Covid-19: Relative risks of non-vaccinated to vaccinated individuals

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Short Report

Keywords: pandemic, Italy, risk, likelihood ratios, non-linearity

Posted Date: July 18th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1815262/v1

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Abstract

Objectives

The aim of this study was to evaluate and quantify the relative risk of hospital admission and death because of Sars-Cov2 infection between non-vaccinated and vaccinated individuals in Italy.

Methods

Data about vaccinated and non-vaccinated people, infections, hospital admissions, intensive care units and fatalities were extracted from the bulletin published by the Italian National Health Institute (Istituto Superiore di Sanità) on the 24th of December 2021.

Likelihood ratios of hospital admission, intensive care and death were calculated between non-vaccinated and vaccinated people for each of the observed patient outcomes, in order to quantify the relative risk in the two sub-populations.

Results

Non-vaccinated people had a 3.1 time higher risk of becoming infected compared to vaccinated individuals. Non-vaccinated individuals had a 5.1 times higher risk of being admitted to hospital and a 10.4 times higher risk of becoming critical compared to vaccinated individuals. Further, non-vaccinated people had a 4.3 times higher risk to die compared to vaccinated individuals.

Conclusions

The relative risk of infection, hospital and intensive care admission is progressively higher in non-vaccinated compared to vaccinated individuals in case of infection by Sars-Cov2, as the condition worsens. Still, the relative risk does not increase further when the outcome is death, possibly because non-vaccinated individuals are younger and healthier of those who decided to take the vaccine. Individual conditions may play a more relevant role than the vaccine when the illness becomes critical.

Introduction

Italy was the first European country to be struck by Sars-Cov-2 infections. The pandemic rapidly spread, saturating intensive care units (ICUs) and demanding the lives of many Italians [1], especially senior citizens. As soon as vaccines became available, the Italian government implemented an extensive vaccination campaign [2], targeting individuals above the age of 12, and starting from the highest age range (80 + years old), since age was considered one of the most important risk factors. Other characteristics which were taken into consideration in order to prioritize vaccination were chronic conditions and a state of immune-suppression or immune-depression, which could increase the risk.

The public at large started to require available data and reliable information to have the possibility to evaluate whether the vaccination campaign was successful. Updates on the ongoing campaign are available on the official Italian government website [3]. In particular, the medical community has questioned how much vaccines have reduced the risk of ICU admissions and fatalities. A study [4] performed in the UK showed a significant reduction in the relative risk of hospital admission between people who received two doses of vaccine compared to those who
received just one. The underlying hypothesis is that vaccinations should diminish the risk of a critical or fatal condition, rather than that of infection. This effect would reduce the pressure on the national health service and on ICUs in particular, beside mortality. The purpose of this study was to quantify the effect of vaccines in diminishing covid-19 related risks compared to the non-vaccinated population.

Sample And Methods

Data on vaccinated (vax) and non-vaccinated (no_vax) people, infections, hospital admissions, ICUs and fatalities were taken from the bulletin published by the Italian National Health Institute (Istituto Superiore di Sanità, ISS) on the 24th of December 2021 [5]. Individuals who did not get any vaccination or who had not completed a vaccination cycle were considered no_vax. Those who completed the vaccination cycle, with or without booster dose, were considered vax.

Likelihood ratios (LRs) were calculated between no_vax and vax. LRs represent the relative risk of an outcome O (infection, admission to hospital, ICU admission or death) compared to a baseline condition of the observed population: vaccinated or not. LR can be calculated from the rule of Bayes as follows:

$$\frac{P(O|\text{no} \_ \text{vax})}{P(O|\text{vax})} = \frac{P(\text{no} \_ \text{vax}|O) P(\text{vax})}{P(\text{vax}|O) P(\text{no} \_ \text{vax})}$$

where $P(O|\text{no} \_ \text{vax})$ is the probability of outcome O among no_vax, $P(O|\text{vax})$ is the probability of O among vax, $P(\text{no} \_ \text{vax}|O)$ is the rate of no_vax among individuals with outcome O, $P(\text{vax}|O)$ is the rate of vax among individuals with outcome O, $P(\text{vax})$ is the proportion of vax in the population, and $P(\text{no} \_ \text{vax})$ is the proportion of no_vax. The higher LR, the higher the risk of getting outcome O.

Results

As of the 4th of December, 15.8% of the target population was no_vax, while the largest majority, 84.2%, was vax. Among infected individuals 37% were no_vax, while were 63% were vax, implying a 3.1 times higher risk for no_vax of becoming infect. Around half (49.5%) of hospital admissions were no-vax, the remaining were vax, implying a 5.1 times higher risk for no_vax of being admitted to hospital. At the same time, 66.2% of ICU admissions were no_vax, while the remaining 33.8% were vax, which implied a 10.4 times higher risk of becoming a critical patient for the former. When it comes to fatalities, 44.7% were no_vax, while 55.3% were vax, which implied a 4.3 times higher risk for the former to die. Results are summarized in Table 1 and in Fig. 1.

<table>
<thead>
<tr>
<th></th>
<th>No_vax</th>
<th>vax</th>
<th>LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infections</td>
<td>37.0%</td>
<td>63.0%</td>
<td>3.1</td>
</tr>
<tr>
<td>Admissions</td>
<td>49.5%</td>
<td>50.5%</td>
<td>5.2</td>
</tr>
<tr>
<td>ICUs</td>
<td>66.2%</td>
<td>33.8%</td>
<td>10.4</td>
</tr>
<tr>
<td>Deaths</td>
<td>44.7%</td>
<td>55.3%</td>
<td>4.3</td>
</tr>
</tbody>
</table>


Discussion And Conclusions

The fact that the risk of being infected is higher for no_vax may appear counter-intuitive for most, since the percentage of no_vax is lower than that of vax among infected individuals. Still, this is consistent with the fact that the largest majority (84.2%) of the target population is vax. Once the whole population will be vax, then 100% of infected individuals will be vax (possibly, very few).

This perceived paradox may be explained as a result of a well-researched cognitive bias known as base rate fallacy [6, 7]. The individual who evaluates the risk may in fact neglect the rate of vax in the population and consider only the distribution of no_vax and vax among infected individuals, getting the impression that the risk is higher for the latter.

As expected, the risks of infection, ICU admission or death are much higher in the no_vax group. Further, it must be considered that relative risk is evaluated for the whole population older than 12 years. If only higher age categories, where the absolute risk is higher, were considered, vaccination would show a larger effect [8–9]. Still, there was an unexpected non-linearity in the distribution of relative risk, which consistently increased from infected to admitted to ICU, but diminished from admitted to ICU to death (even if it remained greater than 4 times in no_vax compared to vax).

A possible explanation may be found in a non-uniform distribution of vaccines among the population. There might have been, so far, a higher rate of vaccinations among fragile individuals. This assumption can be supported by the data released by the Regional Health Service (Servizio Sanitario Regionale) of Emilia-Romagna. The report published on the 21st of December 2021 says that 49.8% of the individuals in the age class above 60 years old were fully vaccinated, while only 25.5% in the 40–59 year-old age class had completed the vaccination cycle in that region. We can certainly acknowledge age as a risk factor, even if this uneven distribution does not necessarily imply a lower propensity to vaccination among the youngest, since they were also the last to get the vaccine.

Notwithstanding, it cannot be ruled out that people who thought that they were at higher risk of serious consequences if infected by the virus (because of age or a medical condition) may have decided to be vaccinated more promptly than other individuals, younger and without chronic illnesses, since vaccination was not mandatory. In any case, as patient became critical, the protection offered by the vaccine was less determinant, and individual characteristics - including age, chronic illnesses or immune conditions – could have played an important role in the outcome of the treatment.

In conclusion, even if the reported data support the hypothesis that vaccination diminishes the risk for the infection to become more serious, there is an interesting non-linearity when the outcome is death, and the relative risk is not as high as expected for no_vax compared to vax.

Declarations
Funding: none

Competing interests: nothing to declare

Authors Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Davide Barbieri], [Gabriele Melegari] and [Geza Halasz] [Elisabetta Bertellini] [Arianna Gaspari]. The first draft of the manuscript was written by [Davide Barbieri] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethics approval

The study does not involve human and consent to participate is not necessary.

Data availability: data on vaccinated (vax) and non-vaccinated (no-vax) people, infections, ICUs and fatalities were taken from the bulletin published by the Italian National Health Institute (Istituto Superiore di Sanità, ISS) on the 21st December 2021.

References


Figures
Figure 1

Relative risk distribution vs outcome.