EE287

Epidemiologic and Economic Impact of COVID-19 Vaccination Among At-Risk Individuals and Individuals Aged ≥60 Years in Germany

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BACKGROUND

- The risk of severe COVID-19 outcomes, including hospitalization and death, is higher among adults aged ≥60 years and in individuals with certain medical conditions such as metabolic disorders and chronic respiratory, cardiovascular, liver, and kidney diseases[1,2]
  - The widely available COVID-19 vaccines, including mRNA-1273 (Spikevax; Moderna, Inc., Cambridge, MA, USA) and BNT162b2 (Comirnaty; Pfizer Inc., New York, NY, USA), have mitigated severe COVID-19 outcomes in the general populations as well as among high-risk groups
- Given the continuing risk, the German Standing Committee on Vaccination (Ständige Impfkommission; STIKO) at the Robert Koch Institute (RKI) has recommended an annual variant-adapted mRNA COVID-19 booster vaccine for high-risk groups and adults aged ≥60 years[2]
- Globally, COVID-19 vaccination programs have been cost-effective and potentially provide cost savings compared with no vaccination[3]
  - However, ongoing evaluation of the cost-effectiveness of mRNA-based COVID-19 vaccines in different population groups is necessary to guide policy decisions

OBJECTIVES

- To estimate the cost-effectiveness, and clinical and economic impact of a hypothetical vaccination approach with the Moderna fall 2023 updated COVID-19 mRNA vaccine (Moderna fall 2023 vaccine) versus 1) no vaccine; or 2) the Pfizer BioNTech fall 2023 updated COVID-19 mRNA vaccine (Pfizer BioNTech fall 2023 vaccine) over a 1-year time horizon in Germany in a target population comprising:
  - Adults aged ≥60 years, and
  - Adults aged 30-59 years at high risk for severe COVID-19

METHODS

Model Overview

- A Susceptible-Exposed-Infected-Recovered (SEIR) dynamic model[4] (**Supplementary Figure 1**; accessible via the QR code) was adapted to estimate the number of COVID-19 infections across a 1-year time horizon between September 1, 2023, and August 31, 2024
- The SEIR model was calibrated to infections in Germany as estimated by the Institute for Health Metrics and Evaluation (IHME) from February 2020 (the start of the pandemic) through April 2022 and by the RKI from May 2022 to April 2023
- Sensitivity was performed around the proportion of individuals with natural immunity and the relative amount of residual vaccine effectiveness (VE) against infection and hospitalization before the start of the analytic period (**see Supplementary Methods for additional methods**; accessible via the QR code)

Cost Consequence

- A decision tree (shown in **Supplementary Figure 2**; accessible via the QR code) was used to assess the cost consequences of no vaccination or vaccination with the Pfizer-BioNTech fall 2023 vaccine versus the Moderna fall 2023 vaccine based on the following outcomes:
  - Number of symptomatic COVID-19 cases
  - COVID-19–related patient outpatient visits
  - COVID-19–related hospitalizations and deaths
  - Quality-adjusted life-years (QALYs)
- The results of the cost-consequences model were reported as incremental cost-effectiveness ratio (ICER) and as societal return on investment (ROI) and benefit-cost ratio (BCR) for cost-saving scenarios

Model Inputs

- The initial VE of the Moderna fall 2023 vaccines was based on a cohort study of the Moderna BA.4/BA.5 bivalent vaccine[5] and a meta-analysis of monovalent vaccines administered during the omicron period[6] (**Table 1**)
  - For the Pfizer-BioNTech fall vaccine, initial VE against infection and hospitalization was calculated using the relative VE (rVE; outpatient visits 5.1% [95% CI, 3.2%-6.9%]; hospitalization 9.8% [95% CI, 2.6%-16.4%]) of Moderna and Pfizer-BioNTech bivalent vaccines from US claims and medical records data[1]
  - Waning of the Pfizer-BioNTech fall 2023 vaccine was assumed to be the same as for the Moderna fall 2023 vaccine

Table 1. Base Case Vaccine Effectiveness of the Fall 2023 Updated COVID-19 mRNA Vaccines

Vaccine	Infection (%)		Hospitalization (%)	
	VE	Waning	VE	Waning
Moderna fall 2023	57.1	4.8	84.3	1.4
Pfizer-BioNTech fall 2023	54.8	4.8	82.6	1.4

VE, vaccine effectiveness.

- Endemic vaccination costs were assumed to be the same for both vaccines
- The ROI was calculated by dividing the health insurance and societal cost savings in COVID-19–related costs by the costs of the vaccination strategy
- BCR was calculated similarly to the ROI, but converting QALY gains to monetary benefit using a willingness-to-pay (WTO) of 50,000 €/QALY and adding them to the cost-saving
- Deterministic sensitivity analyses were performed to assess the impact on specific epidemiologic and economic parameters (key inputs shown in **Table 2**)

Table 2. Epidemiologic and Cost Inputs

Parameter	Value	
Epidemiologic inputs		
Age group	Hospitalizations,[a] %	In-hospital mortality, %
0-4 years	1.3	0.0
5-17 years	0.5	0.1
18-29 years	0.7	0.1
30-39 years	1.2	0.2
40-49 years	1.6	0.5
50-59 years	1.7	2.4
60-69 years	8.4	1.9
70-79 years	11.1	6.6
≥80 years	16.9	7.0
Cost inputs		
Vaccination-related costs[b]	€119	
Non-hospitalized patients seeking outpatient care, %	15.8	
Cost of outpatient care[c]	€122.02	
Cost of non-ICU hospitalization	€6900	
Cost of ICU hospitalization	€27,981	
Cost of ICU hospitalization with ventilation	€38,500	

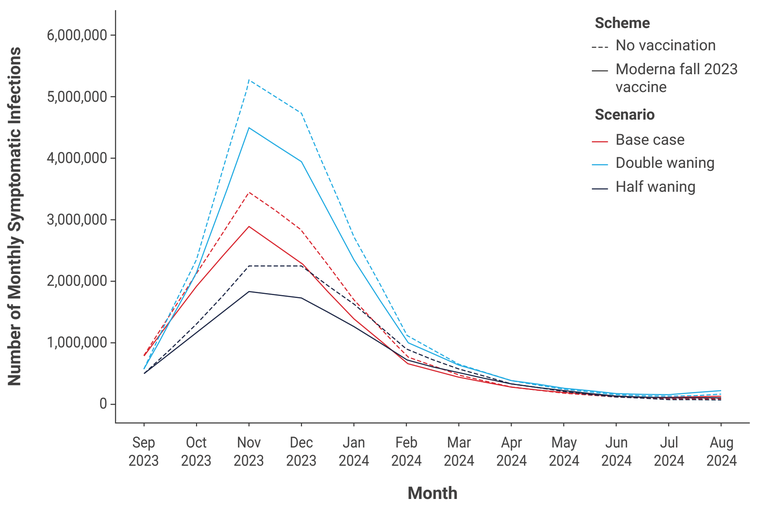
ICU, intensive care unit.
[a]Hospitalization rates among the unvaccinated from Q4 2020. Estimated adjusted for omicron.
[b]Assumes that the vaccine price is €109 and the administration fee is €10. The same price is assumed for the Moderna and the Pfizer vaccine.
[c]Assumes 1.6 outpatient visits at a cost of €76.26 per visit.

RESULTS

Moderna Fall 2023 Vaccine Versus No Vaccination

- In the base-case simulation spanning from September 1, 2023, to August 31, 2024, vaccination with the Moderna fall 2023 vaccine was predicted to prevent 1,697,851 symptomatic SARS-CoV-2 infections in the target population, representing a 13.2% decrease (**Figure 1**)
  - The model also predicted a 27.9% decrease in COVID-19–related hospitalizations and a 36.8% decrease in COVID-19–related deaths in this population

Figure 1. Predicted Incidence of Symptomatic SARS-CoV-2 Infection the Moderna Fall 2023 Vaccine Versus No Vaccination



- Based on the cost-effectiveness analysis, the dominant (ie, more effective and cost-saving) strategy for healthcare payer perspective was the Moderna fall 2023 vaccine compared with no vaccination (**Table 3**)
- In the deterministic sensitivity analyses, vaccination with the Moderna fall 2023 vaccine remained dominant (ie, more effective and cost-saving), except in the case where the VE against infection was at the lower bound of its 95% CI (ICER €3400/QALY gained)

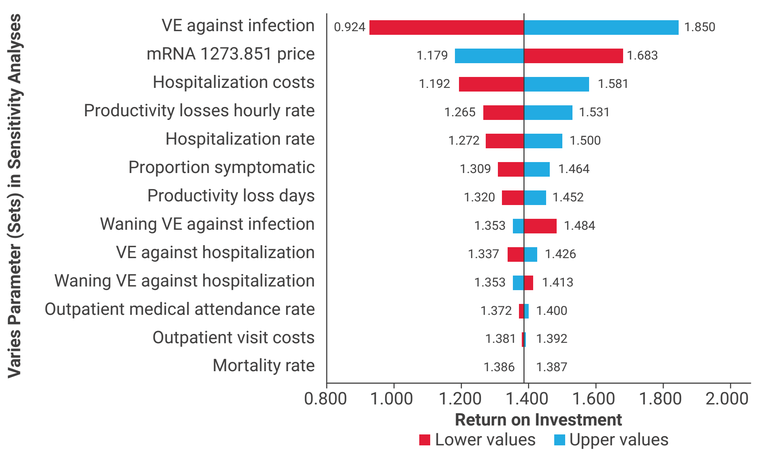
Table 3. Base Case Cost-Effectiveness of the Moderna Fall 2023 Vaccine Compared With No Vaccination (Healthcare Payer Perspective)

Vaccine	Costs (€)	QALYs Lost	Δ Costs (€)	Δ QALYs Gained	ICER (Δ Cost/QALY Gained)
Moderna fall 2023 vaccine	5,079,554,822	484,679	--	--	Moderna fall 2023 vaccine dominates
No vaccination	5,126,177,326	581,617	46,622,504	-96,938	--

ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-year.

- For the base case, the ROI considering the societal perspective was 1.39 (**Figure 2**), and was 1.04 considering the healthcare payer perspective
- Base case BCR was 4.73 from a societal perspective, assuming a WTP threshold of €50,000 per QALY gained

Figure 2. Deterministic Sensitivity Analyses of Societal Return on Investment of the Moderna Fall 2023 Vaccine Compared With No Vaccination



VE, vaccine effectiveness.

Moderna Fall 2023 Vaccine Versus the Pfizer-BioNTech Fall 2023 Vaccine

- Assuming cost parity between the Pfizer-BioNTech and Moderna fall 2023 vaccines, the Moderna fall 2023 vaccine was dominant (ie, more effective and cost-saving) considering both the societal and healthcare perspectives (**Table 4**)

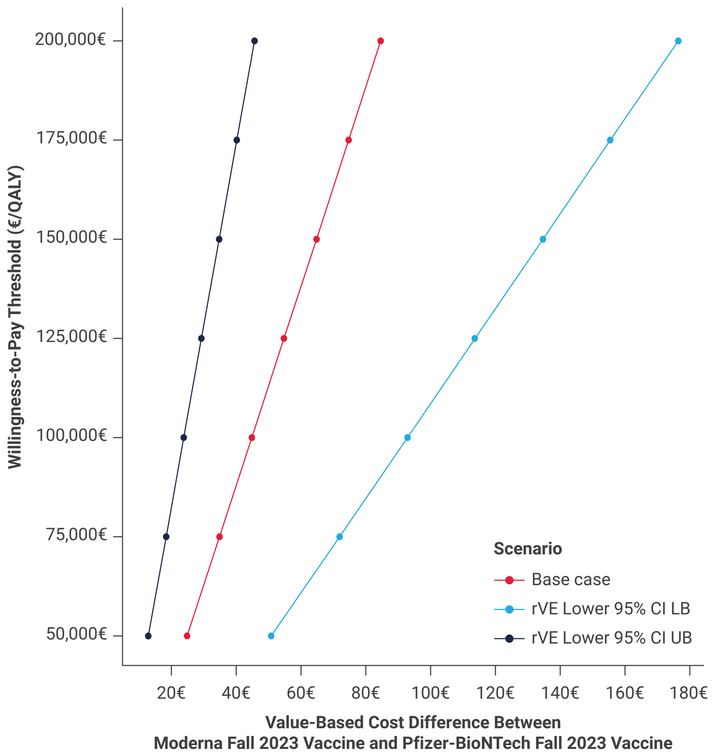
Table 4. Base Case Cost-Effectiveness of the Moderna Fall 2023 Vaccine Compared With the Pfizer-BioNTech Fall 2023 Vaccine (Healthcare Payer Perspective)

Vaccine	Costs (€)	QALYs Lost	Δ Costs (€)	Δ QALYs Gained	ICER (Δ Cost/QALY Gained)
Moderna fall 2023	5,079,554,822	484,679	--	--	Moderna fall 2023 dominant (ie, more effective and cost-saving)
Pfizer-BioNTech fall 2023	5,138,327,691	489,356	58,772,869	-4677	--

ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-year.

- At a €50,000 per QALY willingness-to-pay (WTP) threshold, the value-based price premium for the Moderna fall 2023 vaccine was €24.95, which equates to nearly a 23% premium (range, €13.00 to €51.00) (**Figure 3**)
- With higher WTP thresholds of €100,000 and €150,000 per QALY, the price premiums favoring the Moderna fall 2023 vaccine increase to €44.88 (range, €23.90 to €92.82) and €64.82 (range, €34.80 to €134.64), respectively

Figure 3. Value-Based Price Premium of the Moderna Fall 2023 Vaccine vs the Pfizer-BioNTech Fall 2023 Vaccine at Various Willingness-to-Pay Thresholds, by rVE Scenario



Value-based price difference; Moderna fall 2023 vaccine - Pfizer-BioNTech fall 2023 vaccine.
CI, confidence interval; LB, lower bound; QALY, quality-adjusted life-year; rVE, relative vaccine effectiveness; UB, upper bound.

LIMITATIONS

- The VE of the fall 2023 updated COVID-19 mRNA vaccines is currently unknown and can be affected by the emergence of new variants
- Assumptions regarding the VE of the updated Moderna and Pfizer-BioNTech fall 2023 vaccines were made based on evidence from earlier seasons
- While consequences within the 1-year time horizon were considered, broader factors such as long COVID were not considered

CONCLUSIONS

- To our knowledge, this is the first study to evaluate the potential cost-effectiveness of mRNA-based vaccination programs in Germany
- Vaccination with the Moderna fall 2023 vaccine is a cost-saving measure from both a healthcare payer and societal perspectives compared with no vaccination
  - Considering the impact on productivity, for each €1 invested in COVID-19 vaccination, the expected return would be €1.39
- The Moderna fall 2023 vaccine is predicted to lead to fewer symptomatic infections, hospitalizations, and deaths compared with the Pfizer-BioNTech fall 2023 vaccine, resulting in more QALYs gained and COVID-19 treatment cost savings

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Disclosures

MK is a shareholder of Quadrant Health Economics Inc., which has been contracted by Moderna to conduct this study. MM, AL, and KF are consultants to Quadrant Health Economics Inc. KJ, EB, and NV are employees of Moderna, Inc., and hold stock/stock options in the company. SS and BU are employees of Moderna GmbH, Munich, Germany, and hold stock/stock options in the company.

ADDITIONAL INFORMATION

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