Validating efficacy of current COVID-19 vaccines on different age groups

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INTRODUCTION

Since the first outbreak of COVID-19 and the start of the pandemic in the late of 2019, governments and various pharmaceutical companies around the world have collaborated for the development of vaccines against the disease. Various developed vaccines have shown to be effective in the protection against the disease.
Nonetheless, these statistics have changed with age and the emergence of variants of concern [1]. Also, it is still difficult to predict the effectiveness of the same vaccine administered to another population [2].
Therefore, in this project, we aim to produce a mathematical model to measure an impact of age as a factor in the vaccines' effectiveness in protecting against COVID-19.

REASEARCH QUESTION

Can we get the same efficacy and effectiveness of the COVID-19 vaccines observed in the clinical trials using our statistical analysis and does it vary depending on the age of the population receiving it?

METHODS

Data from the NHS website (open government license v3.0) was retrieved and used to observe the number of cases, vaccination, hospitalization in the UK.

Using this data, different analysis were performed using **Python**.
- *pandas* was used to import our data
- *NumPy* was used for statistical and mathematical analysis
- *Matplotlib* was used to plot clear diagrams and figures

A modified – advanced *SIR model* was used for mathematical analysis of vaccines efficiency, with 2 parameters:
- Effective contact rate (β): affects the transition from susceptible compartment to infected compartment
- Rate of recovery (mortality; γ): affects the transition from the infected state to the recovered state

If the rate of infection bigger than the rate of recovery, an accumulation of individuals in the infected compartment will occur.

RESULTS

1. Initial analysis using the real-world data

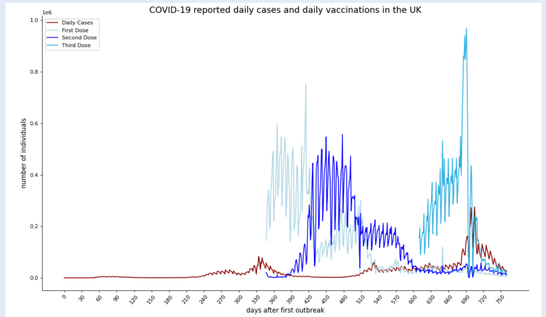

Figure 1. Daily reported cases of COVID-19 (red) and daily vaccinations in the UK (1st dose, 2nd and 3rd dose; blues), from beginning until 2 years after the start of the pandemic.

2. Vaccination and hospitalization for different age groups

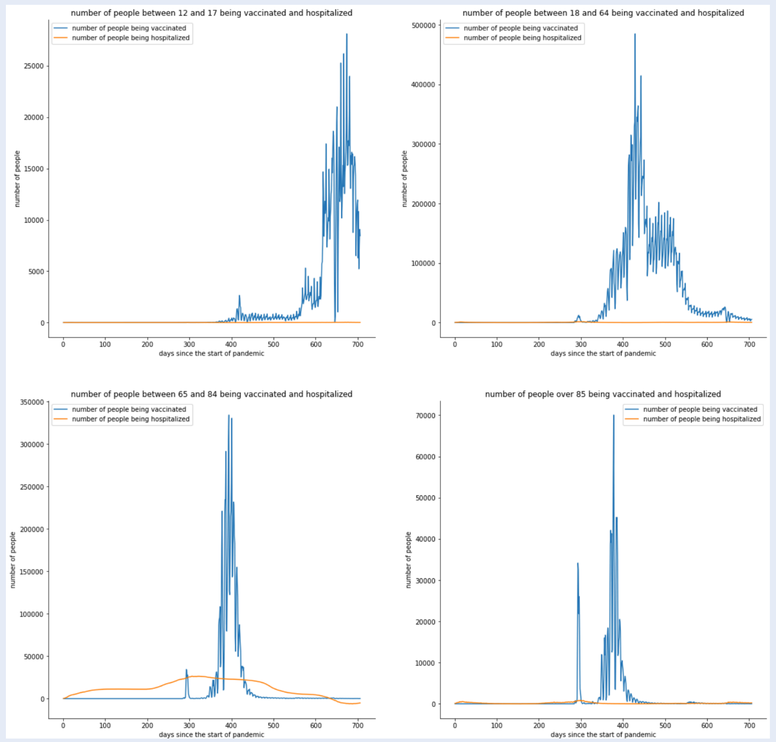

Figure 2. Proportion of population vaccinated (blue) and hospitalised (orange) in different age groups (in years): **(A)** 12-17, **(B)** 18-64, **(C)** 65-84 and **(D)** >85.

3. Proportion vaccinated population in the UK

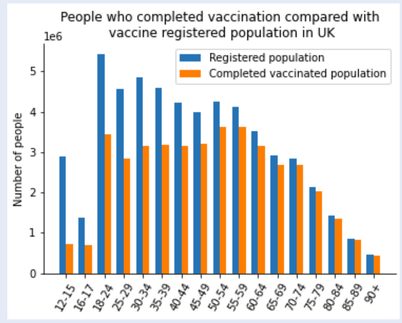

Figure 3. Bar chart showing the proportion of the UK population that took the vaccine (orange) compared to the registered population (blue), based on their age group.

4. Mathematical analysis for vaccines using the SIR model

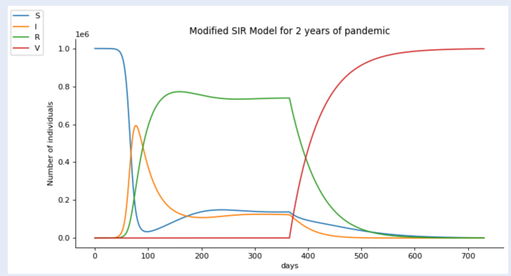

Figure 4. SIR model showing the Susceptible (S; blue), Infected (I; orange), Recovered (R; green) and including the Vaccinated (V; red) number of individuals for COVID-19 from the beginning until 2 years after the start of the pandemic.

CONCLUSION/DISCUSSION

- Roughly starting at the end of the first year of the pandemic, first dose of vaccines started to be taken up, resulting to a drop in the rate of infections. The same can be observed for the second and third vaccine dose but with less drop in the rate.
- However, vaccination rate reaches their peaks before infection rate, could be explained by the time it takes to trigger and fully develop an immunity response. It was estimated to be 14 days after the second dose of the vaccine.
- The virus seems to not take a serious form in young people, based on the number of hospitalised people and the proportion of older people (>50 years old) taking the vaccine is relatively higher than younger people.
- Vaccination against COVID-19 is very effective in protecting older people from developing serious cases of the disease and being hospitalised for it.
- The modified SIR model with vaccination included shows that with increasing rate of vaccination, the number of susceptible, infected and recovered individuals decreases.

REFERENCES

1. Collier, D. A. *et al.* (2021) *Age-related immune response heterogeneity to SARS-CoV-2 vaccine BNT162b2*. Nature, 596(7872), pp. 417–422. doi: 10.1038/s41586-021-03739-1
2. Olliaro, P., Torreele, E. and Vaillant, M. (2021) *COVID-19 vaccine efficacy and effectiveness—the elephant (not) in the room*. The Lancet Microbe, 2(7), pp. e279–e280. doi: 10.1016/s2666-5247(21)00069-0.