The following methods are part of a Commonwealth Fund publication, Eric C. Schneider et al., "Impact of U.S. COVID-19 Vaccination Efforts: An Update on Averted Deaths, Hospitalizations, and Health Care Costs Through March 2022," *To the Point* (blog), Commonwealth Fund, Apr. 8, 2022, available at https://www.commonwealthfund.org/blog/2022/impact-us-covid-19-vaccination-efforts-march-update.

How We Conducted This Study

To evaluate the impact of the vaccination program in the United States, the researchers expanded their age-stratified, agent-based model of COVID-19 to include waning of naturally acquired or vaccine-elicited immunity, as well as booster vaccination. For the timelines of this study, the characteristics of four variants were included in the model, each with cumulative prevalence of at least 3 percent in the U.S., including B.1.526 (Iota), B.1.1.7 (Alpha), B.1.617.2 (Delta), and B.1.1.529 (Omicron), in addition to the original Wuhan-I SARS-CoV-2 strain.

The model parameters included the population demographics of the U.S., an empirically determined contact network accounting for pandemic mobility patterns, and age-specific risks of severe health outcomes due to COVID-19. The model incorporated data on daily vaccine doses administered in the U.S. The minimum age eligibility for vaccination was 16 years before May 13, 2021, after which children 12 to 15 became eligible for vaccination. Vaccination of children ages 5 to 11 with Pfizer-BioNTech started on November 2, 2021. Eligibility for booster was initially set to six months after the second dose of vaccine and changed to five months on January 3, 2022.

Vaccine effectiveness against infection and symptomatic and severe disease for different vaccine types — for each variant and by time since vaccination — were drawn from published estimates. The model was calibrated to reported national incidence data between October 1, 2020, and March 31, 2022, and validated with hospitalization and death trends during the same period.

The researchers evaluated the impact of vaccine rollout by simulating the pandemic trajectory under the counterfactual scenario of no vaccination program. The simulated outcomes of total infections, hospitalizations, and deaths were compared to the fitted model, reflecting the actual pandemic in the U.S. and vaccinations that occurred between December 12, 2020, and March 31, 2022.

To estimate health care costs averted, the researchers used their projections of COVID-19 symptomatic infections and hospitalizations and calculated direct costs associated with COVID-19 illness and hospitalizations with and without vaccination. Costs of health outcomes were stratified into outpatient visits for symptomatic infection, hospitalizations and/or intensive care for severe illness, emergency medical services (EMS) calls, and emergency department visits.

Changing selected assumptions in this analysis could reduce or increase the estimates reported here. For example, the model assumes that the reopening of businesses and schools, along with the increase in social gatherings that occurred during summer 2021, continued despite the Delta and Omicron waves. If people had restricted social activities and travel, or businesses or schools had closed in response to the surges, many deaths and hospitalizations could have been averted even in the absence of vaccination. However, it seems unlikely that the entire nation would have returned to the restrictions imposed during the first year of the pandemic. The model estimates only account for deaths due to COVID-19. However, without vaccination, preventable deaths due to other causes would have increased too, as occurred early in the pandemic in cities like New York City and Los Angeles. We considered only direct costs of health care, but costs without vaccination would have been substantially higher due to loss of lives and productivity during illness, as well as treatment of prolonged effects of disease such as long COVID.