COVID-19 Mass Vaccination Resource Calculator

Grace E. Pryor[1] Kelsea Marble[2] Ferdinand T. Velasco[3] Christoph U. Lehmann[1,4,5,6] Mujeeb A. Basit[4,7]

[1] Department of Pediatrics, University of Texas Southwestern Medical Center, Dallas, Texas, United States
[2] Department of Ambulatory Operations, University of Texas Southwestern Medical Center, Dallas, Texas, United States
[3] Department of Health Informatics, Texas Health Resources, Dallas, Texas, United States
[4] Clinical Informatics Center, University of Texas Southwestern Medical Center, Dallas, Texas, United States
[5] Department of Population and Data Sciences, University of Texas Southwestern Medical Center, Dallas, Texas, United States
[6] Lyda Hill Department of Biostatistics, University of Texas Southwestern Medical Center, Dallas, Texas, United States
[7] Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas, Texas, United States

Address for correspondence Grace E. Pryor, MD, MPH, Department of Pediatrics, UT Southwestern Medical Center, 5323 Harry Hines Boulevard, Dallas, TX 75390-9063, United States (e-mail: grace.pryor@utsouthwestern.edu).

Appl Clin Inform 2021;12:774–777.

Abstract

Background Despite the recent emergency use authorization of two vaccines for the prevention of the 2019 novel coronavirus (COVID-19) disease, vaccination rates are lower than expected. Vaccination efforts may be hampered by supply, delivery, storage, patient prioritization, administration infrastructure or logistics problems. To address the last issue, our institution is sharing publically a calculator to optimize the management of staffing and facility resources in an outpatient mass vaccination effort.

Objective By sharing our calculator locally and through this paper, we aim to help health organizations administering vaccines optimize resource allocation while maximizing efficiency.

Methods Our calculator determines the maximum number of vaccinations that can be administered per hour, the number of check-in staff (clerks) needed, the number of vaccination staff (nurses) needed, and the required room capacity needed for the vaccination and the mandatory 15-minute observation period after inoculation.

Results We provide a functional version of the calculator, allowing users to replicate the calculation for their own vaccine events.

Conclusion An efficient and organized vaccination program is critical to halting the spread of COVID-19. By sharing this calculator, it is our hope that other organizations may use it to facilitate rapid and efficient vaccination.

Keywords

- COVID-19
- vaccine
- vaccination methods
- scheduling tools
- resource management and tracking

Background and Significance

After the emergency use authorization of two vaccines for the prevention of the 2019 novel coronavirus (COVID-19) disease, the U.S. government announced a plan to vaccinate 20 million people before the end of 2020.[1,2] However, as of January 20, 2021 only 16.5 million doses had been administered in the United States.[3] Despite the advances in vaccine technology creating two vaccines in 9 months, distribution and vaccination efforts were slower than expected worldwide.[4] In 2020, 4% of all research output was dedicated to COVID-19,[5] but when human mass vaccination began on December 8, 2020 in the United Kingdom, little research had been conducted on the effective delivery of the novel

received
February 11, 2021
accepted after revision
June 25, 2021

Georg Thieme Verlag KG,
Rüdigerstraße 14,
70469 Stuttgart, Germany

DOI https://doi.org/10.1055/s-0041-1733849.
ISSN 1869-0327.

vaccines.[6] Delivering "vaccines into arms" depends on supply, delivery, storage, prioritization rules defining the targeted population, and lastly on infrastructure for administration.[7,8] Problems or failures at any of these mandatory steps of a mass vaccination program create "implementation bottlenecks" that delay vaccination and subsequent immunity with the effects of continued spread of COVID-19 and loss of public trust.[9]

Focusing on the last step (administration infrastructure), our institution developed a calculator to optimize the management of staffing and facility resources in an outpatient mass vaccination effort. Mass vaccinations include multiple tasks at check-in (patient identification, confirmation that consents are acknowledged/signed, and marking patient as arrived for scheduled appointment) and at vaccination (patient identification, population of vaccine card, and vaccination of the patient).[10] It was our hypothesis that sharing our tool publicly will allow hospitals and health organizations administering vaccines to optimize resource utilization while maximizing efficiency with the explicit goals of reducing waste, minimizing dwell time at the immunization site (reducing risk for infection), and accelerating the pace of inoculations.

Methods

Our calculator computes the following variables: the maximum number of vaccinations that can be administered per hour, the number of check-in staff needed, the number of vaccination staff needed, the required room capacity needed for the vaccination, and the subsequent required 15-minute observation period after inoculation. User input for the calculator includes the number of planned vaccinations and the specified period during which the vaccinations are to be conducted. Users can adjust defaulted factors such as in the check-in rate (the number of patients that a staff member can check in per hour) and the vaccination rate (the number of patients that a staff member can vaccinate per hour). We extracted historical check-in and vaccination performance from our data warehouse. The 25th percentile, median, and 75th percentile ranges for check-in and inoculation rates per hour were calculated from performances at our current vaccination sites by using the number of appointments managed by employee (check-in staff and vaccine staff) and hour (►Table 1). Formulae used to build this calculator are provided in ►Fig. 1.

By default, a period of 1.5 hours of nonproductive time per staff member that the calculator user may edit is included in the calculation, this estimate is derived from one hour-long lunch break and two 15-minute breaks.

Results

When planning a mass vaccination event, organizers must have an ability to predict the number of staff required for the check in-process and the number of staff required for vaccination. ►Fig. 2 shows the mass vaccination calculator interface. Our calculator provides an estimate for required staffing and space based on the desired number of vaccinations to be completed and historical data from our mass vaccination events. Allowing planners of a vaccination event to determine logistic factors in advance reduces wait time for patients and is likely to improve satisfaction of patients and staff.

Our calculator had been shared in mid-January 2021 with a large health care system. When the amount of allocated vaccines for a vaccination day was known, the calculator was used to determine the staff required for that day based on vaccine hours and the planned number of vaccines. The results were used to schedule staff for the vaccine clinic.

We provide a functional version of the calculator as ►Supplementary Material (available in the online version) to this publication to allow users to replicate the calculation for their vaccine events and allows them to modify the duration of the event and the downtime for staff. This tool will aid hospitals and other vaccination sites in the planning and staffing of their events, reducing wait times, and resulting in the utilization of all available vaccine doses.

Table 1 Data from University of Texas southwestern employee vaccination sites

Date of administration	Total vaccinations	Average hourly vaccinations Mean (SD)	Time from arrival to vaccination (min) Median (IQR)
	6,251	60.7 (37.2)	5.4 (3.8–8.1)
December 15, 2020	790	71.8 (30.3)	6.8 (4.7–9.7)
December 16, 2020	1,390	81.8 (33.6)	6.4 (4.5–9.4)
December 17, 2020	972	57.2 (26.3)	4.9 (3.4–6.7)
December 18, 2020	1,646	96.8 (39.4)	5.7 (3.9–8.7)
December 19, 2020	805	53.7 (25.3)	4.4 (3.5–5.6)
December 20, 2020	317	24.4 (9.8)	3.9 (3.1–4.7)
December 21, 2020	331	25.5 (14.8)	5.3 (3.8–7.8)

Abbreviations: IQR, interquartile range; SD, standard deviation.
Note: On average, employees waited 5.4 minutes (IQR: 3.8–8.1) to vaccination.

$$\text{Maximum Vaccinations per Hour} = \frac{\text{Planned Vaccinations}}{(\text{Vaccination Period} - \text{Non Productive Hours})}$$

$$\text{Check-in Staff Needed} = \frac{\text{Maximum Vaccinations per Hour}}{\text{Check-in Rate}}$$

$$\text{Vaccine Staff Needed} = \frac{\text{Maximum Vaccinations per Hour}}{\text{Vaccine Rate}}$$

$$\text{Observation Room Capacity} = \frac{\text{Maximum Vaccinations per Hour}}{2}$$

Fig. 1 COVID-19 vaccination calculator formulae.

Discussion

Several obstacles must be overcome between receiving a vaccine delivery and the mass vaccination of a population. In this study, we focused on the logistics of an optimal vaccination event to reduce wait time for patients. To our knowledge, this is the first published and shared tool provided to help organizations meet staffing and infrastructure needs as they develop vaccination rollout campaigns.

During the process of receiving a vaccine, patients must be checked in by a staff member, educated on the vaccine effects, consented and registered, given the vaccine, and observed for a 15-minute period. Our calculator allows organizations planning a mass vaccination event to quickly determine the number of staff needed, and the size of the room for observation, based on the number of vaccines planned for administration in a given time period.

Limitations

Our calculator has several limitations as follows:

- The calculator does not take into account the physical environment at the vaccination site. Concurrent staffing may be limited by external factors, such as available workstations or computers.
- Patient dwell time at the vaccination event may affected by external factors such as available parking at the site or ease of navigation of the vaccination site.
- Layout and furniture in the observation room capacity may result in the facility not being able to hold the expected number of patients while maintaining 6 feet of separation.

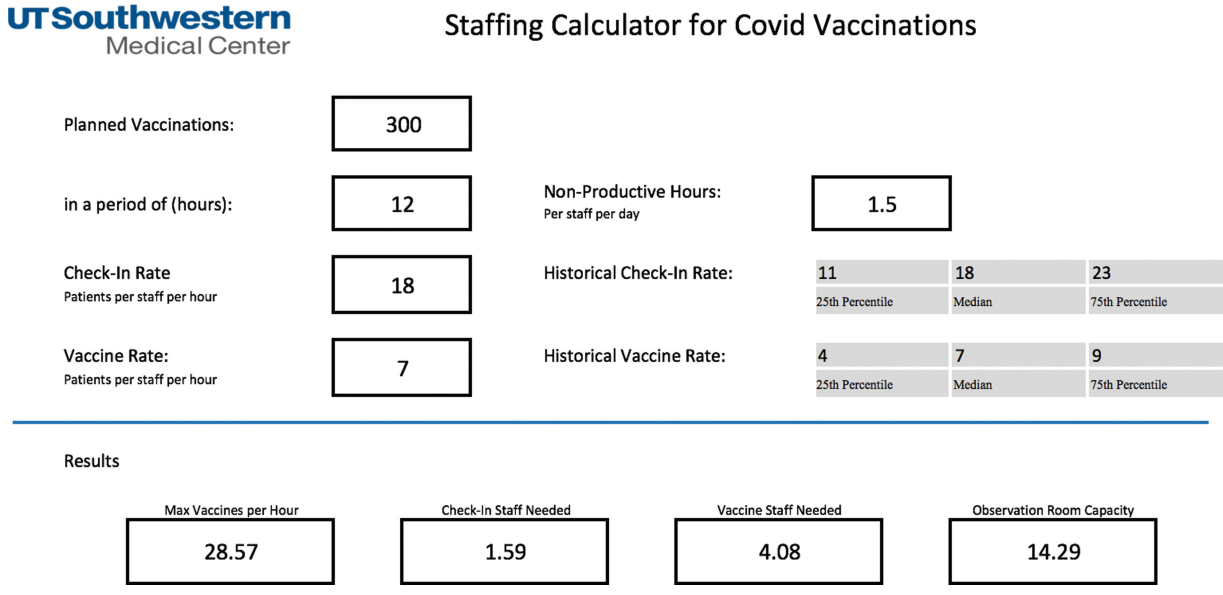

Fig. 2 Screenshot of COVID-19 mass vaccination resource calculator.

- Delayed arrival of patients or during peaks (e.g., during lunch) may also factor in patient-related delays that may contribute to dwell time.
- Patient specific factors may result in deviations such as the need for increased counseling or extended observation times (history of anaphylaxis).
- Our calculator does not take into account no-show rates. While virtually nonexistent during our initial vaccination effort, it might be useful to be able to calculate scheduled appointments based on desired immunization number and anticipated no-show rate.

Future Improvements

Our calculator implementation has limitations and can be improved. We calculated the number of individuals used for staffing (registration and vaccination). If a vaccination event exceeds a single shift (i.e., 12 hours), one must consider the need for staff to be relieved of duty. Therefore, our calculator should calculate the full-time equivalent (FTE) of employees (not people) for events that last longer than a single shift. Another important goal for a vaccination event would be to minimize vaccine dose waste. As vaccine cannot be restored, calculating a percent overbooking of patients or waitlist dynamics to accommodate the effects of no-shows is beyond the scope of this calculator but an important process that should be considered.

Conclusion

An efficient and organized vaccination program is critical to halting the spread of COVID-19. Our accessible calculator can help to determine the resources needed to maximize efficiency and minimize waste. By sharing this calculator, we hope that other organizations can use it to coordinate mass vaccination efforts and make improvements to this tool in the future based on their experience.

Clinical Relevance Statement

Efficient and organized vaccination is critical to stopping the spread of COVID-19. This article introduces an effective, sharable tool to help organizations coordinate vaccination efforts.

Multiple Choice Questions

1. Of the following variables for a mass vaccine event, which one is derived as a function of the others?
   a. Number of vaccine doses to be delivered
   b. Duration of the vaccine events,
   c. Time to register a patient
   d. Time to vaccinate a patient
   e. Number of registrars needed

   Correct Answer: The correct answer is option e. Our calculator uses inputs in the form of the total number of vaccinations, duration of the event, and time from registration to vaccination to calculate resource staffing needs, including the number of check in clerks required for a mass vaccination event.

2. Why is full-time equivalent better for planners of mass vaccine events rather than headcount?
   a. Health care unions mandate the use of full time equivalents
   b. Allows estimation of people needed for events lasting longer than 12 hours
   c. Allows a better estimation of costs for the mass vaccination event
   d. Allows for scheduling of necessary breaks for staff

   Correct Answer: The correct answer is option b. A full-time equivalent is a standardized measure that can be used to convert work hours into the number of people required to staff those hours. Using FTE can enhance both efficiency and accuracy of resource staffing.

Protection of Human and Animal Subjects

We did not conduct human and animal subject research in this study.

Funding

None.

Conflict of Interest

C.U.L. reports other from Thieme Publishers outside the submitted work.

References

1 Schaffer DeRoo S, Pudalov NJ, Fu LY. Planning for a COVID-19 Vaccination Program. JAMA 2020;323(24):2458–2459
2 Jesus EGd. How does the newly authorized Moderna COVID-19 vaccine compare to Pfizer's? Sci News 2020. Accessed 2021 at: https://www.sciencenews.org/article/covid-19-coronavirus-moderna-vaccine-fda-approval
3 Prevention CfDCa. CDC COVID data tracker. Accessed 2021 at: https://covid.cdc.gov/covid-data-tracker/-vaccinations
4 Santora M. Vaccine rollouts in europe are off to a Shaky Start, even as lockdowns expand. The New York Times Accessed 2021 at: https://www.nytimes.com/2021/01/05/world/europe/europe-covid-vaccinations.html
5 Else H. How a torrent of COVID science changed research publishing in seven charts. Nature Accessed 2021 at: https://www.nature.com/articles/d41586-020-03564-y
6 Cabanillas B, Akdis C, Novak N. Allergic reactions to the first COVID-19 vaccine: a potential role of polyethylene glycol? Allergy 2021;76(06):1617–1618
7 Mills MC, Salisbury D. The challenges of distributing COVID-19 vaccinations. EClinicalMedicine 2021;31:100674
8 COVID-19 Vaccination Program Interim Operational Guidance Jurisdiction Operations. Centers for Disease Control and Prevention. Published October 29, 2020. Accessed April 9, 2021 at: https://www.cdc.gov/vaccines/imz-managers/downloads/Covid-19-Vaccination-Program-Interim_Playbook.pdf
9 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(01):33–41
10 Pre-Vaccination Clinic Activities. Centers for disease control and prevention. Published August 11, 2020. Accessed April 9, 2021 at: https://www.cdc.gov/vaccines/hcp/admin/mass-clinic-activities/pre-clinic-activities.html

