BNT162b2 mRNA Covid-19 Vaccine in a Nationwide Mass Vaccination Setting: A Note

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Abstract

In their important and innovative study, Dagan et al. (2021) were the first to provide evidence on the effectiveness of BNT162b2 mRNA Covid-19 vaccine on a large scale population. The authors used a matched pair Israeli sample of 596,618 individuals belonging to the vaccinated group and 596,618 individuals with similar characteristics belonging to the unvaccinated group. Based on the information obtained in Figure 2 of Dagan et al. (2021) on cumulative events 14, 21 and 28 days after the first dose, the authors of this Note found inconsistencies between the calculated effectiveness of the dose from Figure 2, and the reported effectiveness rates in Table 2. Compared to the effectiveness rate reported by Dagan et al. (2021), and referring to the criteria of: documented SARS-CoV-2 infection, symptomatic Covid-19 and severe Covid-19, 14-20 days after the first dose, according to the CDC formula, our calculations suggest an elevated effectiveness of the vaccine ranging between 1.75%-4.67%. Referring to the criteria of Covid-19 hospitalization and death, 14-20 days after the first dose, our calculations suggest a reduced effectiveness of the vaccine ranging between minus 2.77% and minus 2%. Given the widespread public vaccination resistance, transparency and accuracy in vaccination effectiveness might prove to be especially important. As of October 31, 2021, the official accumulated Covid-19 cases are 247,376,970 and deaths worldwide are approx. 5 million persons. Consequently, the implication of a 2% gap after 21 days is 4.947 million cases and 100,000 deaths.

1. Introduction

Israel was one of the first countries to implement an accelerated nationwide vaccination campaign that resulted in the full vaccination (i.e., receipt of two vaccine doses) in more than half the population by the end of March 2021 (Bar-On et al., 2021 [1]; Rosen et al., 2021 [2]). In their important and innovative study, Dagan et al. (2021) [3] were the first to demonstrate the BNT162b2 mRNA Covid-19 vaccine effectiveness on a large scale population. Their sample includes a matched pair Israeli sample of 596,618 individuals belonging to the vaccinated group and 596,618 individuals with similar characteristics belonging to the unvaccinated group.

According to Table 2 in Dagan et al. (2021) [3], the vaccine effectiveness 14 to 20 days after the first dose is 46% (documented SARS-CoV-2 infection), 57% (symptomatic Covid-19), 74% (hospitalization), 62% (severe illness) and 72% (death). The vaccine effectiveness 21 to 27 days after the first dose is 60% (documented SARS-CoV-2 infection), 66% (symptomatic Covid-19), 78% (hospitalization) 80%, (severe illness) and 84% (death).

2. The Effectiveness Of Covid-19 Vaccinations

According to the CDC [4], vaccine effectiveness measures the proportionate reduction in cases among vaccinated persons. The formula is: The risk is measured as the ratio between number of events and the

observed population at a given time interval after the vaccination

$$VE = \frac{\text{Risk Among Unvaccinated Group} - \text{Risk Among Vaccinated Group}}{\text{Risk Among Unvaccinated Group}} = \text{one minus} \frac{\text{Risk Among Vaccinated Group}}{\text{Risk Among Unvaccinated Group}} = 1 - RR.$$

The risk is measured as the ratio between number of events and the observed population at a given time interval after the vaccination

$$(\text{Risk} = \frac{\text{Vaccinated/Unvaccinated number of events}}{\text{Vaccinated/Unvaccinated population}}).$$

Due to the choice of a matched pair sample of 596,618 persons belonging to each group (vaccinated / unvaccinated), the 1-RR formula may be reduced to

$$1 - \frac{\text{Number of Events among the vaccinated group}}{\text{Number of Events among the Unvaccinated group}}.$$

The authors of this note found inconsistencies between the information reported in Figure 2 of Dagan et al. (2021) [3] on cumulative events 14, 21 and 28 days after the first dose (Appendix A), and the reported effectiveness rates in Table 2 (Appendix B). These inconsistencies are reported in Table 1 below.

Table 1: Differences between Figure 2 and Table 2 in Dagan et al. (2021) [3]

A. Documented SARS-COV2 Infection

Days after vaccine		14	21	28
Cumulative	Unvaccinated	3,971	5,104	5,775
Events (Figure 2)	Vaccinated	3,533	4,124	4,405
Calculated		$1 - \frac{4,124-3,533}{5,104-3,971} = 0.4784$	$1 - \frac{4,405-4,124}{5,775-5,104} = 0.5812$	
Reported in Table 2		0.46	0.6	
Difference		$0.4784 - 0.46 = 0.0184$	$0.5812 - 0.6 = -0.0188$	

B. A Symptomatic COVID-19

Days after vaccine		14	21	28
Cumulative	Unvaccinated	2,393	3,079	3,433
Events (Figure 2)	Vaccinated	1,967	2,250	2,373
Calculated		$1 - \frac{2,250-1,967}{3,079-2,393} = 0.5875$	$1 - \frac{2,373-2,250}{3,433-3,079} = 0.6525$	
Reported in Table 2		0.57	0.66	
Difference		$0.5875 - 0.57 = 0.0175$	$0.6525 - 0.66 = -0.0075$	

C. COVID-19 Hospitalization

Days after vaccine		14	21	28
Cumulative	Unvaccinated	125	198	244
Events (Figure 2)	Vaccinated	77	98	108
Calculated		$1 - \frac{98-77}{198-125} = 0.7123$	$1 - \frac{108-98}{244-198} = 0.7826$	
Reported in Table 2		0.74	0.78	
Difference		$0.7123 - 0.74 = -0.0277$	$0.7826 - 0.78 = 0.0026$	

D. Severe COVID-19

Days after vaccine		14	21	28
Cumulative	Unvaccinated	57	114	157
Events (Figure 2)	Vaccinated	26	45	52
Calculated		$1 - \frac{45-26}{114-57} = 0.6667$	$1 - \frac{52-45}{157-114} = 0.8372$	
Reported in Table 2		0.62	0.80	
Difference		$0.6667 - 0.62 = 0.0467$	$0.8372 - 0.8 = 0.0372$	

E. Death Due to COVID-19

Days after vaccine		14	21	28
Cumulative	Unvaccinated	6	16	27
Events (Figure 2)	Vaccinated	2	5	7
Calculated		$1 - \frac{5-2}{16-6} = 0.7$	$1 - \frac{7-5}{27-16} = 0.8181$	
Reported in Table 2		0.72	0.84	
Difference		$0.7 - 0.72 = -0.02$	$0.8181 - 0.84 = -0.0219$	

Compared to the effectiveness rate reported by Dagan et al. (2021) [3], and referring to the criteria of: documented SARS-COV2 infection, symptomatic COVID-19 and severe COVID-19, 14-20 days after the first dose, our calculations suggest an elevated effectiveness of the vaccine ranging between additional 1.75%-4.67%. Yet, of these three criteria, 21-27 days after the first dose, an elevated effectiveness of additional 3.72% was found only referring to the severe COVID-19 criterion. Referring to the criteria of COVID-19 hospitalization and death, 14-20 days after the first dose, our calculations suggest a reduced effectiveness of the vaccine ranging between minus 2.77% and minus 2%. 1.75%-4.67%. Yet, of these

two criteria, 21-27 days after the first dose, a reduced effectiveness of minus 2.19% was found only referring to the death due to COVID-19 criterion.

3. Conclusions

COVID19 is one of the remarkable pandemics in the last century (World Health Organization [5]; Barro et al., 2020 [6]; Wu and McGoogan, 2020 [7]). The mortality rate is one of the major complications of the pandemic. As of October 31, 2021, the official accumulated COVID19 deaths worldwide is approx. 5 million persons, (Worldmeter [11]) compared to 35 million deaths from the Spanish flu of 1918-1921, where adjustment to current world population yields 150 million deaths (Barro et al., 2020 [6]). In the United States, the official accumulated number of COVID19 deaths (710,173 – as of October 7, 2021) is greater than the number of deaths during the 1918-1919 Spanish flu pandemic (AP News, September 21, 2021 [8]).

In their innovative and important study, Dagan et al. (2021) [3] were the first to demonstrate the BNT162b2 mRNA Covid-19 vaccine effectiveness on a large scale population. Their sample includes a matched pair Israeli sample of 596,618 individuals belonging to the vaccinated group and 596,618 individuals with similar characteristics belonging to the unvaccinated group.

Based on the information obtained in Figure 2 of Dagan et al. (2021) [3] on cumulative events 14, 21 and 28 days after the first dose, the authors of this Note found inconsistencies between the calculated effectiveness of the dose from Figure 2, and the reported effectiveness rates in Table 2. The proposed variation in the effectiveness of the vaccine is material. Given the widespread vaccination resistance (e.g., Savulesco & Wilkinson, 2021 [9]; Schmelz & Bowles, 2021 [10]), transparency and accuracy in vaccination effectiveness is especially important.

Declarations

o **Ethics Approval and consent to participate:** This research does not require an IRB approval since it does not involve any experiment or manipulation of subjects. All authors read and approved the final manuscript for submission.

o **Consent for Publication:** All authors agreed to submit the manuscript to Research Square as a preprint.

o **Availability of data and materials:** Irrelevant.

o **Competing interests:** None of the authors have potential conflicts of interest, financially or non-financially, directly or indirectly related to this work.

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o **Authors' contributions:** All authors contributed equally to the study conception and design, data collection and analysis, the first draft and comments on previous versions of the manuscript.

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Supplementary Files

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- [Appendix.docx](#)