

Practical Considerations for Mass SARS-CoV-2 Pandemic Vaccination: A Narrative Review

Niebuhr BP¹ & Whiteside JA¹

¹Indiana University School of Medicine, Indianapolis, IN, USA

Abstract

Vaccine development against SARS-CoV-2 has dominated the literature during the 2019-21 COVID-19 pandemic, with minimal reporting regarding efficacious local implementation of vaccine campaigns—despite its critical role in vaccine uptake. This narrative review identifies practices to consider for local SARS-CoV-2 and future pandemic vaccination campaigns. We searched PubMed and the CDC's Immunization Information Systems database and identified 941 articles, selecting 18 for review based on local implementation relevance. We extracted strategies applicable to state and local SARS-CoV-2 vaccination efforts. Considerations included: establishing well-defined priority groups and partnerships; advanced planning emphasizing communication; surveillance and evaluation; flexibility; and overcoming cost-related limitations. National guidelines, such as those developed by the U.S. Health and Human Services, are necessary but insufficient for high coverage rates, as they depend on variable local supply chains and community strategies. Local Health Departments should recognize prior successful approaches to plan more coordinated, targeted, and successful SARS-CoV-2 vaccination.

Background

Early in the 2019-21 COVID-19 pandemic, the rapid development of an efficacious, safe vaccine was a primary strategy for reducing transmission, disease burden, and mortality. While much focus has been placed on the development of vaccine candidates, there has been minimal reporting to date regarding expeditious local distribution and administration of such a vaccine.

The federal Advisory Committee on Immunization Practices (ACIP) established the ACIP COVID-19 Vaccine Workgroup in April 2020. The ACIP was charged with developing recommendations for supply chain and stock maintenance and protocols for equity in allocation and distribution.¹ While ACIP guidance on vaccine recommendations is critical for targeting who to vaccinate, guidelines alone are insufficient as successful vaccine coverage relies heavily on state and local infrastructure, coordination, planning, and implementation.^{2,3} Failures to meet vaccination targets often lie at the implementation level (i.e. "the last mile") which calls for an increasing need to focus on the practical steps state and local health departments (LHDs) can take to facilitate efficient delivery to strategically targeted groups.

The 2009 H1N1 pandemic illustrated how high variability in vaccination coverage from state to state can occur despite clear guidelines and centralized strategy.⁴ The federal government was the sole H1N1 vaccine purchaser and distributor to states.⁵ While delegating vaccine administration to the states with knowledge of their assets and barriers to mass vaccinations theoretically results in a more fair and coordinated approach through local control, it is highly dependent on existing labor-intensive and robust state, local, and tribal supply chains and infrastructure and strategies for vaccine distribution and administration. Thus, one would expect vaccination coverage to vary considerably by state, which is what occurred in the H1N1 pandemic⁶ and occurred in the early SARS-CoV-2 vaccination campaign.⁷

Achieving sufficient vaccination coverage to reach herd

immunity (estimated to be at least 55-82%)⁸ is further encumbered by vaccine reticence: national surveys show that 10-27% of US adults—and up to 44% of Black Americans—would not get a SARS-CoV-2 vaccine, if such a vaccine were available, due to concerns of vaccine safety, mistrust, and misperceptions about immunity.⁸⁻¹⁰ A unique barrier to SARS-CoV-2 vaccine uptake may be the significant misinformation and disinformation campaigns regarding the COVID-19 pandemic circulating in news and social media.^{11,12}

Efforts have begun to document the complex landscape of vaccine delivery and the vast array of implementation practices.¹³ This is supplemented by recent attempts to identify best practices from past mass vaccination efforts,¹⁴ together highlighting the critical need for an evidence base that local and state health departments can source from. This work adds to recently published articles which identify a growing need to prepare for rapid implementation of mass pandemic vaccination campaigns by presenting such documented strategies.^{1,9,13,14}

Methods

We compiled literature related to the 2009 Influenza A Virus, H1N1, as this campaign was the largest emergency mass vaccination attempt in U.S. history prior to the 2019-21 COVID-19 pandemic. We searched English language articles in the National Library of Medicine's PubMed MESH database on 14 July 2020 without date restrictions. The following Medical Subject Heading (MeSH) terms resulted in 170 articles: "Immunization Programs/methods"[MeSH] OR "Immunization Programs/organization and administration"[MeSH] OR "Immunization Programs/standards"[MeSH] OR "Immunization Programs/statistics and numerical data"[MeSH] OR "Immunization Programs/supply and distribution"[MeSH] AND "Influenza A Virus, H1N1 Subtype"[MeSH]. Of these, we included two articles that were relevant for improving state and local vaccine distribution and excluded 168 articles based on title and abstract that analyzed basic science related to influenza vaccines, basic data about regional incidence rates, as well as commentary pieces and other analyses unrelated to vaccine distribution.^{15,16} The search was rerun on 08 March 2021 and returned 172 results. The additional two results were screened and one was selected for inclusion.¹⁷ We then broadened our search to consider other routine, mass vaccination programs (such as seasonal influenza) which identified 4 additional articles published between 2009-2019 pertaining to vaccination implementation strategies or features.^{2,18-20} We further identified 769 publications from the Center for Disease Control and Prevention (CDC) Immunization Information Systems database²¹ and, screening by title for those related to vaccine delivery and implementation, selected 11 articles for review.²²⁻³¹ We extracted recurring artifacts from 18 articles and attempted to synthesize these into common themes.

Results

WELL-DEFINED PRIORITY GROUPS

A systematic review of studies describing H1N1, seasonal influenza, DPT3, and other U.S. immunization campaigns reported that early identification of priority groups was a common feature of the most successful campaigns.²⁰ Priority groups routinely included those at increased risk of morbidity and mortality due to age or comorbid

conditions, as well as those with poor access to health care or significant vaccine reticence. Successful outreach activities targeting priority groups included personalized communication and maximizing ease of access to vaccines. A qualitative study by a LHD found that vaccination clinics during the H1N1 pandemic were most successful when they clearly defined high priority groups prior to implementing strategic plans or mobilizing clinic resources.¹⁵

ADVANCED PLANNING

Advanced planning of vaccination campaigns is a prerequisite for optimizing vaccine delivery. In addition to defining priority groups, effective vaccination strategies included establishing convenient locations and schedules and intentional planning for hard-to-reach communities (e.g. using well-known local facilities).²⁰ Effective advanced planning included reliable supply chain management of vaccines to prevent shortages²⁰ and prevent misallocated supply (e.g. sending bulk vaccine orders to rural providers and causing wastage).¹⁶ Planning for and obtaining resources for sufficient staffing, supplies, and related resources occurred among the more high-performing public vaccination clinics during the H1N1 pandemic.¹⁵ Recruiting health care providers and having standard operating procedures and standing vaccination orders for clinical staff to perform vaccinations were also useful strategies for increasing vaccinations.¹⁹ In addition to funding, several additional barriers to success were identified, including delays in staff hiring and high staff turnover, lack of on-site vaccine storage space, and lower-than-expected vaccine acceptance as barriers to acceptable vaccination rates.²⁷

COLLABORATIVE PARTNERSHIPS

Early collaboration with community partners and stakeholders was also effective in enhancing vaccination rates. A review conducted by Singh et al. found that high performing LHDs engaged stakeholders (such as high-priority patients and related community organizations) in shared planning to produce effective vaccination campaigns.²⁰ Public-private partnerships were leveraged to provide vaccines at popular contact points for the target populations, such as a local department store. Other effective approaches included: implementing multimodal communication strategies (e.g. TV, radio, billboards, flyers), holding vaccine clinics at familiar buildings (shelters, community centers), and adjusting vaccine clinic hours to accommodate working patients and families.²⁰ A recent study invoked a partnership with a private insurance provider to predict vaccine supply needs and identify active SARS-CoV-2 vaccinator capacity in a Texas county.¹⁷ Additionally, LHDs with existing community partners reported fewer challenges getting stakeholders to agree on priorities and had more streamlined clinic planning processes during the H1N1 pandemic.¹⁵ LHDs also reported useful partnerships with professional schools that supplied volunteers following the rapid introduction of “just-in-time” training into their curricula.¹⁵ Interestingly, 64% of 61 immunization program managers surveyed by Seib et al. after the H1N1 pandemic felt that their relationships with local partners were strengthened by their shared planning and implementation experiences.¹⁶

COMMUNICATION

The application of effective communication strategies and feedback loops was frequently implicated in successful implementation of vaccination campaigns at national, state, and local levels. With respect to influenza vaccination rates, political and policy commitment to practical measures (such as communication and reimbursement) through direct connections with patients was important for reaching national vaccine uptake goals.²³ Extensive advertisement and public informational campaigns are also an effective strategy to increase vaccination uptake, although it is difficult to objectively measure their impact.¹⁸ In positive deviance studies, tenacious communication was a widely shared characteristic of high-performing LHDs. Some high performers employed prompted messages, default communication, or motivational interviewing to overcome patient resistance and encourage uptake.²⁰ Many successful LHDs during the H1N1 pandemic utilized call centers early to provide information about the pandemic and the availability and effectiveness of the H1N1 vaccine. A few LHDs further designed public information

strategies using social media such as Facebook and Twitter to disseminate health and logistical information to the public.¹⁵ Recent suggestions emphasize the increased importance of social media as a leveraged asset for low cost and powerful public health messaging.³² The most effective campaigns employed a variety of media to disseminate information and improve immunization efforts.²⁰ For instance, one study found that an intervention using Human Papillomavirus (HPV) fact sheets, a parent education website, pictures of diseases caused by HPV, a decision aid for HPV vaccination, and communication training for health care providers improved vaccination rates by up to 11%.²⁹ Similarly, one group increased year-over-year vaccination rates by 33% by implementing face-to-face and telephonic communication training in motivational interviewing for pharmacy staff in a supermarket chain pharmacy.³³ To be most effective, message content should be deliberate and tailored to specific target groups. Messengers should be diverse and include members of the target population to build trust and increase vaccine acceptance.^{15,20} Enhancing communication amongst staff, stakeholders, and partners through established feedback loops, frequent team-oriented meetings, and team huddles are also reported with high-performing LHDs.²⁰

The use of Centralized-Reminder/Recall (C-R/R) was an effective evidence-based practice for improving immunization coverage.^{19,34} Common modalities include postcards/letters, auto-dialer telephone calls, emails, and text messages.²³ Although evidence-based and common practice, C-R/R initiatives were difficult to evaluate and separate from other co-interventions, and results were somewhat mixed.^{22,23,26} Most studies suggested that the telephone may be the least effective modality; however, it may be made more effective as an opt-in service or as supplement to other modalities.²⁵ Another study concluded that person-locator services in addition to Immunization Information Systems (IIS) provided more accurate contact data, which may improve C-R/R efficacy and reduce cost.²⁵

SURVEILLANCE

Effective monitoring and surveillance strategies were shown to facilitate rapid identification of “hot-spots” (higher prevalence of disease, gaps in coverage, vaccine refusers, resistance, or barriers to access) to better target additional resources and messaging,²⁰ especially toward vulnerable and high-risk populations.¹⁸ Use of Geographic Information Systems (tools that measure incidence data by geographical distribution) have shown promising results in identifying high-risk target populations to target vaccine messaging, delivery, and supply to areas in proportion to the population in need.²⁹ Another study demonstrated that a variety of data sources could be linked to improve vaccination rates among adolescents through the geographic distribution of known risk factors such as demographics (e.g. age, household size), low household income, lack of health insurance, non-adherence to other vaccination guidelines, lack of healthcare access, and visiting providers who do not regularly document vaccinations into immunization registries.³⁰

Fragmented immunization records and low surveillance of community coverage have been reported as significant barriers to vaccine uptake.³¹ A number of studies reported that routine and complete entry of vaccination data into a local IIS was a key strategy for improved community vaccination rates by identifying places and populations where vaccine uptake was suboptimal.¹⁹ Other studies reported IIS were useful for supplying data to other effective approaches, such as C-R/R initiatives.^{23,24}

PROGRAMMATIC FLEXIBILITY

Amongst high performing LHDs during the H1N1 pandemic, flexibility was important for successful vaccination campaigns.¹⁵ Quickly adapting existing plans for vaccination sites, staffing, and decision-making to local exigencies was necessary to accommodate the changing needs of target populations. When presented with a theoretical future pandemic following the H1N1 pandemic, the most frequently cited improvement immunization program managers recommended was tailoring their program to the specific pandemic event as it unfolded (i.e. considering evolving virulence, vaccine production rates, and public demand for vaccination).¹⁶

COST COMPONENT

Steps to lower out-of-pocket costs, maintain quick reimbursement procedures, and apply financial incentives were reported to enhance vaccination programs' success. One study of annual influenza vaccination rates for 201 WHO Member States from 2004-15 demonstrated that stronger political commitments to influenza control and more comprehensive low-cost vaccination policies were directly correlated with greater vaccine coverage.² Effective policies included a robust reimbursement system—alongside clear recommendations and wide-spread communication activities.^{2,3} Another study of Hepatitis B vaccinations in high-risk populations found that reducing out-of-pocket costs was a common and effective implementation strategy for local vaccination sites achieving broad coverage.¹⁹ As expected, a review conducted in Europe reported that providing free vaccines greatly increased vaccination rates.¹⁸ Interestingly, they also noted that financial incentives for general practitioners were effective in increasing vaccine uptake.¹⁸ Financial incentives can be targeted to providers (to incentivize greater administration) or to patients (to incentivize compliance). However, application of financial incentives could undermine on-going public campaigns aimed to muster excitement as payments may imply an action is undesirable.³⁵

Recommendations

Table 1: Recommendations for SARS-CoV-2 vaccine planners extracted from literature-derived strategies.

STRATEGY	RECOMMENDATION
Maintain Flexibility	
Daily monitoring and procedural adjustments according to the situation allow for rapid mobilization and effective use of short-term opportunities.	Steps to establish regular update/adjustment meetings with staff and key stakeholders may improve adaptive response.
Cross-trained staff (managerial and clinical) can allow for dynamic and rapid reassignment.	Steps to hire and train staff in clinical pandemic response in addition to health department programmatic tasks may improve rapidity of response and facilitate local relationships.
Establish Strategic Partnerships	
Strategic partnerships can be leveraged to supply staffing needs.	Collaborations with professional schools may allow for commensal benefit for obtaining volunteer workforce and student professional training.
Strategic partnerships can allow for improved reach, particularly for vulnerable communities.	Steps to partner with organizations (like fire departments, community centers, shelters) can increase access and cultural sensitivity of vaccine operations.
Enhance Surveillance	
More complete data gathering can improve efficiency and coverage of vaccine on both state and local levels.	Steps to expand IIS usage and establish data feedback loops may increase responsiveness and efficiency.
Local, hard-to-reach communities seem to be best accessed by an intimate, trusted understanding of these groups.	Steps to increase the diversity and community experience of vaccine planners may improve equitable coverage and access.
Improve Communication	
Regular communication and collaboration with stakeholders are essential.	Steps to establish formal communication, team meetings, and strategy may prove useful for both state and LHDs.
Low-cost tools like Centralized-Reminder/Recall systems may be supportive.	Steps to implement communication tools with the public may improve vaccine uptake.
Cost and workforce capacity may limit ability for LHDs to implement communication strategies.	Steps to achieve communication synergies may improve vaccine campaigns (such as state-run television advertisements and LHDs focusing on lower-cost strategies).
Lower Costs	
Out-of-pocket costs for the SARS-CoV-2 vaccine will likely not be applicable.	Steps to further incentivize target populations may include financial incentives, but these may imply being vaccinated is not desirable.
Costs are often a significant barrier for LHDs to operate successful vaccination campaigns.	Steps to engage in resource-sharing or expanding state-wide financial support may allow certain LHDs to greatly improve vaccination efforts.

While there is no one-size fits-all approach for a successful vaccination campaign, there are general characteristics that are common to successful ones. Table 1 presents key artifacts from the literature and related recommendations.

Discussion

The COVID-19 pandemic presented states with a crisis of unprecedented size, complexity, and urgency. The U.S. federal government's Operation Warp Speed resulted in the development and approval of two SARS-CoV-2 vaccines in less than a year.³⁶ State and county health departments were charged with rapidly developing approaches to vaccinating more than 300 million Americans, many of whom were reticent to be vaccinated.³⁶ LHDs had to therefore rely heavily on lessons learned during previous vaccination campaigns, locally available expertise, published literature, and organizational heuristics to develop local strategies for mass vaccination.

Advanced planning early in a pandemic is the most important factor in efficient and effective vaccination campaigns. The development of national guidelines are critical for establishing a general base upon which LHDs can build local strategies. However, developing national guidelines relies on outcomes data of ongoing vaccination programs; a reality which may complicate guideline-driven advanced planning by LHDs in rapidly changing landscapes, as with the SARS-CoV-2 pandemic.³⁷ Therefore, active data capture and analysis with rapid-cycle response and implementation is key. This is especially important where education, poverty, and minority statuses are found to be associated with

poor outcomes of COVID-19. Identifying these high-risk populations and carefully applying ethical principles with cultural competence becomes supremely important in prioritization schema at all levels. Such frameworks have been proposed by ACIP and others.³⁸

As guidelines emerged and recommendations were made from early pandemic outcomes data, flexibility became paramount in LHD response. Indeed, Klaiman et al. found that flexibility was a key differentiating factor for the highest-performing LHDs.¹⁵ The ability to establish off-site testing and vaccination clinics were essential features for effective campaigns. That said, variability in funding, staffing, capabilities, and approaches result in varying success of such campaigns. At all levels, health departments must be agile and ready to respond to daily-changing situations. Such flexibility requires constant monitoring and reevaluation of current practices as well as rapid communication with upstream and downstream stakeholders, with a commitment to making fundamental changes in approaches if necessary.

Engaging local partners, both during and between pandemics, can provide LHDs with avenues to deliver testing or vaccination in more trusted and convenient ways. Partnerships with professional schools can provide a flexible workforce, and need not be coordinated at the state level alone.²⁰

Surveillance, data analysis, and reporting of vaccine community uptake and community coverage gaps are particularly important yet often insufficient. Creating easily accessible and user-friendly IIS is necessary to empower regular, "real-time" evaluations of programs, delivery, and the rapid identification of coverage gaps caused by vaccine refusers, resistance, or barriers to access.

Establishing clear, multimodal, bidirectional, and targeted communication is critical to effective vaccination campaigns at both state and local levels. Reciprocally, communication from local to federal levels with new outcomes data will likely influence living guidelines in the evolving pandemic landscape.³⁷ Communication channels among LHDs, health care providers, and community partners should be established early and accessed frequently. Additional communication training at contact points during pandemics may be effective, with foci on prompted messages (e.g. providers asking about vaccinations during every patient visit, regardless of reason), default language (i.e. "I see you are due for the flu shot—when is a good time to schedule the appointment?"), and technical strategies (e.g. Motivational Interviewing).²⁰

The use of C-R/R systems is an evidence-based best practice for improving immunization coverage despite difficulty in isolating the impact of such programs. Effective C-R/R strategies appear to be multimodal (postcards, telephonic auto-dialers, text messaging), are "opt-in," and have accurate contact information. This is particularly relevant for populations with high address turnover.

Fortunately, SARS-CoV-2 vaccines are offered at no-cost to patients, so a reimbursement system or voucher program is irrelevant. Nonetheless, cost considerations and financial incentives will be important for future pandemic responses particularly for high-risk, harder-to-reach groups, targeting both patients and their healthcare providers. Operational costs also must be considered for factors such as adequate staffing, vaccine cold storage, and data gathering. Indeed, creative use of volunteers, especially health profession students, can offer critical relief from strained budgetary limitations or maintaining agile paid personnel.

This review has limitations. The pool of primary literature aimed at implementation of mass vaccination remains limited. While the narrative format yielded a diverse set of articles, later systematic methodology may strengthen these considerations.

Conclusions

Our literature review describes the evidence-base for strategic decision-making for vaccination strategies in the 2019-21 COVID-19 pandemic. Approaches should include well-defined priority groups, advanced planning, collaborative partnerships, enhanced multimodal communication, rapid and complete data capture and analysis, flexibility and navigating cost-related barriers. Continued attempts to document how LHDs respond to pandemic vaccination are critical to inform national, state, and local plans for managing future pandemics.

Acknowledgements

The authors greatly thank William M. Tierney, MD (Associate Dean for Population Health & Health Outcomes and Professor, Department of Global Health with IU Fairbanks School of Public Health and Emeritus Chancellor's Professor, Department of Medicine with IU School of Medicine) for critical input and guidance.

The author BN thanks support during conceptualization from the Indiana Clinical and Translational Sciences Institute funded, in part by [UL1TR002529] from the National Institutes of Health.

References

1. Lee GM, Bell BP, Romero JR. The Advisory Committee on Immunization Practices and Its Role in the Pandemic Vaccine Response. *JAMA*. 2020.
2. Palache A, Abelin A, Hollingsworth R, et al. Survey of distribution of seasonal influenza vaccine doses in 201 countries (2004-2015): The 2003 World Health Assembly resolution on seasonal influenza vaccination coverage and the 2009 influenza pandemic have had very little impact on improving influenza control and pandemic preparedness. *Vaccine*. 2017;35(36):4681-4686.
3. Palache A. Seasonal influenza vaccine provision in 157 countries (2004-2009) and the potential influence of national public health policies. *Vaccine*. 2011;29(51):9459-9466.
4. Russo T. Pandemic Vaccine Distribution Policy for the Twenty-First Century. Homeland Security Affairs. 2012;8.
5. NCIRD. Pandemic Vaccine Program Distribution, Tracking, and Monitoring. <https://www.cdc.gov/flu/pdf/pandemic-resources/pandemic-influenza-vaccine-distribution-9p-508.pdf>. Published 2020. Accessed.
6. Interim results: state-specific influenza A (H1N1) 2009 monovalent vaccination coverage - United States, October 2009-January 2010. *MMWR Morb Mortal Wkly Rep*. 2010;59(12):363-368.
7. U.S. Centers for Disease Control and Prevention. CDC COVID Data Tracker. U.S. Department of Health & Human Services. <https://covid.cdc.gov/covid-data-tracker/#vaccinations>. Published 2021. Updated 02/17/2021. Accessed.
8. Sanche S, Lin YT, Xu C, Romero-Severson E, Hengartner N, Ke R. High

Contagiousness and Rapid Spread of Severe Acute Respiratory Syndrome Coronavirus 2. *Emerg Infect Dis*. 2020;26(7):1470-1477.

9. Schaffer DeRoo S, Pudalov NJ, Fu LY. Planning for a COVID-19 Vaccination Program. *JAMA*. 2020;323(24):2458-2459.
10. Thigpen C, Funk C. Most Americans expect a COVID-19 vaccine within a year; 72% say they would get vaccinated. Pew Research Center. FactTank: News in the Numbers Web site. <https://www.pewresearch.org/fact-tank/2020/05/21/most-americans-expect-a-covid-19-vaccine-within-a-year-72-say-they-would-get-vaccinated/>. Published 2020. Accessed.
11. Wadman M. Antivaccine forces gaining online. *Science*. 2020;368(6492):699.
12. Brennen JS, Simon F, Howard PN, Nielsen RK. Types, sources, and claims of Covid-19 misinformation. 2020.
13. Weintraub RL, Subramanian L, Karlage A, Ahmad I, Rosenberg J. COVID-19 Vaccine To Vaccination: Why Leaders Must Invest in Delivery Strategies Now. *Health Aff (Millwood)*. 2021;40(1):33-41.
14. Cataldi JR, Kerns ME, O'Leary ST. Evidence-based strategies to increase vaccination uptake: a review. *Curr Opin Pediatr*. 2020;32(1):151-159.
15. Klaiman T, O'Connell K, Stoto MA. Local health department public vaccination clinic success during 2009 pH1N1: a brief. *J Public Health Manag Pract*. 2013;19 Suppl 2:S95-96.
16. Seib K, Chamberlain A, Wells K, et al. Challenges and changes: immunization program managers share perspectives in a 2012 national survey about the US immunization system since the H1N1 pandemic response. *Hum Vaccin Immunother*. 2014;10(10):2915-2921.
17. Litaker JR, Tamez N, Durkalski W, Taylor R. Using Health Insurance Network Provider Data and Public Data Sets to Identify SARS-CoV-2 Vaccinators in the USA. *Front Public Health*. 2020;8:616140.
18. Blank PR, Szucs TD. Increasing influenza vaccination coverage in recommended population groups in Europe. *Expert Rev Vaccines*. 2009;8(4):425-433.
19. Bridges CB, Watson TL, Nelson NP, et al. Challenges with hepatitis B vaccination of high risk adults - A pilot program. *Vaccine*. 2019;37(35):5111-5120.
20. Singh S, Mazor KM, Fisher KA. Positive deviance approaches to improving vaccination coverage rates within healthcare systems: a systematic review. *J Comp Eff Res*. 2019;8(13):1055-1065.
21. Immunization Information Systems Searchable Database. National Center for Immunization and Respiratory Diseases; 2021. <https://www2.cdc.gov/vaccines/IIS/IISPubMain.asp>.
22. Hurley LP, Beatty B, Lockhart S, et al. Randomized controlled trial of centralized vaccine reminder/recall to improve adult vaccination rates in an accountable care organization setting. *Prev Med Rep*. 2019;15:100893.
23. Fisher MP, Gurfinkel D, Szilagyi PG, et al. Supporting and sustaining centralized reminder/recall for immunizations: Qualitative insights from stakeholders. *Vaccine*. 2019;37(44):6601-6608.
24. Kempe A, Saville AW, Albertin C, et al. Centralized Reminder/Recall to Increase Influenza Vaccination Rates: A Two-State Pragmatic Randomized Trial. *Acad Pediatr*. 2020;20(3):374-383.
25. Kuramoto S, St Martin A, Muscoplat MH. Use of Person Locator Service to Facilitate Immunization Information System-Based Adolescent Reminder Project. *J Public Health Manag Pract*. 2020;26(2):148-152.
26. Stolpe S, Choudhry NK. Effect of Automated Immunization Registry-Based Telephonic Interventions on Adult Vaccination Rates in Community Pharmacies: A Randomized Controlled Trial. *J Manag Care Spec Pharm*. 2019;25(9):989-994.
27. Equils O, Kellogg C, Baden L, Berger W, Connolly S. Logistical and structural challenges are the major obstacles for family medicine physicians' ability to administer adult vaccines. *Hum Vaccin Immunother*. 2019;15(3):637-642.
28. Tan LJ, VanOss R, Ofstead CL, Wetzler HP. Maximizing the impact of, and sustaining standing orders protocols for adult immunization in outpatient clinics. *Am J Infect Control*. 2020;48(3):290-296.
29. Cataldi JR, Håbesland M, Anderson-Mellies A, Dempsey AF, Cockburn M. The potential population-based impact of an HPV vaccination intervention in Colorado. *Cancer Med*. 2020;9(4):1553-1561.
30. Cheng WY, Chang R, Novy P, O'Connor C, Duh MS, Hoge CS. Determinants of Meningococcal ACWY vaccination in adolescents in the US: completion and compliance with the CDC recommendations. *Hum Vaccin Immunother*. 2020;16(1):176-188.
31. Hastings TJ, Ha D, Fox BI, Qian J, Lakin J, Westrick SC. Assessing barriers and increasing use of immunization information systems in independent community pharmacies: Study protocol for a randomized controlled trial. *Res Social Adm Pharm*. 2020;16(7):987-992.
32. Patten D, Green A, Bown D, Russell C. Covid-19: Use social media to maximise vaccine confidence and uptake. *Bmj*. 2021;372:n225.
33. Coley KC, Gessler C, McGivney M, Richardson R, DeJames J, Berenbrok LA. Increasing adult vaccinations at a regional supermarket chain pharmacy: A multi-site demonstration project. *Vaccine*. 2020;38(24):4044-4049.
34. Jacobson Vann JC, Szilagyi P. Patient reminder and patient recall systems to improve immunization rates. *Cochrane Database Syst Rev*. 2005;2005(3):Cd003941.
35. Volpp KG, Loewenstein G, Buttenheim AM. Behaviorally Informed Strategies for a National COVID-19 Vaccine Promotion Program. *Jama*. 2021;325(2):125-126.
36. Cohen J. Pandemic vaccines are about to face the real test. *Science*. 2020;368(6497):1295-1296.
37. Bell BP, Romero JR, Lee GM. Scientific and Ethical Principles Underlying Recommendations From the Advisory Committee on Immunization Practices for COVID-19 Vaccination Implementation. *Jama*. 2020;324(20):2025-2026.
38. Hassan-Smith Z, Hanif W, Khunti K. Who should be prioritised for COVID-19 vaccines? *Lancet*. 2020;396(10264):1732-1733.