Evaluation of Five Promising Practices Used During the COVID-19 Public Health Emergency to Improve Pediatric COVID-19 Immunization Rates

Technical Report

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Executive Summary

In February 2023, the Association of Immunization Managers (AIM) engaged Mathematica to conduct the Evaluation of Promising Practices for Improvement of Immunization Rates project to identify promising practices used during the COVID-19 public health emergency to improve COVID-19 vaccination uptake among children ages 6 months to 11 years (hereafter referred to as children). As part of this work, we conducted feasibility, policy, and economic analyses of five promising practices chosen in collaboration with AIM. Below, we list the five practices (Table ES.1). We offer this report for the consideration of jurisdictions interested in implementing the practices.

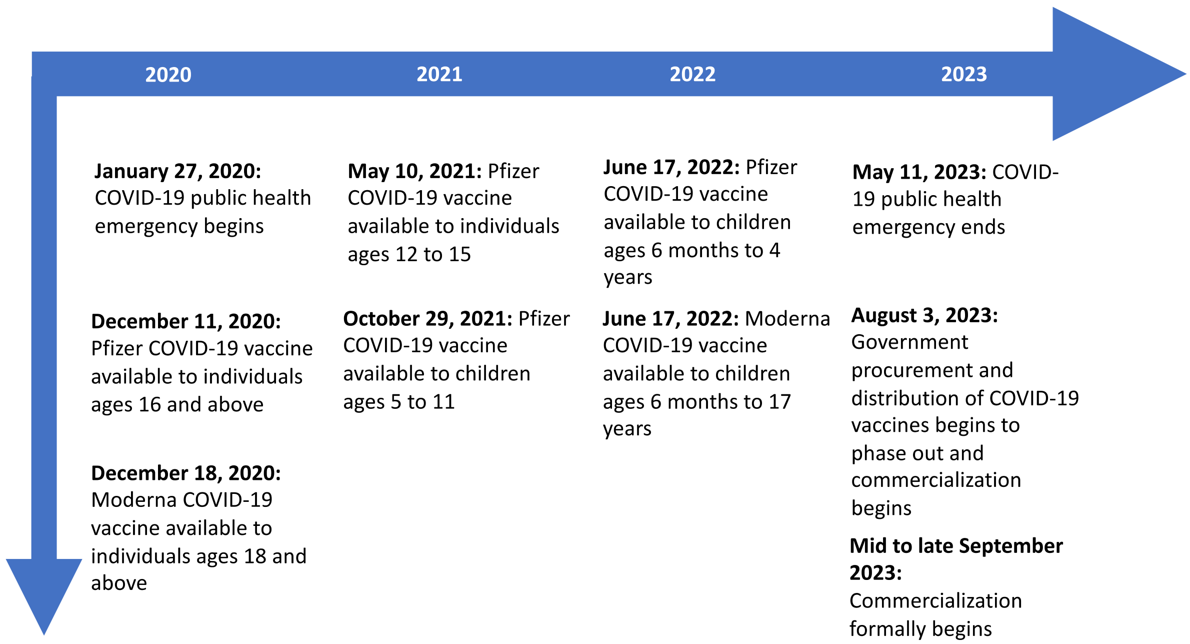
Table ES.1. Five promising practices for increasing uptake of COVID-19 vaccination among children ages 6 months to 11 years

Promising practice	Shorthand practice name	Description
Practice 1: Conducting targeted outreach to Medicaid beneficiaries for COVID-19 vaccines by linking Immunization Information System (IIS) and Medicaid data	Targeted outreach	Jurisdictions, health plans, or providers use IIS and Medicaid data to identify and reach out to families of unvaccinated children enrolled in Medicaid to encourage COVID-19 vaccination. This can include sending emails and texts and making telephone calls to families with unvaccinated children to provide information on the benefits of vaccination and where children can receive their vaccinations.
Practice 2: Connecting opportunities to vaccinate children against COVID-19 with the chance to address basic needs of children and families	Basic needs	Vaccination programs link or bundle COVID-19 vaccination delivery to children with connections to basic social and economic resources for families. Social and economic resources can include food assistance, diapers, home heating support or relief, rent assistance, or public health services. Vaccination programs can partner with organizations that provide social and economic resources to implement this practice.
Practice 3: Using mobile clinics to vaccinate children against COVID-19 at community-based locations	Mobile clinics	Providers use a vehicle, such as a van, to travel to community-based locations to administer COVID-19 vaccines to children. Mobile clinics may be set up to enable individuals to walk into the van to receive a vaccination, visit a tent set up in front of the van, or participate in a drive-thru process.
Practice 4: Vaccinating children against COVID-19 at home	At-home vaccination	Providers administer COVID-19 vaccines to children in their homes. Homes include residential homes, homeless shelters, and group homes.
Practice 5: Reducing operational barriers to help pediatric health care providers vaccinate children against COVID-19	Provider support	Federal, state, or local governments offer financial support, free or reduced-cost supplies, technical assistance, and/or additional staff to providers to support and encourage more of them to offer COVID-19 vaccinations to children. Support is often provided through partnerships with other organizations that might receive federal and state funding, such as community-based organizations, universities, and state and local departments of health.

IIS = Immunization Information Systems.

Key findings in this report are primarily based on pediatric vaccination strategies implemented during the COVID-19 public health emergency. However, these research findings apply more broadly after the public health emergency for COVID-19 vaccinations, routine vaccinations, and future pandemics. Below, we present a timeline of key events and dates regarding the COVID-19 public health emergency and COVID-19 vaccines for children (Figure ES.1). Following the figure, we list some of the major differences in implementation context for immunization program managers during versus after the COVID-19 public health emergency (Table ES.2).

Figure ES.1. Timeline of key events and dates regarding the COVID-19 public health emergency and COVID-19 vaccines for children



Sources: FDA 2021a; FDA 2021b; FDA 2022; Fortner et al. 2021; Katella 2021; Kates et al. 2022; TruMed Systems 2023.
Pfizer COVID-19 vaccine = Pfizer-BioNTech COVID-19 vaccine.

Table ES.2. Differences in the implementation context of pediatric vaccination strategies during versus after the COVID-19 public health emergency

Implementation context	During the public health emergency	After the public health emergency
Vaccine access for children	• The PREP Act temporarily authorized a range of health care providers, such as pharmacists, to administer COVID-19, flu, and routine vaccines to children ages 3 years and older. Some states also enacted new state policies to allow pharmacists to administer COVID-19 vaccines to children. • Access to COVID-19 vaccinations outside of traditional health care settings, such as pop-up clinics, schools, and drive-thru clinics.	• PREP Act provides authority for pharmacists to administer COVID-19 and flu vaccines to children ages 3 years and older through the end of 2024. • Access to pediatric COVID-19 vaccinations largely returned to traditional health care settings, such as doctors' offices and public health departments.

Implementation context	During the public health emergency	After the public health emergency
Funding for COVID-19 vaccines for children	• Federal government paid for all COVID-19 vaccines.	• Federal government pays for some COVID-19 vaccines through Vaccines for Children (VFC) program and private health insurance plans pay for COVID-19 vaccines.
Availability of qualified staff	• Urgent, large-scale need to vaccinate children against COVID-19 required a large number of staff to be hired quickly. • Some jurisdictions experienced high staff turnover, workforce shortages, and increased labor costs that challenged hiring whereas some other jurisdictions experienced low staff turnover and high retention.	• Comparatively fewer staff needed to implement practices given the smaller scale and less urgent nature of implementation. • Some jurisdictions experience fewer hiring challenges due to decreases in staff turnover, workforce shortages, and labor costs whereas some other jurisdictions continue to experience staffing challenges.
COVID-19 vaccine requirements and guidelines	• Rapidly changing requirements and guidelines for storing, transporting, and administering COVID-19 vaccines made it difficult to stay up to date.	• Fewer changes in requirements and guidelines for COVID-19 vaccines, which can make it easier for some jurisdictions to stay up to date; some other jurisdictions continue to experience difficulty staying up to date.
Demand for COVID-19 vaccines	• Relatively high demand despite low levels of vaccine confidence in some communities, potentially due to more public attention to the severity of illness after COVID-19 infection (demand varied by age group, with less demand for children ages 4 years and younger compared to children ages 12 and above).	• Relatively low demand, potentially due to low levels of vaccine confidence in some communities and less public attention to the severity of illness.
Funding for vaccine providers	• Strong will from federal, state, and local governments to support COVID-19 vaccination programs. • Public health emergency declaration made more government funding available for vaccination programs and offered a large number of allowances and flexibilities for spending (e.g., funding for the leasing, rental, and purchase of vans). • Diverse funding streams were more available, including from the commercial and non-profit sectors.	• Less federal funding and fewer allowances and flexibilities for spending exist (e.g., funding is available for the leasing and rental of vans, but not purchase). • Commercial markets play a comparatively larger role in the purchase and distribution of vaccines for privately insured populations.
Support from partners	• Higher engagement from partners to support practice implementation (e.g., co-hosting community events and donating items like vans.)	• Lower engagement from partners to support practice implementation.

Implementation context	During the public health emergency	After the public health emergency
Infrastructure development	• New investments in vaccine infrastructure needed to meet the urgent need and high demand.	• Some new investments in vaccine infrastructure need to be re-established and reinstated, as some investments were rapid and temporary; new investments need to be maintained and expanded.
Data to inform efforts to advance vaccine equity	• Some jurisdictions integrated data systems like Medicaid and IIS, enabling jurisdictions to use more robust data to inform efforts to advance vaccine equity.	• Integrated data systems need to be maintained and improved to inform efforts to advance vaccine equity.

Notes: The public health emergency (PHE) was from January 27, 2020 through May 11, 2023. For more information, see https://aspr.hhs.gov/legal/PHE/Pages/covid19-11Jan23.aspx and https://www.hhs.gov/coronavirus/covid-19-public-health-emergency/index.html.

The VFC program provides free vaccines to eligible children whose families cannot pay for vaccines. Children are eligible if they are age 18 years or younger and meet one of the following requirements: (1) American Indian or Alaska Native, (2) Medicaid eligible, (3) uninsured, or (4) underinsured. For more information, see https://www.cdc.gov/vaccines/programs/vfc/parents/index.html. DHHS = Department of Health and Human Services; PREP Act = Public Readiness and Emergency Preparedness Act.

Methodology. The feasibility, policy, and economic analyses assessed different aspects of the five promising practices. Therefore, each analysis used different research questions and analytic methods (Table ES.3). All three analyses used the same four data sources: (1) information from the Task 1 literature review, (2) articles from targeted internet searches, (3) information from the Vaccine Access Cooperative (VAC) meetings[1], and (4) virtual interviews with immunization program managers. The data sources for the Task 1 literature review included peer-reviewed literature, materials from organizations in the vaccine ecosystem, the AIM Program Practice Database, Centers for Disease Control and Prevention (CDC) internal documents, and CDC suggestions for potential promising practices.

Table ES.3. Research questions and analytic process for the feasibility, policy, and economic analyses

Analysis	Research questions	Analytic process
Feasibility	• What are the key facilitators, challenges, and resources needed to implement each of the five promising practices? • How can the practice be maintained and achieve desired outcomes over time? • How can the practice be applied to or adapted for different settings?	We developed a codebook that included codes for each practice, as well as codes related to the research questions, such as challenges and facilitators. We coded the data sources in NVivo, a qualitative coding software. We then used NVivo to generate queries of coded data by practice and theme, and we summarized code reports. We identified themes by and across each of the five practices.

[1] Vaccine Access Cooperative regional meetings brought together jurisdiction-based teams comprised of representatives of immunization programs, Medicaid medical directors, immunization coalitions, public education, the American Academy of Pediatrics, the American Academy of Family Physicians, pharmacist associations, and other key partners to discuss and design strategies to improve pediatric COVID-19 vaccination rates. Sixty-three teams were assembled and represented all 50 states, 6 major US cities, and 7 US territories and freely associated states.

Analysis	Research questions	Analytic process
Policy	• How does the policy landscape affect the implementation of the five promising practices? • What are examples of policies and/or factors that affect implementation of each practice?	We extracted relevant information from the data sources into an Excel-based tool, organized by policies and factors, that the research team developed. We then reviewed the tool to synthesize the information and identify important themes and nuances.
Economic	• What are the key benefits for each practice? • What are the key cost drivers for each practice? • Which of the five promising practices result in the greatest benefit-cost ratio?	We extracted relevant information from the data sources into an Excel-based tool organized by benefits and costs. We supplemented the previously noted sources with other external information, including but not limited to price information and hourly wage data for relevant professions, using the most recently available data from the Bureau of Labor Statistics (U.S. Bureau of Labor Statistics 2022). We then used the populated tool to calculate the net present value and benefit-cost ratio for each practice. We ranked practices based on their benefit-cost ratio, with practices having a higher ratio receiving a higher ranking. Last, we tested the sensitivity of the practices' benefit-cost ratios and rankings by varying key assumptions. Additional detail on methodology is in the Economic Analysis section.

We note key limitations to our work. First, we did not conduct systematic literature reviews for the five promising practices. Given that the COVID-19 pandemic began recently and is ongoing, the literature is modest and descriptive in nature. For this reason, we relied heavily on a small set of articles and on articles that were not specific to the pediatric population and COVID-19 vaccination. In addition, we did not reach data saturation, meaning we ended the data collection phase of the project before we stopped learning new information about the practices. We also did not gather information on or from every jurisdiction in the U.S. We made this decision in consideration of the project timeline and resources and to avoid placing undue burden on immunization program managers and other health and community leaders during the ongoing COVID-19 pandemic. We tried to minimize burden and maximize their responses by relying on convenience samples for both data collection at the VAC meetings and interviews, as well as CDC internal documents for promising practices. Moreover, our findings reflect the vaccination landscape at the time the three analyses were conducted. This means that some of the practices were implemented with support that was linked to one-time emergency federal funds. Practices were also supported with a mix of state and local government funds and private and philanthropic funds that were available during the public health emergency. As such, the practices may not be identically replicated in the future as the vaccination landscape changes due to the commercialization of COVID-19 vaccines and other factors.

Feasibility analysis key findings. Through the feasibility analysis, we found that jurisdictions can benefit from implementing combinations of the five practices rather than one practice in isolation. Combining practices enables jurisdictions to strengthen each practice's different benefits:

- Jurisdictions may consider implementing practices that increase demand for pediatric COVID-19 vaccinations in tandem with practices that increase access. This helps protect against demand for COVID-19 vaccinations outpacing availability of the vaccines. For example, the targeted outreach practice can increase demand for COVID-19 vaccinations and could be implemented with the mobile clinics practice, which can efficiently meet an increase in demand.
- Jurisdictions may consider implementing practices that efficiently reach large numbers of children in tandem with practices that improve vaccine equity by serving children from historically minoritized and/or underserved communities. For example, the targeted outreach practice can be used to reach a large population and could be implemented with the at-home practice that can reach children who are medically and/or socially underserved.

Jurisdictions that cannot implement combinations of practices due to resource limitations and other factors may consider implementing a single practice based on the level of resources and complexity required to start up, sustain, and scale the practice. For example, the basic needs promising practice could require a low level of resources to start up, sustain, and scale if a jurisdiction can incorporate the practice into existing infrastructure and partner with state and local organizations that can provide basic needs resources at low or no cost. In contrast, mobile clinics and at-home vaccination practices require high levels of resources to start up, sustain, and scale because they both require significant investments in the physical infrastructure to transport, store, and administer vaccines.

We also found that jurisdictions' formal and informal collaboration with local partners can support implementation of practices. Formal collaboration includes structured activities like surveys, interviews, and listening sessions. Informal collaboration involves building and maintaining relationships with local partners who are willing to share information about, and resources within, their communities. Local partnerships help jurisdictions do the following:

- **Draw on local expertise and knowledge,** such as how to navigate difficult terrain to access communities in remote regions.
- **Customize the practice to best serve the target community,** such as offering vaccinations at convenient venues, providing language translation resources, adapting practices to be culturally relevant, and considering how to make community members feel safe.
- **Build trust and acceptance between COVID-19 vaccinating providers and communities** by inviting local partners to play a role in fostering awareness and credibility of pediatric vaccination programs.
- **Improve the long-term capacity for jurisdictions to respond to public health emergencies.** While relationships with local partners may be difficult to establish quickly, they are necessary for effective responses in urgent public health crises, like the COVID-19 pandemic.
- **Share costs of implementing the practices,** with local partners providing free or discounted resources. Examples include local partners distributing basic needs resources to families at

vaccination events, and donating venues, vehicles for transportation, staff time, event promotion, and other support for the event’s operations.

Finally, we identified three main challenges to implementing the five practices during the COVID-19 public health emergency:

- **Difficulties hiring and retaining qualified staff,** given the high turnover during the pandemic as well as the time-sensitive nature of the public health emergency.
- **Complex and evolving guidelines for administering COVID-19 vaccines,** including keeping staff and programs updated on guidelines for storing and administering vaccines.
- **Managing additional reporting requirements** that were new for COVID-19 vaccines, especially for general pediatricians who are often already under resourced.
- After the public health emergency, jurisdictions face new challenges arising from the commercialization of COVID-19 vaccines, decreased demand for and attention to COVID-19 vaccination, and less and more restricted government and non-governmental funding.

Policy analysis key findings. Through the policy analysis, we identified these 11 key factors and policies that can affect the implementation of the five practices:

1. Organized groups can support or challenge the implementation of practices. (Organized groups are bodies of people working together for a specific purpose and can include nonprofits, for-profits, alliances, and associations.)
2. Policies authorizing a range of health care providers, such as pharmacists, to administer COVID-19 vaccines to children can make vaccination more accessible, possibly prompting more discourse and action for or against the practices.
3. Policies on minor consent for vaccination govern jurisdictions’ authorization to administer COVID-19 vaccines to minors who independently seek vaccination.
4. Policies offering state and federal funding to enhance data infrastructure and support data sharing can lead to improvements in vaccination data quality and sharing in the short- and long-term.
5. Managed care organization (MCO) requirements can support targeted outreach to unvaccinated Medicaid enrollees.
6. Policies on entities reporting vaccinations to the Immunization Information Systems (IIS) affect IIS data quality and use.
7. Policies requiring parent or guardian consent to report vaccinations of children to the IIS affect IIS data quality and, potentially, their reported vaccination rates.
8. Policies on COVID-19 vaccination data sharing can support targeted outreach to unvaccinated Medicaid enrollees.
9. State and local governments’ vaccination and resource dissemination events can help adults and children from communities that are disproportionately affected by COVID-19.

10. The changing guidelines for storing, transporting, and administering COVID-19 vaccines adds to the complexity of implementing the practices, potentially deterring some providers from offering vaccinations.

11. Policies offering federal and state funding to support pediatric health care providers in ensuring access to vaccinations.

Of these 11 key factors and policies, we found the following major takeaways:

- Organized groups supporting or opposing practice implementation affect the most promising practices (the targeted outreach, basic needs, mobile clinics, and at-home vaccination practices). This indicates that organized groups who engage in the vaccine ecosystem can have a strong influence on practice implementation.
- The targeted outreach practice is affected by most factors and policies (specifically, state policies). This indicates that practice implementation depends heavily on federal and state policymakers' decisions on funding, data reporting, and data sharing.

Economic analysis key findings. The purpose of the economic analysis is to offer an initial attempt to quantify the possible costs and benefits for each of the promising practices, with the goal of informing more rigorous future economic analyses. With this in mind, we conducted a high-level, hypothetical implementation scenario for an average county in the U.S. Across all five practices, we considered major benefits related to caretaker time, reduction in deaths, reduction in inpatient hospitalizations and other medical costs, and reduction in learning loss. Costs varied by practice but typically included costs associated with vaccination, training, outreach, wastage, refrigeration and storage, and staff time.

Three of the five practices—mobile clinics, basic needs, and targeted outreach—had a benefit-cost ratio greater than one, indicating that the benefits outweighed the costs.

- The mobile clinics practice had the largest benefit-cost ratio, 3.14. This practice is associated with moderate-to-high implementation costs ($1 million) and was approximately twice the cost to implement as the lowest-cost practice (targeted outreach), which was ranked third. However, it had a high benefit-cost ratio due to the large number of vaccinations generated by this practice which in turn generated the largest benefits (through reducing deaths, inpatient hospitalizations, other health care costs, learning loss, and caretaker time). It also has the advantage of bringing vaccination clinics to locations (such as supermarkets) that children and families frequently visit, rather than encouraging families to travel to a new, potentially out-of-the-way, location.
- The basic needs and targeted outreach practices showed the second and third highest benefit-cost ratios, respectively. The basic needs practice benefits from the use of community-based locations which reaches a greater population of children and families, thus the increase in overall benefits.
- The provider support practice had the lowest benefit-cost ratio (0.70) which was due to limited evidence of a large increase in vaccinations for this type of practice.

We assumed a six-month future time frame for the implementation of all five practices, with vaccinations occurring over 20 weeks (or about five months) within that period.

The economic analysis was premised on several assumptions. We varied these assumptions to test their sensitivity and noted that the benefit-cost ratios can vary substantially depending on factors such as assumptions around efficacy of the practice, reduction in deaths, inpatient hospitalizations and other health care costs, and changes in input costs, and many of these costs may change in a post-pandemic environment. Some varying assumptions also altered the ranking of practices. In particular, increasing software costs for the targeted outreach practice reduced the relative ranking of the practice, and increasing the population size increased its relative ranking. Finally, jurisdictions need to keep in mind that many of the inputs in this analysis (such as vaccination cost, inpatient and outpatient costs) will be different after the pandemic, so they need to consider how their jurisdiction may differ from the average county.

Implications. Although the public health emergency expired on May 11, 2023, jurisdictions can use the five promising practices described in this report to increase pediatric COVID-19 vaccination rates and apply the practices more broadly to routine vaccinations and future pandemics. Below, we list facilitators and challenges for implementing each practice during and after the COVID-19 public health emergency (Table ES.4). Following the table, we summarize the three common challenges affecting all or most of the five practices after the public health emergency.

Table ES.4. Facilitators and challenges for implementing each of the five promising practices during versus after the COVID-19 public health emergency

	During	After
Practice 1: Targeted outreach		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • High engagement from partners due to urgent need to vaccinate • Support for new investments in vaccine infrastructure (such as new data sharing functionalities)	• Some investments in vaccine infrastructure from during the public health emergency can be sustained and improved, which facilitates future improvements • Coverage for COVID-19 vaccinations makes vaccination free of charge for nearly all children who are eligible for the Vaccines for Children (VFC) program
Challenges	• Focus was often on making rapid and temporary investments in vaccine infrastructure, rather than long-term and sustainable investments	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding • Low engagement from partners due to competing priorities and perceptions that there is no longer an urgent need to vaccinate • Less support for new investments in vaccine infrastructure

	During	After
Practice 2: Basic needs		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • High engagement from partners due to urgent need to vaccinate • Many opportunities for vaccination outside of traditional health care settings • Federal government paid for all COVID-19 vaccines	• In some jurisdictions, less staff turnover, workforce shortages, and labor costs • Coverage for COVID-19 vaccinations makes vaccination free of charge for nearly all children who are eligible for the VFC program
Challenges	• High staff turnover, workforce shortages, and increased labor costs in some jurisdictions	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding • Low engagement from partners due to competing priorities and perceptions that there is no longer an urgent need to vaccinate • Fewer opportunities for vaccination outside of traditional health care settings
Practice 3: Mobile clinics		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • High engagement from partners due to urgent need to vaccinate • Temporary authorization of a wide range of health care providers to administer COVID-19 vaccines to children (through PREP Act and state policies) • Federal government paid for all COVID-19 vaccines	• Continuation of some states policies that authorized pharmacists to administer COVID-19 vaccines (will play a larger role after the PREP Act expires) • In some jurisdictions, less staff turnover, workforce shortages, and labor costs • Coverage for COVID-19 vaccinations makes vaccination free of charge for nearly all children who are eligible for the VFC program
Challenges	• High staff turnover, workforce shortages, and increased labor costs for some jurisdictions	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding • Low engagement from partners due to competing priorities and perceptions that there is no longer an urgent need to vaccinate • PREP Act authority for pharmacists to administer COVID-19 vaccines to children ages 3 and above expires in 2024 and reverts to state laws, which are more restrictive in many cases

	During	After
Practice 4: At-home vaccination		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • High engagement from partners due to urgent need to vaccinate • Federal government paid for all COVID-19 vaccines	• In some jurisdictions, less staff turnover, workforce shortages, and labor costs • Coverage for COVID-19 vaccinations makes vaccination free of charge for nearly all children who are eligible for the VFC program
Challenges	• High staff turnover, workforce shortages, and increased labor costs for some jurisdictions	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding • Low engagement from partners due to competing priorities and perceptions that there is no longer an urgent need to vaccinate
Practice 5: Provider support		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • Federal government paid for all COVID-19 vaccines	• Changes in requirements and guidelines for storing, transporting, and administering the different COVID-19 vaccines are less rapid, which can make it easier for some providers to stay up to date • Payment for vaccines through the VFC program and private insurance for nearly all children reduces financial risk
Challenges	• Rapidly changing requirements and guidelines for storing, transporting, and administering the different COVID-19 vaccines • Upfront provider costs for equipment and staffing to properly store and administer novel vaccines	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding

Note: The public health emergency was from January 27, 2020 through May 11, 2023. For more information, see https://aspr.hhs.gov/legal/PHE/Pages/covid19-11Jan23.aspx and https://www.hhs.gov/coronavirus/covid-19-public-health-emergency/index.html.

IIS = Immunization Information Systems; PREP Act = Public Readiness and Emergency Preparedness Act.

Three common challenges affect all or most of the five practices after the public health emergency:

1. **Less government and non-governmental funding.** Jurisdictions looking to implement any of the five practices after the public health emergency will likely need to identify new ways to fund practice implementation. For example, a jurisdiction that implemented a practice during the public health emergency only using government funding might implement the practice with a mix of government funding, philanthropic funding, and in-kind donations.
2. **Low engagement from partners.** Jurisdictions implementing the targeted outreach, basic needs, mobile clinics, and at-home vaccination practices after the public health emergency

might see potential and existing partners focusing less on COVID-19 vaccination. Jurisdictions might consider prioritizing building and maintaining long-term relationships with partners as these relationships are investments in the jurisdiction's long-term public health infrastructure. Local partners can provide critical knowledge and resources that can help jurisdictions successfully implement and improve the practices.

3. **Complexities arising from the commercialization of COVID-19 vaccines.** Without the federal government paying for all COVID-19 vaccines, jurisdictions implementing the basic needs, mobile clinics, at-home vaccination, and provider support practices after the public health emergency will need to consider how to support providers in billing multiple insurers for vaccines administered to privately insured patients while managing the requirements of the VFC program for those children who qualify.

Overall, the key findings and implications presented in this report document (1) early implementation experiences and insights of immunization program managers and other health and community leaders working to improve pediatric COVID-19 vaccination rates through five promising practices, (2) early factors and policies affecting implementation of the practices, and (3) estimated costs and benefits associated with the practices. We hope this report can advance opportunities for public health practitioners to share and learn from each other regarding promising practices to improve COVID-19 immunization rates among children. Research combined with dissemination can strengthen the existing infrastructure to respond to new or emerging crises.

I. Introduction

Since 1999, the Association of Immunization Managers (AIM) has been dedicated to working with state, local, and territorial immunization program managers to establish a country free of vaccine-preventable disease. In February 2023, AIM engaged Mathematica to conduct the Evaluation of Promising Practices for Improvement of Immunization Rates project to identify promising practices used during the COVID-19 public health emergency to improve COVID-19 vaccination uptake among children ages 6 months to 11 years (hereafter referred to as children). The project's key tasks are to (1) identify promising practices for improving COVID-19 vaccination uptake among children; (2) conduct feasibility, policy, and economic analyses of five promising practices chosen in collaboration with AIM; and (3) develop lessons-learned materials to aid in the implementation of the five promising practices. It is important to note that this report is offered as consideration for jurisdictions interested in implementing the practices.

> What are the feasibility, policy, and economic analyses?
>
> The feasibility analysis examines the potential for implementing and replicating the five practices in jurisdictions across the country.
>
> The policy analysis examines how the policy landscape affects implementation of the five practices.
>
> The economic analysis examines costs and benefits associated with implementation of the five practices.

In this report, we describe the key findings for the feasibility, policy, and economic analyses (see box). First, we describe the methodology for the three analyses. We then describe the key findings for each analysis. Key findings are primarily based on pediatric vaccination strategies implemented during the COVID-19 public health emergency. However, these research findings apply more broadly after the public health emergency for COVID-19 vaccinations, routine vaccinations, and future pandemics. We also describe the implications of the key findings for individuals and organizations interested in improving COVID-19 immunization rates among children. We conclude by describing how findings from these analyses will be disseminated to immunization program managers working to improve pediatric COVID-19 immunization rates in their jurisdictions. Below, we present the five practices (Table 1).

Table 1. Five promising practices for increasing uptake of COVID-19 vaccination among children ages 6 months to 11 years

Promising practice	Shorthand practice name	Description
Practice 1: Conducting targeted outreach to Medicaid beneficiaries for COVID-19 by linking Immunization Information System (IIS) and Medicaid data	Targeted outreach	Jurisdictions, health plans, or providers use IIS and Medicaid data to identify and reach out to families of unvaccinated children enrolled in Medicaid to encourage COVID-19 vaccination. This can include sending emails and texts and making telephone calls to families with unvaccinated children to provide information on the benefits of vaccination and where children can receive their vaccinations.
Practice 2: Connecting opportunities to vaccinate children against COVID-19 with the chance to address basic needs of children and families	Basic needs	Vaccination programs link or bundle COVID-19 vaccination delivery to children with connections to basic social and economic resources for families. Social and economic resources can include food assistance, diapers, home heating support or relief, rent assistance, or public health services. Vaccination programs can partner with organizations that provide social and economic resources to implement this practice.
Practice 3: Using mobile clinics to vaccinate children against COVID-19 at community-based locations	Mobile clinics	Providers use a vehicle, such as a van, to travel to community-based locations to administer COVID-19 vaccine to children. Mobile clinics may be set up to enable individuals to walk into the van to receive vaccinations, visit a tent set up in front of the van, or participate in a drive-thru process.
Practice 4: Vaccinating children against COVID-19 at home	At-home vaccination	Providers administer COVID-19 vaccines to children in their homes. Homes include residential homes, homeless shelters, and group homes.
Practice 5: Reducing operational barriers to help pediatric health care providers vaccinate children against COVID-19	Provider support	Federal, state, or local governments offer financial support, free or reduced-cost supplies, technical assistance, and/or additional staff to providers to support and encourage more of them to offer COVID-19 vaccinations to children. Supports are often provided through partnerships with other organizations that might receive federal and state funding, such as community-based organizations, universities, and state and local departments of health.

IIS = Immunization Information Systems.

II. Background

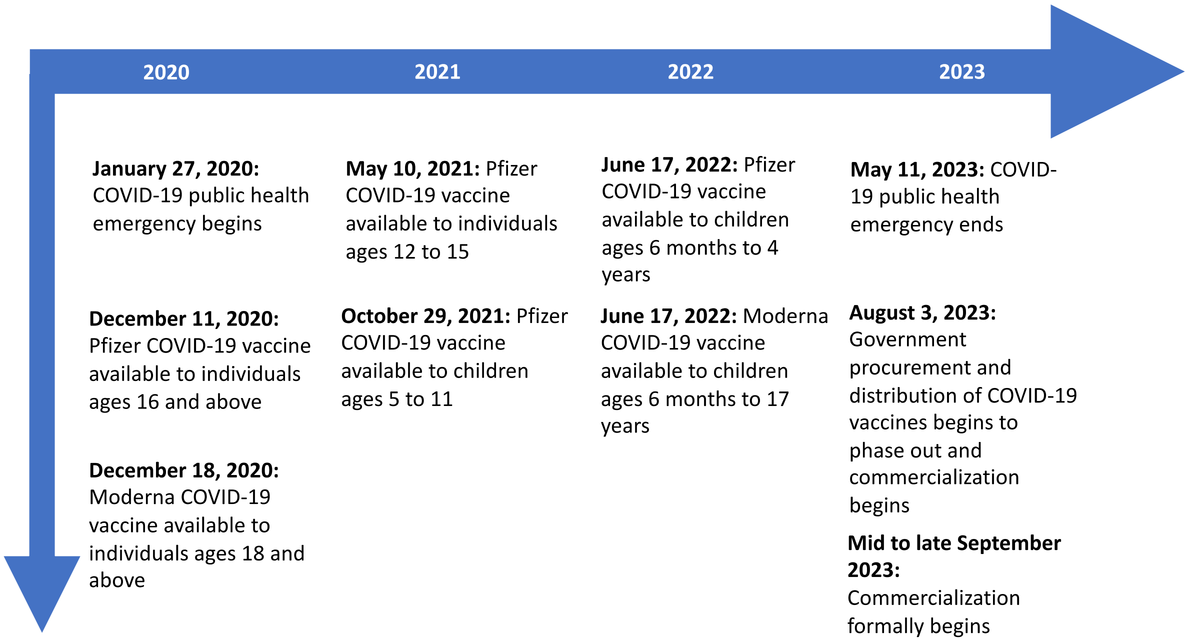
During the COVID-19 pandemic, the United States saw a decline in routine childhood immunizations, diminished vaccine confidence, and poor COVID-19 vaccination coverage among children (Peck 2022; CDC 2021). Addressing these trends and barriers to vaccination is essential to protecting public health and advancing health equity. Routine immunizations, particularly scheduled vaccines for infants, have been essential to preventing and eliminating disease, and reducing hospitalizations (CDC 2014; CDC 2021; Nandi & Shet 2020). COVID-19 vaccines have been an important pandemic mitigation tool and evidence suggests they protect children from severe illness, especially children with underlying medical conditions (CDC 2022a; Galvani et al. 2021; Gupta et al. 2021).

Efforts to promote immunization also play an important role in minimizing disparities in pediatric vaccination coverage rates and health across racial, ethnic, socioeconomic, and geographic lines (Walker et al. 2014). Strategies that tackle barriers to vaccine uptake and disparities in health care access and outcomes are necessary to protect individuals from historically minoritized and/or underserved communities, who are most at risk (DeSilva et al. 2022; Kawai & Kawai 2021).

Key findings in this report are primarily based on pediatric vaccination strategies implemented during the COVID-19 public health emergency. However, these research findings apply more broadly after the public health emergency for COVID-19 vaccinations, routine vaccinations, and future pandemics. As such, immunization programs can use this report as a framework to inform their work to improve vaccination coverage rates, including in response to future pandemics.

Below, we present a timeline of key events and dates regarding the COVID-19 public health emergency and COVID-19 vaccines for children (Figure 1). Following the figure, we list some of the major differences in implementation context for immunization program managers during versus after the COVID-19 public health emergency (Table 2). For example, a primary difference in the implementation context during versus after the COVID-19 public health emergency is the availability of new funding sources that facilitated the implementation of pediatric vaccination strategies. Federal funding sources included the Coronavirus State and Local Fiscal Recovery Funds administered by the Department of the Treasury, the Provider Relief Fund, and the American Rescue Plan Rural Distribution administered by the Health Resources and Services Administration (HRSA), the Coronavirus Relief Fund administered by the Department of the Treasury, and Disaster Grants – Public Assistance administered by the Federal Emergency Management Agency (FEMA) (U.S.A. Spending n.d.). Philanthropic organizations such as the Rockefeller Foundation and the Robert Wood Johnson Foundation also provided grants to support jurisdictions' response to the COVID-19 public health emergency (The Rockefeller Foundation n.d.; Robert Wood Johnson Foundation n.d.). Jurisdictions looking to implement any of the five practices after the public health emergency will likely need to find alternative funding sources.

Figure 1. Timeline of key events and dates regarding the COVID-19 public health emergency and COVID-19 vaccines for children



Sources: FDA 2021a; FDA 2021b; FDA 2022; Fortner et al. 2021; Katella 2021; Kates et al. 2022; TruMed Systems 2023.
Pfizer COVID-19 vaccine = Pfizer-BioNTech COVID-19 vaccine.

Table 2. Differences in the implementation context of pediatric vaccination strategies during versus after the COVID-19 public health emergency

Implementation context	During the public health emergency	After the public health emergency
Vaccine access for children	• The PREP Act temporarily authorized a range of health care providers, such as pharmacists, to administer COVID-19, flu, and routine vaccines to children ages 3 years and older. Some states also enacted new state policies to allow pharmacists to administer COVID-19 vaccines to children . • Access to COVID-19 vaccinations outside of traditional health care settings, such as pop-up clinics, schools, and drive thru clinics.	• PREP Act provides authority for pharmacists to administer COVID-19 and flu vaccines to children ages 3 years and older through the end of 2024. • Access to pediatric COVID-19 vaccinations largely returned to traditional health care settings, such as doctors' offices and public health departments.
Funding for COVID-19 vaccines for children	• Federal government paid for all COVID-19 vaccines.	• Federal government pays for some COVID-19 vaccines through Vaccines for Children (VFC) program and private health insurance plans pay for COVID-19 vaccines.

Implementation context	During the public health emergency	After the public health emergency
Availability of qualified staff	• Urgent, large-scale need to vaccinate children against COVID-19 required a large number of staff to be hired quickly. • Some jurisdictions experienced high staff turnover, workforce shortages, and increased labor costs that challenged hiring whereas some other jurisdictions experienced low staff turnover and high retention.	• Comparatively fewer staff needed to implement practices given the smaller scale and less urgent nature of implementation. • Some jurisdictions experience fewer hiring challenges due to decreases in staff turnover, workforce shortages, and labor costs whereas some other jurisdictions continue to experience staffing challenges.
COVID-19 vaccine requirements and guidelines	• Rapidly changing requirements and guidelines for storing, transporting, and administering COVID-19 vaccines made it difficult to stay up to date.	• Fewer changes in requirements and guidelines for COVID-19 vaccines, which can make it easier for some jurisdictions to stay up to date; some other jurisdictions continue to experience difficulty staying up to date.
Demand for COVID-19 vaccines	• Relatively high demand despite low levels of vaccine confidence in some communities, potentially due to more public attention to the severity of illness after COVID-19 infection (demand varied by age group, with less demand for children age 4 years and younger compared to children age 12 and above).	• Relatively low demand, potentially due to low levels of vaccine confidence in some communities and less public attention to the severity of illness.
Funding for vaccine providers	• Strong will from federal, state, and local governments to support COVID-19 vaccination programs. • Public health emergency declaration made more government funding available for vaccination programs and offered a large number of allowances and flexibilities for spending (e.g., funding for the leasing, rental, and purchase of vans). • Diverse funding streams were more available, including from the commercial and non-profit sectors.	• Less federal funding and fewer allowances and flexibilities for spending exist (e.g., funding is available for the leasing and rental of vans, but not purchase). • Commercial markets play a comparatively larger role in the purchase and distribution of vaccines for privately insured populations.
Support from partners	• Higher engagement from partners to support practice implementation (e.g., co-hosting community events and donating items like vans).	• Lower engagement from partners to support practice implementation.
Infrastructure development	• New investments in vaccine infrastructure needed to meet the urgent need and high demand.	• Some new investments in vaccine infrastructure need to be re-established and reinstated, as some investments were rapid and temporary; new investments need to be maintained and expanded.

Implementation context	During the public health emergency	After the public health emergency
Data to inform efforts to advance vaccine equity	• Some jurisdictions integrated data systems like Medicaid and IIS data systems, enabling jurisdictions to use more robust data to inform efforts to advance vaccine equity.	• Integrated data systems need to be maintained and improved to inform efforts to advance vaccine equity.

Notes: The public health emergency was from January 27, 2020 through May 11, 2023. For more information, see https://aspr.hhs.gov/legal/PHE/Pages/covid19-11Jan23.aspx and https://www.hhs.gov/coronavirus/covid-19-public-health-emergency/index.html.

The VFC program provides free vaccines to children whose families cannot pay for vaccines. Children are eligible if they are age 18 years or younger and meet one of the following requirements: (1) American Indian or Alaska Native, (2) Medicaid eligible, (3) uninsured, or (4) underinsured. For more information, see https://www.cdc.gov/vaccines/programs/vfc/parents/index.html.

DHHS = Department of Health and Human Services; PREP Act = Public Readiness and Emergency Preparedness Act.

III. Methodology

To identify the five promising practices, we conducted a literature review to find public health practices that focus on increasing pediatric vaccination rates in the U.S. (Task 1). Data sources included peer-reviewed literature, materials from organizations in the vaccine ecosystem, the AIM Program Practice Database, Centers for Disease Control and Prevention (CDC) internal documents, and CDC suggestions for potential promising practices. We used PubMed and LitCovid to identify peer-reviewed literature and a Google search to identify materials from organizations in the vaccine ecosystem, including state and local government agencies and news organizations. The CDC provided internal documents and suggestions from CDC Project Officers' review of COVID-19 immunization progress reports. The literature review search was initially designed to only identify information on practices related to pediatric COVID-19 vaccination. However, after our initial search yielded limited information, we expanded the search to include information on practices related to routine vaccination.

For information identified through the data sources, we used a set of screening criteria to review the title and front matter of the information (such as the abstract) to assess the information for relevance. We included information on practices that (1) were implemented in the U.S. or its territories, (2) involved vaccination of children ages 6 months to 11 years or targeted parents or caregivers of children ages 6 months to 11 years, and (3) were implemented after 2020 for COVID-19 vaccination or after 2013 for routine vaccination. We screened information that met these criteria and then reviewed the screened-in information in full. We documented information in an Excel-based tool that we organized by common implementation factors listed in public health materials from CDC, Organization for Economic Cooperation and Development, World Health Organization, and Journal for Public Health Research (Ng & de Colombani 2015; OECD 2022; Spencer et al. 2013; WHO 2017). We then analyzed the details in the tool to identify practices and associated themes and nuances.

Through the literature review, we identified eight promising practices and developed a scoring rubric to assess the practices. The rubric included three domains: (1) process, (2) context, and (3) outcomes. The process domain focused on whether the practice was replicable, ethical, equitable, engaged community, and involved partnerships. The context domain focused on whether the practice was relevant to the target community and addressed its needs. The outcomes domain focused on whether the practice was evidence-based, effective, efficient, and sustainable. Because limited information on practice outcomes was available, we used supplemental resources from the CDC and Journal of Pediatrics to inform our scores in the outcomes domain. These resources included information on outcomes for the practices as they applied to routine vaccination (CDC 2022b; Siddiqui et al. 2022). At least two people on the project team scored each practice in the three domains, ensuring that scoring was executed accurately. We then ranked each practice by its sum score across all three domains. We presented the eight practices and their rankings to AIM and collaborated to select five of the practices to focus on for the feasibility, policy, and economic analyses, prioritizing practices that were novel and had not been studied in depth by AIM in the past.

The feasibility, policy, and economic analyses assessed different aspects of the five practices. Therefore, each analysis used different research questions and analytic methods (Table 3). All three analyses used the same data sources (below). As previously described, the literature review search was initially designed to only identify information on practices related to pediatric COVID-19 vaccination but was expanded to include information on practices related to pediatric routine vaccination[2] after our initial search yielded limited information. As such, the targeted internet searches we conducted for the feasibility, policy, and economic analyses also included identifying information on routine vaccination that could apply to the five practices.

- **Information from the Task 1 literature review.** We used relevant information about the five practices from the literature review described above. Additional details on the Task 1 literature review methodology are in the PowerPoint slide deck titled "Selection of Five Practices from a List of Eight Promising Practices," which was submitted to AIM on March 30, 2023.
- **Articles from targeted internet searches.** We performed targeted internet searches for additional articles related to the practices. Because of the low volume of literature on children's vaccination programs, we expanded our search to include articles about adults and the general population. (The Task 1 literature review excluded articles about these populations and focused solely on children.)
- **Information from the Vaccine Access Cooperative (VAC) meetings.** Mathematica attended three of eight 2023 VAC regional meetings. The VAC meetings convened immunization program managers and other individuals working to increase uptake of COVID-19 vaccination to develop jurisdiction-specific strategies to improve COVID-19 vaccination rates among children.[3] At all three meetings, one member of the project team attended plenaries and took notes. At two of the meetings, we conducted five focus groups with immunization program managers and other health and community leaders to understand their firsthand experiences with and perspectives on the five practices.[4] Each focus group discussed up to two practices. To guide the focus groups, we developed a protocol that included a survey and a discussion guide. The survey asked participants whether they had implemented any of the five practices, and the discussion guide included open-ended questions on issues not adequately described in the literature but for which we needed information for the three analyses. We assigned participants to focus groups on the basis of their jurisdiction. When possible, we assigned participants to a focus group that covered a practice implemented in their jurisdiction. Two to five jurisdictions were assigned to each focus group, and focus groups had between 20 to 35 participants. Each focus group was led by two people from the project team with one leading the discussion and the other taking notes.

[2] Articles were included if they involved strategies for vaccination of children ages 6 months to 11 years or targeted parents or caregivers of children ages 6 months to 11 years.

[3] Mathematica attended VAC meetings in Itasca, Illinois; Denver, Colorado; and Portland, Maine. VAC meetings are convened by AIM in collaboration with the National Academy for State Health Policy and Academy Health.

[4] Mathematica conducted two and three focus groups at the VAC meetings in Itasca and Denver, respectively.

- **Virtual interviews.** We conducted eight virtual, semi-structured interviews with immunization program managers from jurisdictions that had implemented one or more of the five practices. We identified a pool of potential jurisdictions to interview using information from the literature review and VAC meetings, AIM and CDC recommendations, and snowball sampling. We invited immunization program managers or their designees to participate in interviews via email. Interviews were conducted in July and August 2023. Each interview focused on one or two practices that had been implemented in the jurisdiction. Interviews included one to three interviewees. Two project team members conducted each interview: an interviewer and a notetaker. Interviews were recorded and transcribed with WebEx, a secure web conference platform.
- **Input and feedback from the AIM Legacy Council.** The AIM Legacy Council is an advisory group comprised of former immunization program managers that provides guidance to AIM on organizational strategies and awardee program needs. Throughout the development of this report, we consulted with the Legacy Council via virtual meetings and email to incorporate their input and feedback into the report, particularly in the background and economic analysis sections.

We note key limitations to our work. First, we did not conduct systematic literature reviews for the five promising practices. Given that the COVID-19 pandemic began recently and is ongoing, the literature is modest and descriptive in nature. For this reason, we relied heavily on a small set of articles and on articles that were not specific to the pediatric population and COVID-19 vaccination. In addition, we did not reach data saturation, meaning we ended the data collection phase of the project before we stopped learning new information about the practices. We also did not gather information on or from every jurisdiction in the U.S. We made this decision in consideration of the project timeline, resources, and to avoid placing undue burden on immunization program managers and other health and community leaders during the ongoing COVID-19 pandemic. We tried to minimize burden and maximize their responses by relying on convenience samples for both focus groups and interviews, as well as CDC internal documents for promising practices. Moreover, our findings reflect the vaccination landscape at the time the three analyses were conducted. This means that some of the practices were implemented with support that was linked to one-time emergency federal funds. Practices were also supported with a mix of state and local government funds and private and philanthropic funds that were available during the public health emergency. As such, the practices may not be identically replicated in the future, as the landscape changes due to commercialization of COVID-19 vaccines and other factors.

The economic analysis also has specific limitations. We used a variety of assumptions that are heavily time- and context-specific. For example, we assumed that the number of COVID-19 cases during the six-month time frame (with up to 20 weeks of vaccination within this period) for this analysis would be similar to the number of cases during calendar years 2021 and 2022 (when many of the five practices were initially implemented), but with pediatric vaccination rates at the levels that were observed in May 2023 (CDC 2023a). In addition, we assumed that childhood vaccinations reduce both susceptibility to infection and transmission to others in the household, particularly adults (Madewell et al. 2022). This is a crucial assumption, because childhood death rates from COVID-19 could be as low as 1 per 100,000, suggesting that most benefits in terms of reduced deaths would have to come from reductions in transmission to adult caretakers (Flaxman et al. 2023); more generally, our assumptions related to the number of cases hospitalizations, and outpatient medical costs assume that childhood vaccinations prevented transmission to adults. The true distributions of cases, deaths, inpatient hospitalizations, and outpatient medical costs averted due to targeted pediatric vaccination could vary considerably from our assumptions. Finally, many of the assumptions around both costs and benefits come from points in time during the height of the COVID-19 pandemic and may not be applicable going forward; for example, there will likely be less severe labor shortages (and therefore lower labor costs) for health care workers in a post-pandemic environment. As we note below, due to the substantial uncertainty around our estimates—particularly the assumptions around potential benefits—the magnitude of the benefit-cost ratios should be treated cautiously. The purpose of this analysis is to offer an initial attempt to quantify the potential relative costs and benefits for each of the promising practices, with the goal of informing more rigorous future economic analyses.

Table 3. Methodology for the feasibility, policy, and economic analyses

Analysis	Research questions	Analytic process
Feasibility	• What are the key facilitators, challenges, and resources needed to implement each of the five promising practices? • How can the practice be maintained and achieve desired outcomes over time? • How can the practice be applied to or adapted for different settings?	We developed a codebook that included codes for each practice, as well as codes related to the research questions, such as challenges and facilitators. We coded the data sources in NVivo, a qualitative coding software. We then used NVivo to generate queries of coded data by practice and theme, and we summarized code reports. We identified themes by and across each of the five practices.
Policy	• How does the policy landscape affect the implementation of the five promising practices? • What are examples of policies and/or factors that affect implementation of each practice?	We extracted relevant information from the data sources into an Excel-based tool, organized by policies and factors, that the research team developed. We then reviewed the tool to synthesize the information and identify important themes and nuances.
Economic	• What are the key benefits for each practice? • What are the key cost drivers for each practice? • Which of the five promising practices result in the greatest benefit-cost ratio?	We extracted relevant information from the data sources into an Excel-based tool organized by benefits and costs. We supplemented the previously noted sources with other external information, including but not limited to price information and hourly wage data for relevant professions using the most recently available data from the Bureau of Labor Statistics (U.S. Bureau of Labor Statistics 2022). We then used the populated tool to calculate the net present value and benefit-cost ratio for each practice. We ranked practices based on their benefit-cost ratio, with practices having a higher benefit-cost ratio receiving a higher ranking. Lastly, we tested the sensitivity of the practices' benefit-cost ratios and rankings by varying key assumptions. Additional detail on methodology is in the Economic Analysis section.

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IV. Feasibility Analysis

Here, we describe the key findings that emerged from the feasibility analysis. We first describe how the five promising practices influence the demand for and access to pediatric COVID-19 vaccinations. We then describe how jurisdictions used resources and local partnerships to implement, sustain, and scale the practices. Finally, we describe the major challenges that immunization program managers reported facing during the COVID-19 public health emergency.

Using practices that increase demand for pediatric COVID-19 vaccinations in tandem with practices that increase access helps ensure that the demand does not outpace the availability of vaccines. Two practices—targeted outreach and basic needs—increase the demand for pediatric COVID-19 vaccinations, whereas the remaining three practices—mobile clinics, at-home vaccination, and provider support—increase access to vaccinations in communities (Table 4). VAC attendees discussed the importance of implementing demand-focused and access-focused practices together, noting the ethical predicament that can result when practices that increase demand for pediatric COVID-19 vaccination are implemented in communities with limited or poor access to vaccinations. For example, interviewees suggested implementing the targeted outreach practice with the mobile clinics practice, pop-up clinics, or mass vaccination sites—the combination of which can efficiently meet increases in demand for COVID-19 vaccinations. If targeted outreach to families is timed to occur shortly before an upcoming mobile, pop-up, or mass pediatric vaccination event, the two practices can, together, help ensure that demand does not exceed vaccine availability.

Implementation context during the public health emergency (PHE) versus post PHE

During the COVID-19 PHE, there was high demand for, and increased access to, COVID-19 vaccines, potentially due to more public attention on the severity of illness after COVID-19 infection and the urgency to vaccinate against COVID-19. Jurisdictions looking to implement the practices after the PHE may take into account the reduced demand for, and access to, COVID-19 vaccines.

Table 4. How the five promising practices focus on increasing demand or access to pediatric COVID-19 vaccinations

Practice	How demand or access may increase
Increases demand for COVID-19 vaccination	
Practice 1: Targeted outreach	This practice can remind and encourage families to vaccinate their children, for example, by reminding them that their child has not been vaccinated and providing information on the benefits of vaccination.
Practice 2: Basic needs	Families may feel more motivated to seek vaccinations for their children if they can simultaneously vaccinate their children and receive social and economic resources to help them meet their basic needs, as with diapers or food assistance.
Increases access to COVID-19 vaccination	
Practice 3: Mobile clinics	The mobile clinics and at-home vaccination practices increase availability of vaccinations by offering them in locations outside of traditional health care settings.
Practice 4: At-home vaccination	

Practice	How demand or access may increase
Practice 5: Provider support	Financially supporting providers who offer pediatric COVID-19 vaccinations may increase the number of providers who do so.

Practices that efficiently use resources can help reach large numbers of children, while other practices may use higher levels of resources to reach a smaller but more underserved or historically minoritized population. Jurisdictions may consider using a combination of vaccination strategies to achieve efficient *and* equitable improvements in pediatric COVID-19 vaccination rates.

Each of the five promising practices requires different levels of resources to *start up*, *sustain*, and *scale* to different or larger populations. The targeted outreach and provider support practices can strengthen local vaccination infrastructure, using lower levels of resources in the long term (*sustain*), but they require a high level of upfront investment (*start-up*). The targeted outreach practice can be resource-intensive in both time and funding, driven by the high-level resources required to integrate Medicaid and Immunization Information Systems (IIS) data systems (*start-up*). The needed investment can include the resource-intensive activities of upgrading legacy systems to current systems that can facilitate data integration and improving data quality so that missing or inaccurate data do not impede patient matching (Greene et al. 2021). After these initial investments, however, outreach to families with unvaccinated children can be conducted via low-cost, automated, and regular processes like telephone calls, text messages, emails, and other reminder and recall systems (*sustain*) (Community Preventive Services Task Force [CPSTF] 2020c). Similarly, the provider support practice can require substantial upfront resources when funds are being disbursed to providers (*start-up*) but can have a lasting impact without the need to sustain funding for the practice. For example, the California Department of Public Health administered one-time grants of $10,000 to providers serving pediatric populations who enrolled in the federal government's COVID-19 Vaccination Program. Interviewees reported that, after the grant money was disbursed, the county ended the program and providers who participated could continue providing COVID-19 vaccinations at no additional cost to the state.

The mobile clinics and at-home vaccination practices require high levels of resources to both start up and sustain but can potentially improve vaccine equity by reaching children who are medically and/or socially underserved. Because both practices administer vaccines in locations outside of traditional health care settings, they require significant investments in the physical infrastructure required to transport, store, and administer vaccines (*start-up*). The investment includes refrigeration and freezer units, digital data loggers, vehicles, and mobile technology (such as laptops, tablets, and mobile wireless internet devices) for accessing and updating patient records. Moreover, both practices require a high level of ongoing resources compared to the other three practices, given the need to maintain or retain the vehicles, vaccine stock and related supplies, technology, and staff who administer vaccines and run operations (*sustain*).

In contrast, the basic needs practice could require fewer resources to start up, sustain, and scale because jurisdictions can incorporate the practice into existing infrastructure and partner with state and local organizations that can provide basic needs resources at low or no cost. Immunization program managers can add the basic needs practice to existing methods of delivering vaccinations, such as by offering a basic needs resource with a mobile clinic or an at-home vaccination program. Alternatively, an existing program that offers basic needs resources can invite COVID-19 vaccination providers to administer vaccines in its setting. For example, a community-based organization or social service agency may partner with a vaccination program that parks a mobile clinic in its parking lot or creates a pop-up clinic inside its building. Jurisdictions can also save costs by partnering with organizations that already have funding to provide basic needs resources at low or no cost.

The targeted outreach practice can be easily *scaled* to more or larger populations without a substantial investment in resources. The remaining four practices are not as easily scaled but can be important investments for improving vaccine equity. Jurisdictions with integrated Medicaid and IIS data systems and automated outreach processes can potentially reach all unvaccinated children who are insured by the state's Medicaid program without infusing large amounts of additional resources. On the other hand, the remaining four practices have greater potential to target and reach medically and/or socially underserved populations, such as children and families who are homebound, lack transportation or convenient access to vaccination sites, or live in communities where pediatric COVID-19 vaccinations are not accessible through a child's medical home.

Based on its systematic review of community-based vaccination programs that use a combination of interventions, the Community Preventive Services Task Force (CPSTF) recommends that jurisdictions use a combination of resource-efficient and resource-intensive practices (CPSTF 2020c). The combination enables jurisdictions to advance equity in vaccination access and uptake, reaching large portions of the population through resource-efficient practices (like targeted outreach) while also dedicating extra resources to reaching historically minoritized and underserved populations by funding the other four practices. Figure 2 summarizes the level of resources and complexity required to start up, sustain, and scale the practices, and includes information on how the practice can advance vaccine equity.

Figure 2. Resource, complexity, and equity considerations to start up, scale, and sustain each promising practice

	Start up	Scale	Sustain	
Practice 1: Targeted outreach	⊖	☑	☑	• **Resources:** High level to start up, but relatively low level to scale and sustain. For example, a jurisdiction will require a high level of resources to establish technological infrastructure but fewer resources to maintain it. • **Complexity:** Establishing technology infrastructure can be complex. For example, jurisdictions may need to establish data sharing agreements with multiple partners and make several upgrades to their technological functionalities. • **Equity:** This practice can advance equity by focusing outreach on specific medically underserved communities, such as unvaccinated Medicaid beneficiaries in particular zip code areas.
Practice 2: Basic needs	☑	☑	☑	• **Resources:** Low level to start up, scale, and sustain because jurisdictions can partner with organizations that donate basic needs resources, or with existing vaccine programs. • **Complexity:** Not complex if a jurisdiction works with partners to implement. • **Equity:** This practice can advance equity by tailoring the basic needs and vaccine programs to the unique needs of specific medically underserved communities.
Practice 3: Mobile clinics	⊖	⊖	⊖	• **Resources:** Similarly high levels to start up, scale, and sustain. As mobile clinics are implemented in more locations and for longer periods of time, more resources (like staff and equipment) are needed. • **Complexity:** The level of complexity can remain high as mobile clinics are implemented in more locations and for longer periods of time. • **Equity:** Mobile clinics can increase access to vaccination in medically underserved communities.
Practice 4: At-home vaccination	⊖	⊖	⊖	• **Resources:** Similarly high levels to start up, scale, and sustain. The level of resources (such as staff and equipment) needed remains relatively constant, even as more vaccinations at home are given over time. • **Complexity:** The level of complexity of the practice does not change as vaccinations are administered in more homes over time. • **Equity:** Both practices can increase access to vaccination in medically underserved communities.
Practice 5: Provider support	⊖	⊖	☑	• **Resources:** High level to start up and scale because this is a one-time investment for a jurisdiction; there is no additional burden on jurisdictions or providers to sustain the practice. • **Complexity:** Can be complex depending on how many providers a jurisdiction is aiming to support and how. • **Equity:** This practice can advance equity by catering support to providers serving medically underserved communities.

⊖ = Qualitative analysis of literature, interview, and focus group data indicate that the practice requires a *high* level of resources and is complex to implement.

☑ = Qualitative analysis of literature, interview, and focus group data indicate that the practice requires a *low* level of resources and is *not* complex to implement.

Note: These findings are based on the qualitative data included in the feasibility analysis. Findings on practice costs and effectiveness are discussed in the economic analysis in Section IV.

Jurisdictions can improve practice implementation by formally and informally collaborating with local partners to (1) use local expertise and knowledge, (2) customize the practice to best serve the target community, (3) build trust and acceptance between COVID-19 vaccination providers and communities, and (4) share costs of implementing the practices.

Jurisdictions can collaborate with local partners formally or informally. Formal collaboration includes structured activities like surveys, interviews, and listening sessions. Informal collaboration includes building and maintaining relationships with local partners who are willing to share information about the strengths, available resources, needs, and challenges in their communities. Exhibit 1 provides an example of how a formal collaboration contributed to a vaccination program's success.

Exhibit 1. Pima County Health Department's successful strategy for designing and implementing a community-informed COVID-19 vaccination program

In 2021, the Pima County Health Department conducted key informant interviews, recruiting respondents through local partnerships with county officials, local food banks, the local school district, and a community-based nonprofit organization. Through these interviews, the health department learned about the specific challenges the community faces to vaccinating against COVID-19, as well as how the community thinks they could improve their vaccination rates. The health department considered this feedback when designing and implementing an event that aimed to motivate families to vaccinate against COVID-19, with the goal of vaccinating 100 families. The event surpassed its goal, vaccinating 101 families, which included 122 people. The health department also reached an unstated goal of enabling community members to feel heard and appreciated by incorporating their insights into the program.

Source: Monroy & Cullen 2022.

First, collaborating with local partners to incorporate local expertise and knowledge of the community into the design and implementation of the practice can lead to more efficient implementation. For example, when vaccination providers travel to administer vaccines at homes or via mobile clinics, they may have to travel to remote areas or navigate difficult terrain, such as dirt or mountainous roads. In such cases, vaccination providers can benefit from local partners, such as emergency managers, who can offer knowledge about travel conditions in remote areas.

Next, collaborating with local partners can also help jurisdictions customize the practices to be more relevant and helpful to the target community. Some of the interviewees and VAC meeting attendees described how community feedback helped inform adaptations to the practices that were population specific. Examples include the following:

- **Venue selection.** Interviewees and VAC meeting attendees reported that where mobile clinics park affects attendance and that the best locations for parking a mobile clinic vary by community. Local partners can provide detailed insight into the locations that the target population finds convenient and frequently visits. Similarly, for the basic needs practice, local partners can provide input on settings for co-locating vaccination delivery and social and economic resources, such as back-to-school health fairs, vaccination clinics, or the offices of social programs like the Special Supplemental Nutrition Program for Women, Infants, and Children.

- **Language accessibility.** VAC meeting attendees also said that local partners provide insight into the target population’s preferred language and any needs for language translation. As a result of local input, jurisdictions might find that they need to hire multilingual staff or temporary translators. They may also find a need to offer written materials, such as brochures on the benefits of pediatric COVID-19 vaccinations, in the languages and at the reading levels preferred by the target population.
- **Cultural relevance**. For the basic needs practice, local input can help identify which free or low-cost resources will motivate families in the target population to vaccinate their children—or, conversely, which efforts may alienate them.
- **Safety.** Safety is also a consideration. Families are more willing to engage in practices when they feel comfortable and safe. Extra privacy or security measures during vaccination may encourage families to participate.

Third, local partners can facilitate the community’s trust and acceptance of COVID-19 vaccination providers and programs. Interviewees and VAC meeting attendees described the important role of local partners in fostering awareness and credibility of pediatric vaccination programs. Local partners’ roles ranged from promoting the vaccination programs to volunteering or helping run them. Community members may be more likely to engage with a practice they know is supported by those they already trust, such as local pediatricians, faith leaders, elected officials, or local media. One immunization program manager at a VAC meeting said that they asked their local partners who would be the most trusted source for vaccination reminders and recalls; local partners said that the target population preferred hearing from health care providers rather than the local government. Similarly, immunization program managers who attended the VAC meetings spoke of how some communities responded well to COVID-19 vaccination events held at fire stations or other public buildings, while other communities did not feel safe in locations with government employees in uniform. Table 5 provides additional examples of how jurisdictions might collaborate with local partners.

Finally, while the aforementioned collaborations emphasize the role of partners in sharing knowledge and information, local partners can also help jurisdictions manage their costs by providing free or discounted resources. Examples include providing basic needs resources distributed to families at vaccination events, and donating venues, vehicles for transportation, staff time, event promotion, and other support for the event’s operations.

Table 5. Examples of the five promising practices implemented in collaboration with local partners

Promising practice	Examples of collaboration with local partners
Practice 1: Targeted outreach	Jurisdictions might collaborate with Medicaid MCOs, some of which may already have processes, including automated processes, for conducting data-driven outreach to families. These processes might be used to communicate with families with unvaccinated children identified through the Medicaid and IIS systems (Jacobson Vann et al. 2018).
Practice 2: Basic needs	Jurisdictions might collaborate with community organizations, which may have the knowledge and infrastructure required to effectively package and/or distribute information and resources to families. For example, a community organization might include (1) a local food pantry that packages and distributes culturally sensitive food boxes and/or (2) social service enrollment navigators who assist families in applying for social and economic assistance programs.
Practice 3: Mobile clinics Practice 4: At-home vaccination	Jurisdictions might partner with health care organizations or other entities that already have infrastructure to deliver vaccinations via mobile clinics or in homes. For example, when local health departments in Michigan did not have that infrastructure, the state health department contracted with organizations that already had mobile units and the staff capacity to transport and administer vaccines.
Practice 5: Provider support	Jurisdictions might partner with local leaders to champion a practice. For example, the Los Angeles County Department of Public Health partnered with local physician leaders who championed the state's grant program, which provided providers serving pediatric populations with $10,000 for enrolling in the federal government's COVID-19 Vaccination Program.

IIS = Immunization Information Systems; MCO = managed care organization.

Maintaining long-term relationships with local partners, either formally or informally, engenders effective collaboration and contributes to the building of a resilient public health infrastructure. These relationships can be difficult to establish quickly but are necessary for effective responses to urgent public health crises like the COVID-19 pandemic. For example, one state immunization program manager described how their previous role working on maternal and child health in local governments enabled them to coordinate easily with local partners who facilitated vaccination events for mothers and children during the COVID-19 public health emergency.

Implementation context during the public health emergency (PHE) versus post-PHE

During the COVID-19 PHE, jurisdictions experienced high engagement from partners due to the public demand and urgency for COVID-19 vaccination. Moving forward after the PHE, partners may be less engaged. Jurisdictions may prioritize building and maintaining long-term relationships with partners as these relationships are investments in the jurisdiction's long-term public health infrastructure.

During the COVID-19 public health emergency, implementation of the five practices was affected by three major challenges: (1) difficulties hiring and retaining qualified staff, (2) complex and evolving guidelines for administering COVID-19 vaccines, and (3) managing additional reporting requirements.

First, interviewees and VAC meeting attendees described how workforce shortages during the public health emergency exacerbated the typical challenges of hiring qualified staff. At the start of the COVID-19 pandemic, jurisdictions needed to hire staff constantly and quickly, not only because of the time-sensitive nature of the emergency response but also because of high turnover and illness stemming from the spread of COVID-19 infection. VAC meeting attendees also reported difficulty finding staff experienced with vaccinating children. For example, those skilled at putting children at ease and administering vaccines to children who might not sit still.

Second, jurisdictions implementing vaccine programs struggled to keep their programs and staff abreast of the new, changing requirements and guidelines for administering COVID-19 vaccines. Each vaccine could have different guidelines for storage, scheduling, dosage, and more and each new or changing guideline required programs to consider updates to their procedures. For example, one type of vaccine may require that the vaccine program newly procure ultracold storage, including mobile storage for the mobile clinic or at-home practices. As another example, one-time or pop-up vaccination events had to consider whether children could conveniently access vaccine appointments to finish their vaccination series within the recommended time frame. To ensure ethical implementation of vaccine programs, VAC attendees and interview respondents noted that they had to make sure that their vaccine programs planned to return to the same location to administer follow-up shots in four weeks or six weeks.

Lastly, outside of the changing vaccine administration rules guidelines, providers were also burdened by the new reporting requirements for COVID-19 vaccines. The new reporting requirements were an extra layer of burden on the COVID-19 vaccination workflow that they already found fraught and resource-intensive. For general pediatricians especially, these additional reporting requirements squeezed the few resources with which they operate. In one jurisdiction, the immunization program leaders we interviewed said that even the $10,000 grants they offered to pediatric providers who enrolled in the COVID-19 Vaccination Program were not enough to motivate many providers to offer COVID-19 vaccinations.

New challenges with the end of the public health emergency

Complexities of commercialization of COVID-19 vaccines. Without universal purchase of COVID-19 vaccines by the federal government, vaccine providers will face new challenges with billing and managing stocks. During the public health emergency, vaccine providers could more efficiently vaccinate, because they did not have to take patients' insurance information and bill multiple insurers for vaccinating. Vaccine providers must also manage different stocks of vaccines when insurers only pay for certain COVID-19 vaccines.

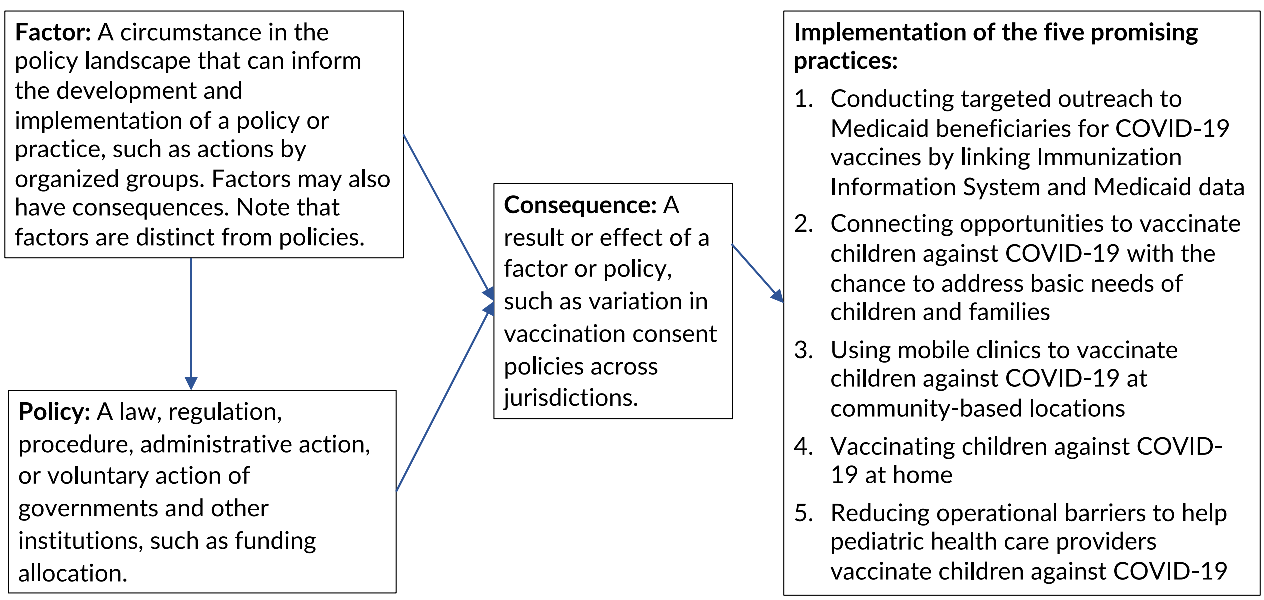
Decreased demand for and attention to COVID-19 vaccination. There is less public attention on COVID-19 given the end of the public health emergency, general pandemic fatigue, and less attention from the media and large institutions. This affects people's desire and demand to be vaccinated and partners' willingness to prioritize spending their time and resources on vaccination.

Less government and non-governmental funding, and more spending restrictions. Government funding issued during the public health emergency offered jurisdictions allowances and flexibilities in how they used the funds. In addition, the commercial and non-profit sectors offered jurisdictions funding. With the end of the public health emergency, jurisdictions have less government funding that offers allowances and flexibilities, and less non-governmental funding. These administrative complexities make it difficult for jurisdictions to sustain the work.

V. Policy Analysis

Here, we describe the key findings that emerged from the policy analysis. We first define factor, policy, and consequence and chart their relationship to the implementation of the five promising practices (Figure 3). We then summarize the 11 key factors and policies that we identified from the policy analysis (Table 6). Last, we describe the key findings in bold text, followed by details on each finding.

Figure 3. Relationship between factor, policy, consequence, and implementation of the five promising practices



Source: CDC 2015.

Note: Organized groups are bodies of people working together for a specific purpose and can include nonprofits, for-profits, and associations.

Table 6. Factor and policies affecting implementation of the five promising practices

Factor or policy	Consequence	Practice affected 1	2	3	4	5
Factor						
Organized groups' support for or opposition to practice implementation	Can influence individuals and other organized groups in the policy landscape, possibly prompting more discourse and action either for or against the practices	x	x	x	x	
Policy						
Policies authorizing a range of health care providers to administer COVID-19 vaccines	Make vaccination more accessible, possibly prompting more discourse and action for the practices			x		
Policies on minor consent for vaccination	Govern jurisdictions' authorization to administer COVID-19 vaccines to minors who independently seek vaccination			x	x	
Policies offering state and federal funding to support vaccination data sharing	Help jurisdictions make short-term and long-term improvements to the data infrastructure needed for engaging in secure and reliable data sharing and supporting data sharing between authorized entities	x				
MCO requirements to reach out to enrollees about vaccination	Might affect how a jurisdiction allocates its resources to unvaccinated Medicaid enrollees and the types of processes it prioritizes	x				
Policies on entities' reporting vaccinations to the IIS	Affect the robustness of IIS data and the ability to use such data as an indicator of vaccination rates	x				
Policies on whether entities need parent/guardian consent to report vaccinations to the IIS	Affect IIS data quality and, potentially, a jurisdiction's reported vaccination rate	x				
Policies on COVID-19 vaccination data sharing	Affect how easily a jurisdiction can conduct targeted outreach to unvaccinated individuals and whether effective data sharing strategies in one jurisdiction can be replicated in another	x				
State and local governments' vaccination and resource dissemination events	Can help adults and children from communities disproportionately affected by COVID-19 and address health-related social needs that impact health		x			
Changing COVID-19 vaccine recommendations	Affect jurisdictions' ability to provide up-to-date support to providers in a timely manner		x	x	x	x
Policies offering state and federal funding to support pediatric health care providers in ensuring access to vaccinations	Can help providers cover overhead costs associated with vaccine administration					x

Notes: Organized groups are bodies of people working together for a specific purpose and can include nonprofits, for-profits, and associations.
Practice 1: Conducting targeted outreach to Medicaid beneficiaries for COVID-19 vaccination by linking immunization information system and Medicaid data.
Practice 2: Connecting opportunities to vaccinate children against COVID-19 with the chance to address basic needs of children and families.
Practice 3: Using mobile clinics to vaccinate children against COVID-19 at community-based locations.

Practice 4: Vaccinating children against COVID-19 at home.
Practice 5: Reducing operational barriers to help pediatric health care providers vaccinate children against COVID-19.
IIS = Immunization Information Systems; MCO = managed care organization.

Influence of organized groups

Organized groups can support or challenge the implementation of practices. Organized groups are bodies of people working together for a specific purpose and can include nonprofits, for-profits, alliances, and associations. Organized groups that support practices can increase momentum in the policy landscape for vaccinations and facilitate coordination and collaboration between jurisdictions and partners implementing the practices. For example, a CDC-funded community of practice with National Academy for State Health Policy; AcademyHealth; and Louisiana, Michigan, Texas, Washington, Wisconsin, and Wyoming facilitated the implementation of the targeted outreach practice (National Academy for State Health Policy 2021). The community of practice aims to improve immunization rates for children and pregnant people with Medicaid coverage. It focused on enhancing collaboration among each state's Medicaid agency, public health agency, and IIS representatives (National Academy for State Health Policy 2021; Kennedy & Krishnan n.d.). In addition, Stanislaus Asian American Community Resource, a community organization working to support the wellness of the Asian American community in Stanislaus County, California, facilitates the basic needs practice by organizing COVID-19 vaccination clinics that can include free food for individuals who get vaccinated. These benefits might be of interest and value to adults and children who are experiencing food insecurity (Stanislaus Asian American Community Resource n.d.; Health Plan of San Joaquin 2022).

In contrast, some organized groups oppose and challenge practice implementation by speaking against the practices, spreading mis- or dis-information about the practices, or obstructing the practices. For example, one VAC meeting participant reported that an organized group in Texas challenged implementation of the mobile clinics practice, working to shut down mobile clinics at schools (VAC Regional Meeting: Frontier and Southwest Regions 2023). Interviewees in Michigan, when describing the at-home vaccination practice, reported that the group Michigan for Vaccine Choice attempted to hinder the jurisdiction from administering COVID-19 vaccinations to children by spreading misinformation about the vaccines (Michigan Department of Health and Human Services 2023). This organized group inaccurately accused the jurisdiction of violating the public health code by requiring COVID-19 vaccination for children attending school. The jurisdiction addressed this challenge by clarifying to the public that vaccination was recommended, not required, for children. These organized groups' actions can influence individuals and other organized groups in the policy landscape, possibly prompting more discourse and action either for or against the practices.

Expansion of scope for vaccination providers

Policies authorizing a range of health care providers to administer COVID-19 vaccines to children can make vaccination more accessible, possibly prompting more discourse and action for the practices. In 2020, the U.S. Department of Health and Human Services (DHHS) invoked the Public Readiness and Emergency Preparedness (PREP) Act and thereafter issued amendments to authorize a range of health care providers to administer COVID-19 vaccines. For example, the PREP Act authorized state-licensed pharmacists, pharmacy interns, and pharmacy technicians to administer COVID-19, seasonal influenza, and routine vaccines recommended by the Advisory

Committee on Immunization Practices (ACIP) to children ages 3 to 18 despite what an individual state's law may have dictated. Although PREP Act authorization and immunity for some COVID-19 countermeasures expired with the end of the public health emergency in May 2023, DHHS extended authorization and immunity for certain countermeasures, such as pharmacists and pharmacy staff administering COVID-19 and seasonal influenza vaccines to children ages 3 years and older through the end of 2024 (ASHP 2023; Hickey 2023). Similar to the PREP Act, some states issued their own laws to authorize a range of health care providers to administer COVID-19 vaccines. For example, one interviewee referenced a California law (CA A 1064) that allows pharmacists to administer COVID-19 vaccines to children when describing policies that facilitate mobile clinics' vaccination of children in California (California Department of Public Health 2023b). The interviewee added that University of Southern California's School of Pharmacy and Pharmaceutical Sciences played a large role in supporting community-based vaccination. Policies like this can make vaccination more accessible, and greater accessibility might prompt more discourse and action from individuals and organized groups for the practices.

Minor consent for vaccination

Policies on minor consent for vaccination govern jurisdictions' authorization to administer COVID-19 vaccines to minors who independently seek vaccination. Most jurisdictions require parent or guardian consent, with a few exceptions (Singer et al. 2021). For example, some jurisdictions do not require minors who are homeless to obtain parent or guardian consent for vaccination (Singer et al. 2021). These policies may affect implementation of the mobile clinics and at-home vaccination practices as a jurisdiction might provide COVID-19 vaccinations to minors in foster care or in temporary shelters where they may be separated from their parents or guardians.

Funding to support vaccination data sharing

Policies offering state and federal funding to enhance data infrastructure and support data sharing can lead to improvements in vaccination data sharing in the short and long term. All jurisdictions used federal (and sometimes state) funding to support data infrastructure and data sharing activities, which can facilitate implementation of the targeted outreach practice (Sekar 2022). For example, California and Utah both used American Rescue Plan Act (ARPA) funding to make improvements to their general broadband infrastructure, which enables electronic data exchange. California allocated approximately $6 billion, most of which were ARPA funds, to enhance its broadband infrastructure, access, and affordability (Hayes et al. 2023). Utah allocated $193.4 million of its ARPA funds to projects related to public health, including $55 million for enhancements to public health information systems (Utah Governor's Office of Planning and Budget 2021). As another example, Colorado uses a mix of state general funding and CDC grant funding from its Immunization and Vaccines

> **Implementation context during the public health emergency (PHE) versus post-PHE**
>
> During the COVID-19 PHE, government funding was available that offered a large number of allowances and flexibilities for spending. Post-PHE, jurisdictions have less of this type of government funding and need to find new ways to fund practice implementation.

for Children cooperative agreement to support data sharing between the Colorado Immunization Information System (CIIS) and the Colorado Department of Health Care Policy & Financing (HCPF), the state's Medicaid agency (Tracking Accountability in Government Grants System 2023). Per their data sharing agreement, HCPF sends CIIS Medicaid immunization claims data, and CIIS returns to HCPF Healthcare Effectiveness Data and Information Set matches for Medicaid enrollees (Immunize Colorado 2021; Tracking Accountability in Government Grants System 2023). Colorado also uses 90/10 Health Information Technology funding to connect providers to CIIS through the state's health information exchange, the Colorado Regional Health Information Organization. These types of funding help jurisdictions make short-term and long-term improvements to the data infrastructure needed to engage in safe and reliable data sharing and support data sharing between authorized entities.

Managed Care Organization (MCO) vaccination outreach requirements

MCO requirements can support targeted outreach to unvaccinated Medicaid enrollees. Whether an MCO is required to conduct outreach to individuals and families who may be unvaccinated affects the implementation of the targeted outreach practice. One VAC meeting participant reported that Indiana's MCOs are contractually required to reach out to Medicaid enrollees about COVID-19 vaccination (VAC Regional Meeting: Great Lakes Regions 2023). Specifically, language from an amendment to a 2021 contract between Indiana and a managed care plan requires the plan to "use internal data review practices to identify unvaccinated, eligible members and implement initiatives that focus on vaccination to this population" (Indiana Family and Social Services Administration 2022). To conduct the targeted outreach, the state is analyzing COVID-19 vaccinations by health plan, geography, and race/ethnicity and other demographic characteristics (Gifford et al. 2021). MCOs required to conduct targeted outreach to unvaccinated individuals may be motivated to allocate their resources to meet the requirement easily. For example, one MCO might allocate funds to support a staff member in analyzing COVID-19 vaccination rates by population characteristics, whereas another MCO that is not required to conduct targeted outreach might choose to allocate funds differently.

Requirements to report vaccinations to the IIS

Policies on entities reporting vaccinations to the IIS affect how easy it is for a jurisdiction to maintain and use data in the IIS. Most jurisdictions require entities to report all or some vaccinations to the IIS (Kolman 2023). A small number do not require reporting of any vaccinations to the IIS (Kolman 2023). Requirements, or the lack thereof, affect implementation of the targeted outreach practice. For example, California, Maryland, and Virginia require certain entities to report all vaccinations to the IIS, whereas Arizona and Michigan require certain entities to report only specific vaccination information to the IIS, such as childhood vaccinations (CA Health & Safety Code 2022; Annotated Code of Maryland 2022; VA Code 2021; Arizona Revised Statutes 2021; Cooper et al. 2021; Michigan Care Improvement Registry 2022; Greene et al. 2021). AZ S 1505 requires providers who administer vaccines to children to report child vaccinations to the Arizona state IIS. Providers who do not report to that system are considered to be in violation of the law and committing "an act of unprofessional conduct" in the practice of medicine (A.R.S. § 36-135).

In contrast, Illinois and Colorado do not require entities to report vaccinations to the IIS (Cooper et al. 2021). In Illinois, provider participation in the Illinois Comprehensive Automated Immunization Registry Exchange is voluntary, and not all providers in Illinois choose to participate in the registry. Table 7 summarizes the requirements in Arizona, California, Colorado, Illinois, Maryland, Michigan, and Virginia. A jurisdiction's policy will affect how easy it may be for it to maintain and use data in the IIS to target outreach to Medicaid enrollees.

Table 7. Examples of variation in jurisdictions' policies on entities reporting vaccinations to the IIS

Jurisdiction	Policy
Jurisdictions that require certain entities to report all vaccinations to the IIS	
Maryland	All vaccinations administered in the state of Maryland are required to be reported to the state's IIS system, ImmuNet, regardless of patient opt-out status in ImmuNet (Maryland Department of Health Center for Immunization n.d.).
Virginia	Any health care provider in the Commonwealth that administers immunizations is required to participate in the Virginia Immunization Information System (VIIS) and report patient immunization history and information to VIIS, as of January 2022.
California	California requires all health care providers and any agencies who administer vaccines (including schools, child care facilities, family child care homes, and county human services agencies)) to report immunization information to the California Immunization Registry and report race and ethnicity information for each patient in the immunization registry to support assessment of health disparities in immunization coverage, as of January 1, 2023 (California Department of Public Health 2023a; CA Health & Safety Code 2022).
Jurisdictions that require certain entities to report only specific vaccination information to the IIS	
Arizona	Arizona requires providers who administer vaccines to children to report child immunizations to the IIS. Providers are encouraged to report data on adult vaccinations but are not required to do so (Arizona Department of Health Services 2023).
Michigan	Health care providers are required to report all immunizations administered to every child born after December 31, 1993, and less than 20 years of age within 72 hours of administration.
Jurisdictions that do not require entities to report vaccinations to the IIS	
Illinois	Provider participation in the Illinois Comprehensive Automated Immunization Registry Exchange is voluntary, and not all providers in Illinois choose to participate in the registry (Illinois Department of Public Health 2023a).
Colorado	Although it is the providers' responsibility to document and send vaccination information to the Colorado IIS, reporting is not mandated (Centers for Disease Control and Prevention 2018; C.R.S. § 25-4-2403).

IIS = Immunization Information Systems.

Consent to report vaccinations to the IIS

Policies on whether entities need parent or guardian consent to report vaccinations to the IIS affect jurisdictions' amount and comprehensiveness of data in the IIS and, potentially, their reported vaccination rate. Some jurisdictions use an opt-in approach for reporting vaccinations to the IIS, requiring entities to obtain parent or guardian consent to report vaccinations to the IIS. Others use an opt-out approach, reporting vaccinations to the IIS unless parents or guardians request otherwise. These different consent laws affect implementation of the targeted outreach practice. For example, Illinois and Michigan use an opt-out approach that offers parents or guardians the choice to not have their child's information in the IIS (CDC 2018). In Illinois, patients who do not want to have their information included in the registry may opt out with their provider (Illinois Department of Public Health 2023a; Immunization Data Registry Act n.d.). Providers in Illinois are also required to provide the patient, or parent or guardian of a minor patient, with a printed immunization data exemption form at least once before reporting immunization data to the Illinois Comprehensive Automated Immunization Registry Exchange. In Michigan, providers are required to report child immunizations unless the child's parent or guardian objects by written notice (Michigan Department of Health and Human Services 2015). Providers in Michigan are also required to notify the parent or guardian of the child of their right to opt out of reporting the child's immunizations to the state IIS before vaccinating the child (Michigan Department of Health and Human Services 2015). In contrast, New Hampshire and Ohio use an opt-in approach before reporting vaccination information to the IIS (CDC 2018; New Hampshire Department of Health and Human Services n.d.). In addition, New Hampshire, through NH H 1608, requires the Department of Health and Human Services to notify individuals that they can withdraw their COVID-19 vaccination information from the IIS (New Hampshire Health & Safety Code 2022). Of note, states that use opt-out approaches tend to have more comprehensive data and higher vaccination rates for individuals. For this reason, New Jersey temporarily changed its IIS consent policy via an executive order, to use an opt-out approach (instead of an opt-in approach) that would last until the expiration of the public health emergency (Levisohn et al. 2021). Overall, a jurisdiction's specific policy will affect the amount and comprehensiveness of data in the IIS and, potentially, its vaccination rate for the jurisdiction.

COVID-19 vaccination data sharing policies

Policies on COVID-19 vaccination data sharing can support targeted outreach to unvaccinated individuals. Some jurisdictions adopted, enacted, or implemented policies facilitating COVID-19 vaccination data sharing. California, Massachusetts, Utah, and Rhode Island have policies that facilitate data sharing across entities within the state. Before the public health emergency, Louisiana implemented a policy that facilitates interstate data sharing. California and Rhode Island allow Medicaid plans or agencies access to COVID-19 vaccination data to track enrollee vaccinations (Campbell & Dyer 2021; LeBlanc & Roy 2021; California Department of Health Care Services 2023). Rhode Island gives both commercial insurers and Medicaid plans access to its COVID-19 vaccination registry (Campbell & Dyer 2021). The Massachusetts IIS is required to share vaccination data with MassHealth, the state's combined Medicaid and Children's Health Insurance Program. Each week, MassHealth receives raw IIS data, which it then shares with Medicaid plans (Greene et al. 2021). Similarly, Utah's Medicaid program has a data sharing

> Implementation context during the public health emergency (PHE) versus post-PHE
>
> During the COVID-19 PHE, some jurisdictions may have focused on sharing data temporarily to help meet the high demand and urgency for COVID-19 vaccines. Moving forward after the PHE, jurisdictions may focus on reestablishing, maintaining, and improving data sharing to inform efforts to advance vaccine equity.

agreement that allows it to directly access information in the Utah Statewide IIS (Greene et al. 2021). Louisiana has a policy that allows data sharing between its IIS and other states' IIS, which can facilitate more accurate and complete vaccination data for individuals that cross state lines to be vaccinated (Kolman 2023). In contrast, some jurisdictions do not have specific data sharing policies, and some state officials are hesitant to authorize data sharing because of liability concerns (Greene et al. 2021). A jurisdiction's specific policy or lack of policy on data sharing within its jurisdiction and with other jurisdictions will affect how easily it can conduct targeted outreach to unvaccinated individuals (Greene et al. 2021).

Vaccination and resource dissemination events

State and local governments' vaccination and resource dissemination events can help adults and children from communities that are disproportionately affected by COVID-19. We identified three instances of state and local governments hosting vaccination and resource dissemination events, which can affect implementation of the basic needs practice. Arizona's Pima County Health Department partnered with local service providers, a neighborhood foundation, and other local organizations to implement a community-wide event that provided individuals and families with COVID-19 vaccination and connections to basic social and economic resources, such as food assistance, oscillating fans, rent assistance, and public health services (Monroy and Cullen 2022). The Los Angeles County Department of Public Social Services worked with local nonprofit organizations to host an event that provided individuals and families with COVID-19 vaccinations and resources such as free groceries, school supplies for children, and hygiene kits for infant care (Los Angeles County Department of Public Social Services 2021; Nile Sisters Development Initiative et al. n.d.). Similarly, the Connecticut Public Health Department partnered with local organizations to implement a summer-long event, titled "Summer on Us," that offered resources to individuals and families who got vaccinated. Resources were family friendly and included free food from restaurants—of particular value to adults and children experiencing food insecurity (Bergman & Funaro 2021; State of Connecticut 2021). Although these events happened before children became eligible for COVID-19 vaccines in November 2021, parents or guardians could receive educational resources that might increase their awareness and understanding of COVID-19 vaccines and make them more willing to vaccinate their children in the future. Vaccination and resource dissemination events can also help adults and children from communities that are disproportionately affected by COVID-19 and address health-related social needs that impact health (Cooper & Rosenthal 2020).

Changes in COVID-19 vaccine recommendations

The changing guidelines for storing, transporting, and administering COVID-19 vaccines have added to the complexity of implementing the practices, potentially deterring some from providing vaccinations. Interviewees in Illinois and Maine reported that changing recommendations regarding COVID-19 vaccines affected implementation of the provider support practice (Illinois Department of Public Health interview 2023b; Maine Immunization Program 2023). Interviewees in Maine reported that the CDC's recommendations changed frequently during the pandemic, making it difficult to provide up-to-date technical assistance to providers. One interviewee in Illinois indicated that changing recommendations, such as those concerning vaccine storage, were overwhelming for providers, discouraging them from enrolling in the CDC's COVID-19 Vaccine Program as vaccination providers.

Implementation context during the public health emergency (PHE) versus post-PHE

During the COVID-19 PHE, rapidly changing requirements and guidelines for COVID-19 vaccines made it difficult for jurisdictions to stay up to date. With fewer changes in requirements and guidelines after the PHE, some jurisdictions find it easier to stay up to date while others continue to experience difficulty.

State and federal funding to support pediatric providers

Policies offering federal and state funding to support pediatric health care providers in ensuring access to vaccinations. Some jurisdictions used state and federal funding to support pediatric providers in vaccinating children against COVID-19; such funding affects implementation of the provider support practice. The Mississippi State Department of Health used CDC funding to implement the COVID-19 Community Vaccination Program, which compensates providers, including pediatric providers, $75 per eligible vaccination outside of their normal clinic setting, such as at community-based sites, mobile vaccination clinics, pop-up vaccination clinics, or patients' homes (Mississippi State Department of Health n.d.; Wilkniss et al. 2021). The California Department of Public Health used a mix of state and federal funding to implement multiple cycles of the KidsVaxGrant, which helped pediatric providers expand their clinic hours to offer families access to vaccinations outside of traditional business hours. During extended hours under the first and second cycles of the KidsVaxGrant, 40-45% of individuals receiving COVID-19 vaccinations were children ages 11 or younger (Physicians for a Healthy California 2023; California Department of Public Health 2022; California Department of Public Health 2023b). These types of funding helped pediatric providers offset overhead costs for vaccine administration. One VAC meeting participant in Maine elaborated on the importance of supporting providers with funding to cover their overhead costs. Although COVID-19 vaccines were made available to providers at no charge during the public health emergency, the participant said, many providers need support for other costs. An example is costs associated with extending clinic hours (VAC Regional Meeting: Northeast/Mid-Atlantic Region 2023).

VI. Economic Analysis

Here, we describe the key findings that emerged from the economic analysis. We first provide additional detail on our methodology to more clearly lay out the assumptions behind this analysis, including the hypothetical implementation scenario and benefit and cost categories used for the analysis. We then summarize the findings from our analysis for all five practices, followed by a practice-by-practice description of the costs and a detailed description of our assumptions related to the benefits that are incurred for all practices. We also describe the results of our sensitivity analysis to determine how sensitive our findings are when varying different assumptions.

A. Additional detail on methodology

We first developed a hypothetical implementation scenario for an average county in the U.S. We derived the basic population characteristics of this county—particularly the population size and age cohorts—by averaging across all 3,144 counties in the U.S. (U.S. Census Bureau 2023a). Table 8 lists the assumptions we used for the implementation scenario. Note that our analysis presents costs from two perspectives: (1) programmatic costs to the immunization program and partners and (2) total costs (includes programmatic and vaccine costs). We assume that an immunization program will not incur costs related to vaccines or vaccine wastage during a public health emergency because the federal government will pay for the vaccines; however, those costs are incurred by society. Costs and benefits are valued during the pandemic (2021); it is likely that the costs of administering programs (particularly the labor costs for nurses), health care costs, and the value of the benefits of receiving vaccinations will change after the pandemic.[5]

> **Implementation context during the public health emergency (PHE) versus post-PHE**
>
> During the COVID-19 PHE, the federal government paid for all COVID-19 vaccines. Moving forward after the PHE, both the federal government (through the Vaccines for Children program) and health insurance plans will pay for vaccines. Jurisdictions implementing the basic needs, mobile clinics, at-home vaccination, and provider support practices after the public health emergency will need to consider how to support providers in billing multiple insurers and managing different stocks of vaccines.

Table 8. Assumptions in the hypothetical implementation scenario

Category	Assumption	Justification
Jurisdiction	Average county in the U.S.	Population estimates for the average county are based on the U.S. Census Bureau, Annual Estimates of the Resident Population for Counties: April 1, 2020, to July 1, 2022 (U.S. Census Bureau 2023a).
Total population	116,000 residents	See above.

[5] The percent unvaccinated is based on a later date (May 10, 2023) because vaccines were not available to children in 2021 so 100 percent were unvaccinated; we assume a more realistic scenario where some individuals would get vaccinated on their own prior to the implementation of these practices.

Category	Assumption	Justification
Children ages 6 months to 11 years	15,000 residents (11,700 not fully vaccinated)	The number of children 6 months to 11 years of age is derived from the proportion of residents in this age group, based on U.S. Census Bureau, National Population by Characteristics: 2020-2022 (U.S. Census Bureau 2023b).
Percent remaining unvaccinated for target group	78 percent	This rate is based on data retrieved from the Centers for Disease Control and Prevention (CDC) Data Application Program Interface on June 1, 2023, for children under age 11.
Cost of vaccines	$28.89/dose	Estimates from the Kaiser Family Foundation found an average cost per dose of $28.89 for vaccines purchased by the government (though this cost will likely be different in the post-pandemic environment as the commercial cost per vaccine is approximately $120). We assume that this cost is only incurred from the "total costs" perspective; an immunization program would not need to incur this cost during the public health emergency.
Vaccine wastage rate	8 percent	Estimates of the vaccine wastage rate vary, but we assume a maximum of 8%. Many jurisdictions have Vaccines for Children provider requirements that limit wastage due to "negligence or mismanagement" to less than or equal to 5% (New York City Department of Health and Mental Hygiene 2023). However, CDC data indicate that about 11% of the doses that the federal government distributed were discarded from December to mid-May 2020 (Eaton 2022). We assume that this cost is only incurred from the "total costs" perspective; an immunization program would not need to incur this cost during the public health emergency.
Economic value of life	$1,655, 868	Estimate from Grosse et al. 2019, inflated to 2021 dollars.
Social discount rate	1.33 percent annually	The social discount rate is a percentage reduction applied to costs and benefits that occur in the future, to portray them as lump-sum present value figures. We used the most recent nominal rate (to make accurate projections for a future program) according to the Office of Management and Budget, Circular No. A-94, re-estimated for the timeframe of this study (Executive Office of the President 2023).
Lives saved per 1,000 children vaccinated	.54	Assumes 0.54 deaths (across all age groups) averted per 1000 childhood vaccines based on Borchering 2023[1]; cost per death assumed to be 1.66 million based on Grosse et al. 2019) inflated to 2021 dollars.[2]
Inpatient hospitalizations averted per 1,000 children vaccinated	3.1	Based on Borchering 2023[1]; cost of $24,826 per hospitalization based on Shrestha et al. 2021.[3]
Outpatient health care costs averted	$1,008	Assumes 28.44 cases prevented per 1000 children vaccinated based on Borchering 2023[1] at a cost of $1,008 outpatient costs per case according to FAIR Health.[4]

Category	Assumption	Justification
Learning loss avoided per 1,000 childhood vaccinations	$94.5 per day multiplied by 4 days per case averted	Assumes 28.44 cases prevented per 1000 children vaccinated[a] with four days lost to COVID-19 on average at an estimated value of $94.5 per day. (Estimated value of learning per day based on NCES estimate of average annual spending of $17,013 per public school pupil divided by 180 days of school per year).[5]
Improvement in caretaker time per 1,000 children vaccinated	$48,750	Estimates of the precise caretaker time savings are limited. However, we assume 50 caretakers save an average of 2.5 workdays caring for a child per 1,000 vaccinations, with an average hourly rate of $32.50,[6] multiplied by 1.5 to account for fringe and overhead ($48.75/hour).

[1] Borchering (2023) estimated the number of adverse events (cases, hospitalizations, and deaths across all age groups) that would be prevented by a childhood vaccination campaign, assuming that 54% of the 28 million children ages 5 to 11 in the US would be vaccinated.

[2] See Grosse et al., 2019 doi: 10.1080/13696998.2018.1542520.

[3] See Shrestha, 2021 doi:10.1093/ofid/ofab561.

[4] See FAIR Health, September 2021, https://s3.amazonaws.com/media2.fairhealth.org/infographic/asset/COVID-19%20Medical%20Hospitalization%20Costs%20by%20State%20-%20FINAL_National.pdf. Note that these costs may be lower in a post-pandemic environment.

[5] See National Center for Education Statistics Fast Facts: https://nces.ed.gov/fastfacts/display.asp?id=66.

[6] See Bureau of Labor Statistics 2022, https://www.bls.gov/ces/data/employment-and-earnings/2022/summarytable_202212.htm

We then used the implementation scenario to develop a high-level assessment of likely benefits and costs for each of the five practices (Table 9), based on available case studies and evidence from the systematic literature review. For each practice, we estimated the costs for the categories that were applicable to that practice and assumed that all practices incurred the same benefits per 1,000 vaccinations delivered. (Benefits still varied across practices because practices resulted in more children vaccinated generated greater benefits). To ensure that we were not biasing the analysis in favor of the cost or benefit side of the equation, and because costs incurred by different parties can be difficult to delineate, we did not limit costs to those only incurred by immunization programs. Specifically, we calculated costs from two perspectives, those programmatic costs incurred by immunization programs and partners, and the total costs (including programmatic costs and the costs of vaccine and wastage). The total cost perspective includes all costs that we could measure regardless of who paid or incurred them. In practice, the programmatic costs were generally similar to the total costs; the main difference was that total costs included those related to vaccines and vaccine wastage, whereas the programmatic costs for immunization programs and partners did not (because the federal government paid for the cost for vaccines during the public health emergency).[6] More generally, we focused on benefits and costs that were most relevant and easiest to quantify based on the limited available data. Importantly, we often had to rely heavily on assumptions, qualitative data, and evidence of effectiveness from adjacent contexts that may not be directly generalizable to pediatric COVID-19 vaccinations. Benefits include the savings due to preventing adverse events such as illness and death, and include a reduction in caretaker time, healthcare expenditures, and the value of

[6] The only exception is the costs for the basic needs practice; the total cost was lower than the programmatic cost because most of the cost of the basic needs was transferred to the individuals that received the benefit, so the net cost to society is low after factoring in the benefit for the individual.

saved lives. Benefits for which readily quantifiable data were not available were excluded from the assessment, such as improved mental and social-emotional health among children and parents, reduction in future infection rates, easing of pressures on the health care system, improvement in future vaccination targeting to Medicaid enrollees, and gains in social equity from providing vaccinations to home-bound children. We also excluded costs associated with the patients' and/or parents' time spent getting the vaccination, which would likely vary depending on the jurisdiction in which the program is being implemented, as well as individual family circumstances.

Table 9. Benefit and cost categories

Category	Description	Source and formula
Benefit		
Improvement in caretaker time	Increased caretaker time from not having to care for a sick child or becoming infected themselves	Assumes the average case averted would involve 2.5 caregiver days at a rate of $48.75 per hour, including fringe benefits and overhead (Bureau of Labor Statistics 2022) and that 28.44 cases were averted per 1,000 children vaccinated per Borchering (2023)[1].
Reduction in deaths	Reduced deaths from COVID-19 vaccination, for both children and adults within a household	Assumes 0.54 deaths (across all age groups) averted per 1000 children vaccinated based on Borchering (2023)[1]; cost per death assumed to be 1.66 million based on Grosse (2019), inflated to 2021 dollars.[2]
Reduction in hospitalizations	Reduced hospitalizations from COVID-19 vaccination, for both children and adults within a household	3.1 hospitalizations averted (across all age groups) per 1000 children vaccinated based on Borchering (2023)[1]; cost of $24,826 per hospitalization based on Shrestha et al. (2021).[3]
Reduction in other health care costs	Reduction in outpatient costs from COVID-19 vaccination, for both children and adults within a household	Assumes 28.44 cases prevented per 1000 vaccines children vaccinated based on Borchering (2023)[1)] at a cost of $1,008 outpatient costs per case according to FAIR Health.[4]
Reduction in learning loss	Reduced learning loss from children's school absences due to illness related to COVID-19	Assumes 28.44 cases prevented per 1000 vaccines[1] with four days lost to COVID-19 on average at an estimated value of $94.5 per day. (Estimated value of learning per day based on NCES estimate of average annual spending of $17,013 per public school pupil divided by 180 days of school per year).[5]
Cost		
Program Administration	Staff time for person to direct program, including providing oversight, training and quality assurance	Assume one program director works for 40 hours a week for 20 weeks at $62.50 per hour ($93.75 per hour with overhead and fringe benefits) per salary of manager in 2021 according to Bureau of Labor Statistics.[6]
Applications	Staff time associated with submitting grant applications	*Only applies to provider support practice:* 5 hours of staff time at $120 per l rate (including fringe benefits and overhead) per site per application; assumes 10% of sites do not receive grants (assumptions based on AIM recommendations).
Basic needs	Deadweight loss associated with provision of basic needs	Assumes that 90% of basic needs transfer ($50 per dose) resulted in an improvement in well-being, and 10% was a "deadweight loss."

Category	Description	Source and formula
Grants	Grants to health care practices or other groups	*Only applies to provider support practice:* Assumes $25,000 in grants to 40 grantees.
Infrastructure	Hardware, software licenses, or other information technology	*Only applies to targeted outreach practice:* Cost of infrastructure for linking 5,000 records in the IIS with state Medicaid records, assuming $15/record.
Legal review	Legal analyses, documentation, meetings	*Only applies to targeted outreach practice*: Legal review includes the cost of meetings with the legal team to determine permissible content for these provider-based text messages and the appropriate consent process for texting parents of patients. (Total of 300 FTE hours for legal review and meetings.) Does not include the development of data use agreements.
Outreach	Marketing or outreach efforts associated with promoting the practice	Estimated time spent on outreach for the practice multiplied by $86.43 loaded hourly rate for a public relations manager (BLS 2021) [6] plus the estimated cost of marketing materials for the practice.
Provider overhead	Provider costs not covered by grants (e.g., rental costs for the practice)	*Applies only to provider support practice:* Additional costs per site, assuming approximately 150 hours of overtime at 15 of 40 provider sites.
Refrigeration and storage	Purchasing and maintaining refrigeration and storage for vaccines	Assumes $5,000 per refrigeration unit (and data logger), multiplied by number of units required by practice. The Vaccine Storage and Handling Toolkit - January 2023 (cdc.gov) suggests purpose-built pharmaceutical grade units to store vaccines.
Resource distribution	Distribution of resources (e.g., gathering and handing out diapers)	*Only applies to basic needs practice:* cost of organizing and distributing basic needs resources at community locations, with up to three events per week. Assumes $65 hourly rate (including fringe and overhead) for 40 hours per week for 6 staff for 20 weeks.
Scheduling and logistics	All staff time associated with scheduling vaccination appointments	Where applicable, assumes $55.97 loaded hourly rate for a logistics manager (BLS 2021)[6] , multiplied by estimated hours per week for particular practice for 20 weeks.
Software development	All staff time associated with developing, upgrading, and maintaining software	*Only applies to targeted outreach practice*: Cost of software development to enhance IIS, integrate with text messaging, and prepare it for linking to state Medicaid system. ($80 hours per hour for 3 staff for 500 hours each for information technology staff.) Does not include cost of upgrades to state Medicaid Management Information System.
Staff time for administering (vaccination)	All staff time associated with preparing for and administering vaccinations	Assumes $125 loaded hourly rate multiplied by 20 minutes per vaccine delivered.
Training	Training needed for healthcare professions, including continuing or "refresher" education, when preparing to administer vaccinations	The AIM Legacy Council provided estimates for the hours of training needed for each practice; training staff assumed to have a loaded hourly rate of $125 (per the AIM Legacy Council's recommendation).

Category	Description	Source and formula
Transportation	Transportation needed to administer vaccinations (costs associated with participant transportation [e.g., traveling to a mobile clinic] were not estimated)	Assumes .625 per mile for cars and $1.00 per mile of vans times estimated mileage incurred by practice.
Vaccinations	Vaccine purchases	Assumes $28.89 per vaccine (estimated by Kaiser Family Foundation) incurred from "total cost" perspective. (No costs are incurred from the "programmatic" perspective since the federal government paid for vaccines during the pandemic).
Wastage	Vaccine wastage due to spoiling or expiration	Assumes 8% wastage incurred from "total cost" perspective. (No costs are incurred from the "programmatic" perspective since the federal government paid for vaccines during the pandemic). [7]

Notes: The costs of vaccinations and vaccine wastage are not incurred by immunization programs and partners. See Tables 11 through 15 for a breakdown of the costs incurred by programmatic costs vs. total costs.

[1] Borchering (2023) estimated the number of adverse events (cases, hospitalizations, and deaths across all age groups) that would be prevented by a childhood vaccination campaign, assuming that 54% of the 28 million children ages 5 to 11 in the US would be vaccinated. For median hourly ages of caretakers, see Bureau of Labor Statistics 2022, https://www.bls.gov/ces/data/employment-and-earnings/2022/summarytable_202212.htm

[2] See Grosse, 2019: doi: 10.1080/13696998.2018.1542520.

[3] See Shrestha, 2021 doi:10.1093/ofid/ofab561.

[4] See FAIR Health, September 2021, https://s3.amazonaws.com/media2.fairhealth.org/infographic/asset/COVID-.

[5] See National Center for Education Statistics Fast Facts: https://nces.ed.gov/fastfacts/display.asp?id=66.[6] Median hourly wage rates for particular occupational job types were drawn from https://www.bls.gov/oes/2021/may/oes_nat.htm, and multiplied by 1.5 to account for fringe benefits and overhead.

[7] Many jurisdictions have Vaccines for Children provider requirements that limit wastage due to "negligence or mismanagement" to less than or equal to 5% (New York City Department of Health and Mental Hygiene 2023), but we assume a higher rate here because CDC data indicate that about 11% of the doses that the federal government distributed were discarded from December to mid-May 2020 (Eaton 2022).

After estimating benefits and costs, we calculated two metrics—benefit-cost ratio and net present value (NPV)—for each practice to summarize economic impact. We ranked the practices against the benefit-cost ratio and the NPV, focusing on the benefit-cost ratio, because it captures how a practice performed relative to its input cost. It is important to note that, due to the substantial uncertainty around our estimates, particularly the assumptions around potential benefits, the magnitude of the benefit-cost ratios should be treated cautiously. The purpose of this analysis is to offer an initial attempt to quantify the possible costs and benefits for each of the promising practices, with the goal of informing more rigorous future economic analyses.

- **Benefit-cost ratio** is the ratio of present value benefits to costs for the practice. A ratio greater than 1 indicates a favorable outcome. The benefit-cost ratio is less biased than the NPV toward practices with larger overall costs but does not indicate the magnitude of a practice's economic impact in dollars. We also calculate the benefit-cost ratio as the ratio of present-value benefits to present-value costs. In the formula, t is the period, i is the discount rate, C is the cost for a given period, B is the benefit for a given period, N is the number of periods.

$$BCR(i, N) = \frac{\sum_{t=0}^{N} \frac{(B)_t}{(1+i)^t}}{\sum_{t=0}^{N} \frac{(C)_t}{(1+i)^t}}$$

- **NPV** is the difference between the present value of benefits and costs for the practice. Calculating this difference in present value terms helps assess the economic impact, while accounting for the time value of money. NPV shows the overall economic impact of the practice in dollars but may be biased toward practices that have larger overall costs. We calculated the NPV using the following formula (t is the period, i is the discount rate, C is the cost for a given period, B is the benefit for a given period, N is the number of periods).

$$NPV(i, N) = \sum_{t=0}^{N} \frac{(B-C)_t}{(1+i)^t}$$

We shared early drafts of the economic analysis findings with the AIM Legacy Council and met with them to obtain feedback. We incorporated their feedback into the economic analysis presented below. For example, we revised the cost of mobile clinics, based on feedback from the Legacy Council.

B. Summary of key findings

Table 10 displays each practice's ranking based on the benefit-cost ratio, along with the estimated benefits, costs, and NPV from the perspective of total costs (including programmatic and vaccine costs) . Three practices—mobile clinics, basic needs, and targeted outreach—had a benefit-cost ratio greater than 1, indicating that the benefits outweighed the costs. The mobile clinics practice has the largest benefit-cost ratio (3.14) and an NPV of $2.8 million. This practice is associated with moderate-to-high implementation costs compared to the other practices; specifically, the implementation costs for the mobile clinics practice were greater than $1 million, which is over twice as expensive as the costs for the lowest-cost practice (targeted outreach practice), which was ranked third. However, the mobile clinics practice also results in the largest number of children vaccinated; this high vaccination rate drives benefits in the categories of reduced deaths, inpatient hospitalizations, other health care costs, learning loss, and caretaker time. Conceptually, the benefits of this practice might be easily realized in jurisdictions where vaccine hesitancy is low and during periods when infection rates are high. The basic needs and targeted outreach practices have the second and third highest benefit-cost ratios and NPVs, respectively. The basic needs practice benefits from the use of community-based locations to reach a wider pool of children and families, thus increasing the number of vaccines delivered and the overall associated benefits with increasing the number of vaccinated children. Unlike these practices, however, the mobile clinic practice has the advantage of bringing vaccination clinics to locations (such as supermarkets) that children and families frequently visit, rather than having to encourage families to travel to a new, potentially out-of-the-way location. In contrast, the provider support practice has the lowest benefit-cost ratio (0.70), implying that the costs outweigh the benefits. Case studies from California's KidsVaxGrant 2.0 program suggest that this practice does not greatly increase the number of vaccinations; the relatively low number of vaccinations contribute to a lower benefit-cost ratio (Physicians for a Healthy California 2023).

Table 10. Summary and ranking of promising practices by benefit-cost ratio from the perspective of the total costs (including programmatic and vaccine costs)

Cost/benefit	Targeted outreach	Basic needs	Mobile clinics	At-home vaccination	Provider support
Ranking	3	2	1	4	5
Vaccines delivered by strategy	1,170	2,340	4,000	1,400	1,000
Total costs of practice, programmatic perspective (excludes costs of vaccines and waste)	$408,750	$809,000	$1,199,058	$1,484,216	$1,443,000
Total costs of practice, societal perspective (includes programmatic costs and costs of vaccines)	$445,255	$776,711	$1,323,863	$1,527,898	$1,474,601
Total benefits of practice	$1,214,700	$2,429,400	$4,152,821	$1,453,487	$1,038,205
Net benefits (not discounted, equal to total benefits minus total costs)	$769,445	$1,652,690	$2,828,959	($74,410)	($436,396)
Present value of net benefits (assuming 1.33 percent annual discount rate)	$763,686	$1,640,594	$2,808,262	($76,236)	($435,750)
Benefit-cost ratio	2.73	3.13	3.14	.95	.70

Note: Costs from the programmatic perspective do not include the costs of the vaccines and waste, as the federal government paid for these costs during the public health emergency; however, the total cost perspective includes both programmatic costs and the costs of vaccines. Benefits are based on the economic value of a life. If instead we used the statistical value of a life –valued at $11.6 million in 2021 (U.S. Federal Register 2023), the net benefits are positive for all 5 practices (ranging from $4.6 million for the provider support practice to $23 million for the mobile clinics practice), but the relative ranking of each practice does not change.

C. Detailed findings by practice

Below we provide detailed findings for each of the five practices.

Practice 1. Conducting targeted outreach to Medicaid beneficiaries for COVID-19 vaccines by linking Immunization Information System and Medicaid data

Our hypothetical implementation scenario includes a state Medicaid agency or a health plan coordinating with a local county health agency to link immunization registry or IIS data with the state's Medicaid system. To simplify the estimate, we assumed that there would be no costs associated with developing data use agreements between the state and county or in upgrading electronic health information systems. This assumption may not hold for certain jurisdictions. The Medicaid agency or health plan would conduct outreach efforts via text message or automated telephone call, encouraging caregivers of unimmunized children enrolled in Medicaid to make a vaccination appointment.

Implementation context during the public health emergency (PHE) versus post-PHE

During the COVID-19 PHE, some jurisdictions may have focused on sharing data temporarily to help meet the high demand and urgency for COVID-19 vaccines. Moving forward after the PHE, jurisdictions may focus on reestablishing, maintaining, and improving data sharing processes, which may incur costs depending on the state of the electronic health information systems and other factors.

In estimating the effects of this practice, we assumed approximately 35 percent of children in the hypothetical county are covered by Medicaid or the Children's Health Insurance Program. To ensure that our estimate is conservative, this rate is slightly lower than the national average of 45 percent (Medicaid 2023). We also assumed that approximately 10 percent of families receiving text messages and telephone calls would schedule a vaccination, which translates to approximately 1,170 vaccinations. Estimates of the effectiveness of the practice in this scenario are based on systematic reviews of literature on more generic reminder recall systems (CPSTF 2020b), as well as from other text reminder programs intended to increase vaccination rates (Stockwell et al 2022) . Table 11 summarizes the costs and benefits associated with the targeted outreach practice, from the largest to the smallest dollar amounts. It is important to note that other sources suggest that the impact of this practice could be stronger, depending on the circumstances and the baseline population vaccination rates. For example, the 2015 New York Bull's Eye program focused on linking New York State Immunization Information System records to address verification through LexisNexis and targeting outreach, through a reminder/recall letter campaign, to promote human papillomavirus vaccination. Evidence from this program indicated that those who "already received a first dose were 35 percent more likely to receive a second dose and letter recipients who had previously received two doses were 20 percent more likely to complete the series than controls" (AIM 2016b). However, the AIM Legacy Council noted this was a different context with an older cohort of children and is likely not generalizable to pediatric COVID-19 vaccinations.

Table 11. Summary of costs of delivering targeted outreach practice

Costs	Description	Programmatic Cost (excluding vaccine costs and wastage) $	Total Costs (including programmatic and vaccine costs) $
Program Administration	Assume one program director works for 40 hours a week for 20 weeks at $62.50 per hour ($93.75 per hour loaded) based on salary of manager in 2021 according to Bureau of Labor Statistics.	$75,000	$75,000
Vaccines	Cost of vaccines (vial and syringe) (1,170 vaccines delivered x $28.89).[1] Note: Staff time to administer vaccines is calculated separately below.	NA	$33,801
Wastage	Vaccine cost multiplied by 8 percent waste. While Vaccines for Children provider requirements that limit wastage due to "negligence or mismanagement" to less than or equal to 5% (New York City Department of Health and Mental Hygiene 2023), we assume a higher rate here because CDC data indicate that about 11% of the doses that the federal government distributed were discarded from December to mid-May 2020 (Eaton 2022).	NA	$2,704

Costs	Description	Programmatic Cost (excluding vaccine costs and wastage) $	Total Costs (including programmatic and vaccine costs) $
Software development	Cost of software development to enhance IIS, integrate with text messaging, and prepare it for linking to state Medicaid system. (Total of 11,500 FTE hours for information technology staff at a loaded hourly rate of $80.) Does not include cost of upgrades to state Medicaid Management Information System. [2]	$120,000	$120,000
Infrastructure	Cost of infrastructure (hardware and software) for linking 5,000 records in the IIS with state Medicaid records, assuming $15/record.[2]	$75,000	$75,000
Staff time (vaccination)	Cost of staff to administer vaccinations (on average, 20 minutes/vaccination for two staff at $125 loaded hourly rate) multiplied by 1,170 vaccines.[3]	$97,500	$97,500
Training	We assume up to six staff would require 80 hours of training at a loaded hourly rate of $125[4]	$60,000	$60,000
Legal review	Legal review includes the cost of meetings with the legal team to determine permissible content for these provider-based text messages and the appropriate consent process for texting parents of patients. (Total of 300 FTE hours for legal review and meetings at a loaded hourly rate of $175.) Does not include the development of data use agreements.	$52,500	$52,500
Outreach	Cost of automated text message outreach (text messages to parents of unvaccinated children, assuming approximately $0.25/text and up to three texts per child for 5,000 children over the 20-week period).	$3,750	$3,750
Total costs for practice	Sum of rows above.	$483,750	$520,255
Number of vaccinations delivered	Assumes 11,700 children (of 15,000 children) are not fully vaccinated, and 10% increase in vaccinations due to this practice (23.4% of families receiving text messages/phone calls).	1,170	1,170
Costs per vaccination delivered	Total costs per practice divided by number of vaccines delivered.	$413	$445

Note: The first column includes the programmatic costs that an immunization program and partners would incur and does not include costs related to vaccines since these were paid by the federal government during the public health emergency. The second column includes all costs, regardless of who paid them (so it includes the costs that were paid by the federal government for vaccines.)

[1] We assume the cost of other ancillary supplies, such as bandages and alcohol wipes, is also captured within this figure. The marginal cost for many of these supplies is likely to be de minimis in most contexts.

[2] Software development and infrastructure costs for linking records in the IIS with state Medicaid records are highly variable and heavily depend on “the scale of the IIS and the target population size” as well as the maturity of the systems (Patel et al. 2015). Our estimate of $15/record may be more suitable for a reasonably mature IIS with some existing data exchange capabilities and is on the lower end of the per-child range in the literature ($5.40 to $60.82). This estimate does **not** include any costs associated with upgrading state Medicaid systems for bidirectional communication with the IIS.

[3] Staff hours for vaccine administration and training are based on feedback from AIM’s Legacy Council and reflect an hourly rate of $125 for licensed nurses during the COVID-19 pandemic. This rate may be lower in different contexts and would vary by jurisdiction.

The Bureau of Labor Statistics estimates the median rate for a registered nurse in the United States to be approximately $40/hour in 2021 (BLS 2022), which translates to $60/hour when accounting for fringe benefits.

[4] Recommended CDC trainings for administering COVID-19 vaccinations include (1) COVID-19 training modules, (2) routine vaccination administration training, and (3) routine vaccine storage and handling training (CDC 2023b). The AIM Legacy Council suggested that these and other trainings can take up to 80 hours.

AIM = Association of Immunization Managers; CDC = Centers for Disease Control and Prevention; FTE = full-time equivalent; IIS = Immunization Information Systems; NA = not applicable.

Practice 2. Connecting opportunities to vaccinate children against COVID-19 with the chance to address basic needs of children and families

Our hypothetical implementation scenario includes a jurisdiction connecting opportunities to vaccinate children against COVID-19 with the chance to help families meet their basic needs over a 20-week period (within a broader one-year implementation period), with up to three events per week. Although basic needs vary by community and individual family, we assumed the jurisdiction would, on average, provide up to $50 of diapers, food assistance, or support for Medicaid enrollment or Medicaid enrollee needs for each COVID-19 vaccine dose administered. This differs from some of the studies we reviewed, in which basic needs were provided on a per-family basis (CPSTF 2020a). It is important to note that this cost could be higher, depending on the jurisdiction's implementation. For example, the Nashville Diaper Connection provided a monthly supply of diapers to each participating family, estimated to be worth approximately $100 each (Nashville Diaper Connection 2023). However, the precise relationship between more generous benefits and increased vaccination uptake (that is, the elasticity) is not clear from the available evidence. We further assumed that vaccinations would be provided through as many as three events per week at community venues and that families would be notified through outreach efforts, such as flyers and social media posts.

Implementation context during the public health emergency (PHE) versus post-PHE

During the COVID-19 PHE, jurisdictions might have implemented the basic needs practice using government funding that offered a large number of allowances and the flexibility to purchase basic needs resources, or they might have collaborated with partners that already provided basic needs resources. Moving forward after the PHE, jurisdictions should consider all the administrative and actual costs upfront to help determine if the practice is feasible to implement in the current environment. The key to implementing this practice is to capitalize on existing infrastructure and engage partners to supply the basic needs resources. Jurisdictions may prioritize building and maintaining long-term relationships with these partners as these relationships are investments in the jurisdiction's long-term public health infrastructure.

Estimates of the effectiveness of the practice in this scenario are based heavily on the CPSTF systematic review of practices that tied pediatric vaccination delivery to basic needs conducted before the COVID-19 pandemic (CPSTF 2020a, 2020e). Table 12 summarizes the costs associated with the basic needs practice, from the largest to the smallest dollar amounts. Based on the systematic evidence in adjacent contexts, we assume a 20 percent reduction in the unvaccinated population between ages 6 months and 11 years, which translates to approximately 2,340 vaccinations.

Table 12. Summary of costs for the basic needs practice

Costs	Description	Programmatic Cost (excluding vaccine and wastage) $	Total Costs (including vaccines and wastage) $
Program Administration	Assume one program director works for 40 hours a week for 20 weeks at $62.50 per hour ($93.75 per hour loaded) per salary of manager according to Bureau of Labor Statistics 2021.	$75,000	$75,000
Staff time (vaccination)	Cost of staff to administer including intake/security staff and time for IIS data entry).[1] Assumes two staff at three rotating clinics, with 20 minutes/vaccination for both staff members at $125 loaded hourly rate) multiplied by 2,340 vaccines.	195,000	195,000
Vaccines	Cost of vaccines (vial and syringe)*2,340 vaccines delivered x $28.89).[1]	NA	$67,603
Wastage	Vaccine cost multiplied by 8 percent waste. While Vaccines for Children provider requirements that limit wastage due to “negligence or mismanagement” to less than or equal to 5% (New York City Department of Health and Mental Hygiene 2023), we assume a higher rate here because CDC data indicate that about 11% of the doses that the federal government distributed were discarded from December to mid-May 2020 (Eaton 2022).	NA	$5,408
Resource distribution	Cost of organizing and distributing basic needs resources at community locations, with up to three events per week. Assumes 6 staff, 40 hours per week for 20 weeks at $65 loaded hourly rate. [2]	$312,000	$312,000
Refrigeration and storage	Cost of refrigeration. Approximately $5,000 per unit, plug-in units with two per clinic (assuming each clinic needs two for backup and/or transportation purposes) at 3 sites, including temperature data logger.[3]	$30,000	$30,000
Outreach	Cost of outreach (weekly marketing over the 20-week period), including small-scale multimodal advertising with email, signage, and paper/digital flyers.[4]	$20,000	$20,000
Training	Cost of training staff, up to 80 hours per staff member for recommended trainings. We assume up to six staff require training at a loaded hourly rate of $125.[5]	$60,000	$60,000
Cost of providing basic needs	Cost of $50 to the immunization program for diapers, groceries, school supplies, or other basic needs per vaccination for 2,340 participants.[6] Note that the net total cost is only $11,700, because we assume 90% of this $117,000 cost was transferred to participants who received a benefit of $105,300; however, there is a 10% ($11,700) net cost due to “deadweight loss” (the economic inefficiency of reallocating resources).	$117,000	$11,700

Costs	Description	Programmatic Cost (excluding vaccine and wastage) $	Total Costs (including vaccines and wastage) $
Total costs for practice	Sum of rows above.	$809,000	$776,711
Number of vaccinations delivered	Based on the systematic evidence in adjacent contexts, assumes a 20 percent reduction in the unvaccinated population between ages 6 months and 11 years old in the average county.	2,340	2,340
Costs per vaccination delivered	Total costs divided by number of vaccinations delivered.	$346	$332

Note: The first column includes the programmatic costs that an immunization program and partners would incur and does not include costs related to vaccines since these were paid by the federal government during the public health emergency. The second column includes all costs, regardless of who paid them (so it includes the costs that were paid by the federal government for vaccines.)

[1] Staff hours for vaccine administration and training are based feedback from AIM's Legacy Council and reflect an hourly rate of $125 for licensed nurses during COVID-19 pandemic. Importantly, while we assume staff time for IIS data entry, we also assume that the software to allow mobile clinics to electronically collect and share information with the IIS has been previously implemented and tested. No additional infrastructure or software costs are included.

[2] AIM Legacy Council members noted that purchase of vans may not be reimbursable in a post-pandemic environment (CDC 2023c). This estimate assumes a cost of $175,000/van (including anticipated customizations) and $1/mile for mileage and maintenance, with mileage not exceeding 60 miles per van per day. The General Services Administration (GSA) authorized payment for privately owned vehicles is slightly lower, at $0.66/mile as of January 1, 2023 (GSA 2023).

[3] The cost of refrigeration can vary widely. An AIM Legacy Council member noted that a cost of $5,000 may be more typical for purpose-built refrigerators, with data loggers and backup power systems.

[4] This estimate assumes $1,000 per week for 20 weeks for advertising, with an additional 10 hours per week for emailing prospective participants. Evidence in adjacent contexts suggests that multimodal marketing can enhance vaccination efforts for mobile clinics (Hannings et al. 2022). These advertising costs are separate from scheduling and logistics.

[5] Recommended CDC trainings for administering COVID-19 vaccinations include (1) COVID-19 training modules, (2) routine vaccination administration training, and (3) routine vaccine storage and handling training (CDC 2023b). The AIM Legacy Council suggested that these and other trainings can up to 80 hours.

[6] The AIM Legacy Council members noted that these costs associated with providing for basic needs would only be reimbursable during the pandemic. Given that context, an additional cost not considered in this analysis may involve coordinating with external partners or community-based organizations.

AIM = Association of Immunization Managers; CDC = Centers for Disease Control and Prevention; IIS = Immunization Information Systems; NA = not applicable.

Practice 3. Using mobile clinics to vaccinate children against COVID-19 at community-based locations

Our hypothetical implementation scenario includes a jurisdiction purchasing two vans to operate as mobile clinics during the 20-week vaccination period. Each van would require up to three professionals, including an inventory manager, clinical administrator, and health care professional. We assume the inventory manager or clinical administrator is also responsible for ensuring directions are followed at each site, but the AIM Legacy Council noted that security may need to be hired separately. The vans would travel no more than 30 miles per day, on average, to get to their mobile vaccination site (60 miles round trip) and would operate five days per week. We also assumed some level of marketing and outreach to inform families about the mobile clinics and encourage parents to prioritize vaccinations.

Estimates of the effectiveness of this practice in this scenario are based on the e the CPSTF systematic review of literature on vaccination at community centers, conducted before the COVID-19 pandemic (CPSTF 2021) and on a more recent study of mobile clinics during COVID-19 (Leibowitz et al. 2021). Table 13 summarizes the costs and benefits associated with the mobile clinics practice, from the largest to the smallest dollar amounts. Based on the systematic evidence in adjacent contexts, we assume a 35 percent reduction in the unvaccinated population between ages 6 months and 11 years, or approximately 4,000 vaccinations. This implies that each van provides an average of 20 vaccinations per day. This is similar to an estimate provided in an interview Mathematica conducted with the Los Angeles County Department of Public Health in the Vaccine Preventable Disease Control Unit, which indicated that "18 patients a day is standard for one mobile clinic in order to cover costs" (Los Angeles County Department of Public Health 2023). We assumed three staff per van, with two intake or administrative staff (including one driver) and at least one vaccinator.

It is important to note that costs for mobile clinics can vary widely. The AIM Legacy Council noted that, under a New York City Department of Health and Mental Hygiene contract for mobile vaccination and testing clinics with a staff of 100 and throughput of 1,000 patients/day, costs were as high as $215,000/day (Office of the New York City Comptroller 2023).

Implementation context during the public health emergency (PHE) versus post-PHE

During the COVID-19 PHE, government funding was available that offered a large number of allowances and flexibilities for spending, including spending on the leasing rental, and purchase of vans. Moving forward after the PHE, jurisdictions will have less of this type of government funding and will likely need to find new ways to fund practice implementation. For example, government funding is now available for the leasing and rental of vans, but not purchase.

Table 13. Summary of costs for the mobile clinics practice

Costs	Description	Programmatic Cost (excluding vaccine and wastage) $	Total Costs (including vaccine and wastage) $
Program Administration	Assume one program director works for 40 hours a week for 20 weeks at $62.50 per hour ($93.75 per hour loaded) per salary of manager according to Bureau of Labor Statistics 2021ab.	$75,000	$75,000
Staff time (vaccination)	Cost of staff ($125 loaded hourly rate) to administer vaccinations (3 staff at each of the 2 clinics for 40 hours per week for 20 weeks), including time for IIS data entry.[1]	$600,000	$600,000
Transportation	Full cost of two mobile clinics (vans), including annual maintenance and mileage for 20 weeks.[2]	$362,000	$362,000
Vaccines	Cost of vaccines (vial and syringe) (4000 vaccinations x $28.89). Note: Staff time to administer vaccines is calculated separately above).		$115,560

Costs	Description	Programmatic Cost (excluding vaccine and wastage) $	Total Costs (including vaccine and wastage) $
Wastage	Vaccine cost multiplied by 8 percent waste. While Vaccines for Children provider requirements that limit wastage due to "negligence or mismanagement" to less than or equal to 5% (New York City Department of Health and Mental Hygiene 2023), we assume a higher rate here because CDC data indicate that about 11% of the doses that the federal government distributed were discarded from December to mid-May 2020 (Eaton 2022).		$9,245
Refrigeration and storage	Cost of refrigeration. (Costs for 4 units (2 per van) at approximately $5,000 per unit including cooler, battery, and temperature data logger, as well as other storage considerations.) [3]	$20,000	$20,000
Scheduling and logistics	Cost of scheduling and logistics oversight for mobile clinics, assuming one administrative full-time staffer for scheduling and coordination and community outreach.[4]	$44,722	$44,772
Outreach	Cost of outreach (weekly marketing over the 20-week period), including small-scale advertising with email and social media advertising.[5]	$37,286	$37,286
Training	Cost of training staff, 6 staff for 80 hours at a loaded hourly rate of $125.[6]	$60,000	$60,000
Total costs for practice	Sum of rows above.	$1,119,058	$1,323,863
Number of vaccinations delivered	Based on evidence in adjacent contexts, assumes 4000 vaccines, assuming a 35 percent reduction of the unvaccinated population between ages 6 months and 11 years old in the "average" county".	4,000	4,000
Costs per vaccination delivered	Total costs divided by number of vaccines delivered.	$300	$331

Notes: The first column includes the programmatic costs that an immunization program and partners would incur and does not include costs related to vaccines since these were paid by the federal government during the public health emergency. The second column includes all costs, regardless of who paid them (so it includes the costs that were paid by the federal government for vaccines.)

[1] Staff hours for vaccine administration and training are based feedback from AIM's Legacy Council and reflect an hourly rate of $125 for licensed nurses during COVID-19 pandemic. Importantly, while we assume staff time for IIS data entry, we also assume that the software to allow mobile clinics to electronically collect and share information with the IIS has been previously implemented and tested. No additional infrastructure or software costs are included.

[2] AIM Legacy Council members noted that purchase of vans may not be reimbursable after the pandemic (CDC 2023c). This estimate assumes a cost of $175,000/van (including anticipated customizations) and $1/mile for mileage and maintenance, 60 miles per van per day for 100 days. The General Services Administration (GSA) authorized payment for privately owned vehicles is slightly lower, at $0.66/mile as of January 1, 2023 (GSA 2023).

[3] The cost of refrigeration can vary widely. An AIM Legacy Council member noted that a cost of $5,000 may be more typical for purpose-built refrigerators, with data loggers and backup power systems.

[4] CDC guidance on what to consider when planning to operate a COVID-19 vaccination clinic includes a variety of other operational and logistics considerations that are not included in this estimate, such as involving public health department staff leadership, establishing critical partnerships, identifying disproportionality impacted communities, and strategically selecting sites (CDC 2023d). Our estimate for the number of full-time staffers is based on feedback from the AIM Legacy Council.

[5] This estimate assumes $1,000 per week for 20 weeks for advertising, with an additional 10 hours per week for emailing prospective participants. Evidence in adjacent contexts suggests that multimodal marketing can enhance vaccination efforts for mobile clinics (Hannings et al. 2022). These advertising costs are separate from scheduling and logistics.

[6] Recommended CDC trainings for administering COVID-19 vaccinations include (1) COVID-19 training modules, (2) routine vaccination administration training, and (3) routine vaccine storage and handling training (CDC 2023b). The AIM Legacy Council suggested that these and other trainings can up to 80 hours.

AIM = Association of Immunization Managers; CDC = Centers for Disease Control and Prevention; IIS = Immunization Information Systems.

Practice 4. Vaccinating children against COVID-19 at home

Our hypothetical implementation scenario includes a jurisdiction delivering vaccinations to children at home through scheduled appointments. Appointments are available to all children, but children with special needs, such as children with physical disabilities and children who are otherwise housebound, would be prioritized. The jurisdiction partners with emergency medical services or local fire services to administer vaccinations, but vaccinations are also provided by licensed medical professionals relying on civilian transportation.

> **Implementation context during the public health emergency (PHE) versus post-PHE**
>
> During the COVID-19 PHE, some jurisdictions experienced difficulty hiring staff because of high staff turnover, workforce shortages, and increased labor costs. In addition, some jurisdictions needed to quickly hire a large number of staff to meet the urgent, large-scale need to vaccinate children against COVID-19. Moving forward after the PHE, some of these jurisdictions might find it easier to hire staff because of decreases in staff turnover, workforce shortages, and labor costs, and because practice implementation is less urgent and smaller scale.

Estimates of the effectiveness of the practice are based heavily on the CPSTF systematic review of at-home vaccination, completed in 2013 (CPSTF 2020d). Given that these data are based on at-home vaccination programs executed before the COVID-19 pandemic and include some studies from outside the US—including Australia, the United Kingdom, and Canada—estimates of effectiveness may be overly optimistic in the current context (CPSTF 2020d). Table 14 summarizes the costs and benefits associated with the at-home vaccination practice, from the largest to the smallest dollar amounts. Based on the systematic evidence in adjacent contexts, we assume an approximately 12 percent reduction in the unvaccinated population between ages 6 months and 11 years, or approximately 1,400 vaccinations. The precise calculation was derived by assuming an average of 3.5 vaccinations per day per vehicle and four active drivers over a 20-week period (within a broader one-year implementation period).

The assumptions under this scenario imply an average cost per vaccination of over $1,000 per dose, including all costs captured below. However, costs for this practice can vary substantially, depending on the specific implementation details, geography, and other factors. AIM Legacy Council members provided a cost range of $300-$369 per visit for at-home vaccinations in New York, exclusive of the cost of vaccine administration, and noted that all other costs were captured in this figure.

Table 14. Costs of delivering at home visits practice

Costs	Description	Programmatic Cost (excluding vaccine and wastage) $	Total Costs (including vaccines and wastage) $
Program Administration	Assume one program director works for 40 hours a week for 20 weeks at $62.50 per hour ($93.75 per hour loaded) per salary of manager according to Bureau of Labor Statistics 2021.	$75,000	$75,000
Staff time (vaccination)	Cost of staff to administer vaccinations (four cars, two staff per car, 40 hours per week for 20 weeks), including time for IIS data entry. [1]	$800,000	$800,000
Transportation	Full cost of four cars, including annual maintenance and mileage for 20 weeks.[2]	$360,000	360,000
Vaccines	Cost of vaccines (vial and syringe) (1400 vaccinations x $28.89). Note: Staff time to administer vaccines is calculated separately above.		$40,446
Wastage	Vaccine cost multiplied by 8 percent waste. While Vaccines for Children provider requirements that limit wastage due to “negligence or mismanagement” to less than or equal to 5% (New York City Department of Health and Mental Hygiene 2023), we assume a higher rate here because CDC data indicate that about 11% of the doses that the federal government distributed were discarded from December to mid-May 2020 (Eaton 2022).		$3,236
Refrigeration and storage	Cost of refrigeration. (Approximately $5,000 per car, including cooler, battery, and temperature data logger, as well as other storage considerations.) [3]	$20,000	$20,000
Scheduling and logistics	Cost of scheduling appointments for at-home visits, assuming 2.5 administrative full-time equivalent staff at $37.31 hourly wage loaded by 1.5 over a 20-week period.	$111,930	$111,930
Outreach	Cost of outreach (weekly marketing over the 20-week period), including small-scale advertising with email and social media advertising.[4]	$37,286	$37,286
Training	Cost of training staff, 8 staff for 80 hours at a loaded hourly rate of $125.[5]	$80,000	$80,000
Total costs for practice	Sum of rows above.	$1,484,216	1,527,898
Number of vaccinations delivered	Based on the systematic evidence in adjacent contexts, we assume an approximately 12 percent reduction in the unvaccinated population between ages 6 months and 11 years old in the average county.	1,400	1,400
Costs per vaccination delivered	Total costs divided by number of vaccines delivered.	$1,060	$1,091

Notes: The first column includes the programmatic costs that an immunization program and partners would incur and does not include costs related to vaccines since these were paid by the federal government during the public health emergency. The second column includes all costs, regardless of who paid them (so it includes the costs that were paid by the federal government for vaccines.)

[1] Staff hours for vaccine administration and training are based feedback from AIM's Legacy Council and reflect an hourly rate of $125 for licensed nurses during the COVID-19 pandemic. Importantly, while we assume staff time for IIS data entry, we also assume that the software to allow staff to electronically collect and share information with the IIS has been previously implemented and tested. No additional infrastructure or software costs are included.

[2] This estimate assumes a cost of $75,000/car, plus $0.625/mile for mileage and maintenance, 240 miles a day for 100 days .AIM Legacy Council members noted that purchase of vehicles may not be reimbursable (CDC 2023c). Legacy Council members also noted that the use of sports utility vehicles is more typical for at-home vaccinations. We ran a sensitivity analysis that assumes an SUV rental with insurance would likely cost $150 to $250/day ($21,000 to $35,000); using this assumption for the transportation cost in place of purchasing SUVs does not alter the ranking of practices.

[3] The cost of refrigeration can vary widely. Portable coolers or containers for vaccine storage may be less expensive for at-home vaccination than mobile clinics. However, AIM Legacy Council members noted other considerations can add to the cost of refrigeration for this practice.

[4] This estimate also assumes $1,000 per week for 20 weeks for advertising, with an additional 10 hours per week for emailing prospective participants. These advertising costs are separate from scheduling and logistics.

[5] Recommended CDC trainings for administering COVID-19 vaccinations include (1) COVID-19 training modules, (2) routine vaccination administration training, and (3) routine vaccine storage and handling training (CDC 2023b). The AIM Legacy Council suggested that these and other trainings can take up to 80 hours.

AIM = Association of Immunization Managers; CDC = Centers for Disease Control and Prevention; IIS = Immunization Information Systems.

Practice 5. Reducing operational barriers to help pediatric health care providers vaccinate children against COVID-19

Our hypothetical implementation scenario includes a jurisdiction providing block grants for up to 40 health care providers who submitted applications requesting support. These providers would use the funds to continue administering COVID-19 vaccinations, particularly by expanding hours of operations to accommodate working families. We assumed a similar duration for this practice as other practices, with extended hours for 20 weeks.

Estimates of the effectiveness of the practice are based on the KidsVaxGrant 2.0, a state-funded vaccination program in California, administered by Physicians for a Healthy California (Physicians for a Healthy California 2023). It is also based on three critical, practice-specific assumptions: (1) grants are $25,000 to each provider; (2) grants do not cover the full cost of provider operations during this period; and (3) rates of vaccination for each provider are similar to those in San Bernadino County, which is similarly sized to our hypothetical average county but differs in variety of population characteristics, such as ethnic and racial demographics and median household income. We assumed that not all providers submitting grant applications would be awarded grants, with approximately 90 percent of providers being awarded grants. Table 15 summarizes the costs and benefits associated with the provider support practice, from the largest to the smallest dollar amounts. There was limited systematic evidence available for this practice. Based on the California case study, we assumed an approximately 8–10 percent

Implementation context during the public health emergency (PHE) versus post-PHE

During the COVID-19 PHE, government funding was available that offered a large number of allowances and flexibilities for spending. Moving forward after the PHE, jurisdictions will have less of this type of government funding and will likely need to find new ways to fund practice implementation. For example, a jurisdiction that implemented a practice during the public health emergency only using government funding might, moving forward, implement the practice with a mix of government funding, philanthropic funding, and in-kind donations.

reduction in the unvaccinated population between ages 6 months and 11 years, or approximately 1,000 vaccinations, for an average of 25 additional vaccinations per practice.

Table 15. Costs of provider support practice

Costs	Description	Programmatic Cost (excluding vaccine and wastage) $	Total Costs (including vaccine and wastage) $
Program Administration	Assume one program director works for 40 hours a week for 20 weeks at $62.50 per hour ($93.75 per hour loaded) per salary of manager according to Bureau of Labor Statistics 2021.	$75,000	$75,000
Grants	Cost of 40 grants of $25,000 each to providers to expand hours of operation for working families.	$1,000,000	$1,000,000
Developing request for applications (applications (RFA) and managing grant)	Cost of developing the application RFA, recruiting providers, reviewing applications and managing the grant after award. [1]	$150,000	$150,000
Provider overhead	Additional costs per site, assuming approximately 150 hours of overtime at 15 of 40 provider sites.	$125,000	$125,000
Vaccines	Cost of vaccines (1,000 vaccines x $28.89). Note: Staff time to administer vaccines is calculated separately below.		$28,890
Wastage	Vaccine cost multiplied by 8 percent waste. While Vaccines for Children provider requirements that limit wastage due to “negligence or mismanagement” to less than or equal to 5% (New York City Department of Health and Mental Hygiene 2023), we assume a higher rate here because CDC data indicate that about 11% of the doses that the federal government distributed were discarded from December to mid-May 2020 (Eaton 2022).		$2,311
Training	Cost of training staff, up to 80 hours per staff member for recommended trainings. We assume up to six staff require training at a loaded hourly rate of $125.[2]	$60,000	$60,000
Applications	Cost of provider time to complete applications for grants (assume 10% of applicants do not receive grants).	$26,400	$26,400
Outreach	Cost of advertising to promote the grant opportunity (up to one week of advertising, at up to $1,000/day).).	$7,000	$7,000
Total costs for practice	Sum of rows above.	$1,443,400	$1,474,601
Number of vaccinations delivered	Based on the California case study, we assumed an approximately 8–10 percent reduction in the unvaccinated population between ages 6 months and 11 years old, or approximately 1,000 vaccinations, for an average of 25 additional vaccinations per practice.	1,000	1,000
Costs per vaccination delivered	Total costs divided by number of vaccinations delivered.	$1,443	$1,475

Notes: The first column includes the programmatic costs that an immunization program and partners would incur and does not include costs related to vaccines since these were paid by the federal government during the public health emergency. The second column includes all costs, regardless of who paid them (so it includes the costs that were paid by the federal government for vaccines.)

[1] This estimate was provided by the AIM's Legacy Council, from a comparably sized grant over a similar time frame. It includes all costs associated with development of the RFA, recruitment, and management of the grant, except for the direct cost associated with advertising the grant opportunity, captured under Outreach.

[2] Recommended CDC trainings for administering COVID-19 vaccinations include (1) COVID-19 training modules, (2) routine vaccination administration training, and (3) routine vaccine storage and handling training (CDC 2023b). The AIM Legacy Council suggested that these and other trainings can take up to 80 hours.

AIM = Association of Immunization Managers; CDC = Centers for Disease Control and Prevention.

Benefits incurred across all practices by averting adverse events

We assume each practice incurred the same benefits per 1,000 vaccinations delivered due to averting cases and medical costs that would have occurred if children were not vaccinated. This means that practices that result in more vaccinations generate greater benefits. Table 16 describes our assumptions and calculations surrounding the adverse events prevented per 1,000 vaccinations.

Table 16. Benefits due to adverse events prevented per 1,000 vaccines, for the five practices

Events	Events averted per 1000 vaccines (1)	Cost per event (2)	Total benefit (Product of columns 1 and 2)
Deaths	0.54 *Based on 8,178 deaths averted per 15,120 children vaccinated (Borchering 2022).*[1]	1,655,858 *Based on economic value of life of 1.5 million in 2016 from Grosse (2019)*[2]*, inflated to 2021 dollars.*	$894,169
Hospitalizations	3.1 *Based on 46,862 hospitalizations averted per 15,120 children vaccinated (Borchering 2022).* [1]	$24,826 *Shrestha et al. (2021)*[3] *estimated inpatient costs of $24,826 per hospitalization.*	$76,961
Reduction in other health care costs	28.41 *Based on 429,526 cases averted per 15,120 children vaccinated (Borchering 2022).*[1]	$1,008 *Outpatient costs per case according to FAIR Health.*[4]	$28,637
Reduction in learning loss	28.41 *Based on 429,526 cases averted per 15,120 children vaccinated (Borchering 2022).*[1]	$378 *$94.5 per day (based on NCES cost per student per year of $17,013 in 2021 dollars in public US school*[5] *divided by 180 days per year) multiplied by 4 days of school lost.*	$10,739
Reduction in caretaker time	*28.41* *Based on 429,526 cases averted per 15,120 thousand children vaccinated (Borchering 2022).*[1]	$975 *Assumes 2.5 workdays (20 hours) per case for caretakers multiplied by a loaded wage of $48.75 per hour.*	$27,700
Total benefits per 1,000 vaccinations delivered (sum of all rows above)			$1,038,205

[1] Borchering (2023) estimated the number of adverse events (cases, hospitalizations, and deaths across all age groups) that would be prevented by a childhood vaccination campaign within a 6 month time-frame, assuming that 54% of the 28 million children ages 5 to 11 in the US would be vaccinated.

[2] See Grosse, 2019: doi: 10.1080/13696998.2018.1542520.

[3] See Shrestha, 2021: doi:10.1093/ofid/ofab561.

[4] See FAIR Health, September 2021, https://s3.amazonaws.com/media2.fairhealth.org/infographic/asset/COVID-.
[5] See National Center for Education Statistics https://nces.ed.gov/fastfacts/display.asp?id=66.

D. Economic sensitivity analysis

To assess the robustness and reliability of the practice benefit-cost ratios and rankings, we conducted a sensitivity analysis by systematically varying key assumptions such as reduction in deaths (Table 17). The shading in the ranges indicate the ranking of practices from highest to lowest in terms of benefit-cost ratio. As we altered the assumptions, this ranking changes in some cases. Across most of the revised assumptions, the mobile clinics practice continued to have the largest benefit-cost ratio, and the provider support practice had the lowest benefit-cost ratio. Four out of 21 revised assumption scenarios altered the relative ranking across the practices. The basic needs practice was ranked the highest if the value of the assistance decreased by 50 percent; however, this scenario should be interpreted cautiously as we assumed that the effectiveness of the intervention was unchanged due to the limited information in the literature about the effects of changing the value of the gift or voucher (CPSTF 2020a). Jurisdictions will likely vary in how much they are willing to provide for items used to address basic needs, which will likely impact the overall cost-benefit ratio. Altering assumptions around the size of the population changed the relative ranking of practices, with the targeted outreach practice scaling the best and moving into the first position as the population increased by 3 times. This aligned with our findings from the feasibility analysis, which suggested that the targeted outreach practice is most likely to scale well to larger populations. However, the targeted outreach practice moved to fourth place if the costs for software increased by 5 times. Adjusting the assumptions around the efficacy of each practice—that is, how well the practice translates into additional vaccinations for children—did not alter the relative ranking of benefits but did impact the overall magnitude of the benefit-cost ratios. The overall cost-benefit ratios are extremely sensitive to our assumptions related to the number and value of deaths averted, as the benefit due to deaths averted is the largest driver of benefits. However, while altering this assumption has a substantial impact on the magnitude of the cost-benefit ratios, it does not impact the relative ranking of practices. We did not vary the cost of the vaccination itself, as the immunization programs did not incur this cost during the pandemic; when we factored in the cost of vaccination in the total costs perspective, the cost-benefit ratio for each practice increased, but did not change their relative ranking. Finally, it is important to note that this analysis does not consider potential side effects from vaccination, which could also impact the anticipated magnitude of benefits.

Table 17. Benefit-cost ratio of the five promising practices under revised assumptions from the immunization manager perspective

	Applicability	Targeted outreach	Basic needs	Mobile clinics	At-home vaccination	Provider support
Baseline	**All**	2.33	3.13	3.14	.95	.70
Statistical value of life (instead of economic value life) per death averted	All	13.72	18.38	18.43	5.59	4.14
Twice as many deaths averted	All	4.35	5.82	5.84	1.77	1.31
Half as many deaths averted	All	1.33	1.78	1.79	0.54	.40
Twice as many hospitalizations averted	All	2.68	3.59	3.60	1.09	0.81
Half as many hospitalizations averted	All	2.25	3.01	3.02	0.92	0.68
Outpatient medical costs twice as high	All	2.40	3.21	3.22	0.98	0.72
Outpatient medical costs half as high	All	2.30	3.08	3.09	0.94	0.69
Software costs 5 times higher	1	.93	3.13	3.14	0.95	0.70
Software costs 50% lower	1	2.87	3.13	3.14	0.95	0.70
Legal review two times higher	1	2.12	3.13	3.14	0.95	0.70
Legal review 50% lower	1	2.46	3.13	3.14	0.95	0.70
Basic needs costs two times higher	2	2.33	3.08	3.14	0.95	0.70
Basic needs costs 50% lower	2	2.33	3.15	3.14	0.95	0.70
Transportation costs 50% higher	3, 4	2.33	3.13	2.76	0.85	0.70
Transportation costs 50% lower	3, 4	2.33	3.13	3.63	1.08	0.70
Grants to providers 50% higher	5	2.33	3.13	3.14	0.95	0.42
Grants to providers 50% lower	5	2.33	3.13	3.14	0.95	1.07
Population 3 times higher	All	3.33	3.30	3.23	0.99	1.35
Population 50% smaller	All	1.61	2.90	3.00	0.90	0.41
Increase in efficacy, 50%	All	3.50	4.69	4.71	1.43	1.06
Decrease in efficacy, 50%	All	1.17	1.56	1.57	0.48	0.35

Notes: Benefit cost ratio rank of practice: = 1 = 2 = 3 = 4 = 5

Practice 1: Conducting targeted outreach to Medicaid beneficiaries for COVID-19 vaccines by linking immunization information system and Medicaid data

Practice 2: Connecting opportunities to vaccinate children against COVID-19 with the chance to address basic needs of children and families

Practice 3: Using mobile clinics to vaccinate children against COVID-19 at community-based locations

Practice 4: Vaccinating children against COVID-19 at home

Practice 5: Reducing operational barriers to help pediatric health care providers in vaccinate children against COVID-19.

VII. Implications and Next Steps

Although the public health emergency expired on May 11, 2023, jurisdictions can use the five promising practices described in this report to increase pediatric COVID-19 vaccination rates, which in turn can help improve the general health of children and their families and decrease COVID-19-related morbidity and mortality. In addition, jurisdictions can consider applying the practices more broadly to routine vaccinations and future pandemics. It is important to note that this report is offered as consideration for jurisdictions interested in implementing the practices. We also stress that jurisdictions need to keep in mind that many of the inputs in this analysis (such as vaccination cost, inpatient and outpatient costs) will be different after the pandemic and should consider recomputing the ratios using post-pandemic data, and need to consider how their jurisdiction may differ from the average county. Below, we list facilitators and challenges for implementing each practice during versus after the COVID-19 public health emergency (Table 18). Following the table, we summarize the three common challenges affecting all or most of the five practices after the public health emergency.

Table 18. Facilitators and challenges for implementing each of the five promising practices during versus after the COVID-19 public health emergency

	During	After
Practice 1: Targeted outreach		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • High engagement from partners due to urgent need to vaccinate • Support for new investments in vaccine infrastructure (such as new data sharing functionalities)	• Some investments in vaccine infrastructure from during the public health emergency can be sustained and improved, which facilitates future improvements • Coverage for COVID-19 vaccinations makes vaccination free of charge for nearly all children who are eligible for the Vaccines for Children (VFC) program
Challenges	• Focus was often on making rapid and temporary investments in vaccine infrastructure, rather than long-term and sustainable investments	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding • Low engagement from partners due to competing priorities and perceptions that there is no longer an urgent need to vaccinate • Less support for new investments in vaccine infrastructure

	During	After
Practice 2: Basic needs		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • High engagement from partners due to urgent need to vaccinate • Many opportunities for vaccination outside of traditional health care settings • Federal government paid for all COVID-19 vaccines	• In some jurisdictions, less staff turnover, workforce shortages, and labor costs • Coverage for COVID-19 vaccinations makes vaccination free of charge for nearly all children who are eligible for the VFC program
Challenges	• High staff turnover, workforce shortages, and increased labor costs in some jurisdictions	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding • Low engagement from partners due to competing priorities and perceptions that there is no longer an urgent need to vaccinate • Fewer opportunities for vaccination outside of traditional health care settings
Practice 3: Mobile clinics		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • High engagement from partners due to urgent need to vaccinate • Temporary authorization of a wide range of health care providers to administer COVID-19 vaccines to children (through PREP Act and state policies) • Federal government paid for all COVID-19 vaccines	• Continuation of some states policies that authorized pharmacists to administer COVID-19 vaccines (will play a larger role after the PREP Act expires) • In some jurisdictions, less staff turnover, workforce shortages, and labor costs • Coverage for COVID-19 vaccinations makes vaccination free of charge for nearly all children who are eligible for the VFC program
Challenges	• High staff turnover, workforce shortages, and increased labor costs for some jurisdictions	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding • Low engagement from partners due to competing priorities and perceptions that there is no longer an urgent need to vaccinate • PREP Act authority for pharmacists to administer COVID-19 vaccines to children ages 3 and above expires in 2024 and reverts to state laws, which are more restrictive in many cases

	During	After
Practice 4: At-home vaccination		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • High engagement from partners due to urgent need to vaccinate • Federal government paid for all COVID-19 vaccines	• In some jurisdictions, less staff turnover, workforce shortages, and labor costs • Coverage for COVID-19 vaccinations makes vaccination free of charge for nearly all children who are eligible for the VFC program
Challenges	• High staff turnover, workforce shortages, and increased labor costs for some jurisdictions	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding • Low engagement from partners due to competing priorities and perceptions that there is no longer an urgent need to vaccinate
Practice 5: Provider support		
Facilitators	• Government funding offered allowances and flexibilities for spending • Non-governmental funding from commercial and non-profit sectors • Federal government paid for all COVID-19 vaccines •	• Changes in requirements and guidelines for storing, transporting, and administering the different COVID-19 vaccines are less rapid, which can make it easier for some providers to stay up to date • Payment for vaccines through the VFC program and private insurance for nearly all children reduces financial risk
Challenges	• Rapidly changing requirements and guidelines for storing, transporting, and administering the different COVID-19 vaccines • Upfront provider costs for equipment and staffing to properly store and administer novel vaccines	• Less government funding and fewer allowances and flexibilities for spending • Fewer opportunities for non-governmental funding

Note: The public health emergency was from January 27, 2020 through May 11, 2023. For more information, see https://aspr.hhs.gov/legal/PHE/Pages/covid19-11Jan23.aspx and https://www.hhs.gov/coronavirus/covid-19-public-health-emergency/index.html.

IIS = Immunization Information Systems; PREP Act = Public Readiness and Emergency Preparedness Act.

Three common challenges affect all or most of the five practices after the public health emergency:

1. **Less government and non-governmental funding.** Jurisdictions looking to implement any of the five practices after the public health emergency will likely need to identify new ways to fund practice implementation. For example, a jurisdiction that implemented a practice during the public health emergency only using government funding might, moving forward, implement the practice with a mix of government funding, philanthropic funding, and in-kind donations.

2. **Low engagement from partners.** Jurisdictions implementing the targeted outreach, basic needs, mobile clinics, and at-home vaccination practices after the public health emergency might see potential and existing partners focusing less on COVID-19 vaccination. Jurisdictions may prioritize building and maintaining long-term relationships with partners as these relationships are investments in the jurisdiction's long-term public health infrastructure. Local partners can provide critical knowledge and resources that can help jurisdictions successfully implement and improve the practices.
3. **Complexities arising from commercialization of COVID-19 vaccines.** Without the federal government paying for all COVID-19 vaccines, jurisdictions implementing the basic needs, mobile clinics, at-home vaccination, and provider support practices after the public health emergency will need to consider how to support providers in billing multiple insurers and managing different stocks of vaccines when insurers only pay for certain COVID-19 vaccines.

Overall, the key findings and implications presented in this report document (1) early implementation experiences and insights of immunization program managers and other health and community leaders working to improve pediatric COVID-19 vaccination rates through five promising practices, (2) early factors and policies affecting implementation of the practices, and (3) estimated costs and benefits associated with the practices. We hope this report can advance opportunities for public health practitioners to share and learn from each other regarding promising practices to improve immunization rates. Research combined with dissemination can strengthen the existing infrastructure to respond to new or emerging crises.

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Appendix A

Pediatric COVID-19 Vaccination Rates

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Table A.1. Pediatric COVID-19 vaccination rates for children ages 11 and under, by state and territory, as of May 2023

State or territory	Population	At least one dose	Full series	At least one dose (rate)	At least one dose (rate per 100k)	Complete series (rate)	Complete series (rate per 100k)
United States	48,478,216	13,406,404	10,494,131	27.65%	27,654	21.65%	21,647
Alaska	122,668	30,049	24,284	24.50%	24,496	19.80%	19,797
Alabama	716,305	83,500	56,747	11.66%	11,657	7.92%	7,922
Arkansas	460,556	80,215	57,309	17.42%	17,417	12.44%	12,443
Arizona	1,072,657	308,203	224,389	28.73%	28,733	20.92%	20,919
California	5,865,958	1,931,641	1,597,092	32.93%	32,930	27.23%	27,226
Colorado	822,675	285,078	223,571	34.65%	34,653	27.18%	27,176
Connecticut	459,340	186,007	149,577	40.49%	40,494	32.56%	32,563
District of Columbia	95,995	57,969	41,215	60.39%	60,388	42.93%	42,935
Delaware	133,957	38,069	29,084	28.42%	28,419	21.71%	21,711
Florida	2,781,709	514,535	397,479	18.50%	18,497	14.29%	14,289
Fed. States of Micronesia	23,178	18,628	13,462	80.37%	80,369	58.08%	58,081
Georgia	1,629,321	284,609	207,348	17.47%	17,468	12.73%	12,726
Guam	37,173	10,747	8,223	28.91%	28,911	22.12%	22,121
Hawaii	204,763	74,184	62,684	36.23%	36,229	30.61%	30,613
Iowa	478,789	108,158	90,464	22.59%	22,590	18.89%	18,894
Idaho	291,658	45,180	37,179	15.49%	15,491	12.75%	12,747
Illinois	1,834,016	603,359	508,004	32.90%	32,898	27.70%	27,699
Indiana	1,027,180	196,055	143,956	19.09%	19,087	14.01%	14,015
Kansas	461,617	116,001	89,129	25.13%	25,129	19.31%	19,308
Kentucky	661,506	117,177	91,299	17.71%	17,714	13.80%	13,802
Louisiana	725,476	89,576	63,766	12.35%	12,347	8.79%	8,790
Massachusetts	875,758	433,810	336,780	49.54%	49,535	38.46%	38,456
Maryland	882,793	352,920	293,223	39.98%	39,978	33.22%	33,215
Maine	159,276	63,314	53,371	39.75%	39,751	33.51%	33,509
Marshall Islands	20,372	9,195	5,393	45.14%	45,135	26.47%	26,473

State or territory	Population	At least one dose	Full series	At least one dose (rate)	At least one dose (rate per 100k)	Complete series (rate)	Complete series (rate per 100k)
Michigan	1,391,855	322,759	269,457	23.19%	23,189	19.36%	19,360
Minnesota	861,544	310,583	257,790	36.05%	36,050	29.92%	29,922
Missouri	901,713	184,886	140,050	20.50%	20,504	15.53%	15,532
Northern Mariana Islands	9,561	5,151	4,363	53.88%	53,875	45.63%	45,633
Mississippi	454,724	51,904	40,142	11.41%	11,414	8.83%	8,828
Montana	151,180	31,507	23,146	20.84%	20,841	15.31%	15,310
North Carolina	1,502,565	401,238	277,214	26.70%	26,704	18.45%	18,449
North Dakota	124,816	26,426	19,036	21.17%	21,172	15.25%	15,251
Nebraska	317,000	79,811	66,677	25.18%	25,177	21.03%	21,034
New Hampshire	161,142	50,636	35,957	31.42%	31,423	22.31%	22,314
New Jersey	1,263,815	414,478	340,119	32.80%	32,796	26.91%	26,912
New Mexico	309,398	108,843	78,383	35.18%	35,179	25.33%	25,334
Nevada	458,354	82,882	63,330	18.08%	18,083	13.82%	13,817
New York	2,680,341	870,036	717,184	32.46%	32,460	26.76%	26,757
Ohio	1,688,398	359,832	301,533	21.31%	21,312	17.86%	17,859
Oklahoma	631,748	97,130	73,540	15.37%	15,375	11.64%	11,641
Oregon	569,968	183,952	139,363	32.27%	32,274	24.45%	24,451
Pennsylvania	1,720,459	551,736	438,245	32.07%	32,069	25.47%	25,473
Puerto Rico	345,401	184,617	159,478	53.45%	53,450	46.17%	46,172
Palau	2,887	1,511	1,130	52.34%	52,338	39.14%	39,141
Rhode Island	131,870	60,595	50,380	45.95%	45,951	38.20%	38,204
South Carolina	728,740	129,052	98,053	17.71%	17,709	13.46%	13,455
South Dakota	146,558	38,195	26,746	26.06%	26,061	18.25%	18,249
Tennessee	993,606	147,387	114,558	14.83%	14,834	11.53%	11,530
Texas	4,894,768	1,343,055	869,860	27.44%	27,439	17.77%	17,771
Utah	613,701	168,884	127,315	27.52%	27,519	20.75%	20,745
Virginia	1,228,546	453,832	365,825	36.94%	36,941	29.78%	29,777

State or territory	Population	At least one dose	Full series	At least one dose (rate)	At least one dose (rate per 100k)	Complete series (rate)	Complete series (rate per 100k)
Virgin Islands	16,865	1,555	1,138	9.22%	9,220	6.75%	6,748
Vermont	73,039	40,679	34,682	55.69%	55,695	47.48%	47,484
Washington	1,113,968	391,635	327,722	35.16%	35,157	29.42%	29,419
Wisconsin	822,642	228,659	191,815	27.80%	27,796	23.32%	23,317
West Virginia	234,310	33,578	26,038	14.33%	14,331	11.11%	11,113
Wyoming	88,038	11,201	8,834	12.72%	12,723	10.03%	10,034

Notes: The “at least one dose” and “complete series” pediatric vaccination rates were retrieved from the CDC application programming interface on August 17, 2023, (https://data.cdc.gov/resource/5i5k-6cmh.json) and are current as of May 10, 2023. We retrieved all states and territories and the following demographic categories in our query: ages_<2yrs, ages_2-4_yrs, ages_5-11_yrs. We then excluded American Samoa due to incomplete data for that territory. For each state and territory, we calculated (1) the total number of children 11 years and under with a completed COVID-19 vaccine series (based on the 'series_complete_yes' field), and (2) the total number of children 11 years and under who received at least one COVID-19 dose (based on the ‘administered_dose1’ field). We then calculated rates by state and territory for each of these variables. Population figures are based on the U.S. Census Bureau 10-year July 2019 National Population Estimates, which are provided through the CDC Data Application Program Interface (based on the ‘census’ field). The CDC uses U.S. Census estimates for the total population within each specified demographic category, regardless of prior vaccine status.

CDC = Centers for Disease Control and Prevention.

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