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Visualizing Health Determinants in a Global Context

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Abstract
In this work, our objective is to visualize the relationship between the variables that impact health in a global context. Recently, Cornia et al. [1] have proposed five main determinants of global health – material deprivation, progress in health technology, acute psychosocial stress, unhealthy lifestyle, and income inequality etc. Results of regression analysis worldwide indicate that almost 90% of the variation in health can be attributed to twelve variables representing these five determinants. We compute correlations between the health variables and its determinants and apply a visualization tool [2] to display these correlations globally and at country level in order to gain a better understanding. We observe that the country-level results obtained through easy-to-understand graphs and simple correlation analysis pose an anomaly to the worldwide regression results and require further analysis to close the gap between correlation and regression analysis and the gap between the country-level and global-level analysis.

Keywords: Globalization, Health, Visualization, Correlation, Regression.

Section 1. Introduction and Motivation

What are the main determinants of health? What changes can be advocated in the health policy at global, regional, and national level to make an improvement in health?

Recently, Cornia et al. [1] have proposed five main determinants of global health:
- (i)   material deprivation,
- (ii)   progress in health technology,
- (iii)   acute psychosocial stress,
- (iv)   unhealthy lifestyle, and
- (v)   income inequality, hierarchy, and social disintegration.

They used a fixed effects model to estimate the dependency of health on its various factors. Specifically, dependency of 3 health variables –
LEB (life expectancy at birth), IMR (infant mortality rate), and U5MR (under 5 mortality rate) – on 12 determinants
(Log GDP/c, GDP/c volatility, GINI income distribution, Gini coefficient more than 4, female illiteracy, log physicians per 1000 people/GINI, DPT Immunization rate, Immigrants Stock/ Total Population, Alochol Consumption/c, War and Humanitarian emergencies, Disasters, and HIV/AIDS)
is estimated using a worldwide regression analysis for 97 countries. Results are reported in Table 10 of the paper [1]. Results indicate that approximately 80 to 90% variation in health can be attributed to these variables.

These results are statistically significant and have far reaching significance. Indeed, the authors note that "practically all variables have the expected sign and plausible and statistically significant coefficients." For example, using these results, the authors conclude that "for instance, model suggests that raising the DPT immunization rate by 30 points would reduce U5MR (under 5 mortality rate) by 18.4 points." Indeed, one of the conclusions is that health will be improved by increasing GDP, physicians, DPT immunization rate, and immigrant stock per total population and by decreasing GDP/c volatility, GINI income distribution, female illiteracy, alocohol consumption, and HIV/AIDS rate. Furthermore, the model provides a quantitative estimate of expected improvement in health variables by making these changes in the underlying health determinants.

This work attempts to understand the results of Table 10 as applied at the country level using correlation between the variables and visualizing correlation coefficients and associated graphs. We have used the same database, GHND (The Globalization-Health Nexus database) [3] that has been put together by the same group of authors as in paper [1] and has been generously made available on the web.

**Section 2. Visualizing Health Determinants**

We have adapted the correlation visualization tool [2] to visualize the relationship between any two variables at the country level. Using this tool, the user can choose any two indicators, for example, LEB (life expectancy at birth) and GINI (Gini index of income inequality). We compute the correlation between these indicators for each country over the time span from 1960 to 2005 and visualize the correlation coefficients between these two indicators for each country ona world map (see Figure 1). Similarly, the correlation coefficients between LEB and female illiteracy above 25 are visualized in Figure 3 and between U5MR (under 5 mortality rate) and alcohol consumption is visualized in Figure 5 respectively.

Furthermore, the user can pick any country and view a scatter plot graph of the relationship between the two variables where scatter data points correspond to different time periods. For example, Figure 2 displays relationships between LEB and GINI for Mexico, Denmark, China, and USA over a 40 year time span. Similarly, Figures 4 and 6 shows relationships between the indicators described above for chosen countries.

We also have the capability of displaying the time series data as line graphs for the two indicators for any chosen country.

We use the visualization and associated data to make some observations regardoing trends of these indicators and how these observations fuel additional questions and a need for further analysis and visualization to help find answers to these questions. We describe these observations and raise some questions for LEB and its relationship to GINI, but we leave it to the readers to make observations about the relationship between the other two pairs of indicators chosen.

Section 3. Analysis and Discussion
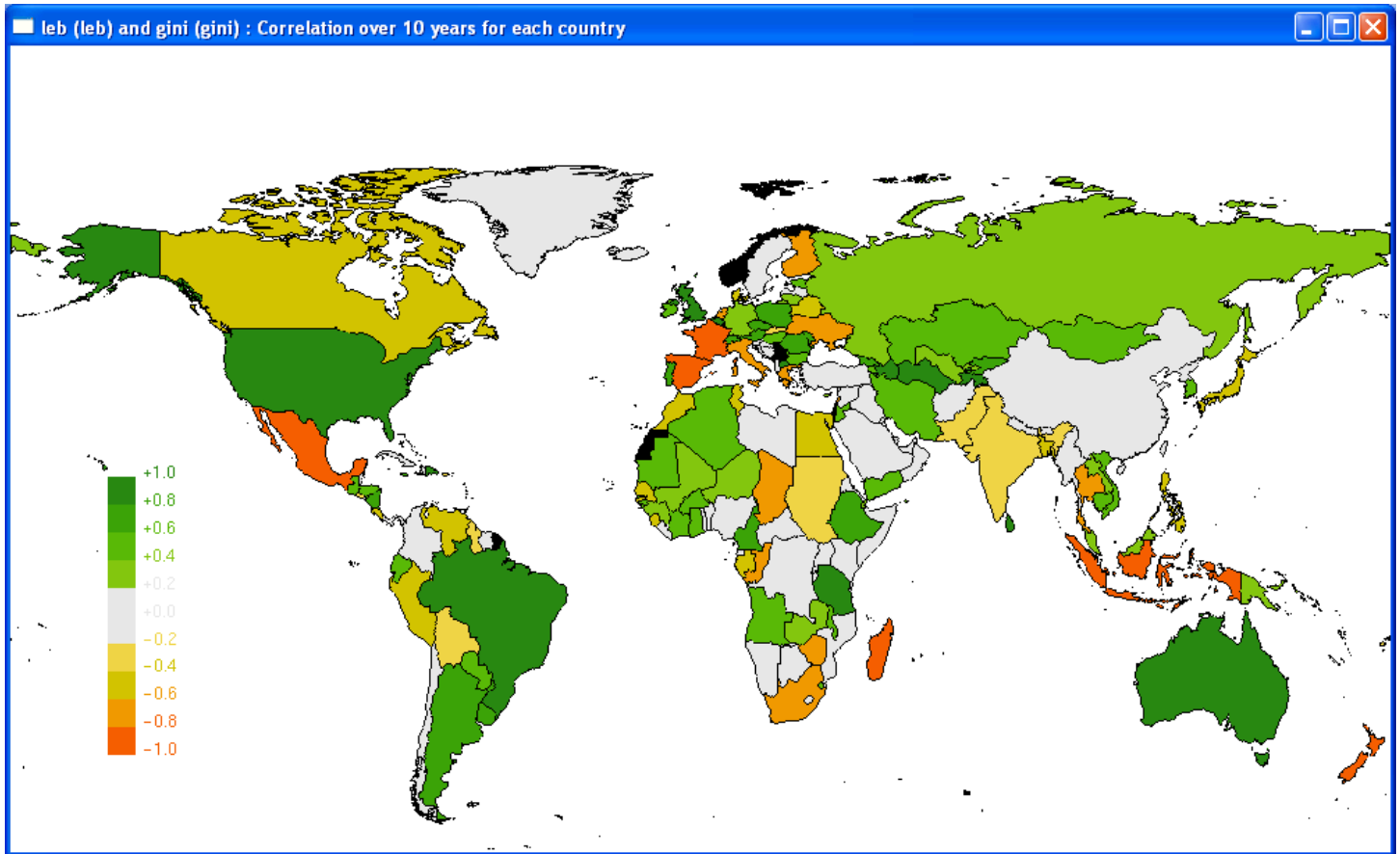
Figure 1: Correlation coefficients between LEB (Life Expectancy at Birth) and GINI index of income inequality (1960-2005); correlation coefficients are shown using a color legend shown on the left above, for example, dark green color means high correlation between the two variables and red color means high inverse correlation; the worldwide regression slope between the two variables, as reported in [1] is - .057 with statistical significance between 1 and 5% level. This regression coefficient implies that an increase in income inequality of 2 points is estimated to result in a decrease of life expectancy at birth roughly by 1.14 years.

We chose four countries: Mexico, Denmark, Chile, and USA to analyze these results at the country level.

|	LEB (1960)	LEB (2005)	Increase In LEB	GINI (1960)	GINI (2005)	Increase In GINI	Correlation Coefficient
Mexico	58	75	17	54	51	-3	-0.905
Denmark	72	77	5	38	34.75	-3.25	-0.487
China	42	71	29	42	45	3	-0.080
USA	70	77	7	40.75	46	5.25	0.853
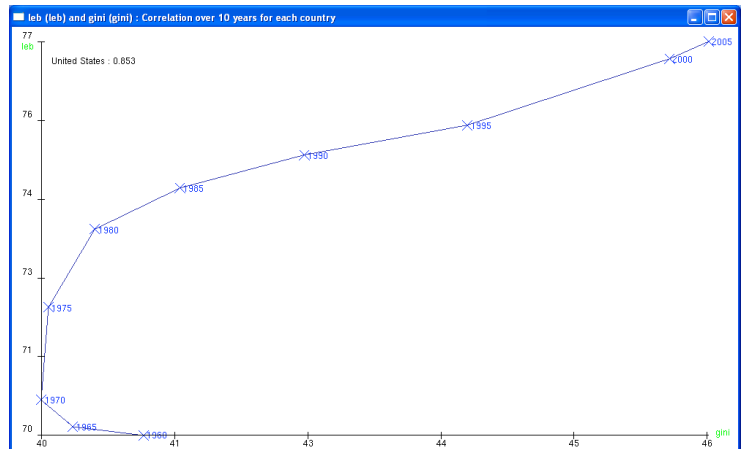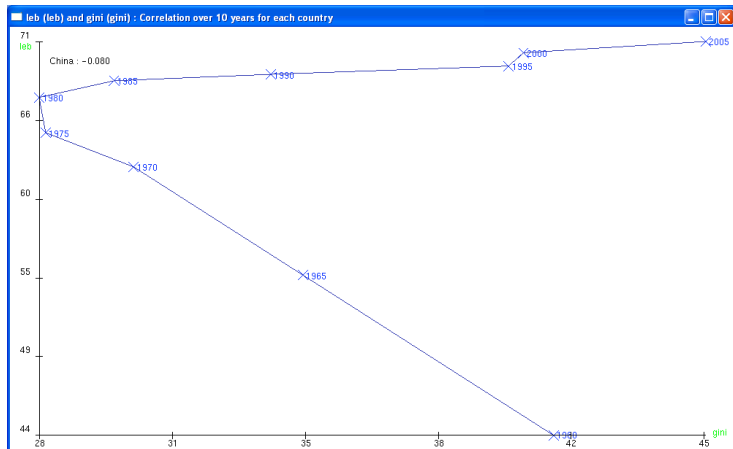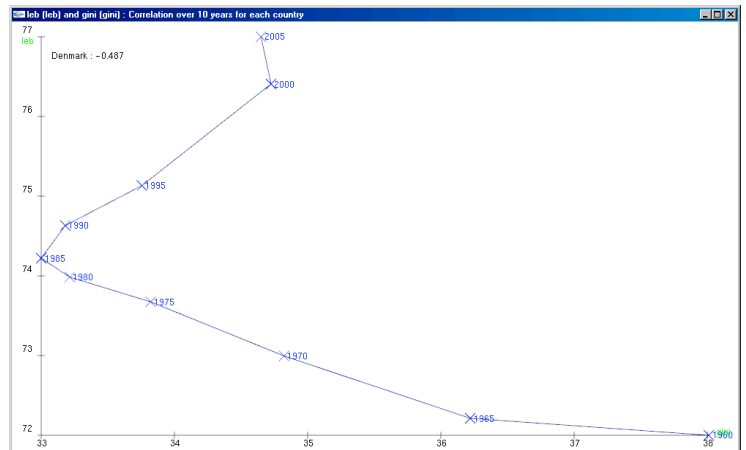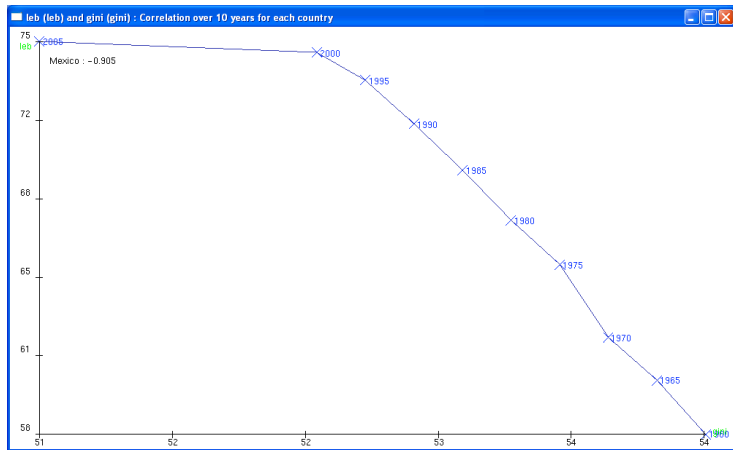
**Figure 2: LEB vs. GINI index of income inequality for Mexico, Denmark, China, and USA.**

LEB has monotonically increased for all the four countries. The gap in LEB between different countries have become much closer. LEBs for these countries are between 71 and 77 years. These observations spur the thought that (i) there are strong barriers to increase the LEB above a certain limit, say, and that (i) perhaps it is possible to achieve LEB of 70 years for all countries. Which countries have LEB less than 70 years? Are they on a trajectory of increasing LEB? If not, what can be done to put them on this trajectory? An analytic visualization tool to answer these questions would be very useful.

GINI index, in contrast to LEB, does not follow a simple path. Nevertheless, there are strong patterns. GINI has decreased monotonically for Mexico over a period of 40 years. GINI index has decreased monotonically for Demark and China from the period 1960 to around 1980 when it reversed its course and has gradually increased since then. GINI index remained fairly stable for USA from 1960 to 1980 when it also started increasing monotonically to its highest value ever. These graphs indicate a need for analyzing the relationship separately for the two time periods: from 1960 to 1980 and from 1980 to 2005.

Correlation coefficients vary from almost -.9 for Mexico to +.85 for USA. In case of Mexico, based on correlation coefficient, one may be tempted to state that a reduction in income inequality helped increase LEB. However, in case of USA, following the same logic, one will be tempted to make an opposite conclusion. As is well known, correlation analysis does not imply causality. However, based on the regression analysis, one may conclude that for Mexico, indeed, a decrease in income inequality helped increase the LEB. However, in case of USA, LEB increased in spite of the increase in income inequality. Will a reduction in income inequality in USA help increase LEB beyond the 80 barrier?
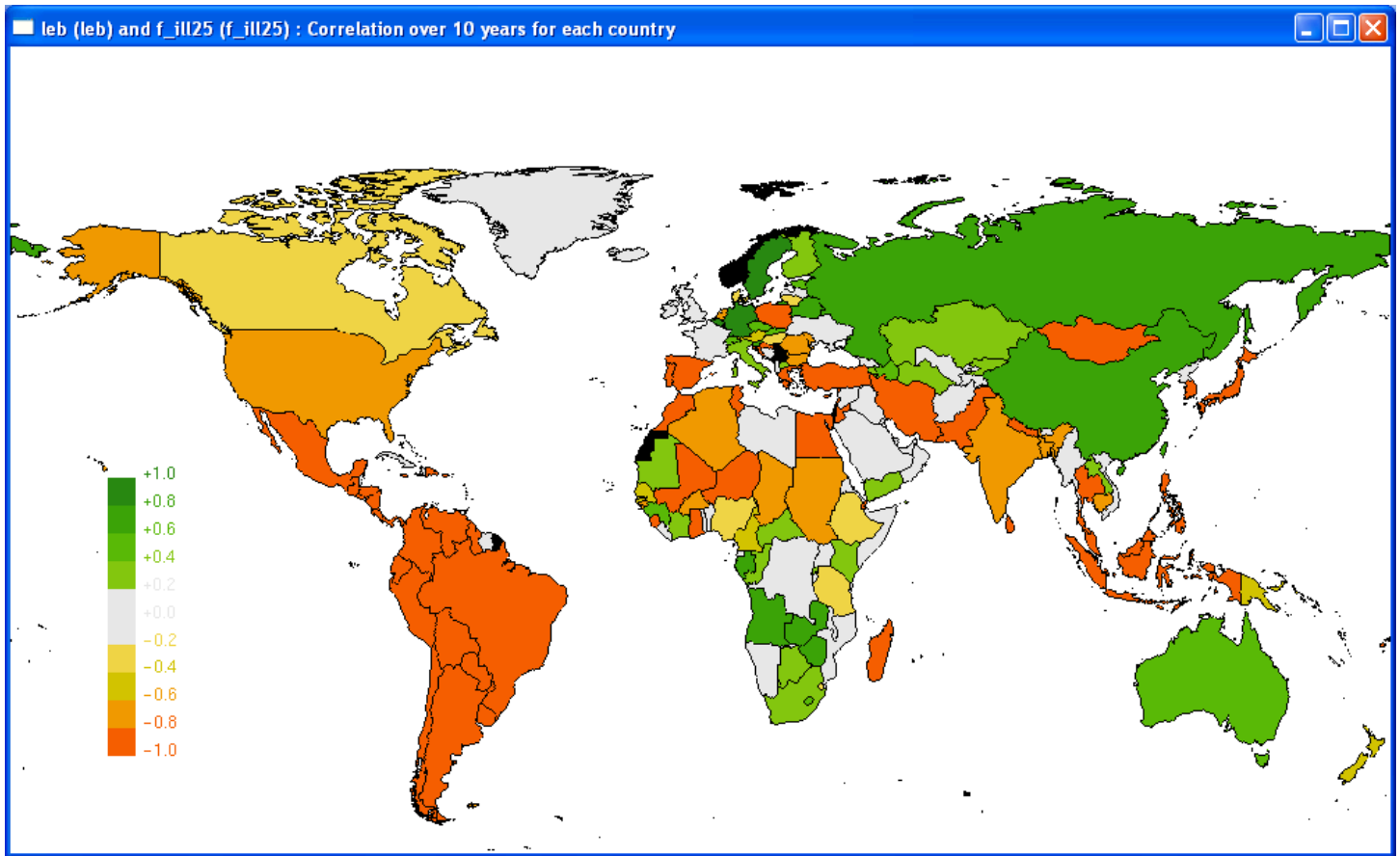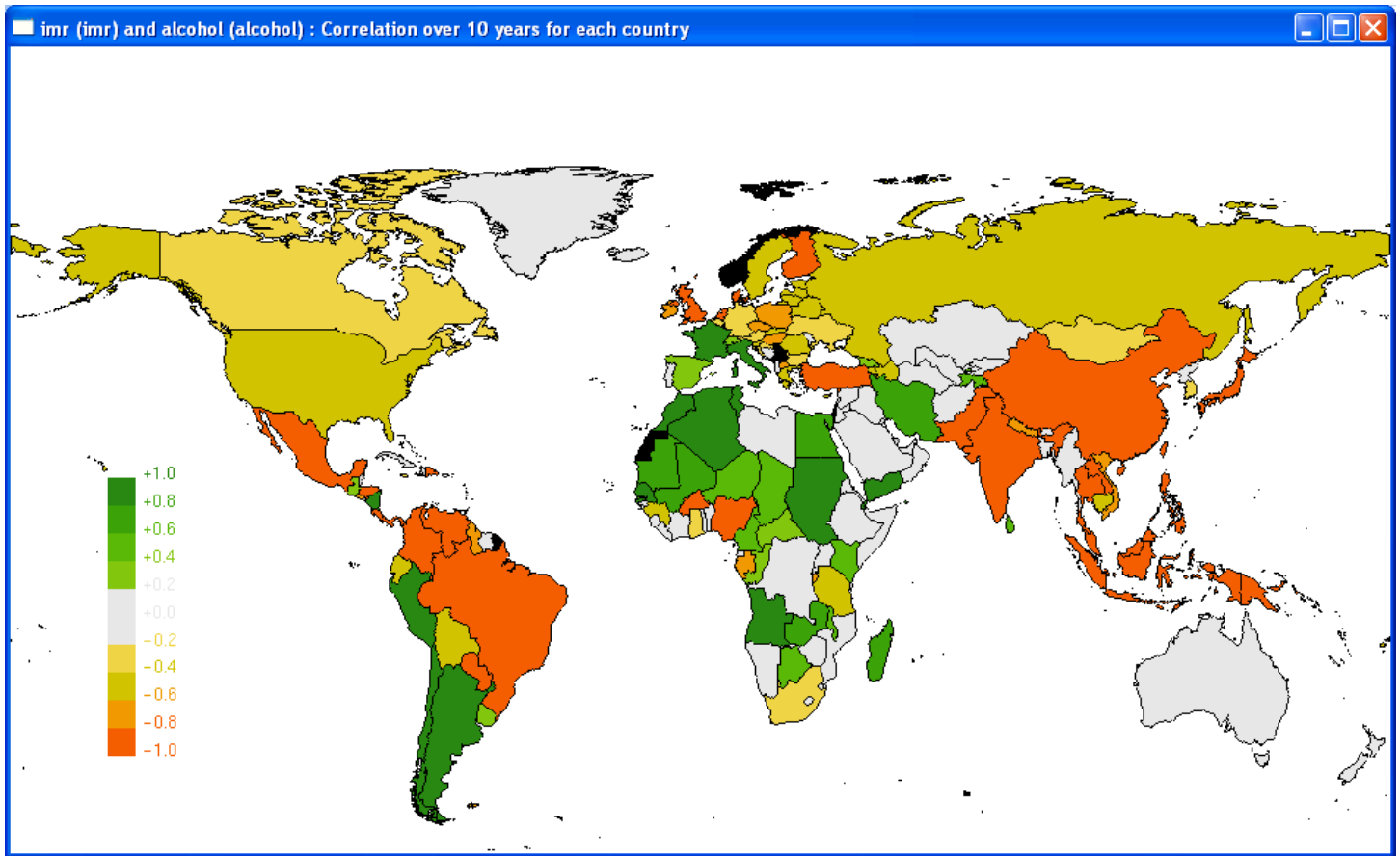
Figure 3: Correlation coefficients between LEB and female illiteracy above 25 years of age (1960-2005); the regression slope between the two variables, as reported in [1] is - .098 with statistical significance at 1% level.
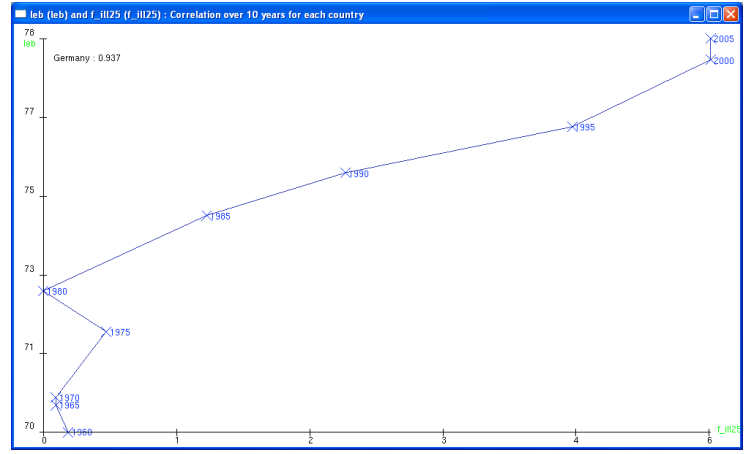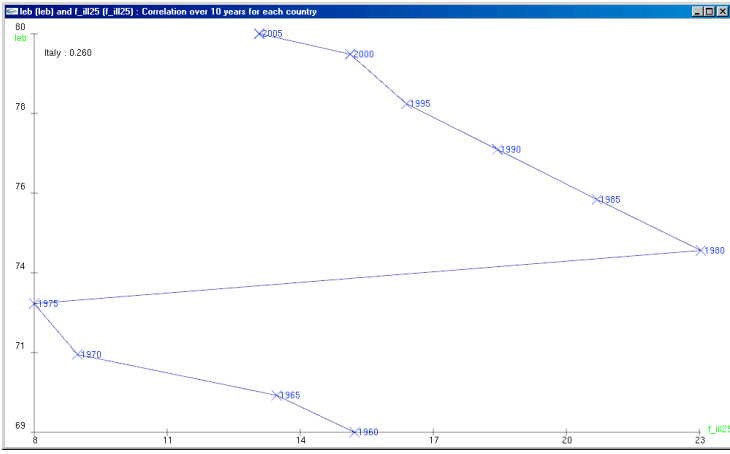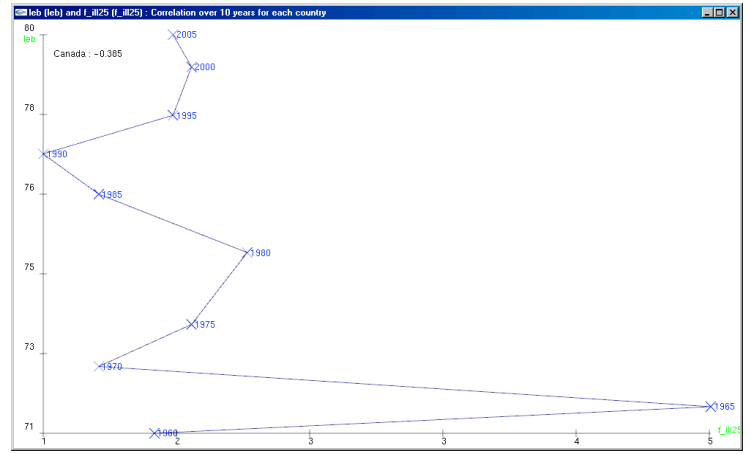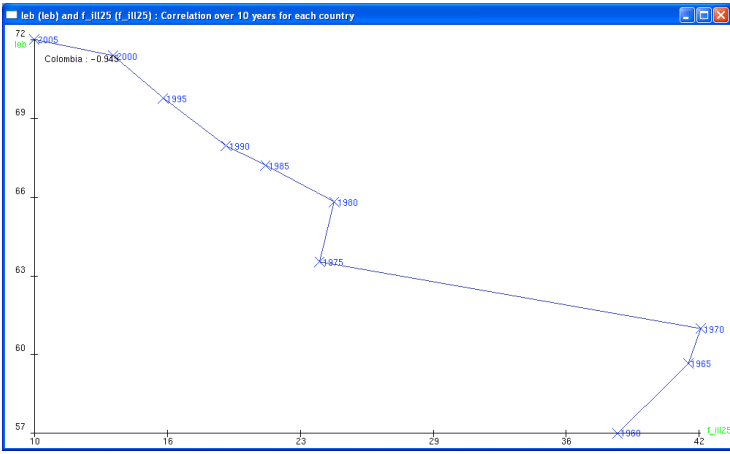
Figure 4: LEB vs. Female Illiteracy above 25 for Columbia, Canada, Italy, and Germany

Make your own observations and list the questions you would like to investigate.

Figure 5: Correlation coefficients between IMR (Infant Mortality Rate) and Alcohol Consumption (1960-2005); the regression slope between the two variables, as reported in [1] is .4841 with statistical significance between 5 to 10% level.
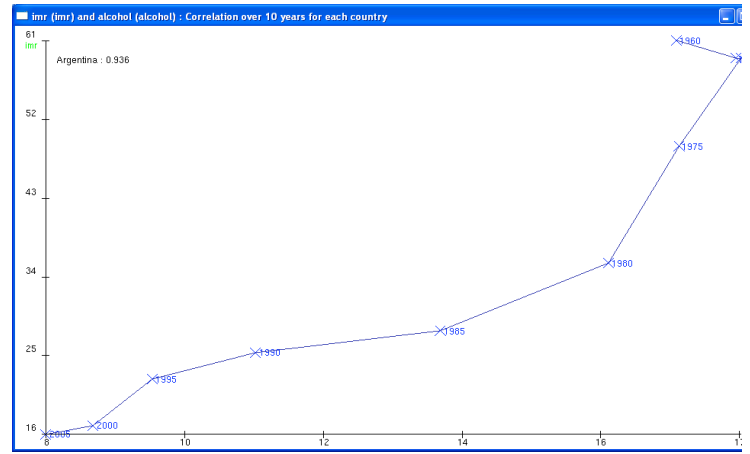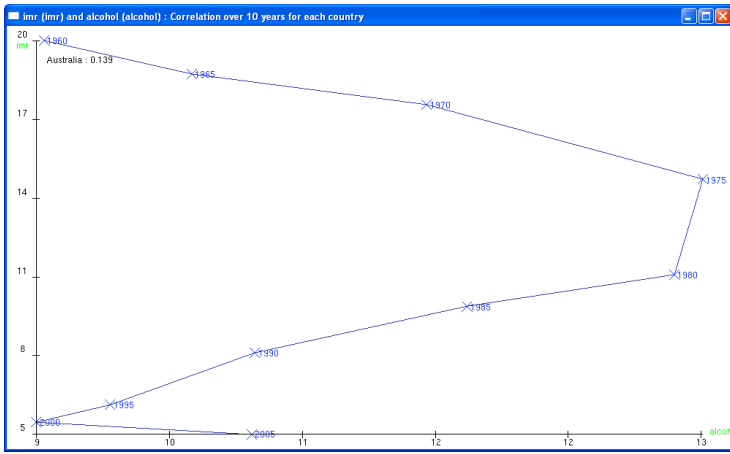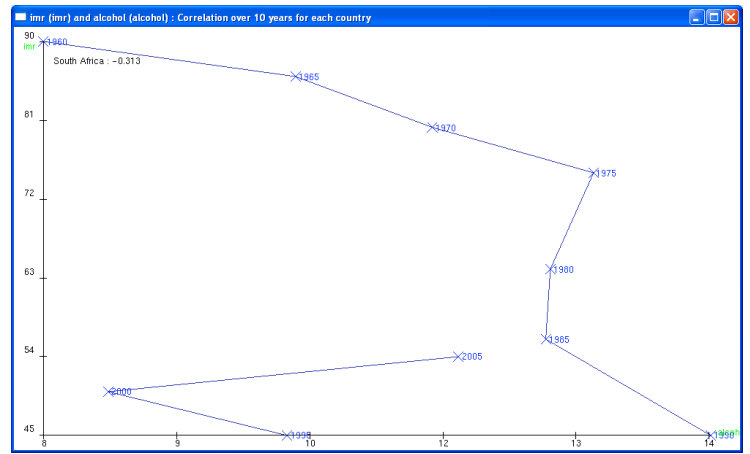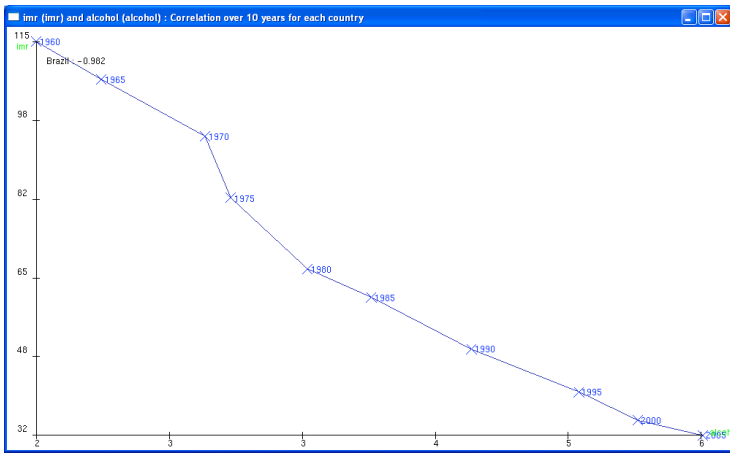
Figure 6: IMR vs Alcohol Consumption for Brazil, South Africa, Australia, and Argentina.

Make your own observations and list the questions you would like to investigate.

Section 5. Conclusions and Future Work

We have presented an application of the visualization tool to reflect upon and analyze the results of health determinants for various countries. Observations described in this work emphasize the need for development of a much more flexible visualization tool for answering questions that arise after the first level investigation. The tool also presents challenges in interpreting simple graphs (such as relationship between two indicators) as presented to a common user via myriad web sites. We plan to link world wide, regional, and country level results by building a powerful and flexible visualization tool that allows sound investigation of econometric analysis of global inequality data indicators produced by researchers worldwide.

References

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