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The Correlation Between Burden of Disease and 8 Human Resource Indicators, 4 Technical Resource Indicators and 2 Infrastructure Indicators in 50 European and Central Asian Countries

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Abstract

The paper checks if there is a linear correlation between burden of disease and 14 indicators below.

The paper studies if there is a linear correlation between burden of disease and the following human resource indicators: practicing physicians / 100000 population, general practitioners / 100000 population, pediatricians / 100000 population, practicing nurses / 100000 population, practicing caring persons / 100000 population, practicing pharmacists / 1000000 population, physicians employed by hospital / 100000 population, nurses and midwives employed by hospital / 100000 population. The linear correlation between burden of disease and the following technical resource indicators was studied: total hospital beds / 100000 population, CT / 100000 population, MRI / 100000 population, radiation therapy equipment / 100000 population. The linear correlation between burden of disease and the following infrastructure indicators was assessed: % of population connected to water supply system, % of population connected to sewage system, septic tank, or other hygienic means of sewage disposal. WHO data from 2004 was used for the following European and Central Asian countries: Albania, Andorra, Armenia, Azerbaijan, Belarus, Belgium, Bosnia & Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, FYR Macedonia, Malta, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine United Kingdom and Uzbekistan. Pearson linear correlation coefficient was calculated for all paired indicators and subsequent scatter diagrams were drawn. The r correlation coefficient was compared with critical values of $\alpha = 0.05$ and $\alpha = 0.01$. It was found a linear correlation between burden of disease and the following indicators: general practitioners / 100000 population, pediatricians / 100000 population, practicing caring persons / 100000 population and physicians employed by hospital / 100000 population. It was found a strong linear correlation between burden of disease and the following indicators: practicing pharmacists / 1000000 population, total hospital beds / 100000 population, CT / 100000 population, and MRI / 100000 population. It was found a very strong linear correlation between burden of disease and the following indicators: % of population connected to water supply system, % of population connected to sewage system, septic tank, or other hygienic means of sewage disposal.

The research shows the resources which have a linear correlation with burden of disease, and to what degree. It provides policymakers a hint to improve allocation efficiency, an insight regarding flaws of health systems and sheds light upon the influence of non-specific factors (infrastructure) upon the health system.

Keywords

Burden of disease • human, technical and infrastructure resource indicators• linear correlation

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The burden of disease is a multidimensional notion encompassing the impact of diseases on a population. Diseases - measured as incidence and prevalence – have an impact on individuals (morbidity) and sometimes lead to their death (mortality). This loss of healthy living years either by death or by illness (time lived in bad health) incurs financial costs to the respective society, either because of the costs of health care or by dwindling the number of working individuals. Health care costs are spent to buy resources to be used in the system for the purpose of providing care. These resources can be human resources (salaries and wages), technical resources (equipment, materials, pharmaceuticals). Before putting these resources to work, two things are essential: training the workforce and investing in facilities and equipment. In order for health care to be effective, technical and human resources are bound together by specific information and knowledge. Access is key factor in putting together the demand for care and the supply of it.

Purpose

The purpose of this paper is to analyze whether there is a linear correlation between burden of disease and several human and technical resource indicators in the health care system, together with few infrastructure resources in European and Central Asian countries. Based on the existence or non-existence of linear correlations as well as their strengths, the paper wants to be a first step in string of studies aimed at helping decision-makers in various countries understand better the flaws of their health system, and help policy-makers choosing various policies in order to improve technical and allocational efficiency. Another purpose is to allow comparison between countries and reveal certain common policies in clusters of countries.

Method

It was studied if there is any linear correlation between burden of disease indicator and the following human resource indicators of the health system: practicing physicians / 100000 population, general practitioners / 100000 population, pediatricians / 100000 population, practicing nurses / 100000 population, practicing caring persons / 100000 population, practicing pharmacists / 1000000 population, physicians employed by hospital / 100000 population, nurses and midwives employed by hospital / 100000 population. Then, it was studied the linear correlation between burden of disease indicator and the following technical resource indicators: total hospital beds / 100000 population, CTs / 100000 population, MRIs / 100000 population, radiation therapy equipment / 100000 population. Finally, it was studied the linear correlation between burden of disease indicator and the following infrastructure indicators was assessed: % of population connected to water supply system, % of population connected to sewage system, septic tank, or other hygienic means of sewage disposal.

In the WHO World Health Report 2004, the burden of disease was calculated as DALY (Disability Adjusted Life Years) with age – standardized weighting and time discounting. DALY measures life time lost due premature health (Years of Life Lost or YLL) combined with life time lost due to ill health or disability (Years Lost due to Disability). Years of Life Lost were calculated based on the formula: YLL= N x L where N = number of deaths and L is standard life expectancy at age of death in years. Years Lost due to Disability were calculated based on the formula: YLD = I x DW x L where I = number of incident cases, DW = Disability weight, L = average duration of case until remission or death (years) (1).

Research Design

Data used comes from 2004 burden of disease study of WHO and resource data (the indicators) comes from Health for All data base of WHO in the same year (2).The resource indicators are also from 2004. Burden and disease was paired with each of the resource indicators, for each country.

Thus, Pearson linear correlation coefficient was calculated for all paired indicators and subsequent scatter diagrams were drawn. The calculated (r) correlation coefficient (3) was compared with critical values of $\alpha = 0.05$ and $\alpha = 0.01$ (4), and depending on the value of r we came out with 4 categories: no correlation, correlation, strong correlation and very strong correlation. When r was between 0 and the +/- value of the correlation coefficient for that number of pairs it was considered no correlation. When (r) was between the critical values $\alpha = 0.05$ and $\alpha = 0.01$ ($\alpha = 0.05 < r < \alpha = 0.01$) it was considered there is a linear correlation between the burden of disease and the respective indicators. In other words (r) exceeding the critical value for $\alpha = 0.05$ means that there is a 95% chance there is a linear correlation. When calculated (r) for certain pairs was between +/1 and +/- $\alpha = 0.01$ respectively, it was considered a strong correlation between burden of disease and the respective indicators. In other words (r) exceeding the critical value for $\alpha = 0.01$ means that there is a 99% chance there is a linear correlation. When calculated r was almost double the value of $\alpha = 0.01$ it was considered a very strong correlation.

Because in real life the burden of disease is the result of many factors, for the paired indicators which showed a linear correlation or stronger, (r^2) was calculated in order to show to which proportion the variation of a variable is attributed to the other variable. The value of (r^2) was translated as % of influence of that factor on the burden of disease (5).

Universe and Sampling

We used data from WHO Health-for-All-Data Base, from the year 2004, when WHO had a large study concerning the burden of disease. This study is the most comprehensive and recent study regarding burden of disease in European and Central Asian countries. To pair burden if disease and the health system resource and infrastructure indicators we used also the 2004 values of the indicators for the respective countries.

The countries included on this study are: Albania, Andorra, Armenia, Azerbaijan, Belarus, Belgium, Bosnia & Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, FYR Macedonia, Malta, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine United Kingdom and Uzbekistan.

Unfortunately we did not find data for all countries and all indicators. This is why the number of pairs ranges from 17 for radiation therapy equipment indicator to 50 for % of population connected to water supply system and % of population connected to sewage system, septic tank, or other hygienic means of sewage disposal indicator respectively. There are also large variations regarding the human resource indicators, variations explained by the way the health system of that country is designed. This specific design puts an emphasis or neglects certain types of health workers. This is reflected in the data reported. However, this variation of data is offset by the calculation method; the correlation coefficient varies with the number of pairs, and in order to assess the linear correlation a table with the critical values of the linear correlation coefficient was used, as stated above. Unfortunately for small samples the critical values of the α coefficient are high and correlation is difficult to prove. This was a limitation in at least two cases.

Data Analysis

For the pairs between burden of disease and the 8 human resources indicators, the findings of this study are the following:

It was found no linear correlation ($-\alpha = 0.05 < r < \alpha = 0.05$) between burden of disease and practicing physicians / 100000 population, practicing nurses / 100000 population, nurses and midwives employed by hospital / 100000 population and radiation therapy equipment / 100000 population.

It was found a linear correlation ($-\alpha = 0.01 < r < \alpha = -0.05$ or $\alpha = 0.05 > r > \alpha = 0.01$) between the burden of disease and the following indicators: general practitioners / 100000 population, pediatricians / 100000 population, practicing caring persons / 100000 population and physicians employed by hospital / 100000 population.

It was also found a strong linear correlation ($r < -\alpha = 0.01$ or $r > \alpha = 0.01$) between burden of disease and the following indicators: practicing pharmacists / 1000000 population, total hospital beds / 100000 population, CT / 100000 population, and MRI / 100000 population.

Finally it was found that there is a very strong linear correlation ($r << -\alpha = 0.01$ or $r >> \alpha = 0.01$) between burden of disease and the following indicators: % of population connected to water supply system, % of population connected to sewage system, septic tank, or other hygienic means of sewage disposal.

The above is illustrated in Table 1 below:

Table 1. Linear Correlation Between Burden of Disease and Indicators

VARIABLES PAIRED WITH BURDEN OF DISEASE	n (pairs)	r value	α = 0.05	α = 0.01	interpretation
practising physicians / 100000 population	39	-0.243	0.335	0.430	no correlation
general practitioners / 100000 population	33	-0.377	0.361	0.463	correlation
paediatricians / 100000 population	38	0.371	0.335	0.430	correlation
practising nurses / 100000 population	39	-0.326	0.335	0.430	no correlation
practising caring persons / 100000 population	20	-0.469	0.444	0.561	correlation
practising pharmacists / 1000000 population	36	-0.506	0.335	0.430	strong correlation
physicians employed by hospital / 100000 population	35	-0.352	0.335	0.430	correlation
nurses and midwives employed by hospital / 100000 population	19	-0.418	0.456	0.575	no correlation
total hospital beds / 100000 population	47	0.393	0.294	0.378	strong correlation
CT / 100000 population	24	-0.577	0.444	0.561	strong correlation
MRI / 100000 population	22	-0.568	0.444	0.561	strong correlation
radiation therapy equipment / 100000 population	17	-0.349	0.482	0.606	no correlation
% of population connected to water supply system	50	-0.626	0.279	0.361	very strong correlation
% of population connected to sewage system, septic tank, or other hygienic means of sewage disposal	50	-0.658	0.279	0.361	very strong correlation

Here is the description of the findings for each pair of indicators: burden of disease and resource indicator:

For the variables burden of disease and practicing physicians / 100000 population, there were 39 pairs, corresponding to 39 countries. The r value found was -0.243 and for this number of pairs the correlation coefficient for α = 0.05 was 0.335 and the correlation coefficient for α = 0.01 was 0.430. Hence, no Pearson linear correlation was found. This is illustrated in Figure 1below:

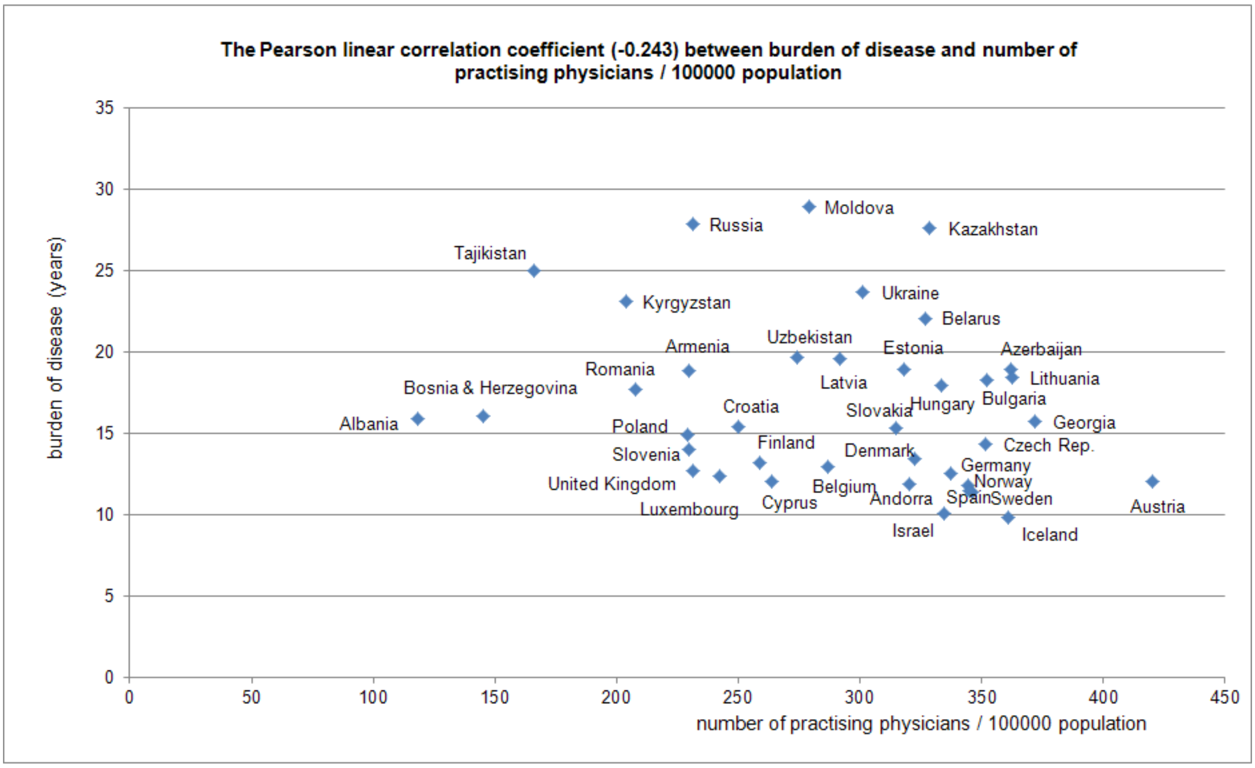

Figure 1. Correlation Between Burden of Disease and Number of Practicing Physicians

It may seem hard to believe that there is no linear correlation between burden of disease and the number of practicing physicians / 100000 population. Indeed countries like Russia and United Kingdom have roughly the same number of practicing physicians / 100000 population but the burden of disease is more than double in Russia than in UK. Similarly, Albania and Georgia have roughly the same burden of disease, while there are 3.5 times more practicing physicians / 100000 population in Georgia than in Moldova. The explanation might rely in the complexity of the health care system where the number of physicians is not a decisive factor. However the fact that there is a negative correlation between the two variables, suggests that having many doctors is more likely to reduce the burden of disease than having less.

For the variables burden of disease and general practitioners / 100000 population, there were 33 pairs, corresponding to 33 countries. The r value found was -0.377 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was 0.361 and the correlation coefficient for or $\alpha = 0.01$ was 0.463. Hence a Pearson linear correlation was found. This is illustrated in Figure 2 below:

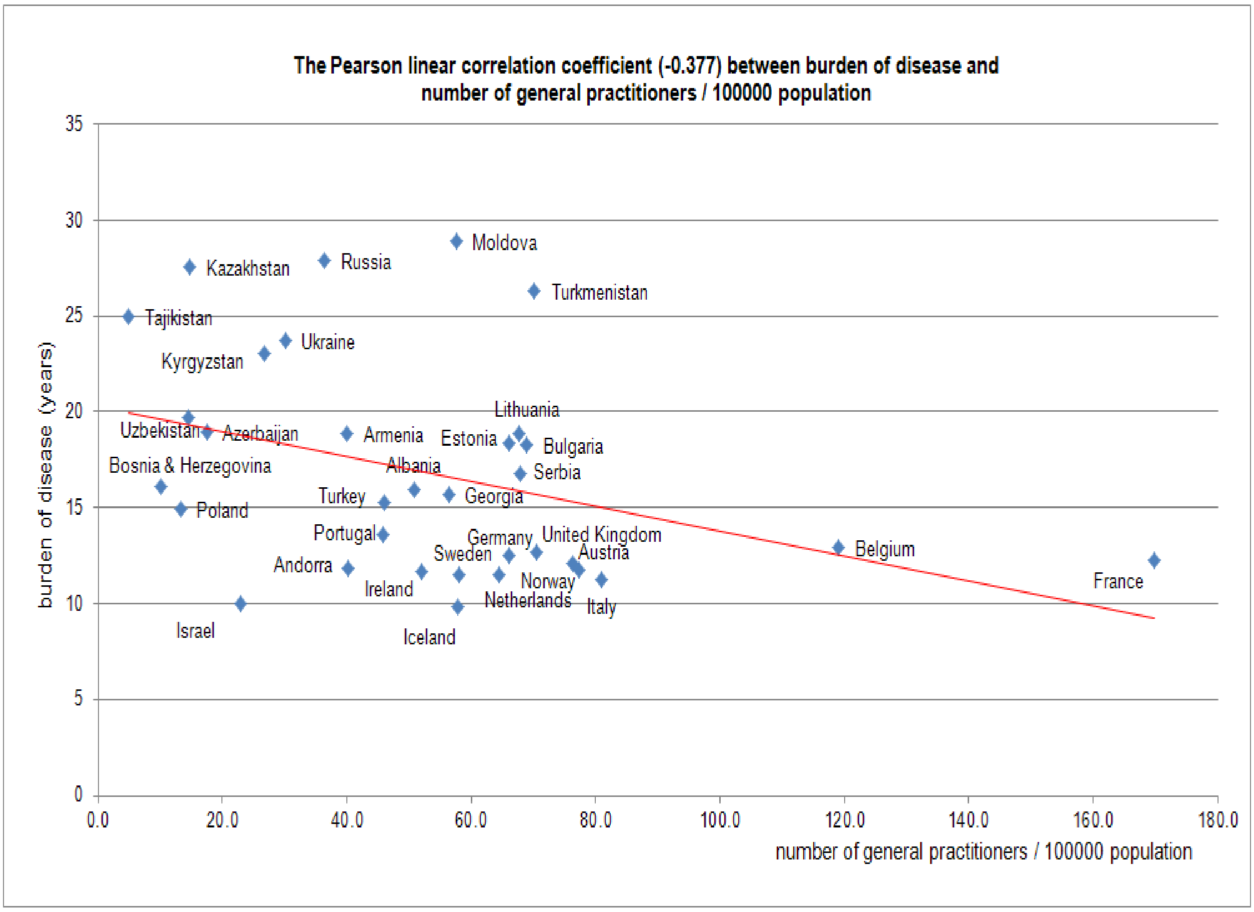

Figure 2. Correlation between Burden of Disease and Number of General Practitioners

The r^2 was 0.14.

As expected, there is a negative linear correlation between the burden of disease and the number of general practitioners. / 100000 population. This was expected, considering that many GPs provide widespread access to the chronic diseases treatment especially at old age. Former soviet republics (except Turkmenistan and the Baltics) have a weak network of GPs below 40 / 100000 population, this group of countries having a burden of disease of 19 years and above. Belgium and France are special cases with large numbers of GPs, probably due to their large network of nursing homes. However the fact that r^2 was only 0.14 suggests that the correlation between the burden of disease and the number of GPs is not very strong, the latter's influence being only 14% of the total factors influencing burden of disease.

For the variables burden of disease and pediatricians / 100000 population, there were 38 pairs, corresponding to 38 countries. The r value found was 0.371 and for this number of pairs the correlation coefficient for or α = 0.05 was 0.335 and the correlation coefficient for or α = 0.01 was 0.430. Hence a Pearson linear correlation was found. This is illustrated in Figure 3 below:

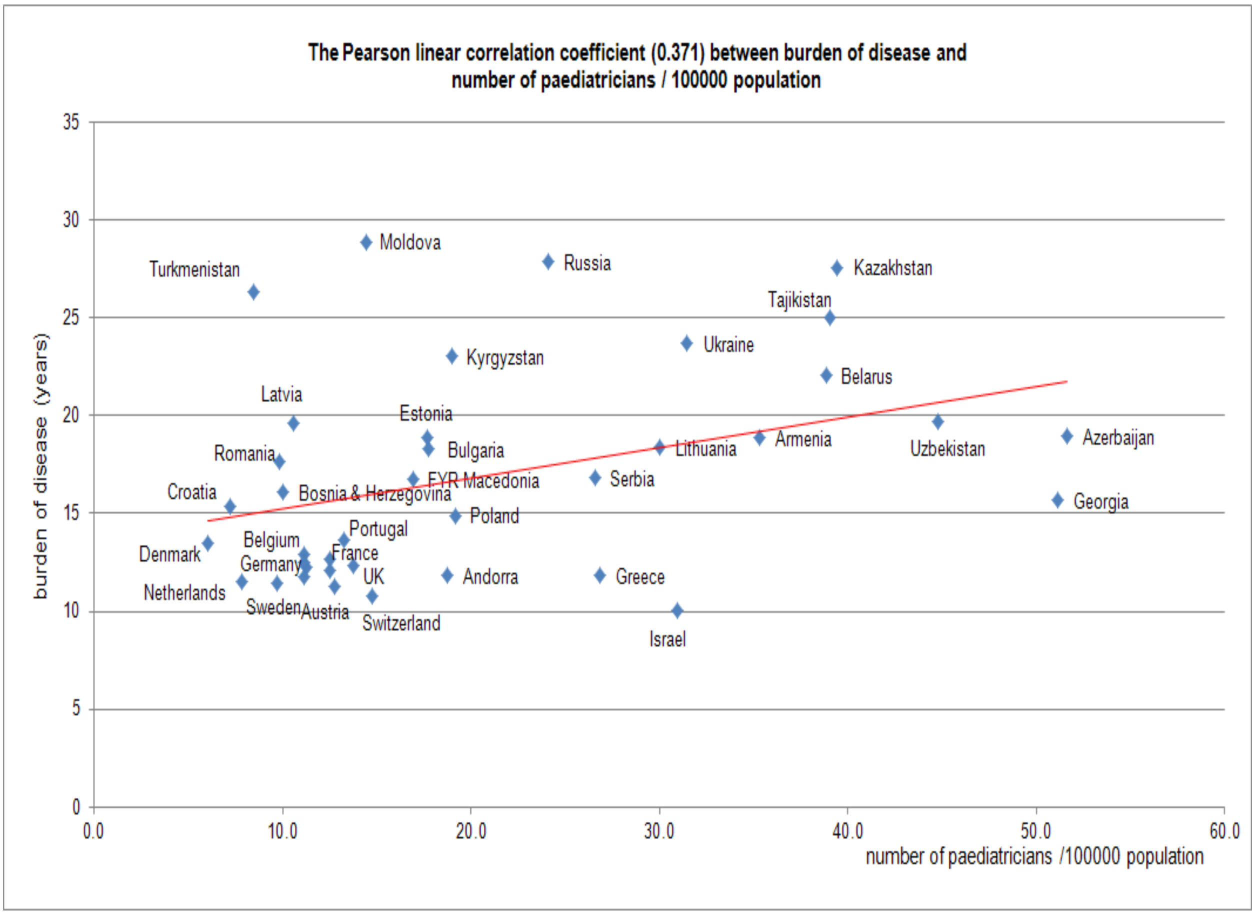

Figure 3. Correlation Between Burden of Disease and Number of Pediatricians

The r^2 was 0.14.

The burden of disease is positively correlated with the number of pediatricians / 100000 population. Former soviet republics (with few exceptions, again Turkmenistan) have large numbers of pediatricians (above 31 pediatricians / 100000 population have only the former soviet republics. This might explain the positive correlation, because if we eliminate from this set the former soviet republics the sign of correlation reverses, although it is not statistically significant. This suggests that there is a model of organizing the health system based on large numbers of pediatricians. Interesting enough if we consider only the former soviet republics in this set, we get also a negative correlation, again not statistically significant; however the majority of these republics have a burden of disease more than 20 years. Because the r^2 was 0.14, we can infer that this is not an important factor in influencing the burden of disease.

For the variables burden of disease and practicing nurses / 100000 population, there were 39 pairs, corresponding to 39 countries. The r value found was -0.326 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was 0.335 and the correlation coefficient for or $\alpha = 0.01$ was 0.430. Hence no Pearson linear correlation was found. This is illustrated in Figure 4 below:

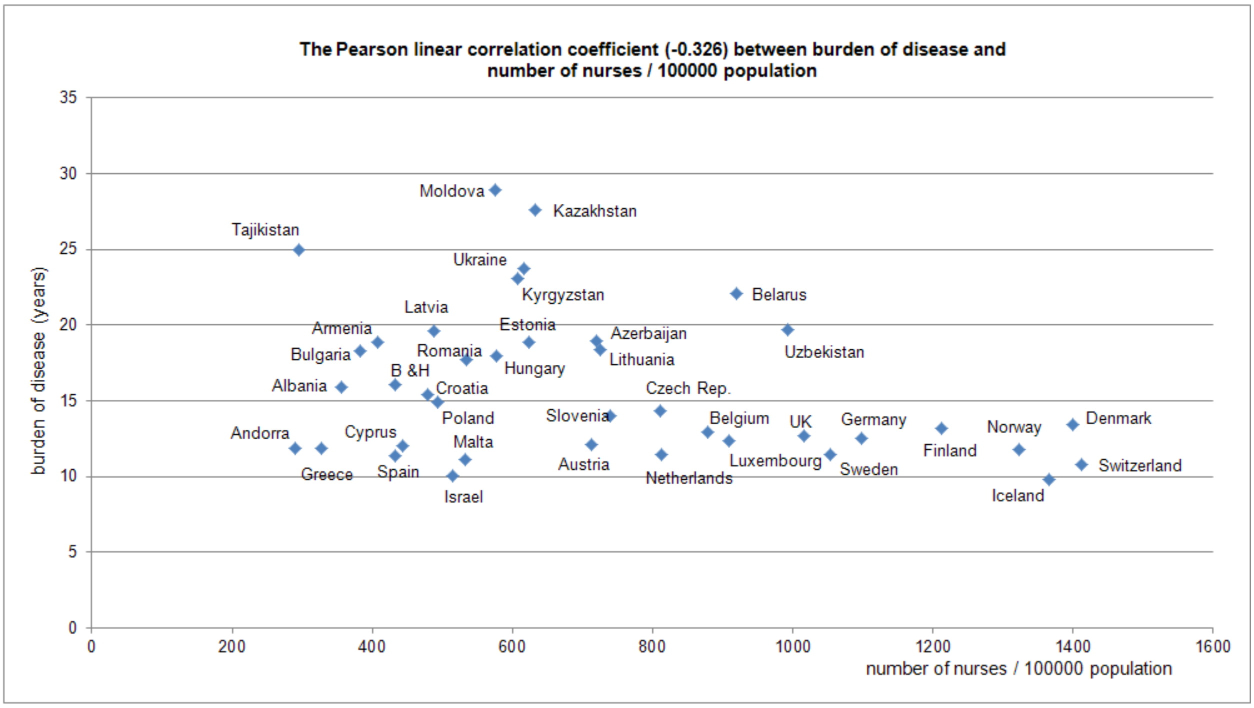

Figure 4. Correlation Between Burden of Disease and Number of Nurses

The only countries with burden of disease above 20 years are former soviet republics , but within this group the number of nurses varies a lot (296/100000 in Tajikistan and 994/100000 in Uzbekistan) , so this makes the whole set of data statistically not significant. Again we can see a pattern all Scandinavian countries have large numbers of nurses (all above 1050 / 100000).

For the variables burden of disease and practicing caring persons / 100000 population, there were 20 pairs, corresponding to 20 countries. The r value found was -0.469 and for this number of pairs the correlation coefficient for or α = 0.05 was 0.444 and the correlation coefficient for or α = 0.01 was 0.561. Hence a Pearson linear correlation was found. This is illustrated in Figure 5 below:

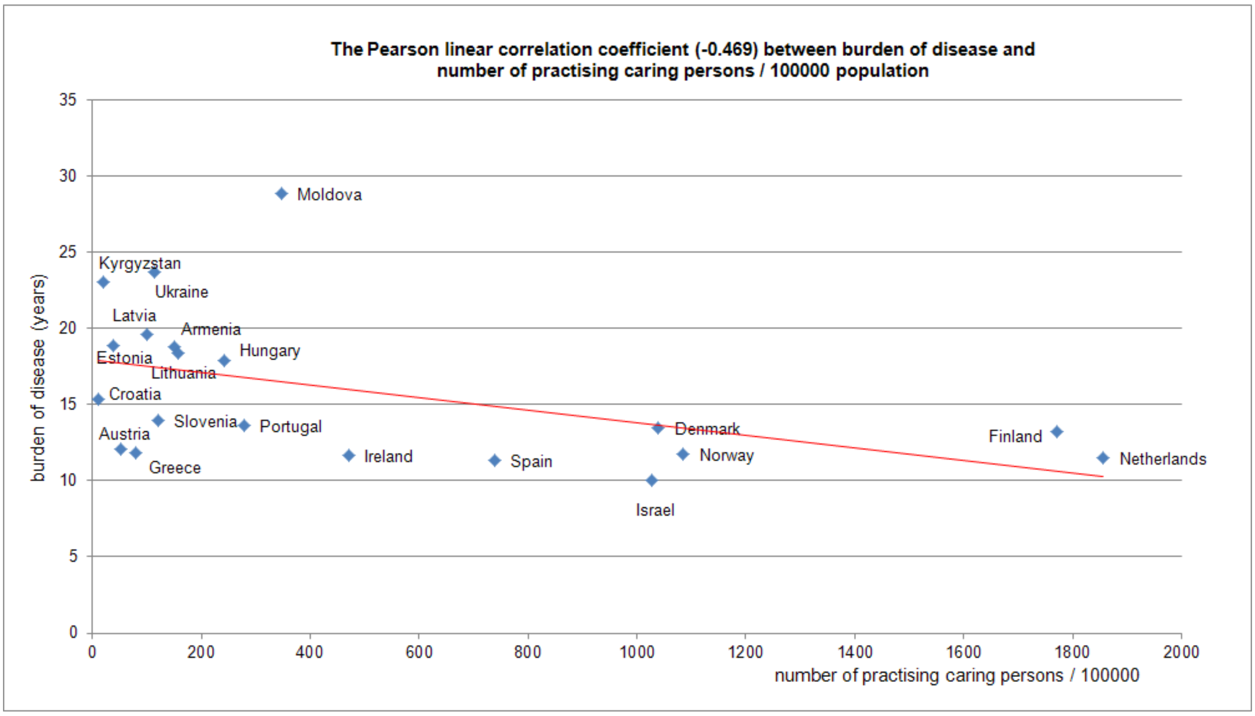

Figure 5. Correlation Between Burden of Disease and Number of Practicing Caring People

The r^2 was 0.22.

Although the set of data was quite limited, it suggests that practicing caring persons play in important role in service delivery. It is striking the variability of numbers from 12/100000 practicing caring persons in Croatia to 1855/100000 in the Netherlands.

For the variables burden of disease and practicing pharmacists / 1000000 population, there were 36 pairs, corresponding to 36 countries. The r value found was -0.506 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was 0.335 and the correlation coefficient for or $\alpha = 0.01$ was 0.430. Hence a strong Pearson linear correlation was found. This is illustrated in Figure 6 below:

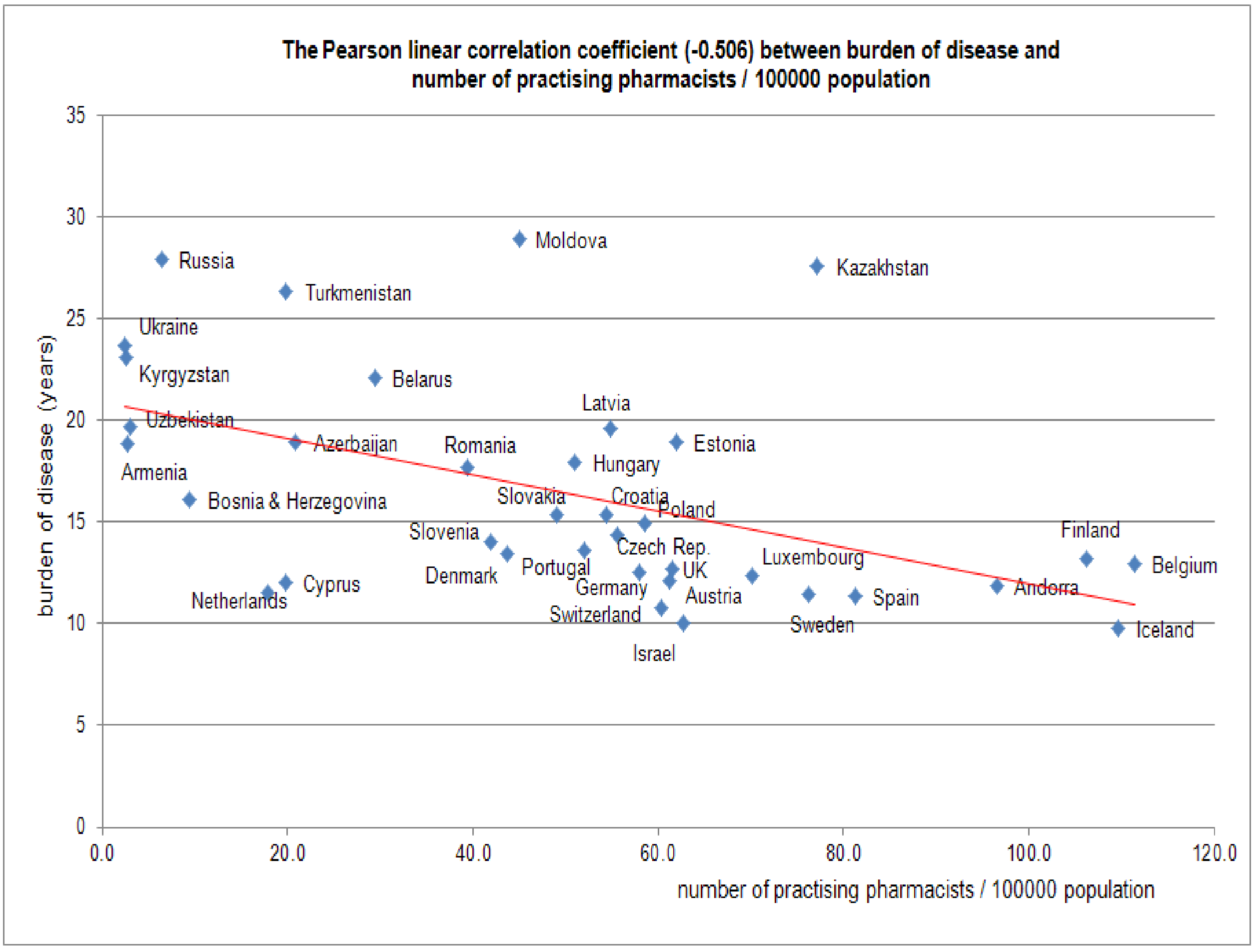

Figure 6. Correlation Between Burden of Disease and Number of Practicing Pharmacists

The r^2 was 0.26.

This strong correlation shows that pharmaceuticals play a strong role (26%) in reducing the burden of disease. More pharmacists means better access to medication and more effective care. There is though a large variability of this indicator for roughly the same burden of disease. For example Belgium has more than 5 times the number of pharmacists than Netherlands for roughly the same burden of disease. This shows that the number of pharmacists is not an absolute factor in reducing the burden of disease and itself is influenced by the pharmaceutical market conditions in the respective country.

For the variables burden of disease and physicians employed by hospital / 100000 population, there were 35 pairs, corresponding to 35 countries. The r value found was -0.352 and for this number of pairs the correlation coefficient for or α = 0.05 was 0.335 and the correlation coefficient for or α = 0.01 was 0.430. Hence a Pearson linear correlation was found. This is illustrated in Figure 7 below:

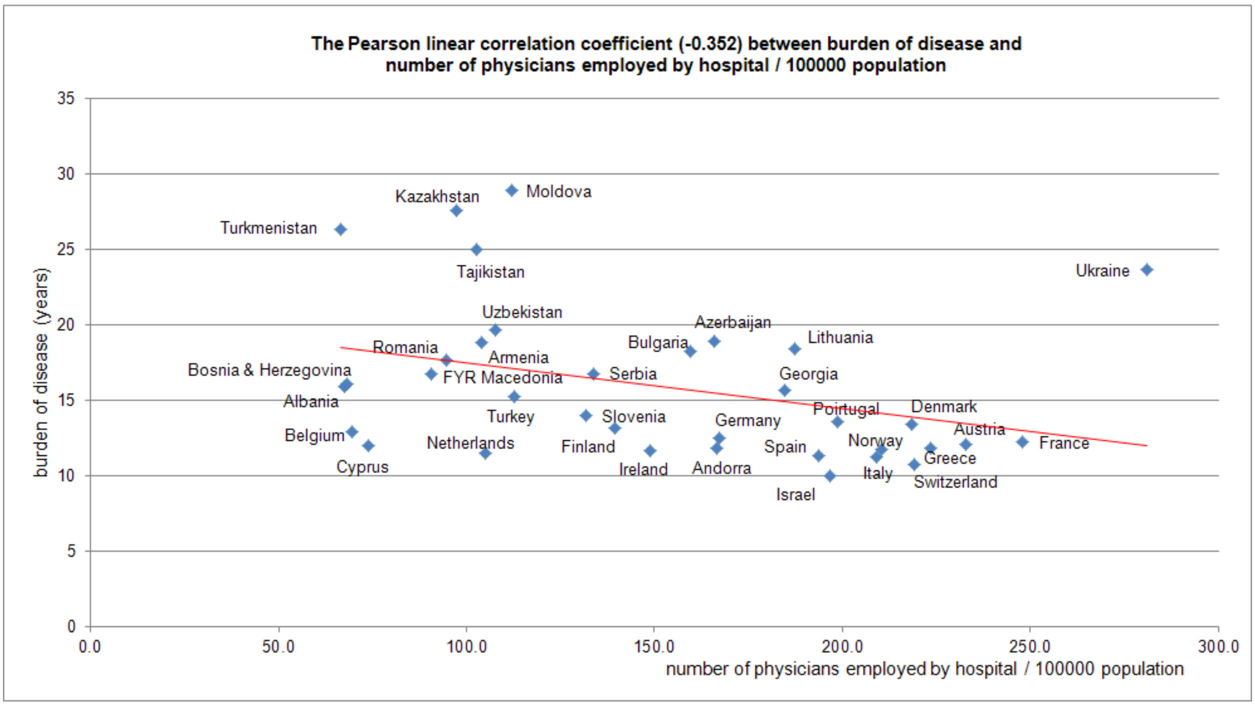

Figure 7. Correlation Between Burden of Disease and Number of Physicians Employed by Hospital

The r^2 was 0.12.

This correlation shows that it is important not only to have hospitals but also to have the qualified manpower to deliver services within these facilities. However this factor contributes only with 12% to the reducing of burden of disease. For the variables burden of disease and nurses and midwives employed by hospital / 100000 population, there were 19 pairs, corresponding to 19 countries. The r value found was -0.418 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was 0.456 and the correlation coefficient for or $\alpha = 0.01$ was 0.575. Hence no Pearson linear correlation was found. This is illustrated in Figure 8 below:

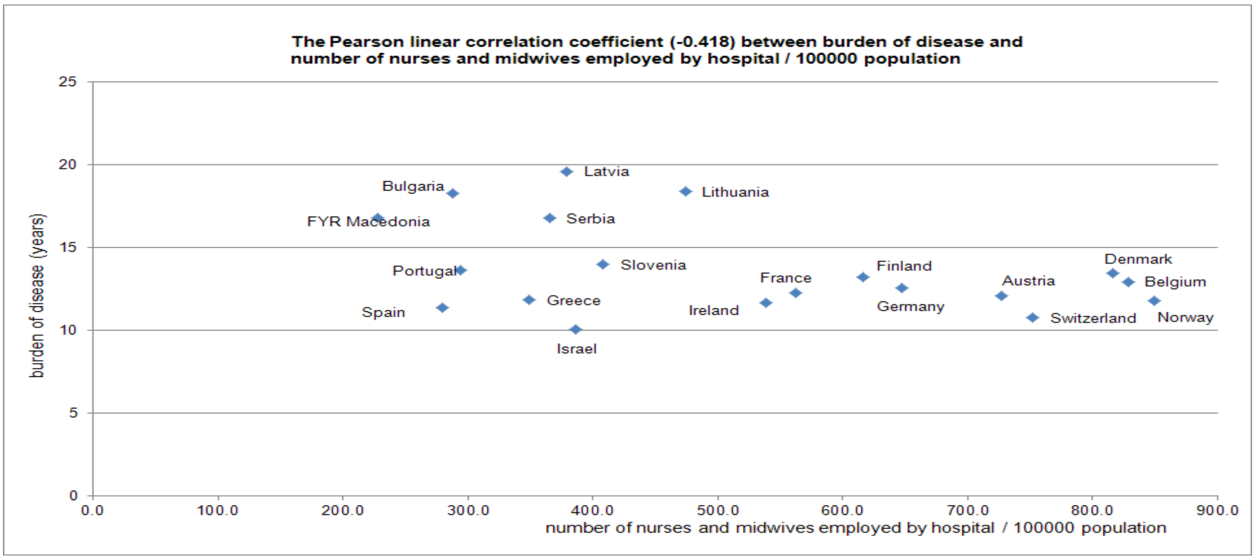

Figure 8. Correlation Between Burden of Disease and Number of Nurses and Midwives Employed by Hospital

The set of data was not large and no linear correlation was found, however we can see patterns of organizing the health services. For roughly the same burden of disease Mediterranean countries (Spain Portugal and Greece) employ less number of nurses in hospitals than Scandinavian and Central European countries.

The above sets of data were all related to human resources. This data shows that in few cases there is no correlation between the variables and but for the majority of the indicators there is a correlation between the number of human resources employed (especially highly skilled), and the reduction of the burden of disease. It is worth mentioning though that the correlation was week except with the number of pharmacists. Beyond the skills employed, large numbers of doctors and pharmacists mean a better access to care.

For the pairs between burden of disease and the 4 technical resources indicators, the findings of this study are the following:

For the variables burden of disease and total hospital beds / 100000 population, there were 47 pairs, corresponding to 47 countries. The r value found was 0.393 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was 0.294 and the correlation coefficient for or $\alpha = 0.01$ was 0.378. Hence a strong Pearson linear correlation was found. This is illustrated in Figure 9 below:

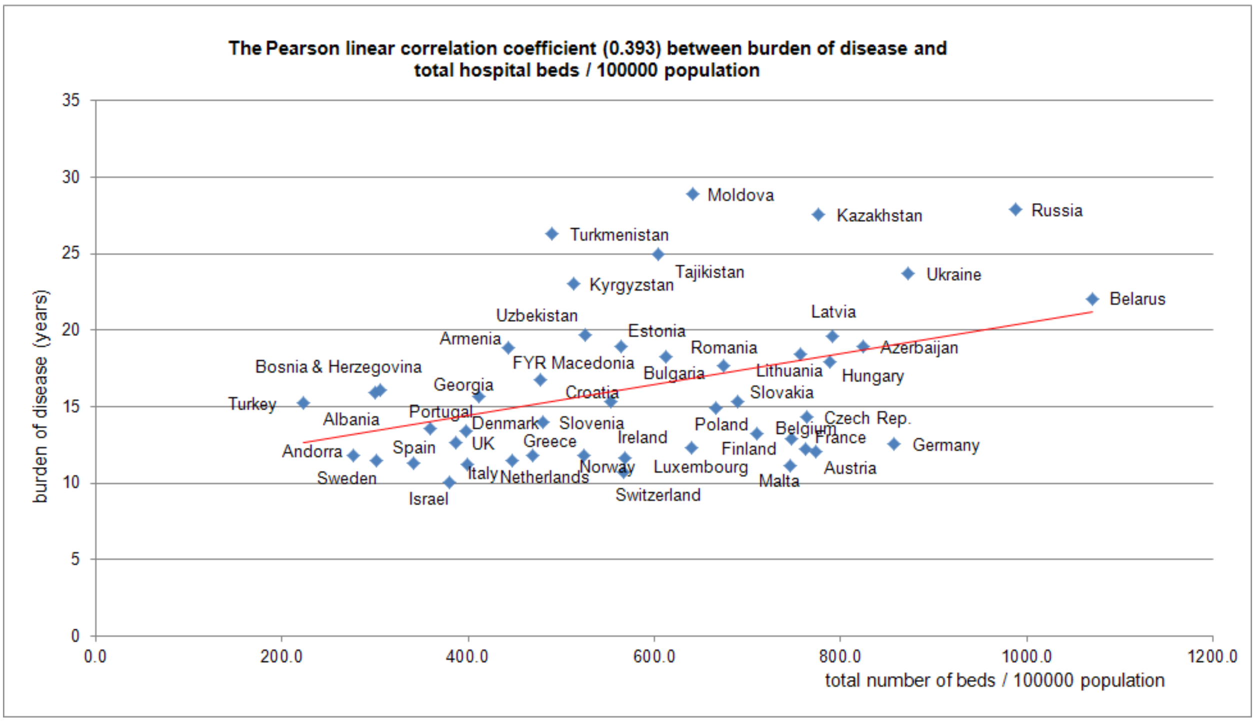

Figure 9. Correlation Between Burden of Disease and Total Hospital Beds

The r^2 was 0.15.

The positivity of this linear correlation can be explained by different health policies. The burden of disease is well known in every country, but some countries are prone to consider that good care is provided only in hospitals, so the reaction to tackle health issues is by investing in hospitals, creating an access problem.

For the variables burden of disease and CTs / 100000 population, there were 24 pairs, corresponding to 24 countries. The r value found was -0.577 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was

0.444 and the correlation coefficient for or α = 0.01 was 0.561 Hence a strong Pearson linear correlation was found. This is illustrated in Figure 10 below:

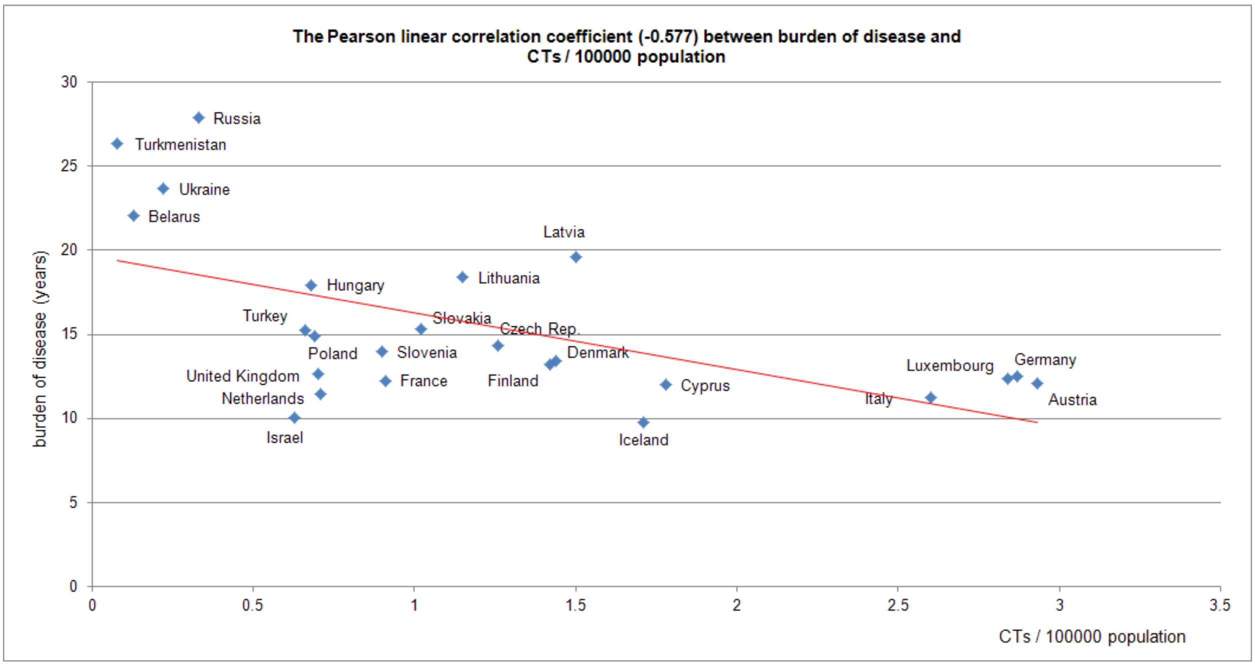

Figure 10. Correlation Between Burden of Disease and CTs

The r^2 was 0.33.

This strong linear correlation shows that countries with good diagnostic capabilities can reduce their burden of disease by having earlier and more precise diagnostics. It is obvious a cluster of former soviet republics with low number of CTs and high burden of disease. This factor contributes with 33% to the reducing of burden of disease.

For the variables burden of disease and MRIs / 100000 population, there were 22 pairs, corresponding to 22 countries. The r value found was -0.568 and for this number of pairs the correlation coefficient for or α = 0.05 was 0.444 and the correlation coefficient for or α = 0.01 was 0.561. Hence a strong Pearson linear correlation was found. This is illustrated in Figure 11 below:

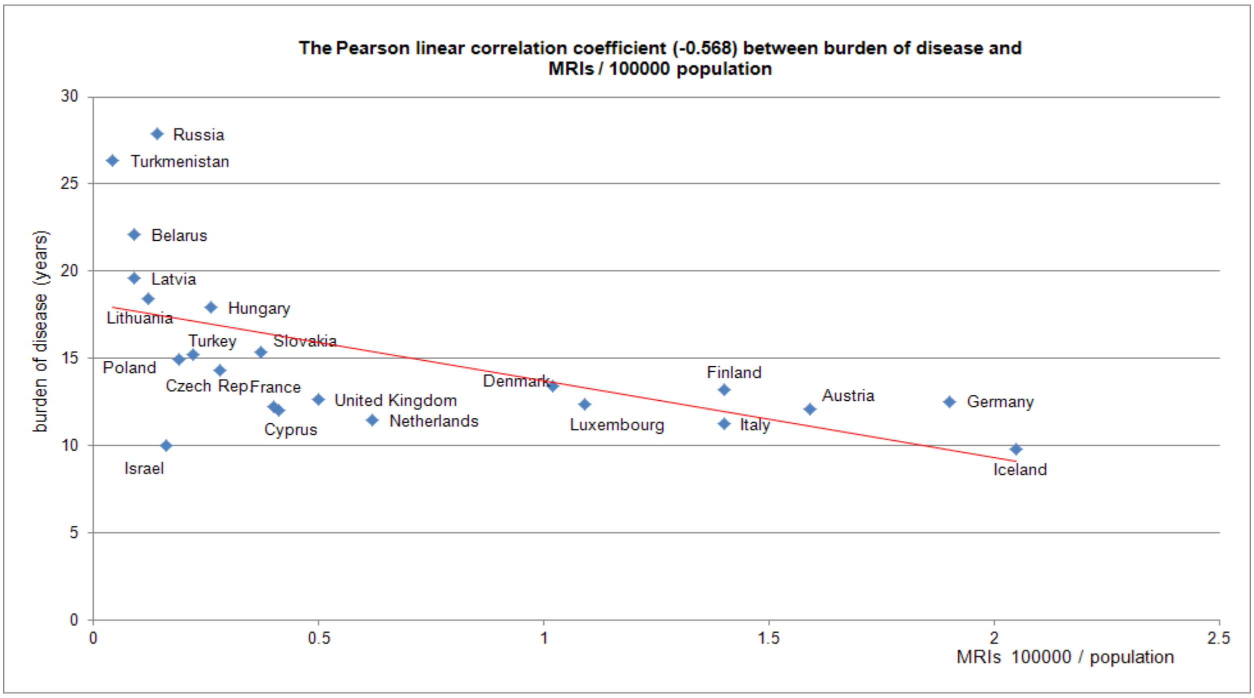

Figure 11. Correlation Between Burden of Disease and MRIs

The r^2 was 0.32.

This is another example of strong correlation between the number of units of diagnostic equipment (MRI) and burden of disease. This factor contributes with 32% in reducing the burden of disease. Although strong the negative correlation is a little weaker than CT / burden of disease correlation. Maybe because MRIs are more seldom and they are used predominantly to diseases creating less burden.

For the variables burden of disease and radiation therapy equipment / 100000 population, there were 17 pairs, corresponding to 17 countries. The r value found was -0.349 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was 0.482 and the correlation coefficient for or $\alpha = 0.01$ was 0.606. Hence no Pearson linear correlation was found. This is illustrated in Figure 12 below:

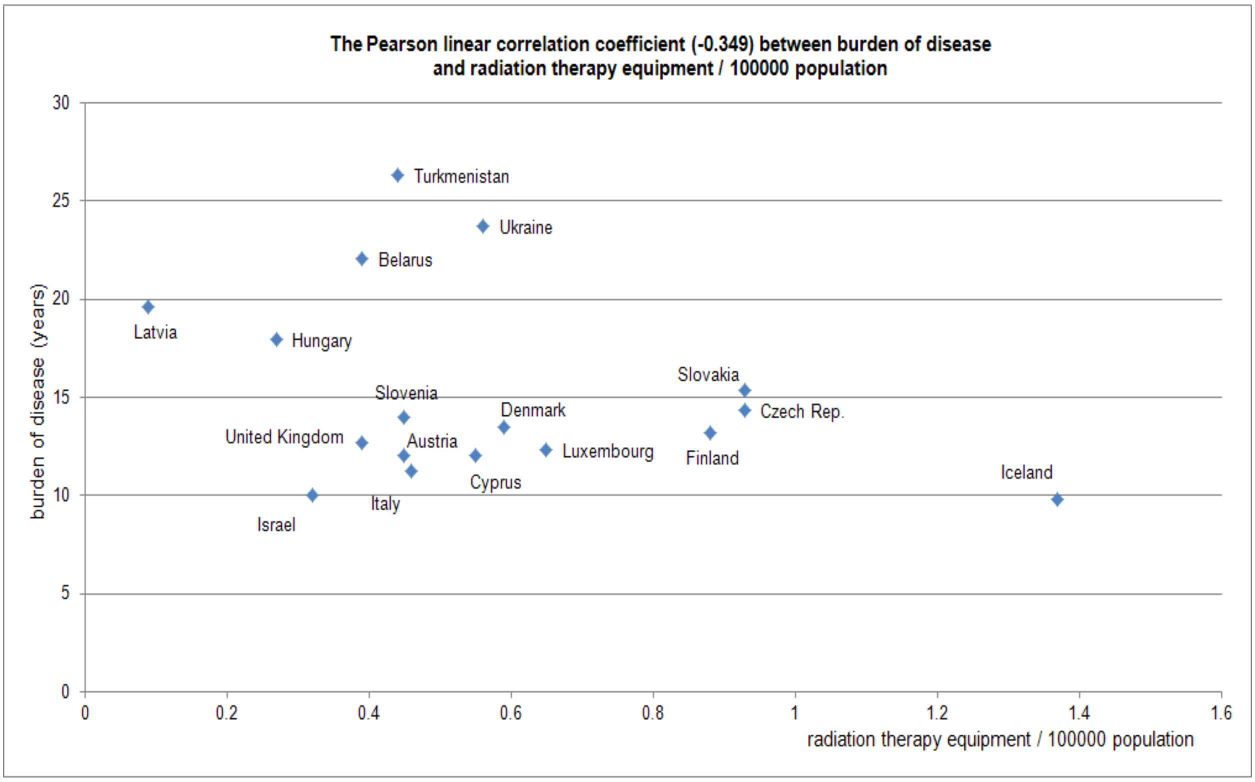

Figure 12. Correlation Between Burden of Disease and Radiation Therapy Equipment

The lack of correlation might be explained by the difference in disease prevalence in various countries, the radiation therapy equipment being specific only to certain types of cancer treatment, or by scarce data.

For the 3 of the 4 technical resource indicators we found strong linear correlations emphasizing the importance of these types of resources. However these can be biased due to the fact that only rich countries can afford this kind of equipment in large numbers and usually the inhabitants of rich countries are also less prone to become ill, or they have access to better treatments..

For the pairs between burden of disease and the 2 infrastructure resources indicators, the findings of this study are the following:

For the variables burden of disease and % of population connected to water supply system, there were 50 pairs, corresponding to 50 countries. The r value found was -0.626 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was 0.279 and the correlation coefficient for or $\alpha = 0.01$ was 0.361. Hence a very strong Pearson linear correlation was found. This is illustrated in Figure 13 below:

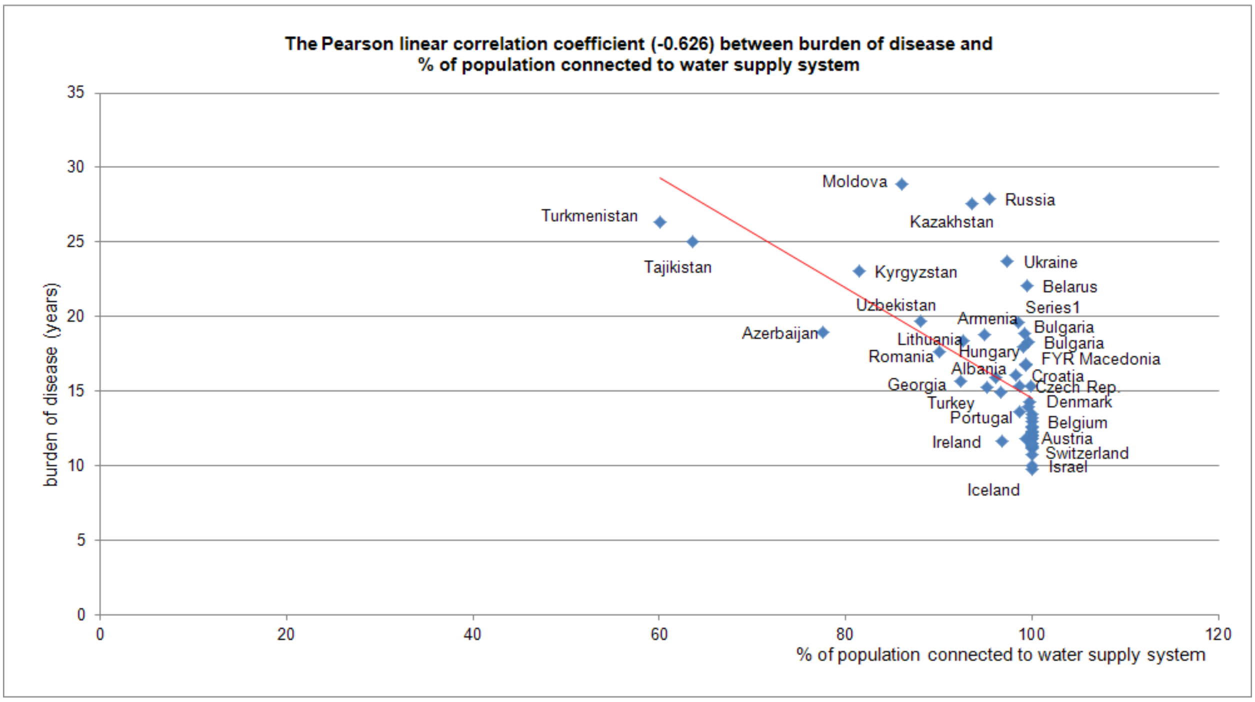

Figure 13. Correlation Between Burden of Disease and % of Population Connected to Water Supply System

The r^2 was 0.39.

This very strong correlation shows how important is the safe water supply infrastructure. Not only that access to safe water reduces the incidence of contagious diseases and intoxications, but in the absence of safe water health care providers cannot function. The water supply system contributes with no less than 39% in the reduction of burden of disease

For the variables burden of disease and % of population connected to sewage system, septic tank, or other hygienic means of sewage disposal, there were 50 pairs, corresponding to 50 countries. The r value found was -0.658 and for this number of pairs the correlation coefficient for or $\alpha = 0.05$ was 0.279 and the correlation coefficient for or $\alpha = 0.01$ was0.361. Hence a very strong Pearson linear correlation was found. This is illustrated in Figure 14 below:

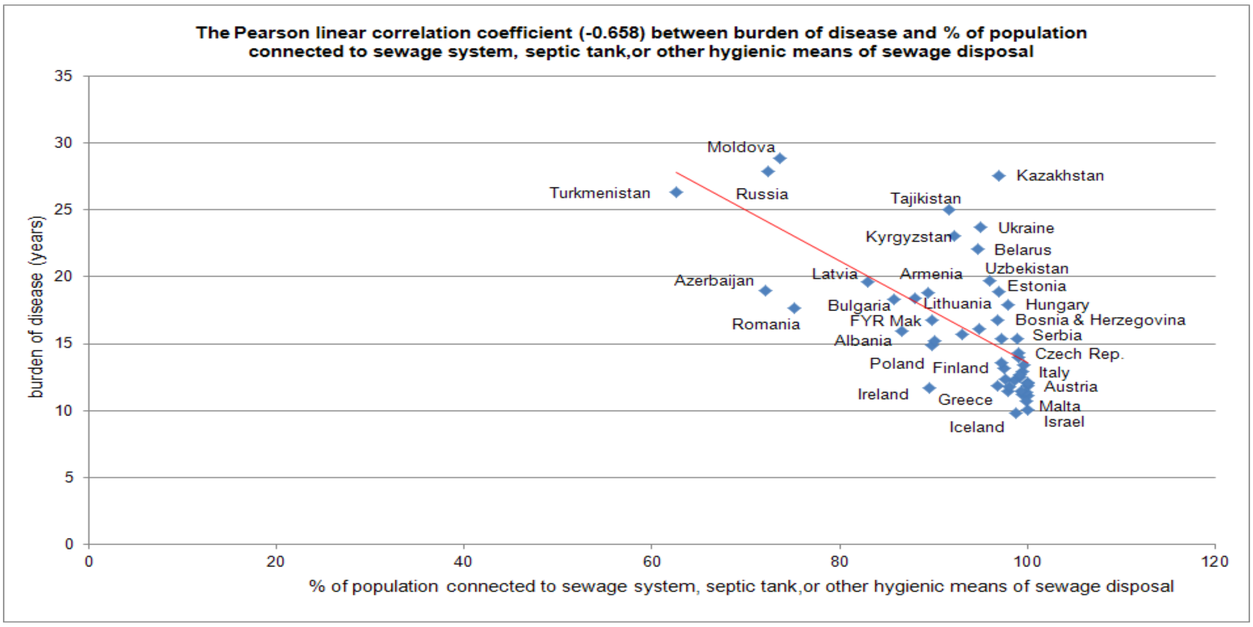

Figure 14. Correlation Between Burden of Disease and % of Population Connected to Sewage System, Septic Tank, Other Hygienic Means of Sewage of Disposal

The r^2 was 0.43.

This is another example of very strong correlation between an infrastructure indicator and burden of disease. It seems to be even more important, because in the absence of a proper sewage system, safe water sources can be contaminated. Again, lack of a proper sewage system is not compatible with the existence of a health care facility, indirectly increasing the burden of disease. The existence of this factor reduces the burden of disease with 43%

The importance of the two infrastructure factors is obvious. They count more than technological resources and human resources in reducing the burden of disease.

Conclusion

Human resources, technological resources and infrastructure resources contribute to the reduction of burden of disease in different degrees. The most important are the infrastructure resources (good sewage system and safe water). Then come the other two: technological resources and human resources. Access to these resources is vital in delivering the care. This study suggests the most effective ways of reducing the burden of disease from the point of view of policy making. This is a not only a matter of technological efficiency but more a matter of allocative efficiency. Comparisons between countries are possible and various characteristics of health systems become obvious.

The data shows that no country has reduced the burden of disease below 9.8 years. This suggests that almost 10 years if not more are lost due to factors that are not comprised within the health system or the infrastructure. There may be biological, social, environmental factors contributing to the incidence of diseases. Delaying the onset of diseases relieves the burden of disease and it can be done through prevention only.

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