# Biology Report

## Is there a relationship between Countries' Human Development Index (HDI) level and the incidence of tuberculosis?

**Introduction**

Tuberculosis is a serious disease caused by the bacterium *Mycobacterium tuberculosis.* If left untreated it might causes the death of its victims or leave the patients with serious lung damage. With 9.4 million recorded cases worldwide in 2009 it is one of the most common diseases in the planet. The vast majority of the cases occur in under developed countries with multiple drug resistant strains appearing frequently. In addition, tuberculosis is one of the main causes of death by HIV positive patients. The symptoms, according to the World Health Organization (WHO, 2011) are a chronic cough with blood-tinged sputum, fever, night sweats, and weight loss. If the infected person receives proper healthcare, the chances of recovery without any traces increases, that is one of the reasons why a well structured health system helps to control the number of cases and the number of deaths caused by tuberculosis.

This research was conducted in order to check whether or not Human Development Index (HDI) had a significant influence on the number of tuberculosis cases. The living conditions can be measured by HDI. It is a statistical analyses made by the United Nation (UN) to check human conditions throughout the world. The HDI is an index that combines the life expectancy at birth, the educational attainment and the real per capita income. A high HDI closer to 1.0 means good human development. According to the National Center of Biotechnology Information (NCBI, 2010), a high HDI level may contribute to reduce the number of tuberculosis cases, because the incidence of this disease increases with factors such as bad nutrition and unsanitary environments,

In order to make this research valid 32 countries were chosen from the same region, Europe, but having very different HDI values. The incidence of tuberculosis was obtained from the World Health Organization database (WHO, 2010) available online. So the research question was: *Is there a relationship between Countries' Human Development Index (HDI) level and the incidence of tuberculosis?* If the hypothesis is correct, then we should find a negative correlation between tuberculosis and HDI.

**Materials and Method:**

- WHO (available on line)
- HDI Database (available on line)
- MSExcel Program

For the initial exploration of the relationship between the incidence of tuberculosis and HDI I decided to select 5 European countries between the years of 2007 up to 2009 in five different European countries: Germany, Poland, Hungary, Switzerland and Portugal. These countries were selected because they had a high range of HDI and the data was thought to be reliable. There populations are all reasonably large (over 7 million inhabitants). All the data were transferred to an MSExcel program file where it could be analysed. Based on that information, we tried to see if there is a relationship between Tuberculosis and HDI.

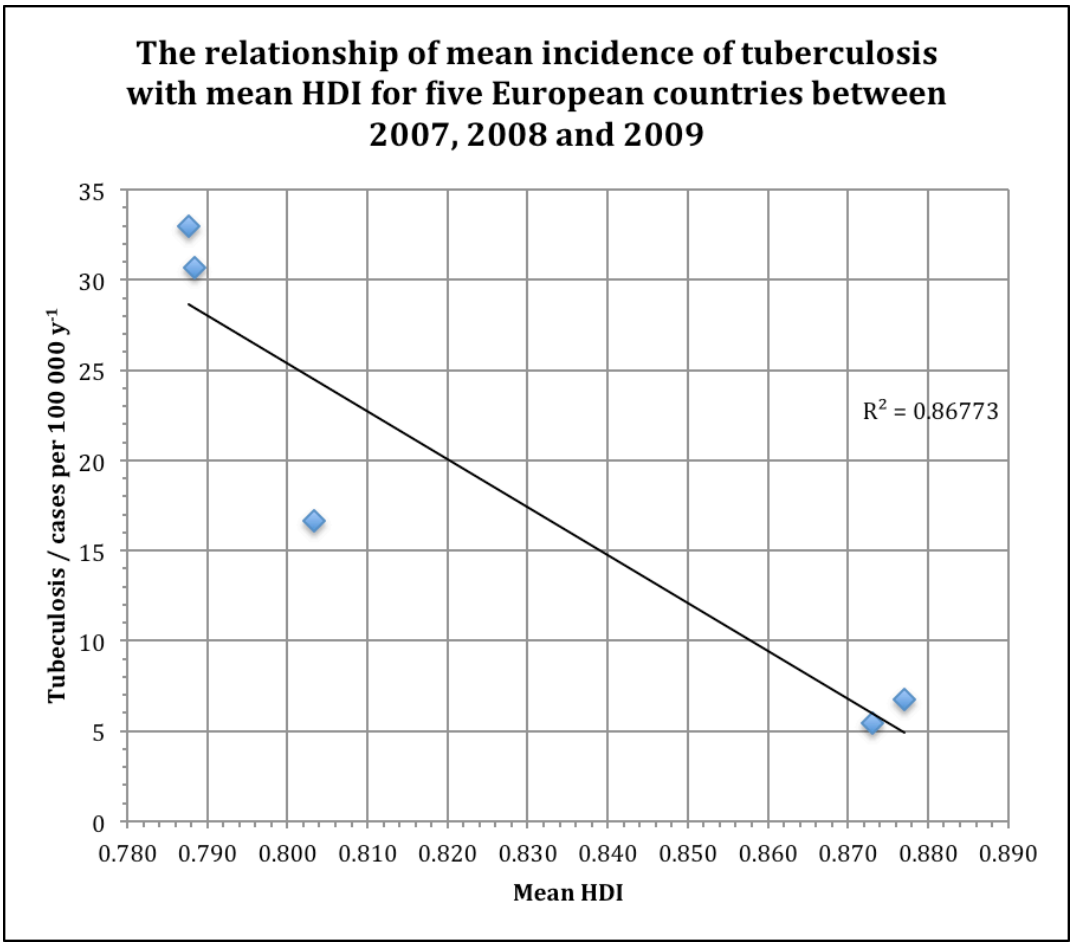
**The number of tuberculosis cases (according to the WHO database), HDI (according to the UN database) and per capita income (according to nationalmaster.com)**

| COUNTRY | Incidence of tuberculosis (per 100000 population per year) | | | HDI | | |
|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2009 | 2007 | 2008 | 2009 |
| POLAND | 34.0 | 33.0 | 32.0 | 0.784 | 0.788 | 0.791 |
| GERMANY | 8.4 | 6.0 | 5.9 | 0.863 | 0.885 | 0.883 |
| HUNGARY | 18.0 | 16.0 | 16.0 | 0.803 | 0.804 | 0.803 |
| SWITZERLAND | 6.5 | 4.9 | 4.9 | 0.876 | 0.871 | 0.872 |
| PORTUGAL | 32.0 | 30.0 | 30.0 | 0.785 | 0.789 | 0.791 |

**Calculating the means of these values**

| COUNTRY | Mean Tuberculosis | Mean HDI |
|---|---|---|
| POLAND | 33 | 0.788 |
| GERMANY | 7 | 0.877 |
| HUNGARY | 17 | 0.803 |
| SWITZERLAND | 5 | 0.873 |
| PORTUGAL | 31 | 0.788 |

These values are then plotted on a scatter graph to see if there is a relationship




The scatter plot shows a negative correlation with a high coefficient of determination ($R^2$). This strongly suggests that the relationship is valid. It was decided to extend the research to all the countries in the European region of the WHO for which there was data.

**Developing the research**

Using the World Health Organization Database we have been able to extend our research on the number of tuberculosis cases, for the most recent year (2009) in 32 different European countries. Using the National Master Database, we have also been able the check the current HDI of each country. As before all the data was transferred to an MSExcel spread sheet where it could be analysed. Based on that information, we were able to find a more precise relationship between tuberculosis and HDI.

**Results**

**Incidence of tuberculosis cases for 2009 (according to the WHO database) and the current HDI (according to nationalmaster.com)**

| Countries | HDI | Incidence of Tuberculosis per 100 000 2009 |
|---|---|---|
| Norway: | 0.963 | 5.9 |
| Sweden: | 0.949 | 6.2 |
| Luxembourg: | 0.949 | 9.2 |
| Switzerland: | 0.947 | 4.9 |
| Ireland: | 0.946 | 8.5 |
| Belgium: | 0.945 | 8.6 |
| Netherlands: | 0.943 | 7.5 |
| Denmark: | 0.941 | 6.8 |
| Finland: | 0.941 | 8.8 |
| United Kingdom: | 0.939 | 12.0 |
| France: | 0.938 | 6.1 |
| Austria: | 0.936 | 13.0 |
| Italy: | 0.934 | 6.4 |
| Germany: | 0.930 | 4.9 |
| Spain: | 0.928 | 17.0 |
| Greece: | 0.912 | 4.5 |
| Slovenia: | 0.904 | 12.0 |
| Portugal: | 0.904 | 30.0 |
| Czech Republic: | 0.874 | 8.8 |
| Malta: | 0.867 | 11.0 |
| Hungary: | 0.862 | 16.0 |
| Poland: | 0.858 | 24.0 |
| Estonia: | 0.853 | 30.0 |
| Lithuania: | 0.852 | 71.0 |
| Slovakia: | 0.849 | 9.1 |
| Croatia: | 0.841 | 25.0 |
| Latvia: | 0.836 | 45.0 |
| Bulgaria: | 0.808 | 41.0 |
| Romania: | 0.792 | 125.0 |
| Belarus: | 0.786 | 39.0 |
| Bosnia and Herzegovina: | 0.786 | 50.0 |
| Albania: | 0.780 | 15.0 |

The total number of cases of tuberculosis recorded in the European region was 420 000. The data for Moldavia and Macedonia were excluded due to lack of statistics on the incidence of tuberculosis.

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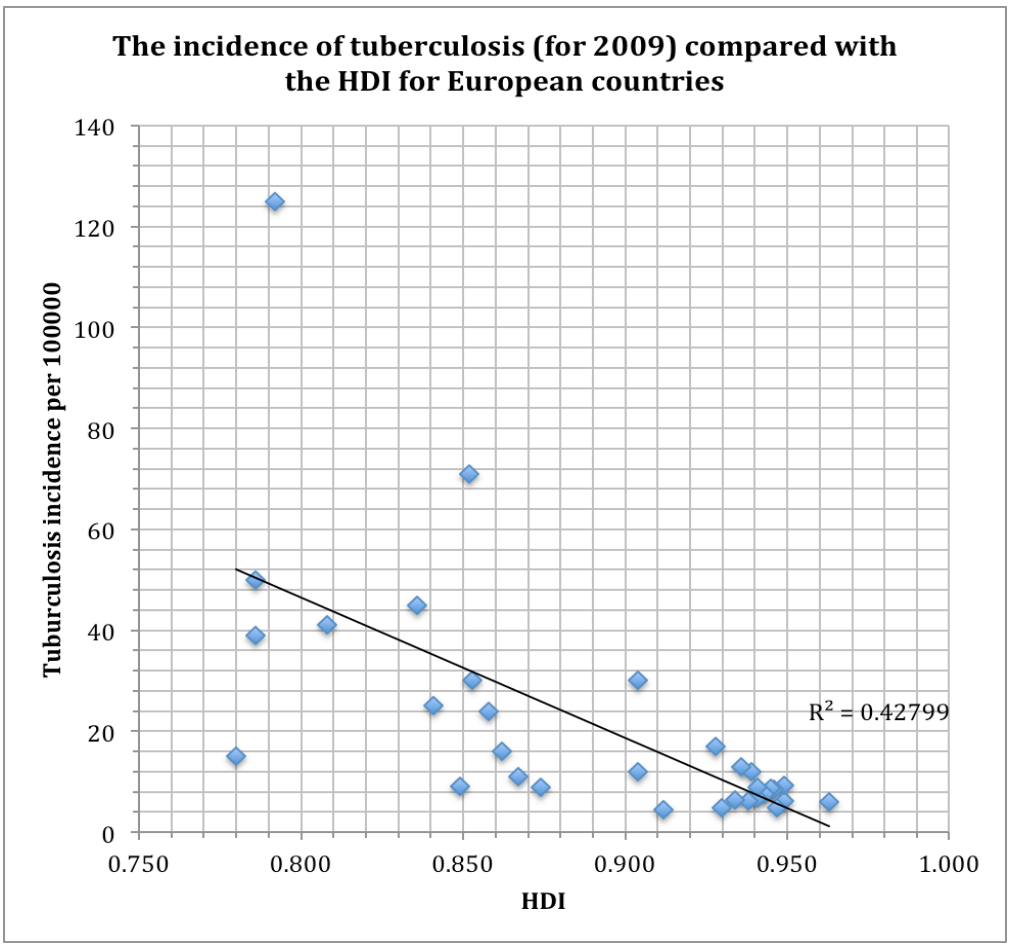
In the graph below, we can see the mean incidence of tuberculosis (per 100000 population per year) and HDI in the researched countries.




On the basis of this graph there appears to be a strong negative correlation between incidence of tuberculosis and a country's HDI.

Using MSExcel, a product-moment correlation was carried out between the data for the incidence of tuberculosis and the HDI.

- The **Null Hypothesis** is that there is no relationship between the incidence of tuberculosis and the HDI of European countries
- The **Alternative Hypothesis** is that there is a negative correlation between these two data for European countries.

Correlation coefficient ($r_{calc}$) for the 32 pairs of data = -0.654

The critical value ($r_{crit}$) for 32 pairs of data (p = 0.05) = 0.349

As the positive value for $r_{calc}$ is higher than $r_{crit}$ the Null Hypothesis is rejected and the Alternative Hypothesis is accepted for $p < 0.01$. Therefore there is a strong negative correlation between the incidence of tuberculosis and the HDI for the European region in 2009.

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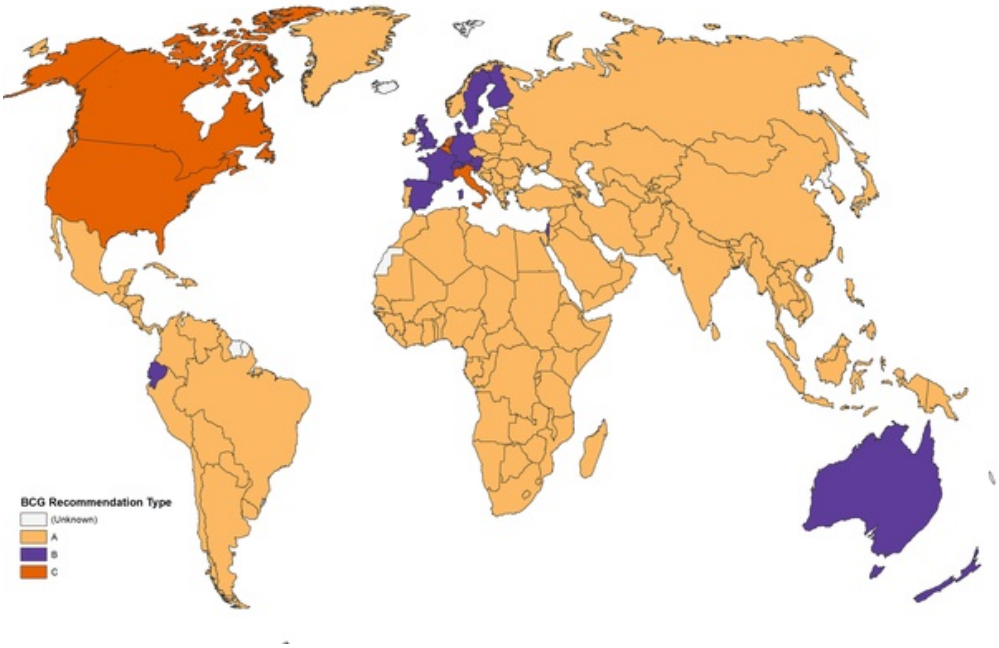
**Conclusion**
Based on the studies made, we found a strong negative relationship between number of tuberculosis cases and country's HDI. Therefore, the hypothesis made in the introduction can be supported by the data collected during this research.

Further research revealed that a number of European countries have stopped their universal BCG (Bacillus Calmette-Guérin) vaccination campaigns for tuberculosis and just focus on high risk groups. We would suggest that this policy is not appropriate for a disease where the incidence is increasing and multiple resistant strains exist.




**A:** The country currently has universal BCG vaccination program.

**B:** The country used to recommend BCG vaccination for everyone, but currently does not.

**C:** The country never had universal BCG vaccination programs.

(doi:10.1371/journal.pmed.1001012.g002)

**Evaluation**
The WHO database was very detailed, but it should have more information about the national health policies. They should not show only how many cases but also why this was happening and what governments were doing to stop it.

A way that I could have used to improve this report was to study the health policies of these countries or to measure if the increase in the per capita income as well as HDI was accompanied by a decrease in tuberculosis cases.

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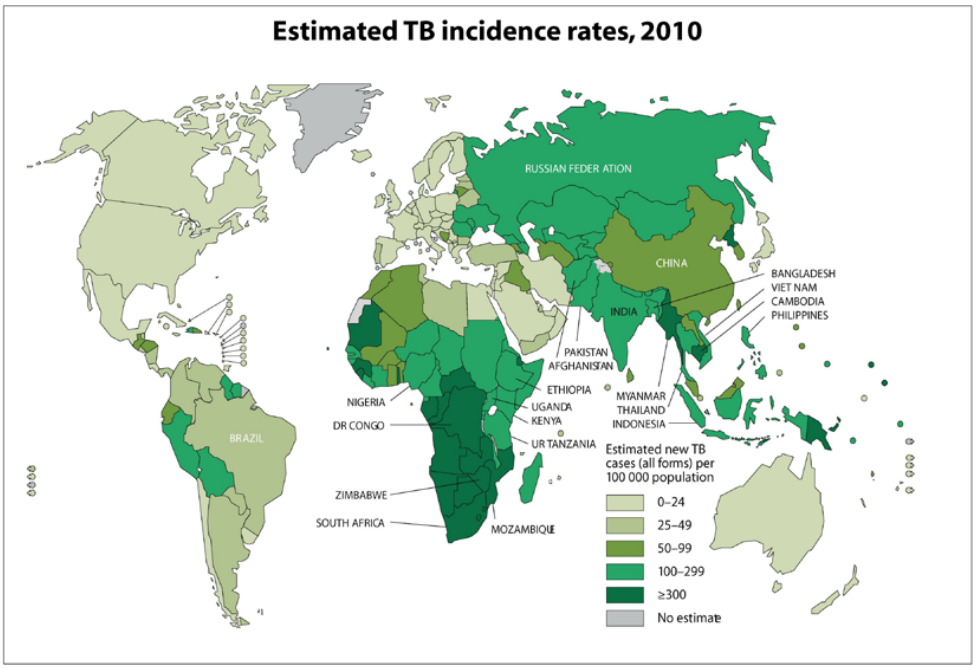
It would be interesting to see if the relationship is the same for countries in other regions of the world.




The WHO distribution map above shows that like Europe, Latin America has a significant range of tuberculosis incidence though the range of climates is greater.

An alternative approach may be to try to find the data of the changes in HDI and the incidence of tuberculosis for single countries through time. This would provide more control over other variables that may influence the incidence of the disease (e.g. cultural practices).

**Bibliography**


- NATIONAL CENTER OF BIOTECHNOLOGY INFORMATION, available at http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001141/ [accessed 24, April, 2010 at 13:30]

- NATIONAL MASTER, available at http://www.nationmaster.com/qraph/eco hum dev ind-economv-human-development-index [accessed 24 April, 2010 at 13:00]

- WHO, available at http://www.who.int/research/en/ [accessed 23 April, 2010 at 14:00]