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Assessment of the Costs of Implementing COVID-19 Vaccination Clinics in 34 Sites, United States, March 2021

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ABSTRACT

Objectives: To estimate the costs to implement public health department (PHD)–run COVID-19 vaccination clinics.

Design: Retrospectively reported data on COVID-19 vaccination clinic characteristics and resources used during a high-demand day in March 2021. These resources were combined with national average wages, supply costs, and facility costs to estimate the operational cost and start-up cost of clinics.

Setting: Thirty-four PHD-run COVID-19 vaccination clinics across 8 states and 1 metropolitan statistical area.

Participants: Clinic managers at 34 PHD-run COVID-19 vaccination clinics.

Intervention: Large-scale COVID-19 vaccination clinics were implemented by public health agencies as part of the pandemic response.

Main Outcomes Measured: Operational cost per day, operational cost per vaccination, start-up cost per clinic.

Results: Median operational cost per day for a clinic was $10 314 (range, $637-$95 163) and median cost per vaccination was $38 (range, $9-$206). There was a large range of operational costs across clinics. Clinics used an average of 99 total staff hours per 100 patients vaccinated. Median start-up cost per clinic was $15 348 (range, $1 409-$165 190).

Conclusions: Results show that clinics require a large range of resources to meet the high throughput needs of the COVID-19 pandemic response. Estimating the costs of PHD-run vaccination clinics for the pandemic response is essential for ensuring that resources are available for clinic success. If clinics are not adequately supported, they may stop functioning, which would slow the pandemic response if no other setting or approach is possible.

KEY WORDS: COVID-19 vaccination, implementation cost, vaccination clinic

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Human Participant Compliance Statement: *This study was reviewed by the RTI Institutional Review Board and determined to be research not involving human subjects.*

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The rapid development of vaccines can be an effective approach to combating pandemics. This has notably been the case in the H1N1pdm09 virus (H1N1) pandemic and the coronavirus 2019 (COVID-19) pandemic. While the rapid development of vaccines poses great scientific challenges, making those vaccines available to the entire population presents great logistical challenges.[1] Primary care providers do not have the capacity to administer vaccines to the entire population in a short span of time, and approximately a quarter of the population does not have a primary care provider.[2] The mRNA COVID-19 vaccines also presented logistical challenges related to the ultracold chain requirements

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for distribution and storage.[1] Therefore, additional vaccine locations that can handle high volumes are essential to the pandemic response, notably large-scale vaccination clinics. Dedicated, large-scale vaccination clinics are especially important early in the response when large portions of the population need to be vaccinated quickly and in areas with fewer both traditional vaccination locations such as primary care providers and health clinics and newer vaccination locations such as pharmacies.

Little is known about the staffing and resource requirements for large-scale vaccination clinics. There is information from annual influenza clinics[3] and public health department (PHD)–run vaccination clinics from the H1N1 pandemic.[4,5] However, the logistics of COVID-19 vaccination clinics are likely substantially different due to increased requirements for social distancing, sanitization, and postvaccination observation. The Centers for Disease Control and Prevention (CDC) developed guidance for large-scale COVID-19 vaccination clinics,[6] and all state health departments created state-specific plans for clinics. Yet, to date, there is only one case study (of 2 clinics) describing the resources needed to implement a COVID-19 clinic in practice.[7] This lack of information is a critical gap for public health practitioners to make informed decisions regarding resource allocation and budgeting.

This study helps fill this gap by collecting data on resources used in 34 PHD-run COVID-19 vaccination clinics during the peak vaccination period in March 2021. We converted reported resource use to costs using standardized national average wages, by profession. This resource use and cost information is important for public health planners and policy makers to consider as they create plans and infrastructure to respond to future pandemics.

Methods

Data collection

We solicited participation in the study from state and local PHDs in 24 states and 3 metropolitan statistical areas (MSAs) (outside of those 24 states) that were supporting COVID-19 vaccination clinics. Of these, 8 states (Arkansas, Colorado, Georgia, Illinois, Michigan, Minnesota, Nevada, and Oregon) and 1 MSA (Seattle-King County, Washington) agreed to participate and supported data collection from large-scale COVID-19 vaccination clinics run by public health agencies in their state or MSA. A total of 34 clinics from these states and MSA participated in the study. Clinic managers from participating clinics completed the data collection tool between May 1, 2021, and June 15, 2021. This study was reviewed by the RTI Institutional Review Board and determined to be research not involving human subjects.

Respondents retrospectively reported data on clinic characteristics and all resources used by the clinic based on a busy day the week of March 15, 2021. This week was chosen because vaccination programs in all states were fully operational and were open to a large portion of the population, leading to high volumes in clinics.

The data collection tool was organized into 5 sections: (1) *clinic overview*, which included information such as the number of patients vaccinated during the reporting week, the types of vaccines offered, and other clinic characteristics; (2) *staffing*, which was organized by clinic role (scheduling, greeter, check-in/registration, vaccine preparation, vaccinator, postvaccination observer, clinic manager, supervisory nurse, logistics supervisor, data entry, and other) and included information on the number of staff filling each role, the number staff hours per day, the type of staff, and whether the staff were volunteer or paid; (3) *daily operation supplies*, which included information on supplies used with patients such as syringes, gloves, and bandages; (4) *start-up supplies*, which included information on supplies needed to set up the clinic such as office equipment, tables, and chairs; and (5) *facilities*, which included information on facility rental price and square footage and contracted services such as cleaning, billing, and emergency medical technician services.

Data analysis

We computed total staff time for each role on a day of clinic operation by multiplying the number of staff per clinic each day by the number of hours per staff member each day. This included all time spent on clinic operation, including time spent with patients (eg, greeting, check-in/registration, vaccine preparation vaccination, and postvaccination observation), time spent on clinic management, and time spent on all back-office operations (eg, scheduling, billing, and data entry). Staff time included time before the clinic opened, time with patients during clinic hours, and time after the clinic closed to patients for the day. This time did not include staff time spent planning to start up the clinic such as finding a clinic location, designing the clinic, recruiting, hiring, training, marketing, and coordinating with stakeholders (eg, government officials, security, faith-based organizations, minority interest groups). To generate cost estimates for each clinic, we standardized the monetary value of the resources reported by respondents using national average wages, supply costs, and facility costs. We standardized wages using 2020 data from Bureau of

Labor Statistics on wages by occupation, adjusted to include benefits.[8] Volunteer time was categorized by staff type and was accounted for in the same manner as paid staff time. Our primary source for standardized supplies was medical supply catalogues.[9-11] For supplies not available from medical supply catalogues, 2 respondents also provided their price lists, for which we calculated averages. Where we were not able to obtain costs from either of those sources, we obtained costs from bulk suppliers (eg, Costco, OfficeMax, Home Depot) and other Internet sources. Respondents either provided monthly facility cost or the square footage of the facility where the clinic was held, and we standardized facility costs using national average rental rate per square foot of commercial and industrial real estate costs for May 2020.[12,13] All costs were reported in 2020 US dollars. We used standardized national average wages and prices to not conflate geographic wage differences, with differential resource as drivers of variation in costs. Standardized cost estimates demonstrate differences in cost due to resource use.

We computed the operational cost per day for each clinic (by summing daily staff and operational supply costs) and the daily facility cost (monthly facility cost divided by the days the clinic was open each month). Since clinics varied in size, we also computed the cost per patient vaccinated for each clinic by dividing the daily operational cost by the daily number of patients vaccinated. We computed the total start-up cost of each clinic by summing the cost of all start-up supplies. We also examined total start-up cost standardized as the average number of patients vaccinated per week, because clinics varied in size. We examined the median and range of each cost metric across clinics. Because cost data are usually skewed, we used the median and range for analysis instead of the mean and standard deviation. Finally, we examined staffing for each clinic role including the average staff hours for each clinic role per 100 vaccinated patients, the 3 types of staff that mostly filled each role, and the percentage of each role that was volunteer. All analyses were performing using STATA 16.[14]

Results

Table 1 shows characteristics of the 34 clinics that participated in the study. On average, clinics administered 476 vaccines per day. During the reporting period, clinics typically used the following flow: patients were (1) greeted at the door and appointment was confirmed, (2) screened for COVID-19 symptoms, (3) completed documentation with a staff member (ie, medical and personal data for documentation in the Immunization Information System [IIS]), (4) vaccinated, and (5) waited for a 15- or 30-minute observation period after which they exited or formally checked out of the clinics. Vaccine eligibility criteria varied by state but were generally available to health care workers, the elderly, individuals with high-risk medical conditions, teachers, school staff, childcare workers, adult caregivers, and other essential workers (see Supplemental Digital Content Table S1, available at http://links.lww.com/JPHMP/A986, for detail on each state). The Moderna and Janssen (Johnson &Johnson) COVID-19 vaccines were approved for

TABLE 1
Characteristics of Public Health Department–Run COVID-19 Vaccination Clinics in 34 Sites From 8 Participating States and 1 Participating Metropolitan Statistical Area[a] During the Week of March 15-19, 2021

Characteristic	Mean	Median	Min	Max
Patients vaccinated per day	476	271	11	2873
Hours open per day	6.6	7.5	2.0	9.0
Days open per week	2.8	2.0	1.0	6.0
Offer multiple COVID-19 vaccines	35%	. . .	. . .	. . .
Vaccine offered[b]				
Pfizer-BioNTech	35%	. . .	. . .	. . .
Moderna	68%	. . .	. . .	. . .
Janssen	32%	. . .	. . .	. . .
Rural[c]	50%	. . .	. . .	. . .
Indoors	88%	. . .	. . .	. . .

[a] *Participating states were Arkansas, Colorado, Georgia, Illinois, Michigan, Minnesota, Nevada, and Oregon, and participating metropolitan statistical area was Seattle-King County, Washington.*

[b] *Including sites offering multiple COVID-19 vaccines; therefore, percent total sums up to more than 100%.*

[c] *Including Micropolitan (codes 5) or non-Core (Code 6) based on 2013 NCHS Urban-Rural Classification.*

TABLE 2

Median and Range of Operational and Start-up Costs of Public Health Department–Run COVID-19 Vaccination Clinics in 34 Sites From 8 Participating States and 1 Participating Metropolitan Statistical Area[a] During the Week of March 15-19, 2021

	Per Day			Per Vaccinated Patient		
Operational Cost Resource Type	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**
Operational staffing	$8 594	$382	$79 051	$29	$5	$182
Operational supplies	$481	$42	$79 051	$1	$1	$26
Operational facilities and services	$851	$25	$14 379	$3	$1	$21
Total operational cost	$10 314	$637	$95 163	$38	$9	$206
Start-up Cost		**Per Clinic**		**Per Clinic Scaled by Average Patients per Week**		
Total start-up cost	$15 348	$1 409	$165 190	$29	$2	$642

[a] *Participating states were Arkansas, Colorado, Georgia, Illinois, Michigan, Minnesota, Nevada, and Oregon, and participating metropolitan statistical area was Seattle-King County, Washington.*

use among those 18 years and older, and the Pfizer-BioNTech COVID-19 vaccine was approved for use among those 16 years and older.[15] During the week of March 15, 2021, the average 7-day incidence and deaths per 100 000 persons among participating states and MSA were 97.1 cases and 1.8 deaths, respectively (see Supplemental Digital Content Table S2, available at http://links.lww.com/JPHMP/A987, for detail on each state/MSA). Clinics were open for 2.8 days per week and 6.6 hours per day on average. Of the clinics, 50% were rural including Micropolitan (codes 5) or non-Core (Code 6) based on 2013 NCHS Urban-Rural Classification,[16] 90% were held indoors, and 40% offered multiple COVID-19 vaccines. Moderna was the most commonly offered vaccine (68%).

Table 2 presents the median and range of operational cost metrics across the 34 clinics. Median operational cost per day for a clinic was $10 314. Most of these costs came from staffing ($8594). There was a wide range in this metric from $637 to $95 163 per day. Median cost per vaccination was $38. The majority of this cost came from staffing ($29). There was also a wide range in this metric from $9 to $206 per vaccination. Table 2 also presents the median and range of start-up costs across the 34 clinics. Median start-up cost per clinic was $15 348 and had a large range from $1409 to $165 190. When standardizing to the average number of patients vaccinated per week, median start-up costs were $29 and still had a large range from $2 to $642.

To examine potential causes of the large range in costs, we compared median operational cost per vaccinated patient by 3 clinic characteristics: urban-rural; whether the clinic was open fewer than 3 days a week; and whether the clinic vaccinated 500 or more patients per day (Table 3). Median operational cost per vaccinated patient was higher for clinics in urban areas and for clinics that were open 3 or more days per week, but the differences were not statistically

TABLE 3

Median Operational Costs per Vaccinated Patient of Public Health Department–Run COVID-19 Vaccination Clinics in 34 Sites From 8 Participating States and 1 Participating Metropolitan Statistical Area[a] During the Week of March 15-19, 2021, by Clinic Characteristics

Clinic Characteristic	**N**	**Median Cost per Patient**	***P*[b]**
Rural	16	$33	.44
Urban	16	$40	
Open 3+ d/wk	15	$44	.29
Open <3 d/wk	19	$34	
500+ vaccinations per day	10	$20	**.05**
<500 vaccinations per day	24	$42	

[a] *Participating states were Arkansas, Colorado, Georgia, Illinois, Michigan, Minnesota, Nevada, and Oregon, and participating metropolitan statistical area was Seattle-King County, Washington.*

[b] **Boldface** *indicates statistical significance (*$P < .05$*).*

significant ($P < .05$). However, the median operational cost per vaccinated patient was significantly higher for clinics that vaccinated fewer than 500 patients per day.

Table 4 presents information on the average staff hours required per 100 vaccinated patients, the 3 most used staff types for each role, and the percentage of staff members who were paid or were volunteer. These are averages across clinics, and some clinics did not include all roles. Furthermore, these were the primary roles filled by each staff member and so they may work across roles at times. Average total staff hours per 100 patients vaccinated was 99. Vaccinators and "other" roles (eg, line control, runners, checkout, billing, security) were the roles that had the most staff hours per 100 vaccinated patients (19.4 hours for vaccinators, 19.5 for "other" staff). Clinical roles (vaccinator and vaccine preparer) accounted for 22.2 hours per 100 patients; management and supervisory roles accounted for 13.0 hours per 100 patients; nonclinical, nonmanagement roles accounted for 63.3 hours per 100 patients. Most roles were filled by registered nurses or administrative assistants. Most of the staff members were paid, but clinical staff members were likely to be volunteers (eg, 47% of vaccine preparers and 33% of vaccinators were volunteers).

Discussion and Conclusion

The results of this study show that clinics required substantial resources, especially staffing, to achieve the high throughput needed for vaccination during an acute pandemic response. This resulted in a median total cost of $38 per person vaccinated. There was a large range in cost estimates, indicating substantial variation in resource use across clinics. Operational costs were higher in urban clinics and clinics that were open 3 or more days per week, but these differences were not statistically significant, so they may not reflect real differences. Costs were also higher in clinics that administered fewer than 500 vaccinations per day. This was statistically significant, indicating that there were economies of scale in this sample of clinics.

Start-up costs per patient vaccinated had a large range ($2-$642). Anecdotally, clinics at the low end of the range were outfitted with more basic supplies and vaccinated a high volume of patients, thus lowering their average per vaccination cost, so reported resources may undercount actual resource requirements. Clinics at the high end of the range were clinics vaccinating relatively few patients but still required high-cost supplies, such as ultracold freezers and automated external defibrillators.

Comparing cost estimates from this study with other studies on the cost to provide vaccination may provide insight into the potential challenges of pandemic response vaccination. Three studies have estimated costs of dedicated clinics for 2009 H1N1 influenza pandemic vaccination and annual influenza vaccination. One study of school-located clinics during the H1N1 pandemic estimated a cost of $18.66 (2020 US dollars, inflated using Medical CPI[17]) per child receiving a vaccination.[4] Another study of H1N1 vaccination clinic costs estimated costs from $32 to $73 (2020 US dollars, inflated using Medical CPI18) per vaccination.[5] A study examined dedicated annual influenza vaccination clinics with a company that runs these clinics in various settings such as workplaces and community buildings and estimated a cost of $28.51 (2020 US dollars, inflated using Medical CPI18) per vaccination.[3] Comparison of cost estimates from the present study of COVID-19 vaccination clinics with cost estimates from 2009 H1N1 vaccination and annual influenza vaccination clinics indicates that COVID-19 pandemic response clinics may require more resources. The only other study of staffing of COVID-19 vaccination clinics found similar resource requirements to vaccinate 100 patients, approximately 100 staff hours in the first clinic and 60 staff hours in the second clinic.[7] This is comparable with the average of 99 hours we found in this study.

As of November 2021, Medicare reimbursement for COVID-19 vaccine administration is $40, which is similar to the median cost found in this study ($38 per vaccination). Prior to March 15, 2021, reimbursement was $16.94 for the first dose of a 2-dose vaccine and $28.39 for the second dose and the first dose of a single-dose vaccine.[18] Reimbursement by private insurers may have differed from Medicare reimbursement. In the early stages of COVID-19 vaccination, clinics run by state and local public health agencies did not necessarily bill insurers for vaccine administration. For example, only half of the clinics in this study reported billing insurers. Factors that may have contributed to less billing for vaccination included that federal funds were also available for clinical setup and operations, and some clinics may have had challenges with initiating billing procedures. Factors impacting billing are an important consideration for future research. Reimbursement is an important point to consider as the United States moves into later phases of the pandemic response and for planning the response to future pandemics to limit financial barriers to conducting PHD-run vaccination clinics. Ensuring timely and equitable vaccine access is key to reducing the health and economic impact of pandemics.[1] Future research can compare the costs of PHD-run COVID-19 vaccination clinics with the societal costs of low vaccination. However, modeling studies show that COVID-19 vaccination is cost-effective even at higher prices.[19]

TABLE 4

Average Staffing of Public Health Department–Run COVID-19 Vaccination Clinics in 34 Sites From 8 Participating States and 1 Participating Metropolitan Statistical Area[a] During the Week of March 15-19, 2021

Role	Average Staff Hours per 100 Patients[b]	3 Most Used Staff Types for Each Role (%)			% Paid	% Volunteer
Vaccinator	19.4	Registered nurse (62%)	EMT/paramedic (10%)	Physician (6%)	67%	33%
Postvaccination observer	8.0	Registered nurse (30%)	EMT/paramedic (25%)	County employee (16%)	81%	19%
Check-in/registration	15.0	Administrative assistant (32%)	County employee (19%)	Billing specialist (10%)	78%	22%
Clinic manager	7.7	Clinic manager (39%)	Registered nurse (37%)	Public health (5%)	100%	0%
Greeter	5.1	Medical assistant (23%)	Administrative assistant (22%)	Retired volunteers (12%)	78%	22%
Supervisory nurse	4.3	Registered nurse (91%)	Nurse practitioner (6%)	Physician (3%)	94%	6%
Scheduling	11.0	Administrative assistant (59%)	Registered nurse (14%)	FEMA staff (10%)	91%	8%
Data entry	5.7	Administrative assistant (46%)	County employee (11%)	Medical assistant (10%)	89%	11%
Logistics supervisor	1.1	Administrative assistant (41%)	Clinic manager (9%)	Registered nurse (9%)	100%	0%
Vaccine preparation	2.7	Registered nurse (81%)	Firefighter (8%)	Pharmacist (5%)	53%	47%
Other	19.5	Administrative assistant (19%)	County employee (17%)	Medical assistant (14%)	85%	15%

Abbreviation: EMT, emergency medical technician.

[a] *Participating states were Arkansas, Colorado, Georgia, Illinois, Michigan, Minnesota, Nevada, and Oregon, and participating metropolitan statistical area was Seattle-King County, Washington.*

[b] *May not add to totals due to rounding.*

Implications for Policy & Practice

This study provides the first estimates of the costs required to start up and run large-scale COVID-19 vaccination clinics during the pandemic response. To date, no other estimates of this important policy parameter are available, which has created a challenge for public health officials and other health care entities. These estimates can help public health officials and other health care entities in the following 2 ways:

- First, these estimate can help evaluate how best to allocate resources to support the pandemic response, including continuing to ensure access to COVID-19 vaccines.
- Second, it is important to note that many of the costs accounted for in these estimates were donated resources such as volunteer time and donated facilities, so the financial expenditures required differ from the total cost.

Limitations

This study was subject to several limitations. First, data were reported retrospectively and may be subject to recall challenges. Second, resources were reported during the peak COVID-19 vaccination period and may not be generalizable to other time periods. Third, costs were standardized using national averages, which may not reflect resource costs for specific areas. Finally, only the operation costs of the clinics themselves were included, so we did not include costs that may have been incurred by state IISs or other entities that supported vaccine distribution and reporting.

Conclusions

Despite the small sample size, these estimates are an important starting point for discussion around clinic costs, especially for PHD-run vaccination sites. To date, only case studies are available to help inform these discussions. Understanding the costs of PHD-run vaccination clinics for the pandemic response is essential for ensuring that resources are available for clinic success. These clinics are especially important for early phases of vaccination during the pandemic response when coordination of vaccine efforts for large numbers of people in targeted groups is required.

References

1. Goralnick E, Kaufmann C, Gawande AA. Mass-vaccination sites—an essential innovation to curb the COVID-19 pandemic. *N Engl J Med*. 2021;384(18):e67.
2. Levine DM, Linder JA, Landon BE. Characteristics of Americans with primary care and changes over time, 2002-2015. *JAMA Intern Med*. 2020;180(3):463-466.
3. Prosser LA, O'Brien MA, Molinari N-AM, et al. Non-traditional settings for influenza vaccination of adults. *Pharmacoeconomics*. 2008;26(2):163-178.
4. Cho B-H, Asay GRB, Lorick SA, Tipton ML, Dube NL, Messonnier ML. Costs of school-located influenza vaccination clinics in Maine during the 2009-2010 H1N1 pandemic. *J Sch Nurs*. 2012;28(5):336-343.
5. Cho B-H, Hicks KA, Honeycutt AA, et al. A tool for the economic analysis of mass prophylaxis operations with an application to H1N1 influenza vaccination clinics. *J Public Health Manag Pract*. 2011;17(1):E22-E28.
6. Centers for Disease Control and Prevention. Guidance for planning vaccination clinics held at satellite, temporary, or off-site locations. https://www.cdc.gov/vaccines/hcp/admin/mass-clinic-activities/index.html. Published 2021. Accessed August 31, 2021.
7. Moyce S, Ruff J, Galloway A, Shannon S. Implementation of a COVID-19 mass vaccination clinic to college students in Montana. *Am J Public Health*. 2021;111(10):1776-1779.
8. US Bureau of Labor Statistics. *May 2020 National Occupational Employment and Wage Estimates*. Washington, DC: US Bureau of Labor Statistics; 2021.
9. Simply Medical. Medical supplies. https://www.simplymedical.com. Accessed August 31, 2021.
10. Vericor LLC. Cool Cube. https://www.vericormed.com/product/cooler-cool-cube-08-vaccine-transport-cooler-at-refrigerated-temperatures-fresh-vaccine-vt-08. Accessed August 31, 2021.
11. LABRepCo. Laboratory equipment to help combat COVID-19 https://www.labrepco.com/laboratory-equipment-to-help-combat-covid-19. Accessed August 31, 2021.
12. NEWS Offices.net. United States commercial property prices 2020: per square foot. https://offices.net/news/2020-united-states-commercial-real-estate-prices-per-square-foot. Published 2021. Accessed August 31, 2021.
13. Statistia. Average rent per square foot paid for industrial space in the United States in 4th quarter 2020, by type. https://www.statista.com/statistics/626555/average-rent-per-square-foot-paid-for-industrial-space-usa-by-type. Published 2021. Accessed August 31, 2021.
14. StataCorp. *Stata Statistical Software*. Release 16. College Station, TX: StataCorp LLC; 2019.
15. HHS.gov. COVID-19 vaccine distribution: the process. https://www.hhs.gov/coronavirus/covid-19-vaccines/distribution/index.html. Accessed July 30, 2022.
16. Ingram DD, Franco SJ. 2013 NCHS Urban-Rural Classification Scheme for Counties. *Vital Health Stat 2*. 2014;(166):1-73.
17. US Bureau of Labor Statistics. *Consumer Price Index for All Urban Consumers: Medical Care*. Washington, DC: US Bureau of Labor Statistics; 2021.
18. Centers for Medicare & Medicaid Services. Medicare COVID-19 vaccine shot payment. https://www.cms.gov/medicare/covid-19/medicare-covid-19-vaccine-shot-payment. Published 2021. Accessed September 20, 2021.
19. Kohli M, Maschio M, Becker D, Weinstein MC. The potential public health and economic value of a hypothetical COVID-19 vaccine in the United States: use of cost-effectiveness modeling to inform vaccination prioritization. *Vaccine*. 2021;39(7):1157-1164.