A Comparative Analysis on the Effectiveness of Vaccines against SARS-CoV-2

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In general

Nowadays, SARS-CoV-2 is the causative agent of long term pandemic. 6,16 Million casualties, 494 Million infected cases and economic crisis worldwide caused by SARS-CoV-2 (17). One of the most effective methods to control the epidemic is proper vaccination of large populations. In our study, the efficacy of 5 SARS-CoV-2 vaccines, inactivated (BBIBP-CorV in the following as **Sinopharm**), vector (AZD1222 in the following as **Astra Zeneca**, Gam-COVID-Vac in the following as **Sputnik**), mRNA (mRNA-1273 in the following as **Moderna**, BNT162b2 in the following as **Pfizer**) used in Hungary were compared to each other. Due to the small number of samples, the JNJ-78436735 (Janssen) vaccine was omitted from the analysis

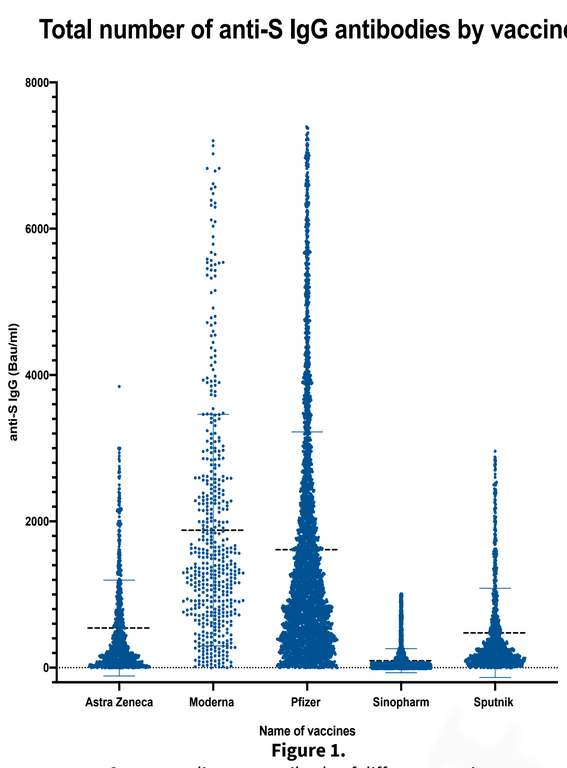

Figure 1.
Summary diagram antibody of different vaccines, each point is a measurement result

As we can see in the **Figure 1.**, high level of anti-S-IgG is present in most patients vaccinated with mRNA-based vaccines. Vector-based vaccines performed moderately with an elevated variance. This may mean that the patient's current state of health and age may matter most about these vaccines. Sinopharm, an inactivated virus vaccine, produced lowest levels of anti-S-IgG in all groups, but weak results include the fact that Sinopharm in Hungary is administered mostly to the elderly. However, this type of vaccine also induces IgG production against other antigens, including anti-N-IgG.

Figure 2. shows that the results are similar at the lowest values (25><100 Bau/ml) except for mRNA-based vaccines. The two third-generation vaccines, reaches values above the limit of >100 Bau/ml compared to other vaccines. They are followed by the vector-based vaccines and after the inactivated virus vaccine, Sinopharm. It can be seen, that over time, the lower antibody levels are rarer for all vaccines. This can be explained by the fact that more complete immune protection may have developed over time.

Materials and methods

Since December 2020, more than 40,000 serological samples have been processed. Antibody levels in these blood samples were detected by ECLIA method. Vaccination effectiveness is characterized by anti-S-IgG, post-infection protection is tested by anti-N-IgG in serum. Nearly 100,000 additional PCR assays were performed to monitor parallel infection. The backbone of our analysis is the results of measurements of different specific antibody levels, anti-S-IgG and their changes over time, follow- up of various special cases. From the analyzes we generated exciting charts from which we can draw conclusions that help to compare different vaccine types and may contribute to a deeper understand of immune response to SARS-CoV-2 infection.

After examining the blood samples, a comprehensive retrospective clinical analysis was performed. Only data at least 14 days later after the second dose of vaccine were included in our analysis. No data were used where the patient's infection was confirmed by PCR or anti-N IgG serological testing. We classified our patients into three age groups: adultus to 20-40 years, maturus to 40-60 years, and senium to 60 years of age. Samples were also sorted by days after the second vaccination as follows: 14-90 days, 90-180 days, and 180-270 days. Based on these, a total of 4743 sample data were examined. The sorting of detailed groups is shown in **Table 1**.

Name of vaccine	Astra Zeneca	Moderna	Pfizer	Sinopharm	Sputnik
Total	918	492	1277	1139	917
14-90 days	172	94	185	475	113
90-180 days	215	206	770	411	384
180-270 days	531	192	322	253	320
Men	430	170	501	485	534
Women	488	322	776	654	383
Adultus	215	98	337	242	186
Maturus	555	201	520	242	586
Senium	148	193	419	655	145

Table 1.
Sorting of detailed vaccines by days after the second dose, by gender and age group.

Statistical analyzes were performed with GraphPad Prism 8. No significant differences were found between the sexes based on the Wilcoxon signed-rank test, so this is not discussed further.

Based on the results, value ranges for the vaccines were formulated, and the success of the vaccination was evaluated in the light of these with the interpretation 'suitable for vaccination' or 'not suitable for vaccination'. Because there are no standard titer categories and the SARS-CoV-2 history and immune system of these patients were highly variable, in our laboratory only this interpretation protocol is considered acceptable in SARS-CoV-2 vaccination control serology. This can be seen in **Table 2**.

Name of vaccine	Anti-S IgG were not detectable (Bau/ml).	Anti-S IgG levels are below the normal range expected (Bau/ml).	Anti-S IgG levels are in the normal range expected (Bau/ml).	Anti-S IgG levels are in the high range expected (Bau/ml).
AstraZeneca	<0,4	0,8-25	25-1000	>1000
Moderna	<0,4	0,8-50	50-1000	>1000
Pfizer	<0,4	0,8-50	50-1000	>1000
Sinopharm	<0,4	0,8-10	10-500	>500
Sputnik	<0,4	0,8-25	25-1000	>1000

Table 2.
Value ranges for the vaccines

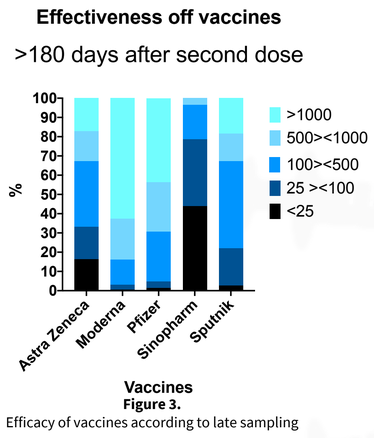

Figure 3.
Efficacy of vaccines according to late sampling

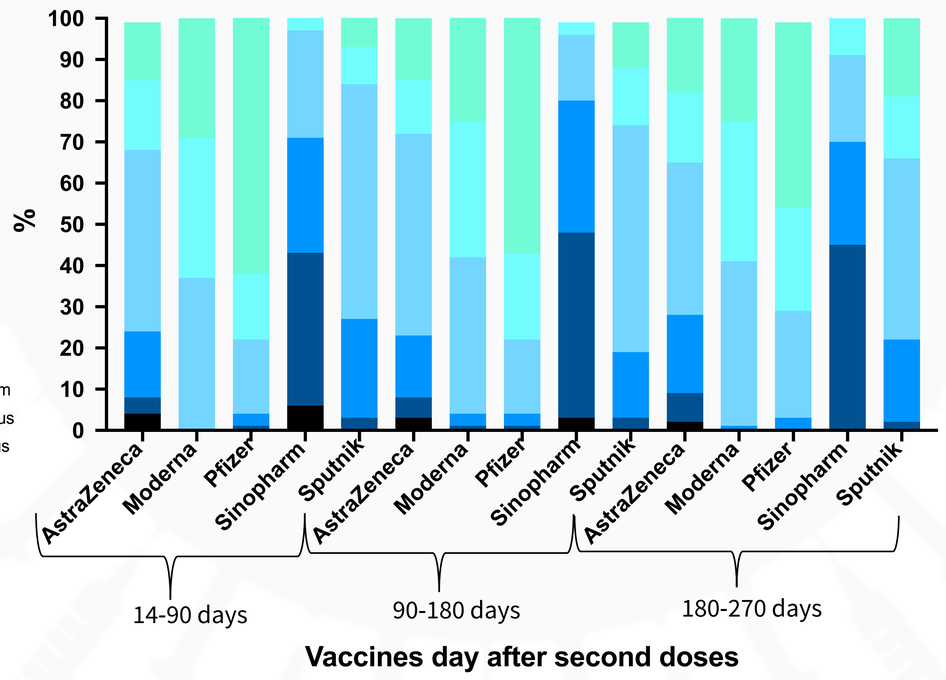

Figure 2.
Effectiveness of vaccines by days

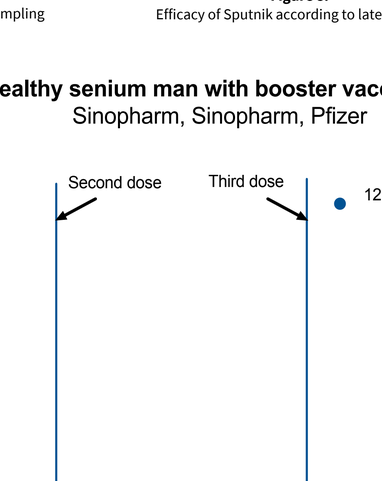

Figure 6.
Efficacy of Pfizer according to late sampling

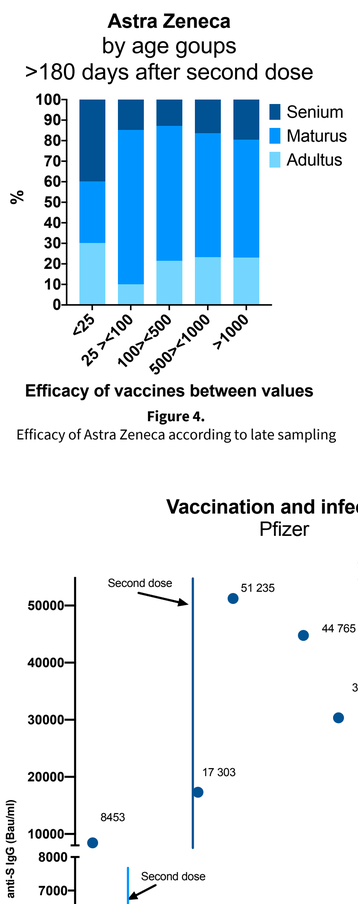

Figure 4.
Efficacy of Astra Zeneca according to late sampling

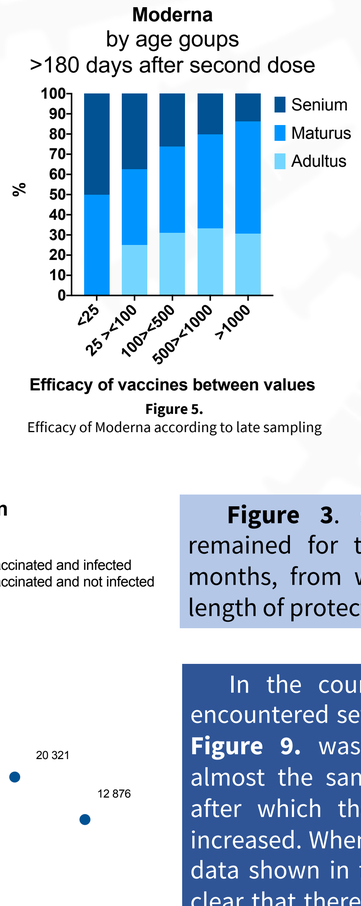

Figure 5.
Efficacy of Moderna according to late sampling

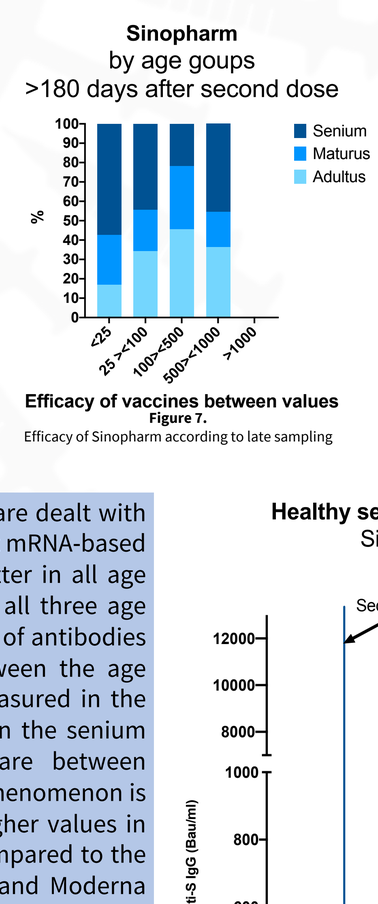

Figure 7.
Efficacy of Sinopharm according to late sampling

Figure 8.
Efficacy of Sputnik according to late sampling

Figure 9.
Development of an infected and vaccinated case

Figure 3. shows how many antibodies remained for the given vaccines after three months, from which we can also deduce the length of protection.

In the course of our analyzes, we have encountered several unusual cases. Depicted in **Figure 9.** was infected with SARS-CoV-2 at almost the same time as he was vaccinated, after which the antibody count was greatly increased. When this is compared to the patient data shown in the light blue graph below, it is clear that there are orders of magnitude higher values in the infected patient. However, the trend between the two follow-ups is very similar. This is one of the reasons why we selected these extremely outstanding infected data. After the administration of the second dose apparently caused an essential increase in the number of produced antibodies, this is called the booster effect.

The age groups according to the vaccine are dealt with in **Figures 4, 5, 6, 7, 8.** It can be observed that mRNA-based vaccines performed orders of magnitude better in all age groups and performed relatively similarly in all three age groups. In the case of Sinopharm the amount of antibodies is less, here there is also a difference between the age groups, the adultus the average amount measured in the age group is almost double that measured in the senium age group. The Sputnik vaccine values are between Sinopharm and AstraZeneca. An interesting phenomenon is that AstraZeneca is the only vaccine with higher values in both the maturus and senium age groups compared to the younger adult age group. In general, Pfizer and Moderna with the exception of vaccines, the variance is very large for other vaccines.

One of the questions these days is what happens after the third, booster dose. We can only get an initial answer to this, as this study is still ongoing. What can be seen in the **Figure 10.** is that after two Sinopharm vaccinations, the seropositive decreased antibody levels after a third dose (in this case Pfizer) significantly and relatively rapidly increases antibody levels. This is only the case for anti-S IgG, Sinopharm vaccination induces other antibodies, including anti-N IgG, but this is not discussed here.

Figure 10.
Result of booster vaccination

Plans

Our other plans include measuring and comparing vaccine-induced T cell immunity. Memory T helper cells may be of particular interest in the subject, as one of the dangerous symptoms of COVID sufferers is the so-called cytokine storm. Respectively, we will continue to investigate the efficacy of the third and possibly fourth booster vaccinations.

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18. Photo By Noma Bar