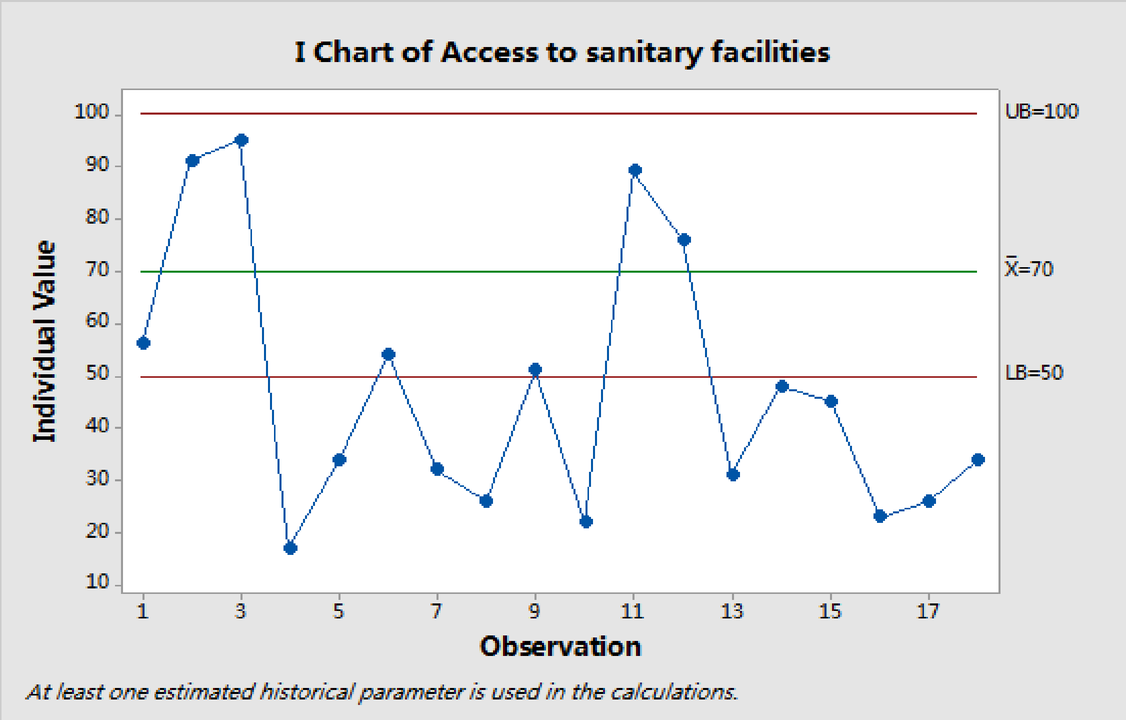

Figure 5: Control chart of access to sanitary facilities for each country vs control limits we have set

In the chart above, we set control limits UCL 100, LCL 50 (1 IN 2 TIMES), average 70 (we hope) We set our lower bounds to be 50 because we want people to have access to sanitary facilities at least 1 in 2 times. We also set our average to 70 because this is the average access to sanitary conditions we hope to achieve. We chose to set our UCL to 100 because that is the ideal system we wish to have set up for all countries. By analyzing the data, we see that we have many out of control points that correspond to the countries Haiti, India, Kenya, Lesotho, Mali, Nepal, Pakistan, Papua Guinea, Somalia, Sudan and Uganda (numbers correspond to the Figure 1) as they are much below the LB. This tells us these countries do not even meet our condition of 50% access to a sanitary facility, and we need to suggest recommendations for improvement.

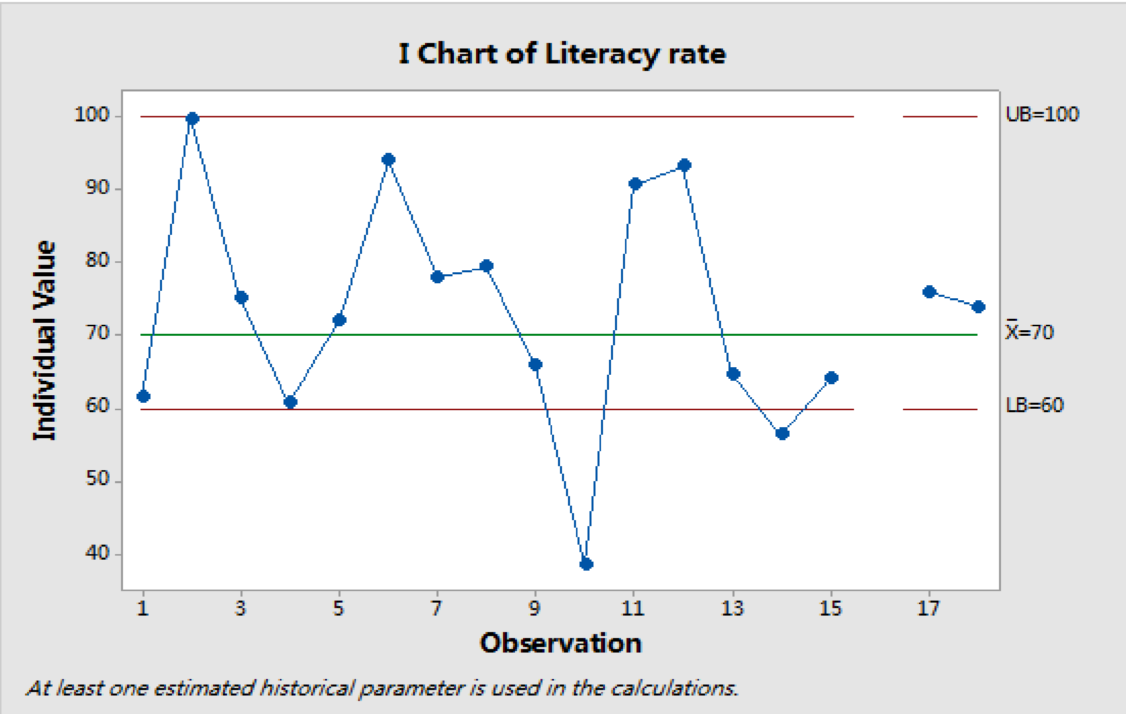

Figure 6: Control chart of literacy rate for each country vs control limits we have set

In the chart above, we set control limits UCL 100, LCL 60, average 70 (we hope). We set our lower bounds to be 60 because that is the minimum literacy rate we wish to tolerate. We also set our average to 70 because this is the average literacy rate we hope to achieve. We chose to set our UCL to 100 because that is the ideal system we wish to have set up for all countries. By analyzing the data, we see that Mali and Pakistan (numbers correspond to the Figure 1) fall out of the set control limits. Also notice Cuba shows an almost perfect literacy rate because it touches the UB (point 2). This tells us that Mali and Pakistan do not meet our condition of at least 60% literacy rate and we need recommendations for improvement.

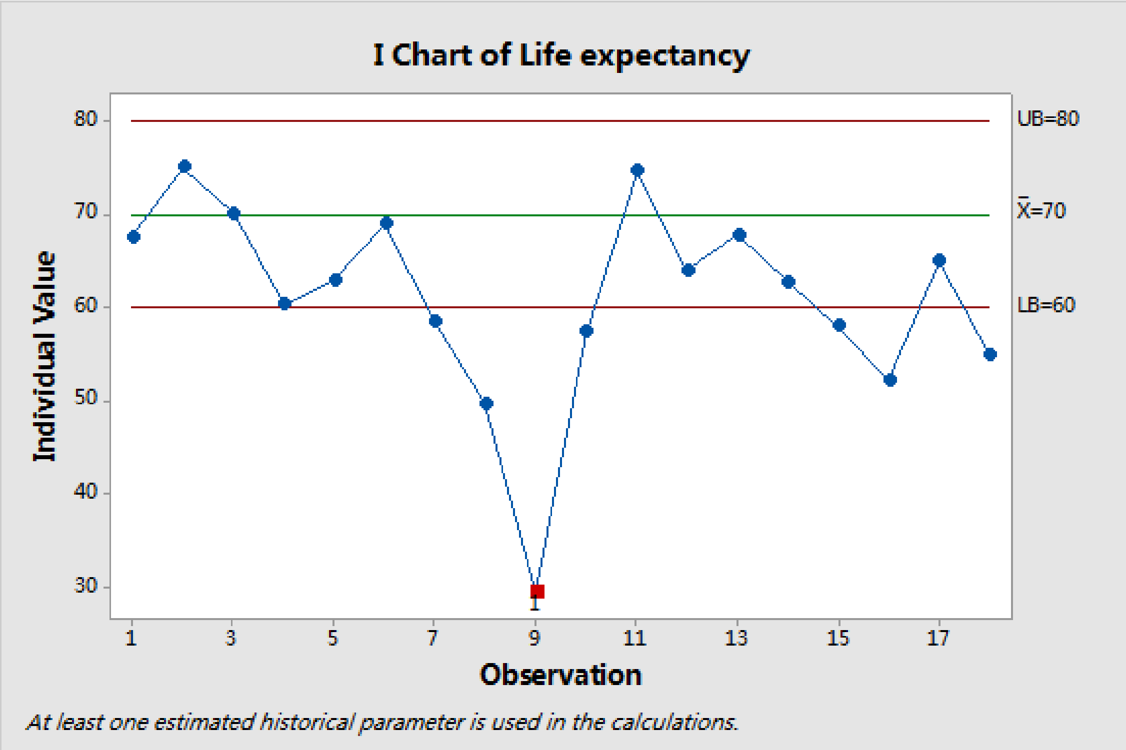

Figure 7: Control chart of life expectancy for each country vs control limits we have set

In the chart above, we set control limits LCL 60 UCL (DENMARK), average 70. We set our lower bounds to be 60 because that is the minimum life expectancy we wish to tolerate. We also set our average to 70 because this is the average life expectancy we hope to achieve. We set Denmark to be our UB because it has one of the best life expectancies in the world, and is the standard we wish to emulate. By analyzing the data, we see that the countries Kenya, Lesotho, Malawi, Mali, Papua New Guinea, Somalia and Uganda (numbers correspond to the Figure 1) fall below the set control limits. This tells us that these countries do not meet our condition of at least 60% life expectancy and we need recommendations for improvement.

Regression Analysis/ Improvement Recommendations

We will do multiple regression analysis for various factors that we recognize are of much importance in causing these diseases, and observe how their increasing and decreasing amount affects another factor, that we recognize as outcome factor. (We know sanitation, income and availability of doctors affects malaria cases so we see impact of these three factor on number of malaria cases as these are improved over the years).

Regression analysis-1 Improved Sanitation, Income Per Person VS Malaria Per 100000

YEAR	IMPROVED SANITATION(%)	INCOME PER PERSON	MALARIA PER 100000
1990	18	316.42	234.69
1991	18	313.27	240.95
1992	19	323.85	236.83
1993	20	332.6	240.84
1994	20	347.95	268.47
1995	21	367.27	313.14
1996	22	387.74	311.99
1997	23	396.18	268.28
1998	24	413.28	220.09
1999	25	440.56	222.22
2000	25	450.41	194.2
2001	26	464.97	195.97
2002	27	475.45	170.18
2003	28	505.24	170.02
2004	29	536.61	171.47
2005	30	577.65	160.13
2006	31	621.9	154.99
2007	31	673	153.33
2008	32	689.27	153.09
2009	33	735.63	151.56
2010	34	794.8	150.65

SUMMARY OUTPUT

IMPROVED SANITATION,INCOME PER PERSON VS MALARIAPER 100000

Regression Statistics	
Multiple R	0.835039426
R Square	0.697290843
Adjusted R Squar	0.663656492
Standard Error	30.50298771
Observations	21

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	2	38578.52939	19289.26	20.7315089	2.13E-05
Residual	18	16747.78066	930.4323		
Total	20	55326.31006			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	437.0828398	55.46321235	7.88059	3.034E-07	320.559	553.6067	320.559	553.6067
X Variable 1	-9.84419701	5.537630725	-1.77769	0.09235379	-21.4783	1.789933	-21.4783	1.789933
X Variable 2	0.04730791	0.193791701	0.244117	0.80990082	-0.35983	0.454449	-0.35983	0.454449

We observe if sanitation is improved over the years, coefficient has a negative sign, which shows how outcome is decreasing with increased level of sanitation. But we do not see any such effect on income, thus it is positive.

We know malaria cases are outcomes of unhygienic conditions, lack of sanitation etc Malaria cases have less to do with income level and more to do with sanitation, so we improve over sanitation instead of income per person to reduce malaria (better sanitation is must for reducing malaria cases).

Regression Analysis/ Improvement Recommendations cases

Regression analyses-2 Improved Sanitation, Income per person VS Tuberculosis per 100000

YEAR	IMPROVED SANITATION(%	INCOME PER PERSON	TUBERCULOSIS PER 100000
1990	18	316.42	217
1991	18	313.27	216
1992	19	323.85	216
1993	20	332.6	216
1994	20	347.95	216
1995	21	367.27	216
1996	22	387.74	217
1997	23	396.18	217
1998	24	413.28	217
1999	25	440.56	217
2000	25	450.41	216
2001	26	464.97	216
2002	27	475.45	215
2003	28	505.24	214
2004	29	536.61	212
2005	30	577.65	209
2006	31	621.9	205
2007	31	673	201
2008	32	689.27	196
2009	33	735.63	191
2010	34	794.8	185

SUMMARY OUTPUT

IMPROVED SANITATION,INCOME PER PERSON VS TUBERCULOSIS PER 100000

Regression Statistics	
Multiple R	0.988301
R Square	0.97674
Adjusted R	0.974155
Standard E	1.533702
Observatic	21

ANOVA

	df	*SS*	*MS*	*F*	*'gnificance F*
Regressior	2	1777.945	888.9727	377.9255	1.99E-15
Residual	18	42.34038	2.352243		
Total	20	1820.286			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	213.8183	2.788713	76.67275	4.27E-24	207.9594	219.6771	207.9594	219.6771
X Variable	2.834587	0.278434	10.18045	6.78E-09	2.249618	3.419556	2.249618	3.419556
X Variable	-0.15589	0.009744	-15.9992	4.36E-12	-0.17637	-0.13542	-0.17637	-0.13542

We observe effect of income on TB cases. As income per person increases we observe occurrence of TB cases per 100,000 reducing (negative coefficient). But we have an increasing effect of improved sanitation.

Sanitation does surely play an important role in disease like TB but besides sanitation, income has more of an effect, because Tb depends more on nutrition, living conditions and treatment (availability of doctors). Thus, as the income goes up we see a decline in TB cases.

For diseases like TB, focus should be more on increasing incomes or making treatment available to patients (expenditure on healthcare).

Regression Analyses-3 Income Per person, Health Expenditure VS Life Expectancy

INCOME PER PERSON	HEALTH EXPENDITURE PER PERSON	LIFE EXPECTANCY
316.42	4.09773063	58.2
313.27	4.09773063	58.5
323.85	4.09773063	58.8
332.6	4.09773063	59.1
347.95	4.09773063	59.5
367.27	4.09773063	59.9
387.74	4.07533927	60.2
396.18	4.61096966	60.5
413.28	4.71078943	60.8
440.56	5.09770195	61.2
450.41	5.08230115	61.5
464.97	4.99358646	61.9
475.45	4.88120375	62.3
505.24	5.39036747	62.8
536.61	6.00643062	63.2
577.65	7.31977194	63.6
621.9	8.2100212	63.9
673	10.42370188	64.3
689.27	11.92058097	64.7
735.63	13.42071482	65
794.8	15.82486231	65.4

INCOME PER PERSON,HEALTH EXPENDITURE PER PERSON VS LIFE EXPECTANCY

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.996658
R Square	0.993327
Adjusted R	0.992586
Standard E	0.195567
Observatic	21

ANOVA

	df	*SS*	*MS*	*F*	*'gnificance F*
Regressior	2	102.4839	51.24197	1339.785	2.62E-20
Residual	18	0.688435	0.038246		
Total	20	103.1724			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	52.6597	0.21844	241.0715	4.85E-33	52.20078	53.11863	52.20078	53.11863
X Variable	0.024125	0.000881	27.39223	3.98E-16	0.022275	0.025975	0.022275	0.025975
X Variable	-0.40836	0.037307	-10.9457	2.18E-09	-0.48674	-0.32998	-0.48674	-0.32998

We observe life expectancy increases as income per person increases while we observe negative coefficient for health expenditure. We know increase in income makes people live better, afford better facilities. But there is a negative coefficient for health expenditure. As health expenditure increases, life expectancy should also increase, instead, it stays low like in the case of India).

So if expenditure on health is not significant we can focus on increasing income levels.

Regression Analyses-4 Health Expenditure by Government, Expenditure by Private sector VS HDI

YEAR	% OF TOAL SPENDING ON	HUMAN DEVELOPMENT II	HUMAN DEVELOPMENT II
1990	73.9591	0.428	0.428
1991	73.9591	0.428	0.428
1992	73.9591	0.428	0.428
1993	73.9591	0.428	0.428
1994	73.9591	0.428	0.428
1995	73.9591	0.462	0.462
1996	74.3012	0.462	0.462
1997	74.8772	0.462	0.462
1998	74.4108	0.462	0.462
1999	72.0330	0.462	0.462
2000	74.0293	0.496	0.496
2001	76.1348	0.496	0.496
2002	76.8200	0.496	0.496
2003	77.2141	0.496	0.496
2004	77.2787	0.496	0.496
2005	76.0950	0.539	0.539
2006	75.1806	0.539	0.539
2007	74.1985	0.539	0.539
2008	72.3579	0.539	0.539
2009	69.7253	0.539	0.539
2010	70.8273	0.586	0.586

PERCENT OF HEALTH EXPENDITURE BY GOVERNMENT,PRIVATE SECTOR VS HUMAN DEVELOPMENT INDEX

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.171985
R Square	0.029579
Adjusted R	-0.07413
Standard E	0.047537
Observatic	21

ANOVA

	df	*SS*	*MS*	*F*	*'gnificance F*
Regressior	2	0.001309	0.000654	0.579126	0.570492
Residual	19	0.042935	0.00226		
Total	21	0.044244			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	0.798377	0.410298	1.945844	0.066618	-0.06039	1.657141	-0.06039	1.657141
X Variable	0	0	65535	#NUM!	0	0	0	0
X Variable	-0.0042	0.005524	-0.761	0.455997	-0.01577	0.007358	-0.01577	0.007358

We observe a negative coefficient, which shows if share of private sector is decreasing in healthcare industry, HDI is getting affected adversely. Also, we have zero coefficients for government spending. This is because government share is already quite low and with increasing population, government is not spending that much and private sector is not growing with that much pace as to compensate for growth in population.

Regression Analyses-5 Food Supply per Day, Physician per 1000 vs HDI

YEAR	%OF TOAL SPENDING ON	HUMAN DEVELOPMENT IN	HUMAN DEVELOPMENT IN
1990	73.9591	0.428	0.428
1991	73.9591	0.428	0.428
1992	73.9591	0.428	0.428
1993	73.9591	0.428	0.428
1994	73.9591	0.428	0.428
1995	73.9591	0.462	0.462
1996	74.3012	0.462	0.462
1997	74.8772	0.462	0.462
1998	74.4108	0.462	0.462
1999	72.0330	0.462	0.462
2000	74.0293	0.496	0.496
2001	76.1348	0.496	0.496
2002	76.8200	0.496	0.496
2003	77.2141	0.496	0.496
2004	77.2787	0.496	0.496
2005	76.0950	0.539	0.539
2006	75.1806	0.539	0.539
2007	74.1985	0.539	0.539
2008	72.3579	0.539	0.539
2009	69.7253	0.539	0.539
2010	70.8273	0.586	0.586

SUMMARY OUTPUT

PERCENT OF HEALTH EXPENDITURE BY GOVERNMENT,PRIVATE SECTOR VS HUMAN DEVELOPMENT INDEX

Regression Statistics	
Multiple R	0.171985
R Square	0.029579
Adjusted R	-0.07413
Standard E	0.047537
Observatic	21

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regressior	2	0.001309	0.000654	0.579126	0.570492
Residual	19	0.042935	0.00226		
Total	21	0.044244			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	0.798377	0.410298	1.945844	0.066618	-0.06039	1.657141	-0.06039	1.657141
X Variable	0	0	65535	#NUM!	0	0	0	0
X Variable	-0.0042	0.005524	-0.761	0.455997	-0.01577	0.007358	-0.01577	0.007358

We see the coefficient for physician per 1000 people is higher than coefficient for food supply per day. In countries like India food supplied per day is having better scenario than doctors available per 1000 people, as food shortage is not that much of a problem as having availability of doctor (number of doctors as compared to population is quite low). So we see a larger impact on availability of doctors than food supply, so we need to improve the number of doctors available to peoples.