Is the public healthcare system better at handling healthcare crises? Statistical analysis of the management of COVID-19.

1. Introduction

The COVID-19 pandemics turned out to be the biggest test of our healthcare systems in recent years. Even though it was not entirely unexpected and the experts were consistently trying to warn humanity of the possible future pandemics, the countries were still not well prepared for the outbreak. Thankfully though, the last two years provided researchers and academics with extensive data, allowing us to prepare for the next pandemics outbreaks. Whether or not the governments will actually comply with the recommendations is a topic for another, qualitative research, as for now they have proved to be more efficient during crises due to short-term motivation rather than during a long-term care. Nevertheless, more pandemics are sure to appear in the future if humans continue their current style of life and consumption[1]. The role of the researchers and academics is then to draw as many conclusions from COVID-19 pandemics as possible and communicate them to policymakers and the general public.

Over the last two years, many papers concerning this issue have been released. Most of them are extensively broad and include many aspects from a complex perspective. Recommendations include, but are not limited to:

- strengthening public health system,
- promoting the wellbeing of healthcare workers,
- implementing the data monitoring and information system,
- improving the accessibility to medical equipment and drugs,
- increasing the level of social trust in government and institutions[2].

Overall, one of the most common recommendations in the public debate and media was the first point. McKinsey & Company, which is a private, mainstream source of rapports, even published a whole extensive article on ways to strengthening public health, stating that "Government leaders remain focused on navigating the current crisis, but making smart investments now can both enhance the ongoing COVID-19 response and strengthen

[1] L. Ferrante et al, *Brazil's planned exploitation of Amazonian indigenous lands for commercial agriculture increases risk of new pandemics*, Reg Environ Change 21 (81), 2021.
[2] H. Alami et al, *How Can Health Systems Better Prepare for the Next Pandemic? Lessons Learned From the Management of COVID-19 in Quebec (Canada)*, Frontiers in Public Health, vol. 9, art. 671833, 2021.

public-health systems to reduce the chance of future pandemics" and, moreover, that "Investments in public health and other public goods are sorely undervalued"[3]. This point was especially visible in European debate, where politicians, journalists and experts stated that the public healthcare facilities are quicker and more efficient at reacting to national and global health crises such as pandemics. Considering all of the above, the point of this paper is to find out whether the hypothesis of public healthcare being more efficient in such circumstances is also reflected in the statistical data.

2. Methodology

The work is based both on the literature review already existing on the topic, as well as statistical data available online. The statistical data used for the report was acquired from the websites Our World in Data (COVID-19 data) and World Development Index (other indicators and variables). The data was acquired on 18th of March. The programme used for the analysis was RStudio.

3. Data analysis

3.1. Variables choice and general trends in each of them

The research question I am going to try to answer in this paper is: do countries with more public-based healthcare systems handle COVID-19 pandemics better? The very first step in this procedure should be deciding on the variables choice. How should we measure how well the specific country handled the pandemics? Should we do that concerning the number of cases, mortality rate, or vaccination rate? Or maybe all of them? Surely, to access the best conclusions from the data, it would be best if the researcher included multiple variables, and therefore approach the topic from various perspectives. However, such an extended study would surely be a material for a whole dissertation. Therefore, due to the existing time limit, I am going to cover only one COVID-related variable. I have decided to focus on vaccination rate, as vaccines are currently the only effective way of dealing with, or even eventually eliminating, the pandemic. Therefore, first, I checked what countries have the biggest vaccination rate.

[3] M. Craven et al, *Not the last pandemic: Investing now to reimagine public-health systems, McKinsey & Company,* 2021, p. 2.

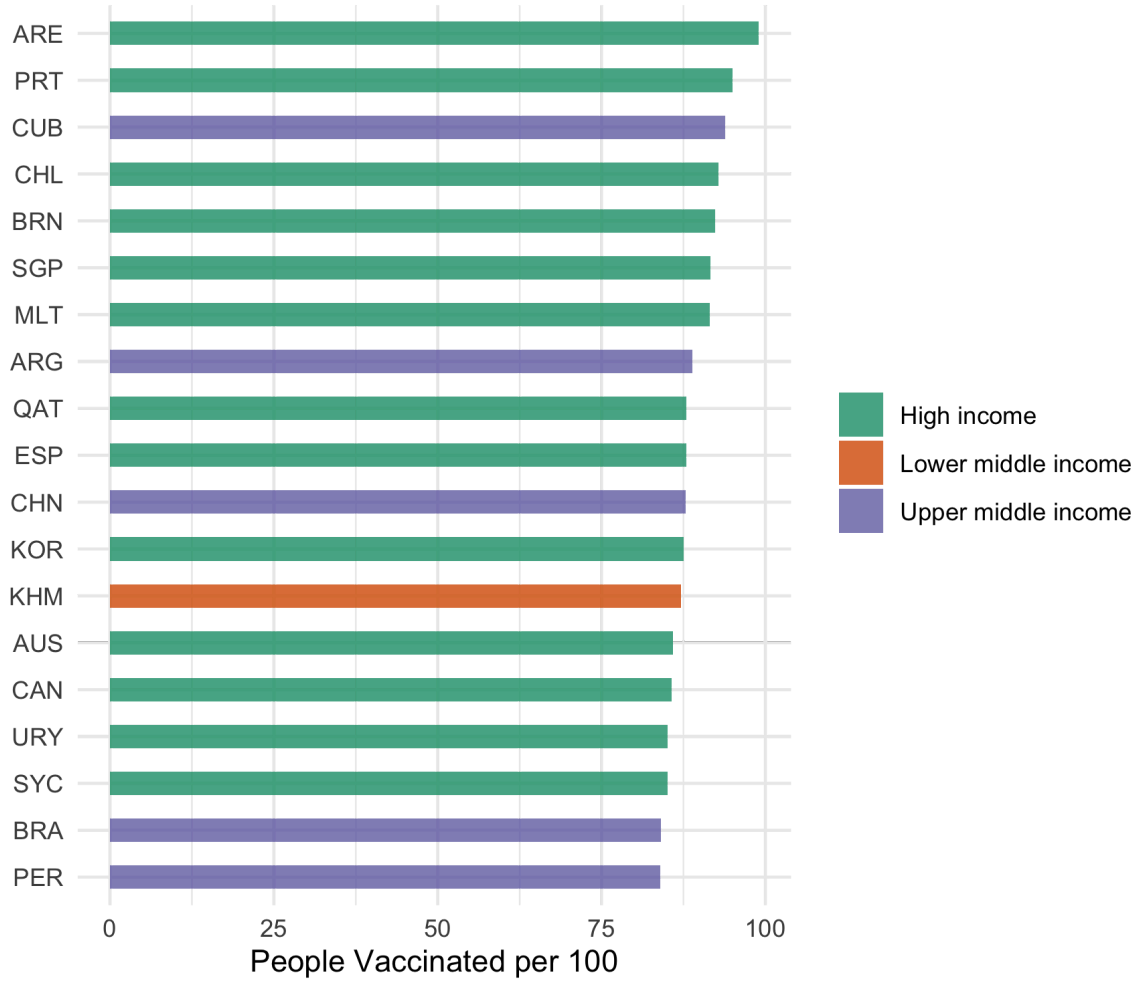

Fig. 1 Countries with the most vaccinated population (top 10%), based on vaccination rate (people vaccinated per 100 people).

The graph on Figure 1 shows which countries have the most vaccinated population (top 10%) in vaccination rate (people vaccinated per 100 people). What could be seen at first on the graph is that most countries from above are high income countries, but there are also some of the upper middle income group, as well as one lower middle income country. There is no low income country.

Then, to answer the research question, the correlation between vaccination rate and financing of the healthcare system must be established. Again, the question of the right choice of variable appears, especially concerning the fact that the financing and spendings on healthcare might be counted in dozens of ways. This time, I decided to examine not only one, but four of them, namely:

- Current health expenditure per capita, PPP (current international $),

- Domestic general government health expenditure per capita, PPP (current international $),
- Domestic general government health expenditure (% of current health expenditure),
- Domestic private health expenditure (% of current health expenditure).

Firstly, I took a deeper look into current health expenditure per capita (PPP, in current international $), which includes all types of expenditure (private, governmental, domestic, external). This variable estimates how much it is spent on healthcare in a given country, but including all sources of expenditure.

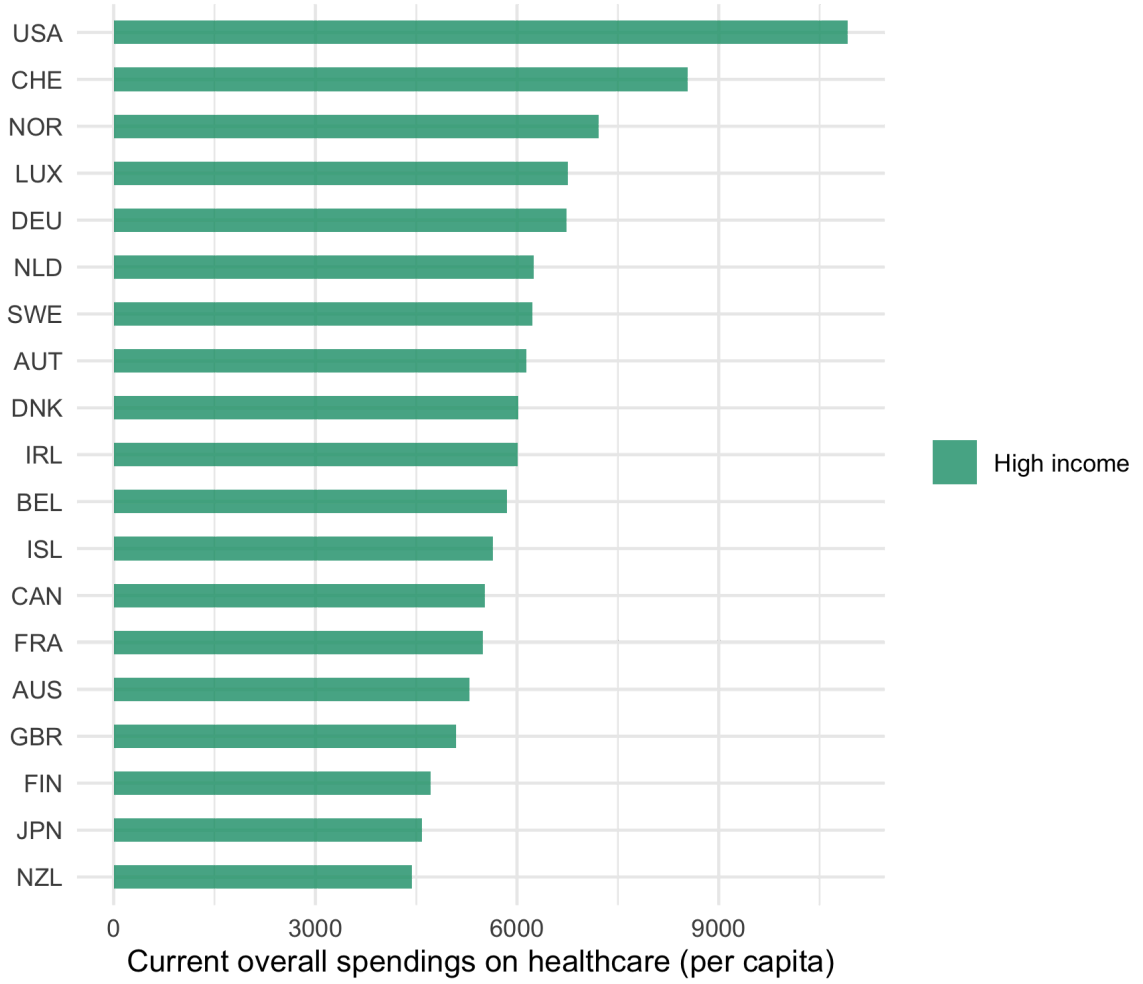

Fig. 2 Countries with the biggest current overall expenditures on healthcare per capita, PPP (top 10%).

On this graph, one could see that the countries that spent the most on healthcare are all high income countries. The top state is the U.S., which might be surprising due to the common narrative about the healthcare system in that country being of a very poor quality. But it is

important to remember that, as will be shown later in the text, it actually covers a big part of its expenses from private funds.

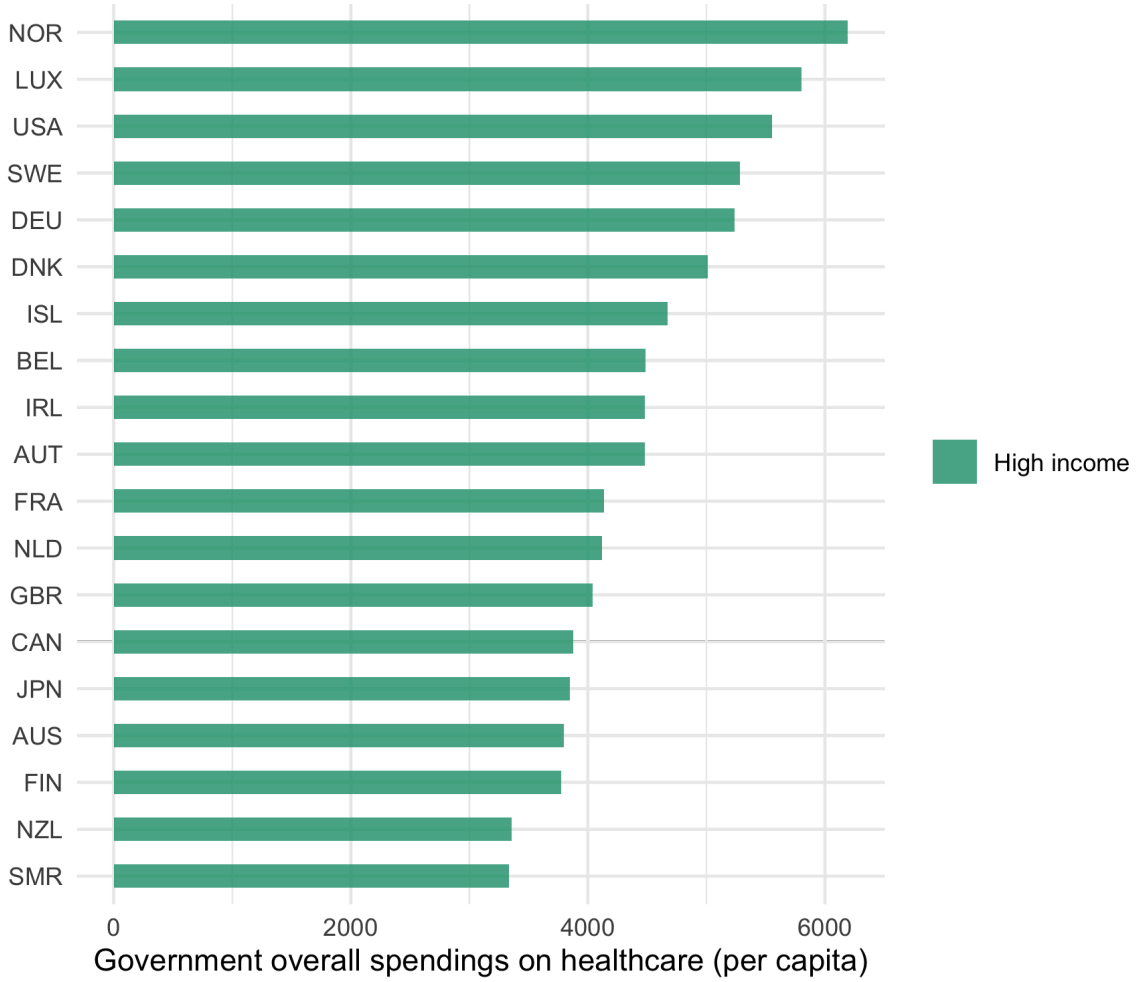

Fig. 3 Top 10% countries with the biggest current overall expenditures on healthcare per capita, PPP (current international $).

On Figure 3, it is visible that the U.S. no longer leads in the ranking, when calculated based on government spendings per capita, although its position still remains pretty high. What did not change either is the fact that only high income countries remain on the top of the ranking. Nevertheless, the situation will slightly change when examining the governments' inputs in the overall healthcare expenditure. This variable is crucial in this paper, as it will show which countries rely on more public, rather than private, health services.

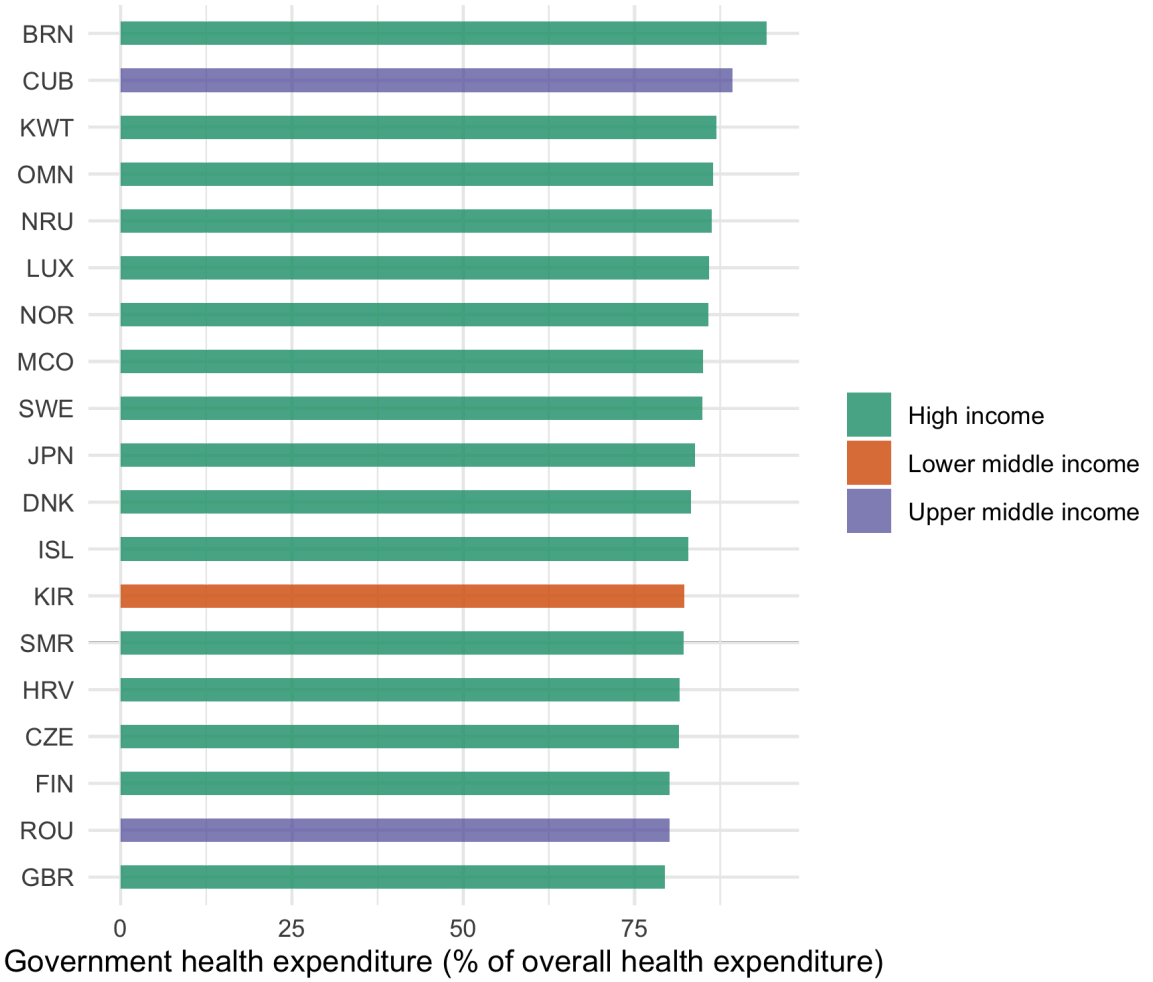

Fig. 4 Top 10% countries with the biggest domestic general government health expenditure (% of current health expenditure).

As shown on Figure 4, countries from other income groups appeared, such as Cuba which was also one of the countries with the most vaccinated population. Nevertheless, to have a full insight into the situation, it is also important to check which states rely on a more private healthcare system.

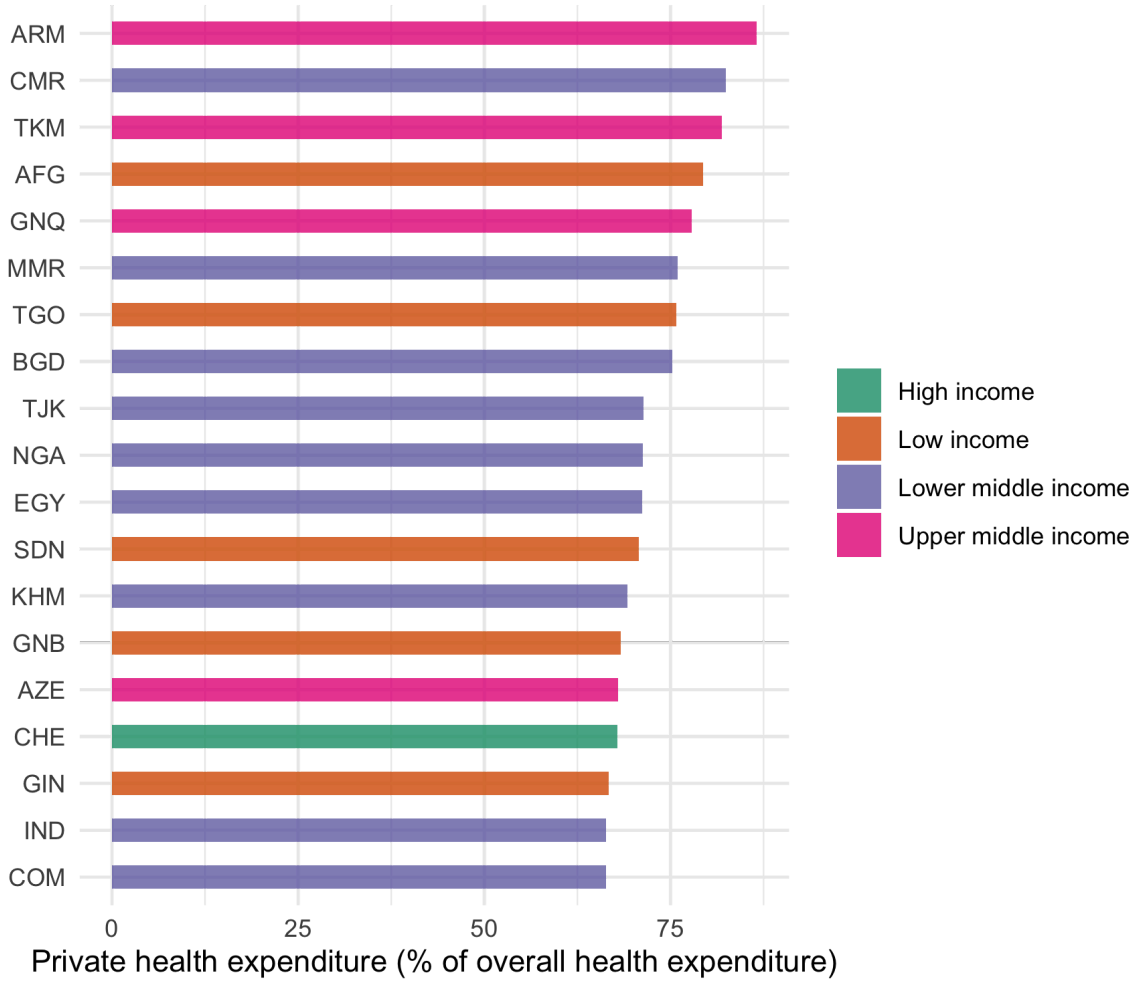

Fig. 5 Top 10% countries with the biggest domestic private health expenditure (% of current health expenditure).

As it is visible on Figure 5, countries that have more private-based healthcare systems are usually the poorer ones. Interestingly though, one of the high income countries also appeared in this graph, namely Switzerland (CHE).

3.2. Correlations

Having determined and presented the top 10% countries in terms of the amount of expenses, as well as those that put pressure on either public or private healthcare, it is crucial to establish the correlation. For the full analysis, it is not enough just to present a couple of separate graphs. To draw reliable conclusions, it is necessary to perform and examine a correlation between given variables. The correlations will be shown separately as two-dimension graphs, later adjusted and put together in terms of the scale. The variables have been presented using log.

a. The correlation between vaccination rate and current health expenditure per capita, PPP (current international $).

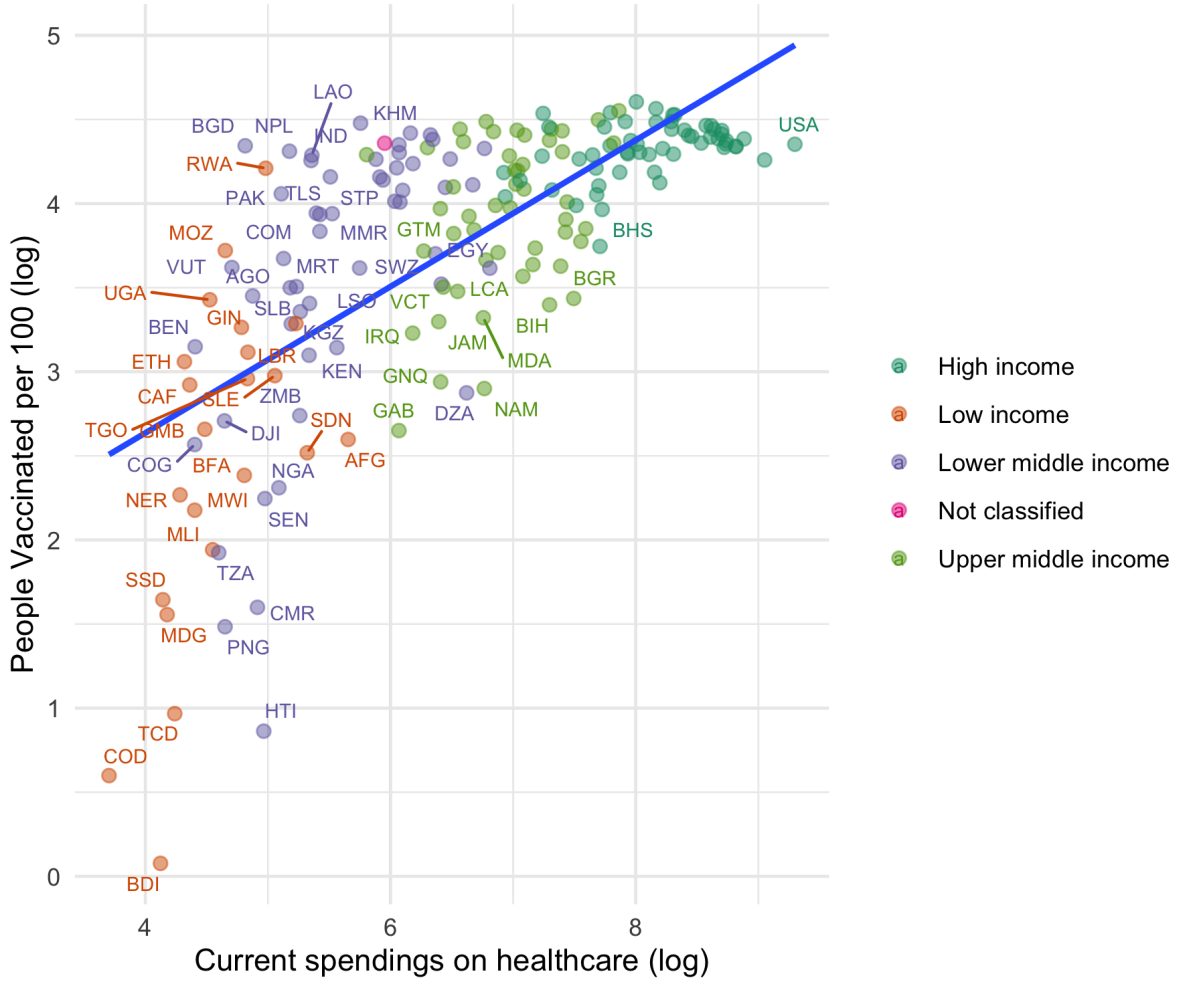

Fig 6. The correlation between vaccination rate and current overall healthcare expenditures.

This correlation turned out to be positive.

b. The correlation between vaccination rate and domestic general government health expenditure per capita, PPP (current international $).

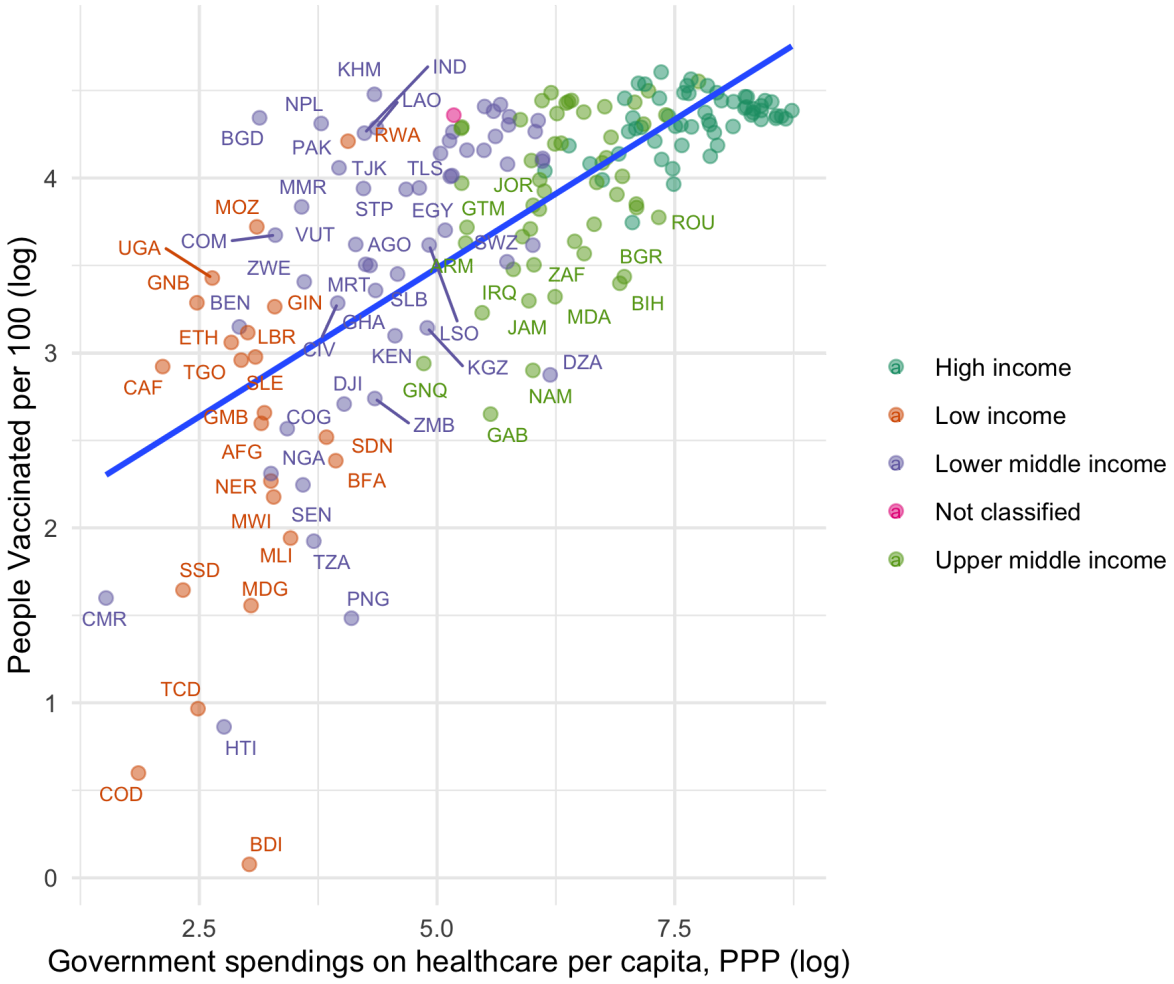

Fig. 6 The correlation between vaccination rate and domestic general government expenditures on healthcare per capita, PPP (international current $).

This correlation is also positive.

c. The correlation between vaccination rate and domestic general government health expenditure (% of current health expenditure).

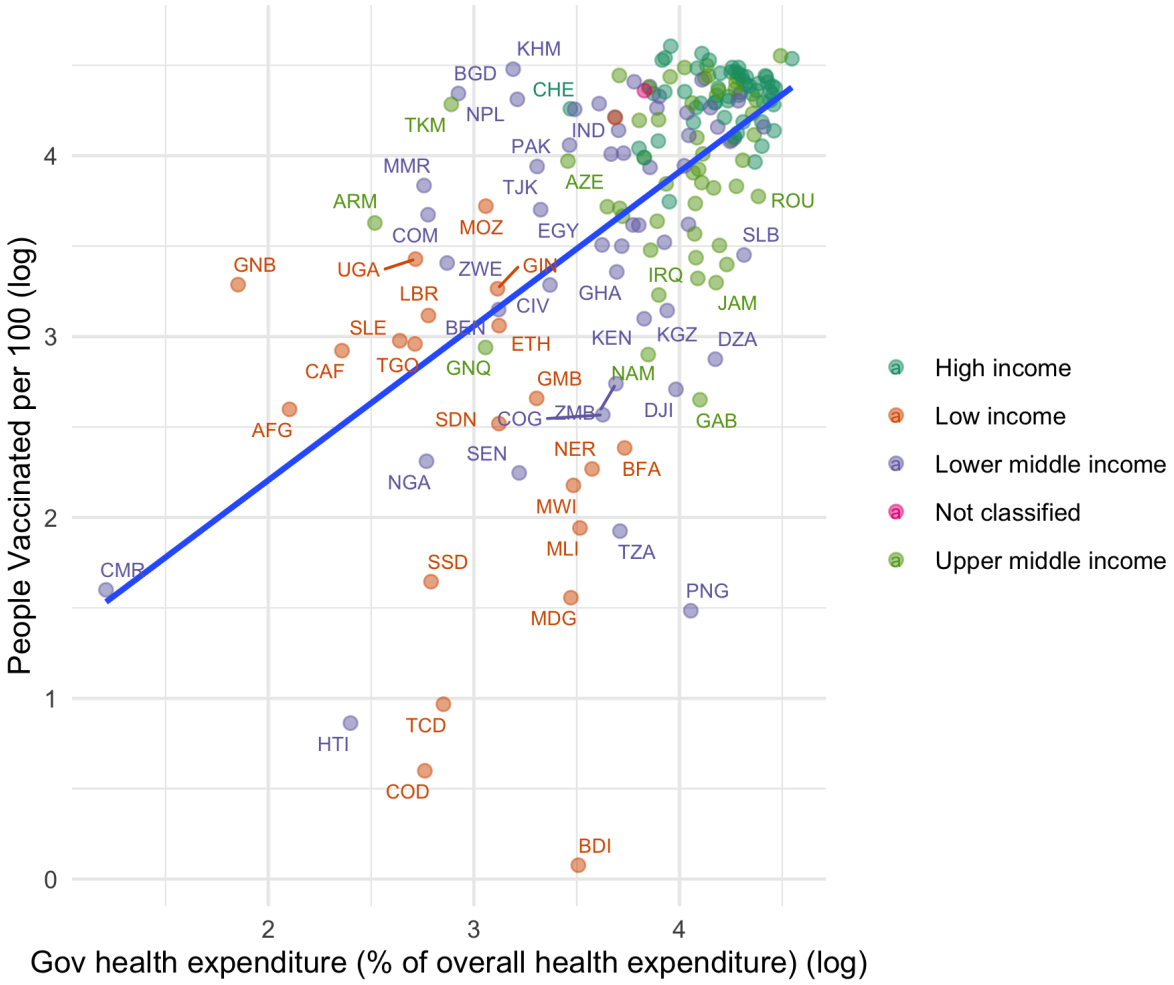

Fig. 7 The correlation between vaccination rate and domestic general government expenditures on healthcare (% of overall current health expenditures).

The third presented correlation also turned out to be positive.

d. The correlation between vaccination rate and domestic private health expenditure (% of current health expenditure).

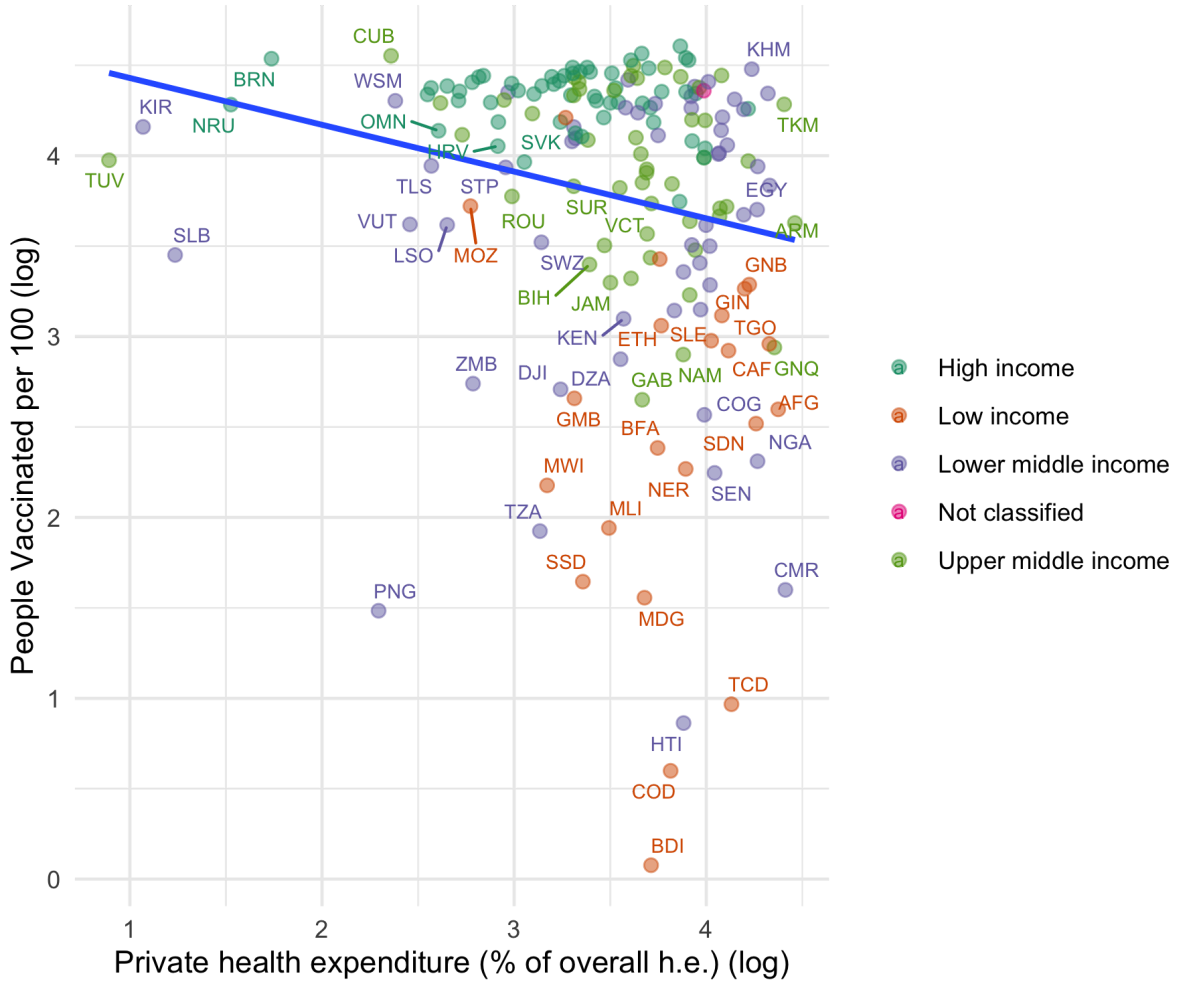

Fig. 8 The correlation between vaccination rate and domestic private expenditures on healthcare (% of overall current health expenditures).

Importantly, the last correlation is the last one that turned out to be negative.

However, in order to fully examine these correlations, they should be put into a scale and then compared to each other, as they could be easily mistaken as positive on the same degree.

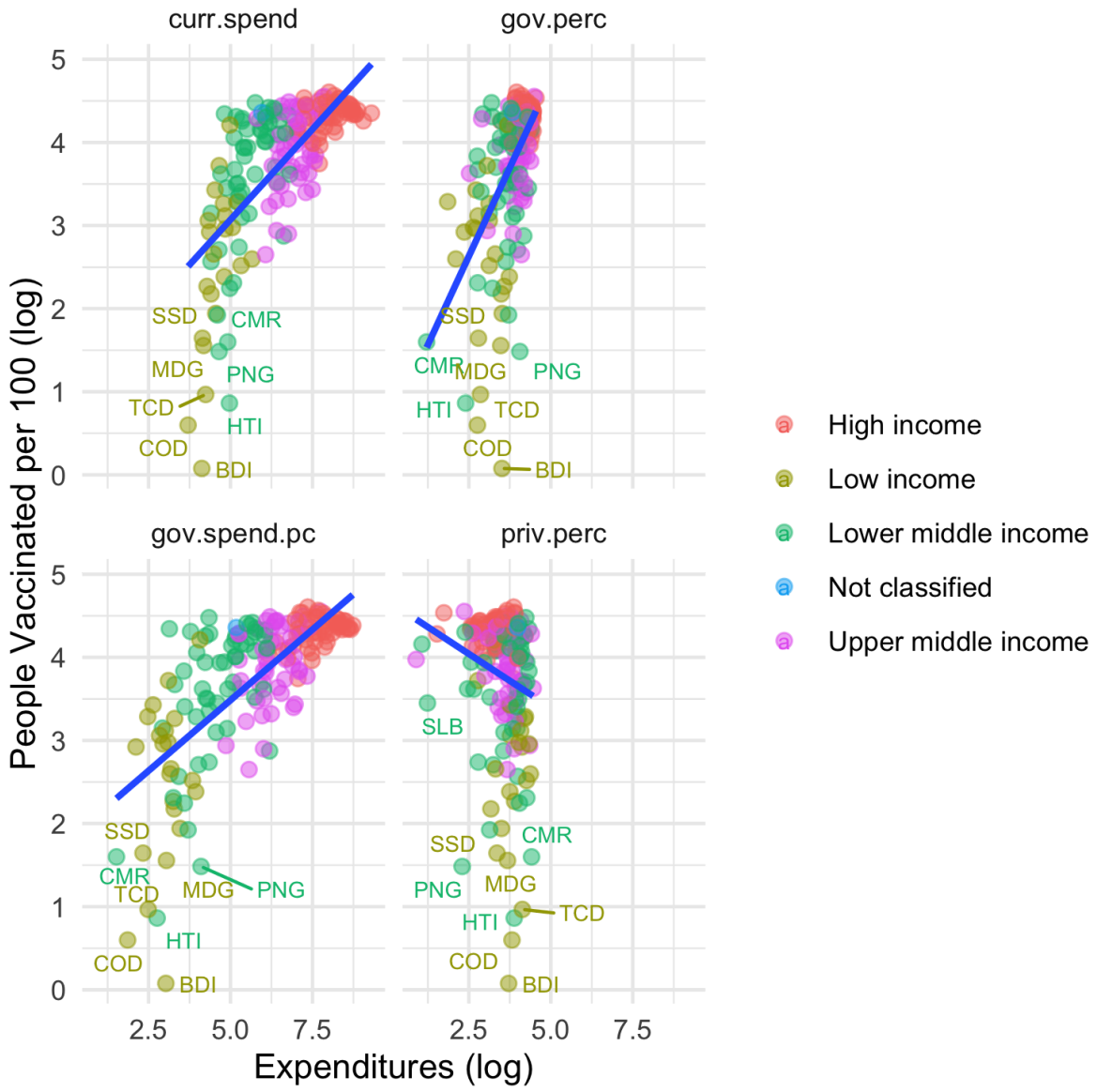

Fig. 9 All four correlations adjusted to scale.

On Figure 9, when adjusted the scale, it is visible that the biggest positive correlation is between vaccination rate and domestic general government health expenditure (as % of current health expenditure). This gives a positive answer to the research question asked at the beginning of the paper - the countries with more public-based healthcare systems handle vaccinations (and, therefore, COVID-19) better than the ones with more private-based ones.

3.3. Models

The next step in the analysis is creating and examining the empirical models with multiple variables. This will show the importance of each factor in finding out the outcome variable (in this case - the vaccination rate). This will also give an answer to the question to what extent the source and amount of expenditures affect the vaccination rate. The models are going to be based on the equation:

$$v_i = \alpha + \beta g_i + \varepsilon_i$$

Where:

- v_i is the log of vaccination rate,
- i is a given country,
- α is the constant,
- β is the slope,
- g_i is the log of a given variable,
- ε_i is the error term or residual.

Therefore, concerning all of the four variables mentioned above, the models present as following:

	Dependent variable:				
	outcome				
	(1)	(2)	(3)	(4)	(5)
log(curr.spend)	0.435***				-32.560
	(0.033)				(217.384)
log(gov.spend.pc)		0.340***			32.890
		(0.025)			(217.384)
log(gov.perc)			0.853***		-32.458
			(0.090)		(217.387)
log(priv.perc)				-0.259***	0.139
				(0.099)	(0.093)
Constant	0.895***	1.786***	0.500	4.688***	150.904
	(0.225)	(0.151)	(0.351)	(0.355)	(1,001.088)
Observations	182	182	182	182	182
R2	0.487	0.512	0.331	0.036	0.518
Adjusted R2	0.484	0.509	0.327	0.031	0.507
Note:					*p<0.1; **p<0.05; ***p<0.01

Fig. 10 Five models with four expenditure variables.

Surely, it cannot be said that the models above are good. The elements of the fifth model does not have any statistical importance and creating a model with just one variable does not allow for a possible error. Therefore, in the next step I am going to look for some other models that may, in turn, be any useful. I will pursue that through creating models based on not all variables, but only some of them.

	Dependent variable:								
	outcome								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log(curr.spend)	0.435***					0.350***	0.037		-32.560
	(0.033)					(0.043)	(0.134)		(217.384)
log(gov.spend.pc)		0.340***					0.312***	0.350***	32.890
		(0.025)					(0.102)	(0.043)	(217.384)
log(gov.perc)			0.853***		1.073***	0.312***		-0.037	-32.458
			(0.090)		(0.110)	(0.102)		(0.134)	(217.387)
log(priv.perc)				-0.259***	0.335***				0.139
				(0.099)	(0.101)				(0.093)
Constant	0.895***	1.786***	0.500	4.688***	-1.527**	0.262	1.700***	1.873***	150.904
	(0.225)	(0.151)	(0.351)	(0.355)	(0.701)	(0.302)	(0.343)	(0.344)	(1,001.088)
Observations	182	182	182	182	182	182	182	182	182
R2	0.487	0.512	0.331	0.036	0.370	0.512	0.512	0.512	0.518
Adjusted R2	0.484	0.509	0.327	0.031	0.363	0.507	0.507	0.507	0.507
Note:									*p<0.1; **p<0.05; ***p<0.01

Fig. 11 Nine models with four expenditure variables.

Having examined multiple different models concerning health expenditures, it seems that many of them have a similar goodness of fit, with R^2 being a little bit over 0.5. In such a situation, it should be considered which of them is the simplest one. Therefore, in this particular case, model 2 (with only one variable - domestic general government health expenditure per capita, PPP) is the simplest one.

One last element missing from the equation given above is the error, which on the graphs is visible as a distance between a country's data point and the linear scope. To take an error into account, it is important to run a model with a couple of variables that might affect the main variable I am focusing on (in this case, it would be domestic general government health expenditure per capita). Two of the main determinants of health care expenditures of a given country are GDP per capita and population age[4]. The second one might be measured differently, but in this paper the chosen variable will be life expectancy at birth.

[4] K. Xu et al, *The determinants of health expenditure. A Country-Level Panel Data Analysis, World Health Organisation*, 2011, p. 3.

	Dependent variable:				
	outcome				
	(1)	(2)	(3)	(4)	(5)
log(gov.spend.pc)	0.340***			0.217***	0.168***
	(0.025)			(0.080)	(0.050)
log(life.expect)		5.762***		3.264***	3.336***
		(0.420)		(0.828)	(0.826)
log(gdp.pc)			0.380***	-0.067	
			(0.033)	(0.088)	
Constant	1.786***	-20.889***	0.461	-10.879***	-11.482***
	(0.151)	(1.798)	(0.294)	(3.292)	(3.287)
Observations	182	175	180	173	175
R2	0.512	0.521	0.425	0.544	0.551
Adjusted R2	0.509	0.518	0.421	0.536	0.545
Note:				*p<0.1; **p<0.05; ***p<0.01	

Fig. 12 Five models with three variables.

As shown on the table above, even though existing literature shows that GDP per capita is a strong determinant of the health expenditures, when included in the model along with life expectancy and government expenditures per capita, it does not have a high correlation with vaccination rate, nor is it statistically significant. However, one variable is both very highly correlated and statistically significant, and that is life expectancy. Therefore, it should definitely be included in the model.

In conclusion, a long search for the best model has finished at this point. The model that fits the calculations best and most precisely is the fifth model of Figure 12.

4. Conclusions

This paper's aim was to examine whether recommendations for national government's after the COVID-19 pandemic had their reflection on the statistical data. My job as a researcher was to find out whether states that invest more in the public healthcare system handle nation-wide health crises better and that job was done. The answer to the research question turned out to be positive - countries that rely on public healthcare indeed dealt with

the situation better. Therefore, it was proven in this paper that the recommendations made both by researchers and academics, as well as private institutions are well-based on the statistical results. It means that the governments should take enormous efforts not only to handle this particular pandemic, but should also put pressure on strengthening the public services and facilities in the long term, especially concerning the fact that this particular outbreak was not the world's last pandemic. The 2020 pandemic should be a lesson to both national and global leaders who should realize that the public systems must be ready to surge, as well as maintain essential services on a daily basis.

Bibliography:

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List of figures: