



Statistical Analysis of Investment in Healthcare and Health Outcomes for OECD Countries

A report submitted in partial fulfilment of the course MIS41130, Statistical Methods

Master of Science - Business Analytics

University College Dublin - Michael Smurfit Graduate School of Business

Autumn Trimester - 1st December 2023

Statement of Authorship

We, the students of Group 9 from the course MSc. Business Analytics, collectively affirm that this report, entitled Statistical Analysis of Investment in Healthcare and Health Outcomes for OECD Countries, is the outcome of our collaboration. Each team member made significant contributions to the analysis and composition of the report.

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Abstract

The aim of this statistical analysis is to find out if the government expenditure in healthcare has statistically impact the health outcomes such as life expectancy, maternal mortality rate, incidence of Aids and Measles. The study focuses on OECD countries and also studies if governments across the globe are investing in healthcare on recommended levels. Based on this study we also propose recommendations on healthcare spending for specific countries and recommend areas of further study for best practices, from Turkey and less than average outcome for resources spent (Israel). This study also demonstrates the importance of public provisioning of health care as in Europe contrary to the USA.

Introduction

Historically, the debate of European healthcare model and the United States healthcare model. While European healthcare model is a form of socialised model, the USA's is a predominantly out of pocket model (McAlister & Helton, 2021). Furthermore, the USA spends the most on healthcare than any other OECD (Organisation for economic cooperation and development) country and yet have low levels of patient outcomes (Tikkanen and Abrams, 2020). Hence it would be of interest to leaders and public policy decision makers across Europe and the USA to understand the relationship between components of healthcare expenditures and healthcare outcomes. This helps decision makers to decide on government funding of healthcare schemes.

In this study we are employing statistical methods to explore if different healthcare modes of spending have statistically significant impact on health outcomes. The chosen healthcare outcomes are life expectancy at birth, maternal mortality rate, incidence of two communicable diseases viz, Human Immunodeficiency virus – acquired immunodeficiency syndrome (HIV-AIDS) and Measles. The components or modes of healthcare expenditure being studied are government spending (public), out of pocket spending (private) and spending in voluntary schemes. Spendings are considered in terms of percentage of GDP and in per capita US dollars purchasing power parity (PPP).

In this study we are attempting to answer which mode of healthcare investment shows statistically significant improved health outcomes. In addition to this we will also try and answer if there is a statistically significant difference in government healthcare spending, life expectancy, maternal mortality rate between OCED and non-OECD countries. Another question we are trying to answer is how governments are performing in terms of achieving recommended 5% of GDP (CSEM, 2019) spending into healthcare.

World Bank and OECD data repository are the two main data sources of all the data we have used in this study, and it is of the year 2019 pre covid disruption levels. Domestic general government health expenditure (% of GDP) (The World Bank, 2023), Domestic general government health expenditure per capita, PPP (current international \$) (The World Bank, 2023), Life Expectancy at birth (in years) and Maternal Mortality, deaths per 100,000 live births for OECD countries data is sourced from OECD (OECD.Stat, 2023) and for non-OCED countries, source of data is World Bank data repository (The World Bank, 2023). Additionally, Voluntary health care payment schemes, Household out-of-pocket payments (OECD.Stat, 2023), Incidence of AIDs and Measles is sourced from OECD data repository (OECD.Stat).

Statistical Analysis

Our analysis is carried out under two heads they are descriptive analysis and inferential analysis. Inferential analysis has further subsections of one mean test, two population mean tests (OECD vs non-OECD countries) and logistic regression analysis to study how healthcare investment impact health outcomes.

I. Descriptive Analysis

As the first step in our pursuit of understanding the relationships between healthcare investments and key health outcomes, a thorough descriptive analysis is conducted for each parameter considered in our study and the summary is gathered in table 1.

	Domestic general government health expenditure (% of GDP)	Domestic general government health expenditure per capita, PPP (current international \$)	Life Expectancy at birth (in years)	Maternal Mortality, deaths per 100,000 live births	Incidence of Acquired immunodeficiency syndrome (AIDS) per 100,000 population	Incidence of Measles per 100,000 population
Mean	6.24	3037.20	81.01	8.87	2.714	3.713
Median	6.17	2764.63	81.95	5.30	0.7	0.85
Mode			82.1	0.00	0.4	0.2
Standard Deviation	1.83	1533.84	2.56	11.48	5.46	8.45
Q1	4.73	1702.51	78.95	1.10	0.38	0.3
Q3	7.87	4174.06	82.93	10.90	1.93	3.56
IQR (Inter Quartile Range)	3.13	2471.54	3.98	9.80	1.55	3.25
Lower Limit	0.03	-2004.80	72.99	-13.60	-1.95	-4.575
Upper Limit	12.56	7881.37	88.89	25.60	4.25	8.43
90 th Percentile	9.03	5102.11	83.39	20.16	7.41	6.57
Range	6.54	5512.57	9.3	50.70	24	44
Skew	0.03	0.17	-0.90	2.24	3.06	3.93
Kurtosis	-1.112	-1.14	-0.31	5.31	9.18	16.13

Table 1: Descriptive analytics measures for OECD

Critical observations of descriptive measures are follows:

- Expenditure in terms of PPP has a higher range and the standard deviation is over half the mean, implying a spread in values. Upon investigation we see, Mexico has the least PPP expenditure of \$542.46 while Norway has the highest expenditure of \$6055.04.
- Maternal Mortality rates has a high range of 50.70 and standard deviation of 11.48 which is significantly higher than the central measures. With further investigation we see that Columbia has the highest of 50 followed by Latvia (37.6) and Mexico (34.2).
- Measles has a positive skew of 3.93 implying a right tail and a higher value away from the central measure and standard deviation is 8.45 is almost twice the mean. Upon investigating we observe, New Zealand has 44 followed by Lithuania (29.8) and Israel (12.6).

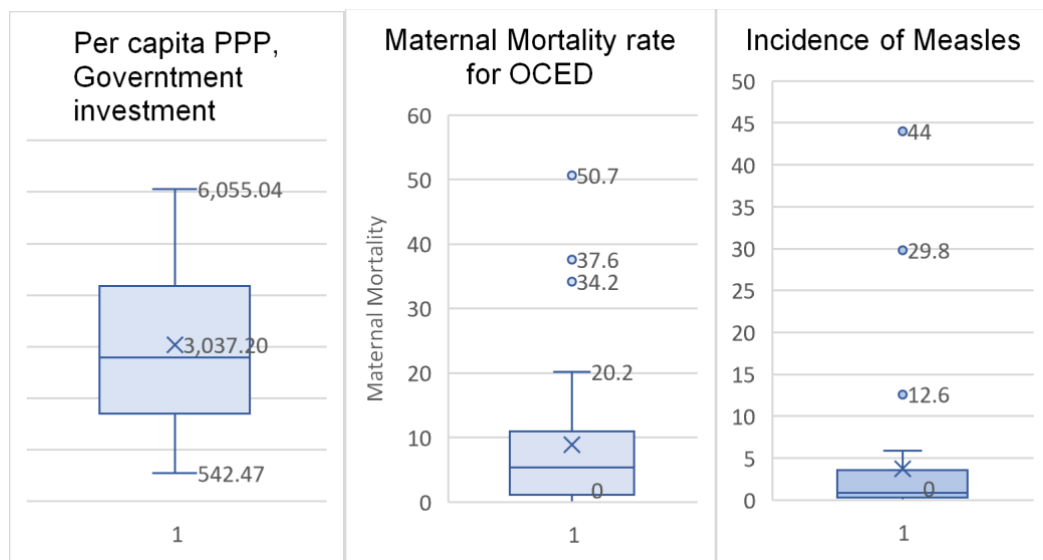


Figure 1: Observations from descriptive statistics

II. Inferential Analysis

This is the extensive section of our study which contains identification of confidence intervals, results of One-mean t-test for government expenditure in percentage GDP and life expectancy. Then we have performed Two-mean t-tests for expenditure, life expectancy and parameters between OECD and non-OECD countries, followed by regression analysis of expenditure modes and health outcomes.

1. One mean t-test:

a. Domestic general government health expenditure (% of GDP):

Civil Society engagement mechanism for UHC2030 (CSEM,2019) recommended healthcare expenditure by governments in healthcare to be at least 5% of the GDP to reach the goal of universal health coverage. Hence, we chose 5% as our benchmark and we tested if the mean of government spending is close to the recommended levels. The test details and results are in the table 2 below.

Significance Level (α)	0.05
Benchmark value of population mean (μ_0)	5.00
Null Hypothesis	$H_0: \mu = 5$
Alternative Hypothesis	$H_a: \mu < 5$
Type of test	Left tailed
Sample size	36
Sample mean	3.60
Sample standard deviation	2.60
Standard Error	0.432
Test Statistic	-3.25
p-value	0.0013
Critical Value	-1.69
Test Decision	Reject Null Hypothesis

H_0 (Null Hypothesis): The mean of government expenditure across countries is 5% of GDP.

H_a (Alternate Hypothesis): The mean of government expenditure across countries is lesser than 5% GDP.

The interpretation is that at 5% significance, there is statistically significant evidence to reject that mean expenditure of governments on healthcare is 5% and we accept alternate hypothesis that mean government expenditure is less than 5%.

Following this we then checked the confidence interval for the mean and the results are as in the below figure 3. The maximum possible value of mean government expenditure is 4.4% of GDP, lower than the recommended 5%.

Table 2 : One mean t-test of domestic government spending in percentage GDP for all countries

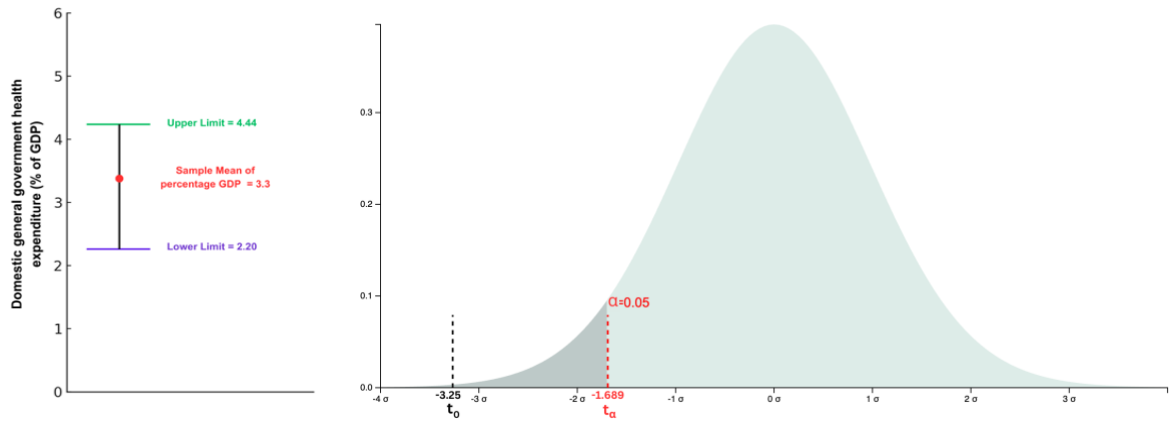


Figure 2: Confidence interval and one mean t-test (% of GDP)

b. Life Expectancy at birth:

A prevalent benchmark of the maximum age up to which a person is covered by life insurance is 85 years across many OECD countries (Irish Life, 2023). Here, we are going to use this as an approximate value of the actual mean life expectancy of all people in OECD countries. The performed one mean test results are as follows in table 3.

Significance Level (α)	0.05
Benchmark value of pop. Mean (μ_0)	85
Null Hypothesis	$H_0: \mu = 85$
Alternative Hypothesis	$H_a: \mu < 85$
Type of test	Left tailed test
Sample size	30
Sample mean	81.17
Sample standard deviation	2.61
Standard Error	0.48
Test Statistic	-8.0702
p-value	3.35462×10^{-9}
Critical Value	-1.699127
Test Decision	Reject H_0

H_0 : Average life expectancy of all countries is equal to 85.

H_a : Average life expectancy of the countries is lesser than 85.

At a significance level of 5%, we have sufficient statistical evidence to reject the null hypothesis and to accept that the mean life expectancy of OECD citizens is lesser than 85 years.

Table 3: One mean t-test for Life expectancy of OECD countries

So, we further investigated to find out that with a confidence of 95%, the upper limit for the mean of OECD population is 82.13 years as shown in figure 3 below. In addition to this, we can also infer that the maximum life term policy is covering more than the mean of Life expectancy for OECD citizens.

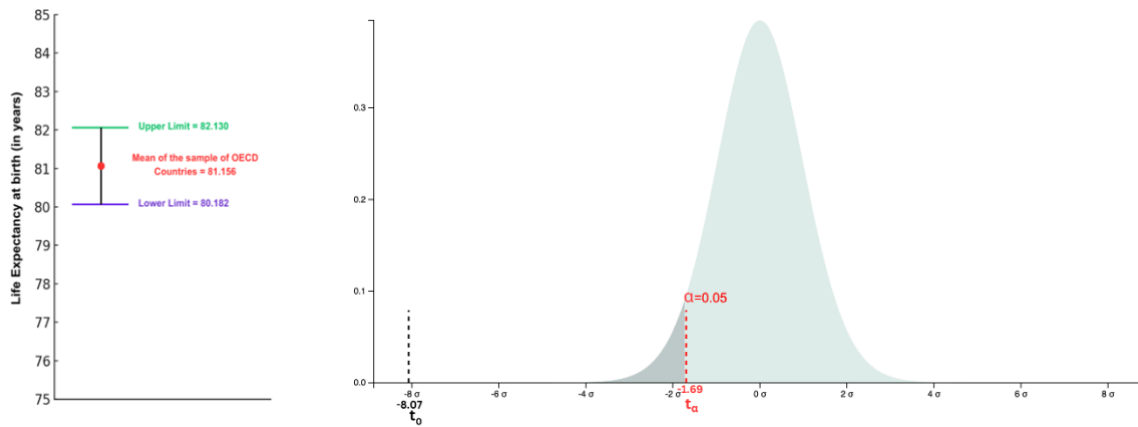


Figure 3: Confidence interval and one mean t-test (Life expectancy at birth)

2. Two mean t-test:

The question of if OECD countries are performing better than non-OECD countries is being investigated via two mean t-tests.

We performed two mean t-tests for 4 parameters between OECD and non-OECD countries. This analysis becomes more important as OECD countries are also referred to as industrialised countries (Black *et al*, 2009) are hypothesised to perform significantly better in all parameters than non-OECD countries.

The H_0 for the two mean tests is that the mean measures (columns in the below table 4) of OECD countries and non-OECD countries are equal, and H_a would be that OECD measures are greater than non-OECD measures except for Maternal mortality rate in which case, OECD measure is lower than non-OECD measure. The results of the tests are explained in table 4.

	Domestic general government health expenditure (% of GDP)	Domestic general government health expenditure per capita, PPP (current international \$)	Life Expectancy at birth (in years)	Maternal Mortality, deaths per 100,000 live births
H_0	Reject H_0	Reject H_0	Reject H_0	Reject H_0
Test result	At 5% significance there is statistical evidence to conclude that mean OECD expenditure in terms of percentage GDP is greater than non-OECD expenditure.	At 5% significance level, we have statistical evidence to accept that mean OECD government expenditure on healthcare in terms of PPP is greater than non-OECD countries.	At 5% significance level, there is conclusive statistical evidence that the average life expectancy of the OECD countries is statistically greater than the average life expectancy of the non-OECD countries.	At 5% significance level, there is conclusive statistical evidence that average maternal mortality rate of the OECD countries is less than the average maternal mortality rate of the non-OECD countries

Table 4: Results from two mean t-tests

Based on the test results as in the above table 4, the hypothesis of OECD performing better than non-OECD countries hold true.

3. Linear Regression hypothesis tests:

This test is performed to answer if expenditure in healthcare result in better health outcomes. The expenditures considered here are as row headers in the below table 5 and the health outcome measures are in the column headers.

The H_0 , null hypothesis for these tests states that the health outcomes are not correlated with the health expenditures and H_a would be, that health outcomes are correlated with health expenditures. The table value of 'Yes' indicates if p-value is lesser than the significance level of 5% for the hypotheses' slope value and 'No' otherwise.

	Life Expectancy at Birth	Maternal Mortality, per 100,000 live births	Incidence of AIDS per 100,000 population	Incidence of Measles per 100,000 population
Domestic general government health expenditure (% of GDP)	Yes $R^2= 0.24$ P-value= 0.0018 Slope (co-efficient) = 0.69	No	No	No
Domestic general government health expenditure per capita, PPP (current international \$)	Yes $R^2=0.33$ P-value= 0.00014 Slope (co-efficient) =0.001	Yes $R^2= 0.23$ P-value= 0.0040 Slope (co-efficient) = -0.0035	Yes $R^2=0.15$ P-value = 0.018 Slope(co-efficient) = -0.0014	No
Voluntary health care payment schemes	No	No	No	No
Household out-of-pocket payments	No	No	No	No

Table 5 : Summary of Linear regression hypotheses test results

While health expenditure Domestic general government health expenditure (% of GDP) shows a statistically significant correlation with Life expectancy, Domestic general government health expenditure per capita, PPP shows a statistically significant correlation with Life Expectancy, Maternal Mortality rate and AIDS. For the rest, Voluntary health scheme and Household out-of-pocket schemes, there is no statistically significant correlation.

Interpretation of the results from table 5 are below:

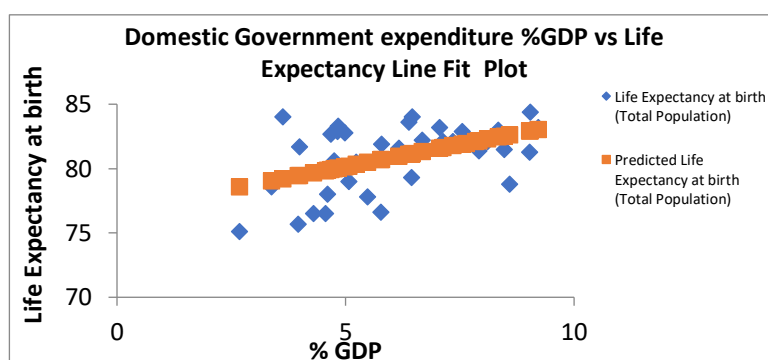


Figure 4.1: % GDP Vs Life Expectancy

- Life expectancy at birth is positively correlated (Figure 4.1) with a slope of 0.69 to Domestic general government health expenditure (% of GDP). A 24% change in Life expectancy can be explained by a unit change in Domestic general government health expenditure (% of GDP).

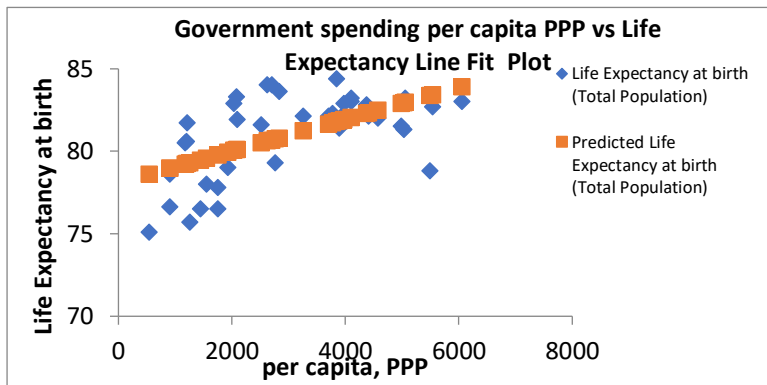


Figure 4.2: Govt. spending per capita PPP Vs Life Expectancy

- Life expectancy at birth is positively correlated with a slope of 0.001 to Domestic general government health expenditure per capita, PPP (Figure 4.2). A 33% of change in Life expectancy can be explained by a unit change in Domestic general government health expenditure per capita, PPP.

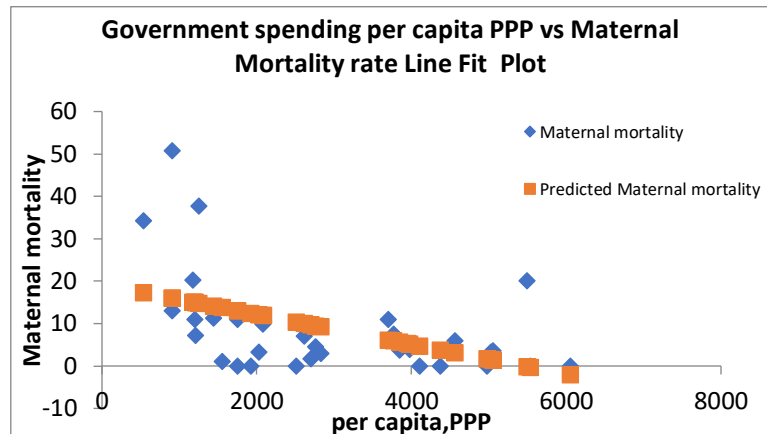


Figure 4.3: Govt. spending per capita PPP Vs Maternal Mortality

- Maternal mortality rate is negatively correlated with a slope of -0.0035 to Domestic general government health expenditure per capita, PPP (Figure 4.3). A 23% of change in Maternal mortality rate can be explained by a unit change in Domestic general government health expenditure (% of GDP).

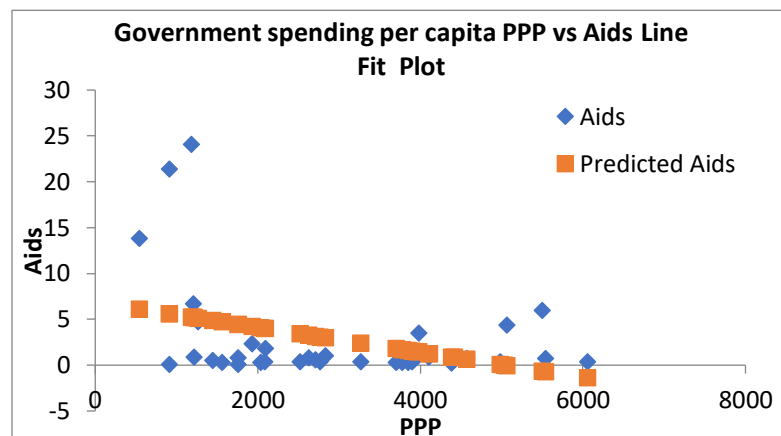


Figure 4.4: Govt spending per capita PPP Vs AIDS

- Incidence of AIDS is negatively correlated with a slope of -0.0014 to Domestic general government health expenditure per capita, PPP (Figure 4.4). A 15% of change in Incidence of AIDS can be explained by a unit change in Domestic general government health expenditure (% of GDP).

Conclusion

While OECD countries fare better than non-OECD countries, there are still significant disparities within the grouping. As Mexico has very less domestic spending by government on healthcare per capita, PPP, New Zealand has the highest burden of Measles of 44 per 100,000 population and Columbia has a maternal mortality rate of 50 per 100,000 live births which are significantly different from other counties in the grouping.

In terms of government health spending matching recommended levels of 5% of GDP, the global mean expenditure could be maximum 4.4% at 99% confidence interval. All countries have a long way ahead to achieve this goal, which would be a step towards universal health care.

Furthermore, while it is also evident that increasing government spending in real dollar value, per person PPP has a positive impact on health outcomes in terms of life expectancy, maternal mortality rate and incidence of AIDS, increasing government expenditure in terms of percent of GDP would have a positive impact longevity (life expectancy).

Recommendations

1. National governments which are spending less than 5% of GDP should strive to increase their spending to achieve the target of 5% at least as it would positively impact life expectancy.
2. National Governments of Columbia, Costa Rica and Mexico should invest more in healthcare in PPP, per capita terms as they have high burden of incidence of AIDs.
3. National Governments of Columbia, Mexico and Latvia should invest more in healthcare in PPP, per capita terms as they have high burden of Maternal mortality rates.
4. Meanwhile, Israel's healthcare efficiency needs to be studied further as the maternal mortality outcome is low when respect to how much is being spent in terms of per capital PPP by the government.
5. Another study to identify best practices in the healthcare system of Turkey. While government spends USD 909 per person, AIDs incidence is very low (0.1), measles (3.4), maternal mortality rate is high at 13 and life expectancy is 78.6 which can be improved.

Appendix

Definitions:

OECD definitions from (OECD.org, 2023)

1. Life expectancy at birth: Life expectancy at birth and at ages 40, 60, 65 and 80 years old is the average number of years that a person at that age can be expected to live, assuming that age-specific mortality levels remain constant.
2. Maternal Mortality Rate: Number of maternal deaths, all causes, per 100 000 live births
3. Acquired Immunodeficiency Syndrome (AIDS): Number of AIDS cases and incidence rates per 100 000 population at year of diagnosis.
4. Incidence of hepatitis B: Rate of reported cases per 100 000 population
5. Gross domestic product: Gross domestic product is an aggregate measure of production equal to the sum of the gross values added of all resident institutional units engaged in production (plus any taxes, and minus any subsidies, on products not included in the value of their outputs). The sum of the final uses of goods and services (all uses except intermediate consumption) measured in purchasers' prices, less the value of imports of goods and services, or the sum of primary incomes distributed by resident producer units.
6. Purchasing Power Parity: Purchasing power parities (PPPs) are the rates of currency conversion that eliminate the differences in price levels between countries. Per capita volume indices based on PPP converted data reflect only differences in the volume of goods and services produced. Comparative price levels are defined as the ratios of PPPs to exchange rates. They provide measures of the differences in price levels between countries. The PPPs are given in national currency units per US dollar. The price levels and volume indices derived using these PPPs have been rebased on the OECD average. Per capita volume indices should not be used to rank countries as PPPs are statistical constructs rather than precise measures. Minor differences between countries should be interpreted with caution.

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Assignment Contributions:

We divided the parameters amongst the group members and all members have performed all analytical tests. All the three group members contributed equally in the doing the research, performing the statistical analysis (descriptive and inferential), and preparing the report including generating the necessary graphs, plots and tables.

A statement from each team member is as below:

- Vignesh Yalagondahalli Sreenath (23200087)

For the chosen topic of interest, I had the opportunity to apply my learnings from the course towards the assignment. The parameter from the topic that I chose were Life Expectancy (at birth). I have performed descriptive analysis and inferential analysis for life expectancy parameter. Further, for the % share of GDP, PPP, Voluntary healthcare payment schemes and Household out-of-pocket expenditure data, linear regression was performed against the life expectancy parameter. Overall, I enjoyed working on the assignment as it provided me with some good hands-on experience, which I wish to carry and apply for my future endeavours.

- Rufus Meera Gomathi Sankar (23200015)

I worked on Maternal Mortality as a measure of healthcare outcome to study the major descriptive measures and called out the significant outliers. I have performed both descriptive and inferential statistical analysis. Furthermore, I also performed Linear Regression hypothesis testing to find the relation of this metric against various expenditure indicators (% share of GDP, PPP, Voluntary healthcare payment schemes and Household out-of-pocket expenditure data). I applied the concepts that I have learnt from the lectures, and I enjoyed working on this assignment.

- Bhargav Bachanahalli Shekarmurthy (23200186)

The parameters I chose were Government health expenditure in healthcare as part of GDP and per capita, PPP and disease burden. Descriptive analytics was performed for all parameters. One mean t-test, two mean t-test for expenditure as % of GDP and two-mean t-test for both expenditure indicators. Lastly, linear regression was performed for all the combination of parameters. I also contributed towards writing the report and structuring it.