fortune Journals

Research Article

JOURNAL OF BIOTECHNOLOGY AND BIOMEDICINE

ISSN: 2642-9128

A Cost-Benefit Analysis of Bivalent Covid-19 Vaccines

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Abstract

The cost-benefit ratios of the bivalent vaccines were unknown. To address this issue, we considered surveillance data on the administration of the Moderna and Pfizer-BioNTech bivalent vaccines and clinical outcomes from September 1, 2022 to February 10, 2023 for North Carolina residents 12 years of age or older. We found that booster vaccination was much more beneficial for people 65 years of age or older than for people 12–64 years of age, mainly because the risks of hospitalization and death were much higher in the older age group.

Keywords: Covid-19-related death; Hospitalization; SARS-CoV-2; Vaccination; Vaccine boosters; Vaccine effectiveness

Introduction

Covid-19 vaccination was effective against SARS-CoV-2 infection and severe outcomes; however, vaccine effectiveness waned over time, and repeated booster vaccination was required to enhance immunity [1-3]. The United States government alone has spent more than $30 billion on Covid-19 vaccines, and the prices of the updated bivalent vaccines are expected to rise sharply after the end of the federal COVID-19 Public Health Emergency declaration [4]. A question naturally arises: what are the cost-benefit ratios of the bivalent vaccines?

Methods

To answer this question, we considered surveillance data on the administration of the Moderna and Pfizer-BioNTech bivalent vaccines and clinical outcomes from September 1, 2022 to February 10, 2023 for North Carolina residents 12 years of age or older [3]. Of the 6,306,311 participants who had been previously vaccinated or boosted, 1,279,802 received the bivalent vaccines as a booster dose. A total of 154,581 SARS-CoV-2 infections, 2,208 Covid-19-related hospitalizations, and 867 Covid-19-related deaths were reported over this 23-week period [3].

We estimated the effectiveness (one minus relative risk) of one booster dose under a proportional hazards model for hospitalization (or death) and a proportional rates model for recurrent infection, while adjusting for baseline characteristics [3]. Using the fitted models, we predicted the cumulative frequency of infection and the cumulative incidences of hospitalization and death when none of the participants received a bivalent booster versus when every participant received a bivalent booster on September 1, 2022. We then calculated the differences between the two sets of predicted values and multiplied them by 1 million to estimate the numbers of infections, hospitalizations, and deaths that would be prevented by administering 1 million doses of bivalent vaccines, which would cost $120 million at the price

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Citation: Dan-Yu Lin, Yangjianchen Xu, Donglin Zeng, Shadia Khan Sunny. A Cost-Benefit Analysis of Bivalent Covid-19 Vaccines. Journal of Biotechnology and Biomedicine. 6 (2023): 551-553.

Received: October 13, 2023
Accepted: October 20, 2023
Published: November 01, 2023

Lin D, et al., J Biotechnol Biomed 2023
DOI:10.26502/jbb.2642-91280116

of $120 per dose. We obtained the confidence intervals by the bootstrap method.

Results

The results are shown in column A of Table 1. For individuals 65 years of age or older, 1 million doses would prevent 3,010 (95% CI, 2,737 to 3,283) infections, 489 (95% CI, 362 to 616) hospitalizations, and 179 (95% CI, 117 to 242) deaths. For individuals 12–64 years of age, 1 million doses would prevent 2,379 (95% CI, 2,168 to 2,590) infections, 55 (95% CI, 41 to 68) hospitalizations, and 10 (95% CI, 6 to 14) deaths. The number of infections prevented would be much higher than the numbers of hospitalization and death prevented, and the numbers of hospitalizations and deaths prevented would be much higher in the older age group than in the younger age group. The impact of bivalent boosters on the study cohort is shown in Table 2.

The number of prevented events depends on the duration of follow-up. The above results pertain to a duration of 23 weeks after booster administration. Because of the rapid waning of booster effectiveness against infection [3], no additional infections would be prevented after 23 weeks.

Table 1: Number of Covid-19 Events Prevented by One Million Doses of Bivalent Vaccines.

Age Group	Covid-19 Outcome	Scenarios A	Scenarios B	Scenarios C
		Observed Levels	2 × Observed Levels	½ Observed Levels
≥12 Yr	**Infection**			
	Background cumulative frequency	0.025	0.050	0.013
	Number of events prevented (95% CI)	2,556 (2,328 to 2,784)	5,111 (4,655 to 5,568)	1,278 (1,164 to 1,392)
	Hospitalization			
	Background cumulative incidence	4.41×10^{-4}	8.82×10^{-4}	2.21×10^{-4}
	Number of events prevented (95% CI)	183 (136 to 229)	365 (272 to 459)	91 (68 to 115)
	Death			
	Background cumulative incidence	1.22×10^{-4}	2.43×10^{-4}	6.08×10^{-5}
	Number of events prevented (95% CI)	59 (38 to 79)	117 (76 to 158)	29 (19 to 39)
≥65 Yr	**Infection**			
	Background cumulative frequency	0.030	0.059	0.015
	Number of events prevented (95% CI)	3,010 (2,737 to 3,283)	6,020 (5,474 to 6,567)	1,505 (1,368 to 1,642)
	Hospitalization			
	Background cumulative incidence	1.18×10^{-3}	2.36×10^{-3}	5.90×10^{-4}
	Number of events prevented (95% CI)	489 (362 to 616)	977 (723 to 1,230)	244 (181 to 308)
	Death			
	Background cumulative incidence	3.73×10^{-4}	7.46×10^{-4}	1.86×10^{-4}
	Number of events prevented (95% CI)	179 (117 to 242)	358 (234 to 483)	90 (58 to 121)
12–64 Yr	**Infection**			
	Background cumulative frequency	0.023	0.047	0.012
	Number of events prevented (95% CI)	2,379 (2,168 to 2,590)	4,758 (4,336 to 5,180)	1,190 (1,084 to 1,295)
	Hospitalization			
	Background cumulative incidence	1.32×10^{-4}	2.64×10^{-4}	6.59×10^{-5}
	Number of events prevented (95% CI)	55 (41 to 68)	109 (82 to 137)	27 (20 to 34)
	Death			
	Background cumulative incidence	2.04×10^{-5}	4.08×10^{-5}	1.02×10^{-5}
	Number of events prevented (95% CI)	10 (6 to 14)	20 (11 to 28)	5 (3 to 7)

Table 2: Numbers of events that would have been prevented (95% CI) if all non-booster participants had received boosters on September 1, 2022 and additional numbers of events that would have occurred (95% CI) if booster recipients had not received boosters during the period of September 1, 2022—February 19, 2023 among North Carolina residents 12 years of age or older who were eligible to receive bivalent boosters.

Age Group	Covid-19 Outcomes	Non-Booster Participants	Booster Recipients
≥12 Yr		N=5,026,509	N=1,279,802
	Infection	14,134 (13,062 to 15,205)	5,833 (5,612 to 6,054)
	Hospitalization	675 (517 to 832)	320 (281 to 358)
	Death	255 (184 to 325)	161 (141 to 181)
≥65 Yr		N=1,172,870	N=592,075
	Infection	4,323 (3,985 to 4,660)	3,059 (2,897 to 3,222)
	Hospitalization	538 (421 to 654)	297 (260 to 334)
	Death	229 (169 to 288)	151 (132 to 171)
12–64 Yr		N=3,853,639	N=687,727
	Infection	9,811 (8,966 to 10,657)	2,774 (2,655 to 2,892)
	Hospitalization	137 (91 to 184)	23 (16 to 29)
	Death	26 (13 to 39)	10 (7 to 13)

Booster effectiveness against hospitalization and death also waned over time but was 34% and 38%, respectively, at 23 weeks [3], such that the numbers of hospitalizations and deaths to be eventually prevented would be greater than what are shown in column A of Table 1.

The surveillance system did not fully capture clinical outcomes, especially infections and hospitalizations, such that the actual numbers of infections and hospitalizations prevented would be greater than what are shown in column A of Table 1. More importantly, the transmissibility and lethality of the virus vary over time. Thus, we performed sensitivity analyses by assuming that the background risks of infection, hospitalization, and death are two times or half of the levels observed in our study while booster effectiveness remains the same. The results are shown in the last two columns of Table 1. Unsurprisingly, the number of prevented events increases (or decreases) as the disease incidence rises (or drops).

Discussion

Booster vaccination was much more beneficial for people 65 years of age or older than for people 12–64 years of age, mainly because the risks of hospitalization and death were much higher in the older age group. The cost-benefit ratio of a vaccination program will depend on vaccine effectiveness, the background risks of infection and severe outcomes, the prices of the vaccines, as well as the costs associated with hospitalization and years of life lost.

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