Reductions in Deaths and Hospitalizations Associated with COVID-19 Vaccinations Among Medicare Beneficiaries: Full Year 2021 Estimates

Updating previous estimates with more recent data, we estimate that county-level primary COVID-19 vaccination rates of adults ages 18 and older were associated with 670,000–680,000 fewer COVID-19 hospitalizations and 330,000–370,000 fewer deaths among Medicare beneficiaries.

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KEY POINTS

- Previous ASPE research estimated that county-level primary COVID-19 vaccination rates through May 2021 were associated with reductions in mortality and hospitalizations among Medicare beneficiaries. This study updates those findings by extending the study period through the end of 2021, to include COVID-19 surges driven by the Delta variant in the summer and the Omicron variant in the winter.
- During 2021, we find the largest vaccine-related reductions in COVID-19 hospitalizations and deaths occurred during the summer Delta surge.
- Our model results indicate that COVID-19 vaccinations were associated with an estimated 670,000–680,000 fewer hospitalizations and 330,000–370,000 fewer deaths among all Medicare beneficiaries through the end of 2021. This represents a 39–47 percent reduction in these outcomes.
- Reductions in COVID-19 hospitalizations were associated with an estimated savings of $16.3–16.5 billion in direct hospitalization costs, a 6-fold increase in savings compared to our earlier study through May 2021.
- In the absence of any COVID-19 vaccinations in 2021, we estimate that there would have been more than 1.7 million COVID-19 hospitalizations and 700,000 deaths among the 64 million Medicare beneficiaries in 2021.
- Reductions in hospitalization and deaths linked to vaccination rates occurred in all racial and ethnic groups and in all 50 states, the District of Columbia, and Puerto Rico, highlighting the importance of achieving high levels of primary vaccinations in the US population to reduce morbidity and mortality, especially among older adults.

BACKGROUND

Throughout the COVID-19 pandemic, deaths from COVID-19 have been higher among adults 65 and older than all other age groups, and early in the pandemic, older adults in most states had higher rates of COVID-19 related mortality than mortality from other causes.[1] In December 2020, less than a year after the first case of COVID-19 was confirmed domestically, the United States began offering COVID-19 vaccinations to high-risk groups. Consistent with recommendations by the Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices (ACIP), older adults – particularly those residing in nursing homes – were generally among the first to be eligible for vaccinations in early 2021 due to their high risk of severe illness and death from COVID-19.[2] Vaccines for adults ages 18-64 became available in March 2021 through state and local vaccine distribution sites.

Vaccines developed by Pfizer-BioNTech, also known as Comirnaty, and Moderna, also known as SpikeVax, were the first to receive emergency use authorization (EUA) by the FDA in December 2020.[3] Both vaccines use mRNA technology and require two doses as part of the primary vaccination series. Since then, two additional vaccines have become available: a viral vector vaccine produced by Johnson & Johnson, which received EUA in February 2021, and a protein subunit vaccine by Novavax, which received EUA in July 2022.[4] In addition, both monovalent and bivalent booster vaccines have become available to strengthen immunity against the various strains of COVID-19.

We previously conducted analysis examining the relationship between county-level primary COVID-19 vaccine coverage rates and adverse outcomes among older adults, the majority of whom are covered by Medicare, and found that COVID-19 vaccination was associated with fewer infections, hospitalizations, and deaths from COVID-19 among this population.[5] In this study, we update our previous analysis of the associations between COVID-19 hospitalizations and deaths among Medicare beneficiaries and county-level vaccination rates, including estimated hospitalization cost savings.[6] This study extends our previous work through the end of 2021, compared to the previous analysis, which had a study period ending in May 2021. This longer study period includes the summer surge from the Delta variant, which produced more severe outcomes than the Alpha variant.[7] Using the information generated from these models, this report provides updated estimates of reductions in COVID-19 hospitalizations and deaths in 2021 in the overall Medicare population associated with primary COVID-19 vaccination rates.

METHODS

This analysis largely follows the methods from our previous analysis estimating the reduction in COVID-19 outcomes associated with COVID-19 county-level vaccination rates, with a few modifications. Overall, our approach estimated the reduction in the total number of hospitalizations within three weeks and deaths within nine weeks of a COVID-19 diagnosis.[*] We extended the initial study period (from September 2020 to May 2021) to include the full 2021 year (September 2020 to December 2021), which allows us to evaluate vaccinations during the Delta and initial Omicron variant periods. Our study analyzed rates of adults 18 years and older who were fully vaccinated with the primary vaccination series; we did not model vaccine boosters because booster adoption among all adults was still fairly low at the end of 2021.

Regression coefficients were first estimated on a random 10 percent sample of the Medicare fee-for-service (FFS) population to identify the association between county-level vaccination rates and individual-level COVID-19 outcomes. Texas and Hawaii were excluded from the sample due to incomplete vaccination data. The models then simulated probabilities of COVID-19 hospitalizations and deaths using a 20 percent sample. The

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[*] We use diagnosis code U07.1 to identify a COVID diagnosis in the Medicare FFS claims data.

main regression model was largely the same as the previous study with some minor refinements detailed below.

The main changes to our approach were threefold. First, given increasing reliance on home testing typically not reported in official statistics on infections, we no longer estimate reductions in the number of infections. However, we still use a diagnosis of COVID-19 in Medicare claims to identify COVID-19-related hospitalizations and deaths because in cases with severe outcomes such as these, even if an infection was initially diagnosed via home testing, the COVID-19 infection is still highly likely to show up in claims as a diagnosis code for subsequent complications. Second, given this concern about undercounting infections, we shifted from our previous approach that was a two-part model (first modeling infection, and then modeling severe outcomes conditional on infection), and instead modeled hospitalizations and deaths directly as a function of vaccination rates without estimating infection rates. Third, we made minor refinements to the model including using county-level primary vaccination rates among all adults ages 18 years and older instead of separate vaccination rates for age categories 18-64 years and 65 years and older for our main model (Model 1), and we tested the sensitivity of our results by estimating an alternate model with vaccination rates for age categories 18-64 years and 65 years and older as separate predictors, along with adding interaction terms between state- and month-fixed effects to account for potential state-level temporal confounding (Model 2). State estimates in this brief are from the main model, with a range reported for national estimates based on both models.

For the two states (Texas and Hawaii) excluded from the regression model, the estimated reduction in COVID-19 hospitalizations and deaths were imputed from the observed number of COVID-19 hospitalizations and deaths using the average rates of reduction (ratio between counterfactual/predicted), and then combined with the study cohort estimates.

As in our prior analysis, we extrapolated our study findings from the FFS study sample to the entire Medicare population to estimate the number of COVID-19 hospitalizations and deaths that were averted. We applied the average COVID-19 hospitalization cost estimate of $24,304 to estimate direct savings in Medicare spending due to vaccination.[8] Additional details of our approach are provided in the [Appendix](#).

FINDINGS

Association between County-level Vaccination Rates and COVID-19 Hospitalizations and Deaths

Table 1 shows the regression results for our key predictor variable, county-level rates of adults ages 18 years and older fully vaccinated with the primary COVID-19 vaccination series, from our main model (Model 1). These results reflect the independent association between county-level primary COVID-19 vaccinations and observed changes in COVID-19 hospitalizations and deaths among Medicare beneficiaries over time.

In 2021, we find a 12 percent decrease in the odds of COVID-19 hospitalizations and 15 percent decrease in the odds of deaths for every 10 percent increase in county-level COVID-19 vaccination rate.

For COVID-19-related hospitalizations and deaths, a 10 percent increase in county-level COVID-19 vaccination coverage among adults ages 18 and older was associated with 12 percent (OR=0.988, 95 percent CI: 0.987-0.989) and 15 percent (OR=0.985, 95 percent CI: 0.983-0.986) decrease in the odds of COVID-19 hospitalizations and deaths, respectively, among Medicare beneficiaries (P<0.001). For ease of interpretation, the changes in odds are interpreted

as changes in the rate of hospitalizations and deaths.[†] Compared with our earlier study of the initial vaccination period, this indicates a larger protective relationship between vaccination rates and reductions in deaths.

Table 1: Association between County-Level COVID-19 Vaccination Rates in Adults 18 and Older and COVID-19 Hospitalizations and Deaths Among Medicare Beneficiaries, 2021

	Risk of COVID-19 hospitalization, OR *(95% Confidence Interval)*	Risk of COVID-19 death, OR *(95% Confidence Interval)*
County-Level COVID-19 Vaccination Rate, Adults 18 and Older	**0.988**[**] (0.987, 0.989)	**0.985**[**] (0.983, 0.986)

Notes: *p<0.05, **p<0.001. All models were estimated on a 10 percent random sample of Medicare FFS beneficiaries. TX and HI were excluded from the sample due to inadequate vaccination data. Results are reported to 3 decimal places, which translates to percentages to 1 decimal place.

Sensitivity analyses conducted with the alternate model (Model 2) that included separate vaccination rates for adults in age categories of 18-64 and 65 and older show a strong negative association for vaccination rates among adults 18-64, which may suggest vaccination rates in non-elderly adults had a protective effect on Medicare seniors. A 10 percent increase in COVID-19 vaccination rate among those ages 18-64 in the county was associated with a 19 percent reduction in hospitalizations and 24 percent reduction in deaths among Medicare beneficiaries.

Estimated Reduction in COVID-19 Hospitalizations and Deaths Associated with Vaccinations

Figure 1 summarizes the total reduction in COVID-19 hospitalization and deaths in 2021 associated with county-level rates of primary COVID-19 vaccinations among adults 18 years and older, from our main model, projected to the full Medicare population. The figure plots the estimated weekly cumulative reduction in COVID-19 hospitalizations and deaths in the Medicare population associated with county-level vaccination rates among adults ages 18 and older. The two lines in the figure show hospitalizations in yellow and deaths in red. The gray bars show cumulative county-level vaccination rates among adults ages 18 years and older increasing over time. The reduction in hospitalizations and deaths associated with vaccinations grew rapidly starting with the summer Delta surge. This occurred even as vaccination rates started to slow compared to the spring, suggesting that the greater risk of the Delta variant may have enhanced the collective benefit of having been vaccination previously.

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[†] The decrease in odds is calculated as the odds ratio for the vaccination rate minus one, and then multiplied by 100% (e.g., 0.988-1 *100% = - 0.012 *100% = - 1.2%. A 10 percent increase in vaccination rate would therefore decrease odds of hospitalizations by 12 percent.

Figure 1: Estimated Reduction in COVID-19 Hospitalizations and Deaths Among Full Medicare Population (N=64 million) Associated with County-Level Vaccination Rates, 2021
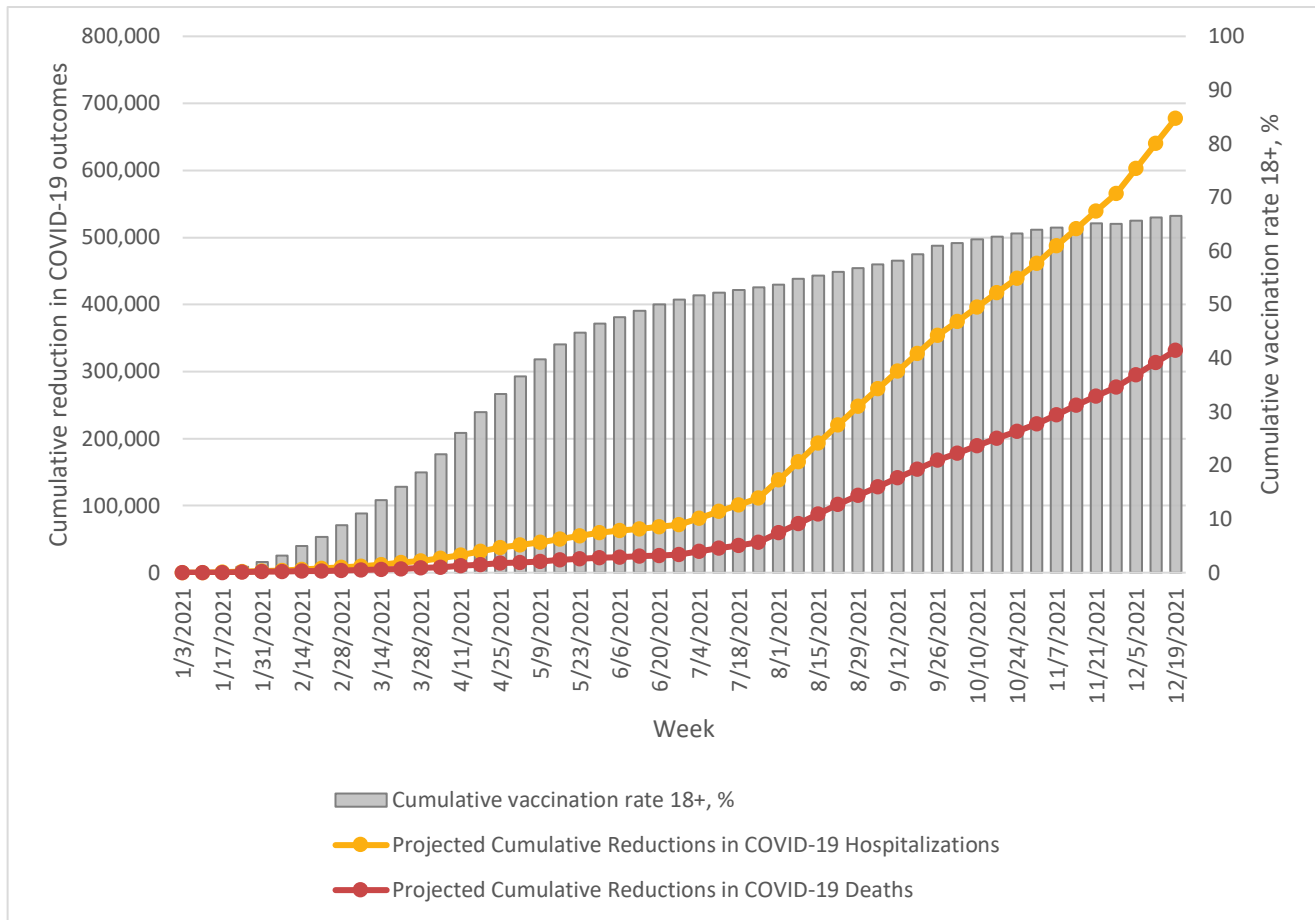
Source: CDC COVID Data Tracker – Vaccine Distribution and Coverage, https://covid.cdc.gov/covid-data-tracker/#vaccine-delivery-coverage; ASPE's analysis of Medicare 2021 claims data.

The estimated reductions in the total number of COVID-19 hospitalizations and deaths in the study cohort and the full Medicare population are presented in Table 2. Based on the main and alternate models tested, we estimate reductions of 670,000–680,000 hospitalizations and 330,000–370,000 deaths in the full Medicare population associated with COVID-19 vaccinations. These numbers reflect approximately 39 percent fewer hospitalizations and 47 percent fewer deaths compared to a scenario in which no vaccines were available.

Table 2: Estimated Reductions in COVID-19 Hospitalizations and Deaths Among Medicare Beneficiaries Associated with County-Level COVID-19 Vaccination Rates, 2021

Key Predictors of COVID	COVID-19 Hospitalizations	COVID-19 Deaths	Estimated Hospitalization Cost Savings¥
Study Cohort	N=26.8 million		
Estimated outcomes without vaccines	720,000	293,000	
Estimated outcomes with vaccines	440,000	156,000	-
Estimated reduction in COVID-19 outcomes* **associated with vaccines** (percent reduction)	**280,000** (-39%)	**137,000** (-47%)	-
Projected to Full Medicare Population**	N=64 million		
Main Model (Model 1) Estimated outcomes without vaccines	1,720,000	700,000	
Estimated outcomes with vaccines	1,050,000	370,000	
Estimated reduction in COVID-19 outcomes* **associated with vaccines**	**670,000**	**330,000**	**$16.3 Billion¥**
Alternate Modelᵝ (Model 2) **Estimated reduction in COVID-19 outcomes*** **associated with vaccines**	**680,000**	**370,000**	**$16.5 Billion¥**

Source: CDC COVID Data Tracker – Vaccine Distribution and Coverage, https://covid.cdc.gov/covid-data-tracker/#vaccine-delivery-coverage; ASPE's analysis of Medicare 2021 claims data.
Notes: * COVID-19 outcomes included hospitalizations and deaths
** Study cohort results are multiplied by a factor of 2.4 to project to the full Medicare population of 64 million. Estimates are rounded to the nearest ten thousand for projected estimates, and nearest thousand for the study cohort.
¥ Hospitalization cost savings in the table are based on the rounded estimates of hospitalization reductions of 670,000 - 680,000, reported in billions of dollars and rounded to 1 decimal place. Hospitalization cost savings are estimated by multiplying the reduction in COVID-19 hospitalizations by the average cost of a COVID-19 hospitalization, $24,304.
ᵝ The alternate model included separate primary COVID-19 vaccination rates for 18-64 years and 65 years and older who are fully vaccinated, and interaction terms between state- and month-fixed effects, whereas the main model used vaccination rates for all adults 18 years and older, state and month fixed effects without interactions.

Results by Race and Ethnicity

Table 3 shows the projected reductions in COVID-19 hospitalizations and deaths associated with COVID-19 vaccinations by race and ethnicity. Overall, COVID-19 vaccinations were associated with reduced hospitalizations among people across multiple racial and ethnic groups: Asian American (43 percent), Latino (41 percent), American Indian and Alaska Native (AI/AN) (40 percent), White (39 percent), and Black beneficiaries (38 percent).

For mortality, COVID-19 vaccinations were associated with similar reductions in COVID-19 deaths of nearly half —46 to 52 percent—among all groups, translating into more than 4,000 fewer deaths among AI/AN beneficiaries, nearly 8,000 among Asian American beneficiaries, more than 20,000 fewer deaths each among Black and Latino beneficiaries, and 260,000 among White beneficiaries.

Table 3: Estimated Reductions in COVID-19 Hospitalizations and Deaths Among Medicare Beneficiaries Associated with County-Level Vaccination Rates, by Race and Ethnicity, 2021

Race and Ethnicity	Full Medicare Population			
	Estimated Reductions in COVID-19 Hospitalizations	Percent Reduction**	Estimated Reductions in COVID-19 Deaths	Percent Reduction**
Total	667,000	39%	326,000	47%
White	515,000	39%	261,000	46%
Black	67,000	38%	27,000	46%
Latino*	47,000	41%	22,000	50%
Asian	16,000	43%	8,000	52%
American Indian and Alaska Native (AI/AN)	8,000	40%	4,000	48%
Other/Unknown	14,000	41%	5,000	49%

Source: CDC COVID Data Tracker – Vaccine Distribution and Coverage, https://covid.cdc.gov/covid-data-tracker/#vaccine-delivery-coverage; ASPE's analysis of Medicare 2021 claims data.
Notes: Estimated reductions in COVID-19 outcomes are rounded to the nearest thousand.
* Latino ethnicity included all beneficiaries reporting Latino ethnicity in combination with any race. Remaining categories were among non-Latino beneficiaries.
**Percent reduction was calculated as the estimated reduction in outcomes divided by the number of outcomes if no vaccinations were available.

State-Specific Estimates

The average county-level COVID-19 vaccination rate for all adults ages 18 and older in 2021 was 41 percent, but there was a wide range across counties even within the same state. For example, in Georgia, county vaccination rates in 2021 ranged from 18 to 82 percent.

Table 4 presents state- and territory-specific estimates of reductions in 2021 COVID-19 hospitalizations and deaths associated with vaccinations, along with state and territory vaccination rates as of December 2021. Estimated reductions in deaths were greatest in the following ten states: California (28,700), Texas (22,800), Florida (20,500), New York (18,600), Illinois (16,500), Pennsylvania (16,300), Ohio (14,200), Michigan (11,300), North Carolina (10,800), New Jersey (9,500) and Tennessee (8,800), which largely reflect both the size and age composition of these states and their Medicare populations.

To account for differences in population size, Appendix Table 1 shows the average estimated reduction in hospitalizations per 100,000 Medicare beneficiaries. The national average was approximately 1,000 fewer hospitalizations per 100,000 beneficiaries and ranged, by state, from a low of 200-300 in Hawaii, Vermont, and Puerto Rico to 1,300 in Indiana, Illinois, New Jersey, Oklahoma, and South Dakota.

The average estimated reduction in deaths associated with vaccinations per 100,000 Medicare beneficiaries was approximately 500 nationally. States with the highest estimated death reduction rate – about 700 per 100,000 Medicare beneficiaries – were Indiana, Kansas, Kentucky, North Dakota, and Oklahoma. Nearly a dozen states – Connecticut, Iowa, Illinois, Michigan, New Mexico, Nevada, Ohio, Pennsylvania, South Dakota, Tennessee, and Wyoming – had estimated reductions in deaths of approximately 600 per 100,000 Medicare beneficiaries.

Table 4: State and Territory Estimates of Reductions in COVID-19 Outcomes Associated with Vaccinations for the Full Medicare Population

State	% of Adults 18 and Older Fully Vaccinated by Dec. 31, 2021	Estimated Reductions in COVID-19 Outcomes in Medicare Population	
		Reductions in COVID-19 Hospitalizations	Reductions in COVID-19 Deaths
Total US	66.5	**668,500**	**327,800**
Alaska	64.5	1,800	900
Alabama	52.6	9,700	4,700
Arkansas	54.0	7,600	4,800
Arizona	64.5	15,300	6,800
California	73.2	54,700	28,700
Colorado	71.2	6,700	3,400
Connecticut	83.2	7,500	3,500
D.C.	72.8	1,000	400
Delaware	71.3	3,700	1,600
Florida	69.9	43,700	20,500
Georgia	34.4	10,000	4,900
Hawaii*	70.0	500	300
Iowa	66.6	10,300	5,400
Idaho	57.9	3,700	1,700
Illinois	71.3	35,800	16,500
Indiana	61.1	19,000	10,400
Kansas	61.9	9,500	5,200
Kentucky	59.7	12,500	6,600
Louisiana	56.6	8,800	3,600
Massachusetts	70.1	18,200	8,100
Maryland	78.9	17,300	7,800
Maine	80.8	2,000	1,100
Michigan	64.4	24,100	11,300
Minnesota	70.5	10,100	4,300
Missouri	54.9	14,800	7,000
Mississippi	57.2	8,900	4,300
Montana	59.2	3,700	1,900
North Carolina	63.6	20,600	10,800
North Dakota	58.3	2,500	1,400
Nebraska	60.5	5,800	2,400
New Hampshire	71.5	3,000	1,500
New Jersey	75.9	23,200	9,500
New Mexico	74.4	4,900	2,500
Nevada	62.9	6,600	3,200
New York	79.9	41,200	18,600
Ohio	62.8	27,200	14,200
Oklahoma	58.8	12,600	7,000
Oregon	70.5	5,000	2,300

State	% of Adults 18 and Older Fully Vaccinated by Dec. 31, 2021	Estimated Reductions in COVID-19 Outcomes in Medicare Population	
		Reductions in COVID-19 Hospitalizations	Reductions in COVID-19 Deaths
Pennsylvania	66.4	32,200	16,300
Puerto Rico	79.3	500	300
Rhode Island	79.2	1,800	900
South Carolina	59.1	11,900	5,800
South Dakota	65.8	3,300	1,700
Tennessee	58.4	15,300	8,800
Texas[*]	67.7	45,200	22,800
Utah	68.5	4,200	1,600
Virginia	60.0	12,100	6,600
Vermont	61.2	600	400
Washington	72.9	9,300	4,700
Wisconsin	69.5	12,900	6,100
West Virginia	66.3	3,000	1,600
Wyoming	54.9	2,600	1,300

Source: CDC COVID Data Tracker – Vaccine Distribution and Coverage, https://covid.cdc.gov/covid-data-tracker/#vaccine-delivery-coverage; ASPE's analysis of Medicare 2021 claims data.

Notes: Numbers may not sum precisely due to rounding. All estimates are rounded to the nearest hundred. State hospitalization and death reduction estimates are projections from the main model and may differ from the alternate model estimates. Estimates are based off COVID-19 diagnoses on claims which may not be consistent across states. Estimates for smaller states should be interpreted with caution due to small sample sizes which can lead to unreliable estimates.

[*] State vaccination rates for Hawaii and Texas may be imprecise as not all counties submitted data to CDC. These two states were excluded from the estimation model due to incomplete data. The reduction in COVID-19 hospitalizations and deaths were imputed based on the average rate of reductions in COVID-19 hospitalizations or deaths and applied to the actual number of COVID-19 hospitalizations and deaths observed in each state to generate imputed state-specific estimates and projected to the full Medicare population.

DISCUSSION

Our findings demonstrate a significant association between county-level COVID-19 vaccination rates and improved outcomes for Medicare beneficiaries. Compared to a scenario with no vaccines available, we estimated that COVID-19 vaccines in 2021 were associated with 39 and 47 percent declines in COVID-19 hospitalizations and deaths, respectively, and an estimated $16.5 billion savings in hospitalization costs among Medicare beneficiaries, with much of these effects accruing during the Delta wave.

Relative to our previous study, vaccinations were associated with larger estimated reductions in COVID-19 hospitalizations and deaths when the Delta surge was included in the sample in the second half of 2021. Our findings show that the county-level rate of primary COVID-19 vaccinations was associated with large estimated

These updated findings show COVID-19 vaccinations are associated with 39% decline in hospitalizations and 47% fewer deaths

reductions in hospitalizations and deaths across all racial and ethnic groups and all states.

Our findings are generally consistent with existing research that demonstrates a protective association between community COVID-19 vaccination rates and reductions in deaths, hospitalizations, and other adverse outcomes among the general population and among populations with conditions that make them particularly

susceptible to COVID-19.[9,10,11,12] Compared to our study, Steele et al.,[13] estimated COVID-19 vaccinations through September 2021 reduced more hospitalizations (759,000) among those ages 65 years and older. After accounting for the difference in study periods, our estimate for reductions in deaths was very close to their estimate (165,000 vs. 154,000). Estimates may vary as studies use different timeframes, study populations by age group, modelling approaches, number of doses received by the study population, and baseline scenarios relative to varying projection scenarios (e.g., what if vaccination rates were zero percent vs. 100 percent). Because we modeled county-level vaccination rates and not individual vaccination status, our findings also highlight the likely positive externality of vaccinating the larger population, namely the benefits for those people who are at increased risk of severe COVID-19 illness, including Medicare beneficiaries.

Our analysis has several limitations. We were unable to control for all confounders that may be impacting the key outcomes, particularly time-varying confounders related to state and local contextual factors. In an alternate model we incorporated interactions between state and month fixed effects to account for state temporal effects, and this approach did not change our findings substantially. Future analyses may explore including other time-varying covariates, such as state mitigation policies that may also have contributed to reductions in outcomes. We used a single model to estimate the impact of county-level vaccinations on race and ethnic groups, which assumes the effect of vaccination rates is the same across groups. To address potential differential impacts, future analysis can explore race- and ethnicity-specific vaccination rates. Our projections also assume the rest of the Medicare population is similar to our study cohort. The estimated number of deaths reduced may in part reflect differences in age composition across states, as the risk of COVID-19 mortality is higher among seniors 80 and older than those 65-79 years of age.[14] Finally, our analysis did not model vaccine boosters and only considered the primary COVID-19 vaccination series, as booster adoption among all adults was still fairly low at the end of 2021 – about a third of the adult population.[15] In addition to the primary vaccine series, ACIP recommends COVID-19 vaccination boosters for all adults, and especially older adults, to strengthen their immunity against the various strains that have emerged since the beginning of the COVID-19 pandemic.[16] Future studies can examine the effects of the COVID-19 vaccine boosters.

Our estimates of cost savings are conservative for several reasons. Our approach focused only on estimated reduction in costs from prevented hospitalizations and did not include cost savings that accrue from vaccine-related reductions in physician services, post-acute care, or follow-up services. Moreover, our estimates also did not reflect the economic benefits from the wider and safer resumption of economic activities enabled by COVID-19 vaccinations. For a broader assessment, another ASPE research study on the full U.S. population estimated at least $1.38 trillion in economic benefits, including mortality reductions, through July 2021.[17]

These findings suggest nearly 680,000 hospitalizations prevented among Medicare beneficiaries and up to $16.5 billion in hospitalization cost savings in association with vaccinations.

CONCLUSION

This study demonstrates that high levels of community-wide primary COVID-19 vaccination rates in 2021 were associated with large reductions in COVID-19 hospitalizations and deaths among Medicare beneficiaries, as well as significant savings from reduced hospitalizations costs.

APPENDIX

Appendix Table 1. Estimated Reductions in COVID-19 Outcomes per 100,000 Medicare beneficiaries Associated with Primary COVID-19 Vaccinations, 2021 by State

State	Primary COVID -19 Vaccination Rates at end of Dec. 2021		Estimated Reductions in COVID-19 Outcomes	
	18-64 Vaccination Rate, %	65+ Vaccination Rate, %	Reductions in COVID-19 Hospitalizations per 100,000 Medicare beneficiaries	Reductions in COVID-19 Deaths per 100,000 Medicare beneficiaries
Total US	**61.7**	**82.2**	**1,000**	**500**
Alaska	60.7	82.0	900	500
Alabama	46.1	74.4	1,000	500
Arkansas	48.7	70.9	900	600
Arizona	59.1	80.5	1,100	500
California	70.5	83.6	1,000	500
Colorado	67.1	86.2	800	400
Connecticut	80.4	93.0	1,200	600
D.C.	70.5	85.6	900	300
Delaware	64.4	89.3	1,100	500
Florida	62.4	87.1	1,000	500
Georgia	31.6	46.6	600	300
Hawaii**	70.0*	90.0	200	100
Iowa	59.5	88.4	1,200	600
Idaho	50.6	81.7	900	400
Illinois	67.3	84.8	1,300	600
Indiana	54.5	84.0	1,300	700
Kansas	56.3	80.5	1,200	700
Kentucky	54.2	78.8	1,200	700
Louisiana	50.7	78.6	1,000	400
Massachusetts	67.7	78.5	1,000	500
Maryland	75.8	90.2	1,100	500
Maine	76.5	92.3	600	300
Michigan	58.2	84.3	1,300	600
Minnesota	64.9	88.9	1,100	500
Missouri	48.9	74.7	1,100	500
Mississippi	50.7	80.3	1,100	500
Montana	52.0	79.8	1,100	500
North Carolina	57.7	82.4	1,000	500
North Dakota	52.4	78.8	1,200	700
Nebraska	55.4	77.7	1,100	500
New Hampshire	66.4	87.9	800	300
New Jersey	73.6	83.0	1,300	500
New Mexico	70.3	86.9	1,100	600
Nevada	58.7	77.9	1,200	600
New York	77.7	87.1	1,200	500

	Primary COVID -19 Vaccination Rates at end of Dec. 2021		Estimated Reductions in COVID-19 Outcomes	
State	18-64 Vaccination Rate, %	65+ Vaccination Rate, %	Reductions in COVID-19 Hospitalizations per 100,000 Medicare beneficiaries	Reductions in COVID-19 Deaths per 100,000 Medicare beneficiaries
Ohio	56.3	84.4	1,200	600
Oklahoma	53.0	79.0	1,300	700
Oregon	65.1	85.2	600	300
Pennsylvania	61.5	81.7	1,200	600
Puerto Rico	79.2	79.5	300	200
Rhode Island	75.4	92.2	1,000	500
South Carolina	52.5	80.0	900	400
South Dakota	59.3	85.6	1,300	600
Tennessee	51.8	80.6	1,100	600
Texas**	67.7*	84.3	1,100	600
Utah	64.2	87.2	1,000	400
Virginia	55.7	74.3	600	300
Vermont	57.2	72.9	300	100
Washington	68.6	86.8	600	300
Wisconsin	63.1	89.8	1,100	500
West Virginia	57.5	88.2	600	300
Wyoming	47.4	79.3	1,200	600

Source: CDC COVID Data Tracker – Vaccine Distribution and Coverage, https://covid.cdc.gov/covid-data-tracker/#vaccine-delivery-coverage; ASPE's analysis of Medicare 2021 claims data.

Notes: Numbers may not sum precisely due to rounding. All estimates are rounded to the nearest hundred. State hospitalization and death reduction estimates are projections from the main model and may differ from the alternate model estimates. Estimates for smaller states should be interpreted with caution due to small sample sizes.

*State vaccination rates for adults 18 years and older; age break-downs were not consistently available.

** Estimates for Hawaii and Texas are imputed based on the average rate of reductions due to lack of county-level vaccination data.

APPENDIX - METHODOLOGY

Our entire study cohort consists of 26.8 million Medicare FFS who were continuously enrolled in Part A and B for 12 months prior to the study period. Our study employs a panel study design and combines individual level Medicare FFS claims data with weekly cumulative county-level primary COVID-19 vaccination rates from CDC to estimate the association between county-level COVID-19 vaccinations and weekly changes in COVID-19 hospitalizations and deaths among Medicare FFS beneficiaries over time. We used CDC's weekly county-level data on the proportion of adults 18 years and older fully vaccinated (i.e., completed primary COVID-19 vaccination series). Primary COVID-19 vaccinations became available from January 2021 to December 2021. In addition to county-level COVID-19 vaccination rates (adults ages 18 years and older who were fully vaccinated with a primary series, meaning they received two doses for Pfizer/Moderna or one dose for Johnson and Johnson vaccines), the model also controlled for demographic characteristics, comorbidities, and local area characteristics such as population density and the CDC's Social Vulnerability Index, both at the Census tract level and state/month fixed effects. Regression coefficients were first estimated on a random 10 percent sample of the Medicare fee-for-service (FFS) population. Texas and Hawaii were excluded from the estimation sample due to incomplete vaccination data. The models then simulated probabilities of COVID-19 outcomes with and without vaccines using a 20 percent sample.

Overall, the study followed the same multi-step process that consists of the following:

1) We used a discrete-time hazard model estimated by logit regression to estimate an individual's risk of COVID-19 outcomes associated with county-level rates of primary COVID-19 vaccinations.
2) Using this model to simulate the probabilities of COVID-19 outcomes with and without vaccines over time, we calculated the difference in expected number of COVID-19 outcomes if no vaccines were available compared with vaccinations during the study period. This allows us to obtain an estimate of the reduction in COVID-19 outcomes (hospitalizations and deaths) associated with primary COVID-19 vaccinations.
3) We extrapolated the study cohort results to the full Medicare population of 64 million beneficiaries by multiplying the study cohort findings by a factor of 2.4.

Of note, Texas and Hawaii did not have complete county-level vaccination rates in the CDC data, so those two states were excluded from the estimation model. State-specific estimates were imputed using the national rate of reductions in COVID-19 hospitalizations and deaths applied to the observed number of COVID-19 hospitalizations and deaths in these two states.

All study results are reported projected to the full Medicare population of 64 million beneficiaries. The projection factor of 2.4 is calculated by dividing 64 million by the combined study cohort including Hawaii and Texas (26.8 million).

The data was prepared, and analyses conducted by Acumen LLC and its subcontractor Cloud Harbor Economics LLC under the supervision of ASPE.

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