Rolling Up the Sleeve: Equitable, Efficient, and Safe COVID-19 Mass Immunization for Academic Medical Center Employees

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Abstract

Background Novel coronavirus disease 2019 (COVID-19) vaccine administration has faced distribution barriers across the United States. We sought to delineate our vaccine delivery experience in the first week of vaccine availability, and our effort to prioritize employees based on risk with a goal of providing an efficient infrastructure to optimize speed and efficiency of vaccine delivery while minimizing risk of infection during the immunization process.

Objective This article aims to evaluate an employee prioritization/invitation/scheduling system, leveraging an integrated electronic health record patient portal framework for employee COVID-19 immunizations at an academic medical center.

Methods We conducted an observational cross-sectional study during January 2021 at a single urban academic center. All employees who met COVID-19 allocation vaccine criteria for phase 1a.1 to 1a.4 were included. We implemented a prioritization/invitation/scheduling framework and evaluated time from invitation to scheduling as a proxy for vaccine interest and arrival to vaccine administration to measure operational throughput.

Results We allotted vaccines for 13,753 employees but only 10,662 employees with an active patient portal account received an invitation. Of those with an active account,

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- COVID-19
- immunization
- patient portal
- electronic health record
- employee health

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6,483 (61%) scheduled an appointment and 6,251 (59%) were immunized in the first 7 days. About 66% of invited providers were vaccinated in the first 7 days. In contrast, only 41% of invited facility/food service employees received the first dose of the vaccine in the first 7 days ($p < 0.001$). At the vaccination site, employees waited 5.6 minutes (interquartile range [IQR]: 3.9–8.3) from arrival to vaccination.

Conclusion We developed a system of early COVID-19 vaccine prioritization and administration in our health care system. We saw strong early acceptance in those with proximal exposure to COVID-19 but noticed significant difference in the willingness of different employee groups to receive the vaccine.

Background and Significance

Since the emergence of the severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) and the ensuing global pandemic, governments of affected countries have focused on decelerating the spread of novel coronavirus disease 2019 (COVID-19) infection until the deployment of effective vaccines or treatments. Governments collected COVID-19-related data,[1] explored risk factors,[2] and implemented containment measures (e.g., border closures)[3] and nonpharmaceutical interventions (NPIs), like mask wearing,[4] social distancing,[5] and contact tracing, of infected individuals.[6] Hospital systems focused on capacity development for physical bed space and required workforce.[7] The Food and Drug Administration (FDA) Emergency Use Authorizations (EUA) for the Pfizer/BioNTech and Moderna vaccines on December 11 and 18, 2020, respectively, shifted the attention of U.S. governments and hospitals to vaccine distribution, delivery, and acceptance.[8,9]

While the question of vaccine acceptance for the general population[10] is still being debated, health care institutions globally have been offering and administering vaccinations to their staff. In this manuscript, we describe our prioritization/invitation/scheduling process, as well as the vaccination process, to inoculate our employees against COVID-19. We further discuss employee vaccine readiness and ways to improve it.

Objectives

It is our hypothesis that our prioritization/invitation/scheduling framework would (1) provide an efficient, high throughput/high reliability infrastructure to optimize speed and efficiency of vaccine delivery while minimizing risk of infection during the immunization process and (2) provide insight into vaccine acceptance among health care workers.

Methods

UT Southwestern Medical Center (UTSW) in Dallas, Texas, with 18,800 employees provides medical care in approximately 80 specialties to more than 105,000 hospitalized patients, nearly 370,000 emergency room cases, and approximately 3 million outpatient visits a year. UTSW's tenet on vaccine distribution has been that workers in health care settings willing to step into harm's way to serve COVID-19-positive patients, regardless of their position and rank, deserve first access to available protection in the form of a vaccine, with availability prioritized by their individual work-related risk. Our goals at vaccine availability were to (1) immunize faculty, staff, learners, contractors, and other employees (referred to jointly as "employees" from here on) based on exposure risk prioritized by domain experts; (2) immunize as many employees in as short as possible time period; and (3) minimize time at the vaccine event to reduce risk of transmission.

Prioritization/Invitation/Scheduling System

We implemented a prioritization/invitation/scheduling system that allocated vaccines based on exposure risk and stepwise invited employees to schedule the vaccine administration. A multidisciplinary task force composed of medical ethicists, administrative leadership, nursing leadership, infectious diseases physicians, critical care physicians, and regulatory affairs outlined vaccination phase criteria (prioritization) adapted from state-wide (Texas) criteria and Centers for Disease Control and Prevention (CDC) guidance. We intended to maximize vaccination benefit while minimizing inequity with deference to reciprocity and transparency such that all individuals with a given exposure risk had the same access to the vaccine.

Phases

The first phase (phase 1a.1) included individuals working in COVID-19 hospital units, labor and delivery, emergency department, and COVID-19 testing sites. Subsequent phases involved individuals with decreasing exposure risk. We did not consider profession, training level, or seniority of an employee in the prioritization. For example, a physician who did not provide direct care for COVID-19 patients would not have been included in phase 1a.1 but may have been included in phase 1a.4. When the employees received access to scheduling, they were invited by e-mail and allowed self-scheduling in our electronic health record's (EHR) patient portal. Multiple discussions among hospital and legal leadership led to the decision to use the integrated patient portal instead of our traditional occupational health-based software (Readyset) to facilitate implementation and monitoring of our prioritization/invitation/scheduling system. Several invitation waves (phases 1a.1–1a.4) went out over the first week. We also phased students according to risk exposure for their clinical assignments in January 2021 and offered vaccine in the first week of vaccinations. Employees and students without an EHR patient portal were first invited by email to create portal access.

Vaccine Staffing

Vaccination staffing was optimized for 12 parallel vaccine administration stations with 5-minute slots (144 vaccinations per hour maximum) from 6 a.m. to 10 p.m. (maximum capacity: 2,304 vaccinations/day) with flexible staffing based on demand.[11]

Human Subject Research

This study was formally reviewed and approved as quality improvement by UTSW's Human Research Protection Program and deemed not to require institutional review board (IRB) oversight.

Outcomes and Analysis

We collected data on date and time of the invitation e-mail, scheduling by the employee, vaccine appointment, arrival at vaccine administration site, and administration of vaccine, in addition to job type, vaccination phase, and other employee-specific demographics. For the analysis, we categorized employees into six groups: providers (physicians, nurse practitioners, and physician assistants), nurses, ancillary health care workers (e.g., respiratory therapist, physical therapist, social workers, and chaplains), facility & food services, research staff, and administrative and support staff (administration). Residents and fellows were included in the provider category. Clinical research staff and administration/support staff allocated to a vaccination phase were those who directly interacted with COVID-19 patients (e.g., trial manager and unit clerk) or whose projects directly involved or impacted COVID-19 patients. We measured the period from invitation to scheduling the vaccination appointment through the patient portal as a proxy measure for the level of interest in receiving the COVID-19 vaccination and stratified data by phase and job category. To assess operational efficiency, we evaluated the time from arrival at the vaccination site to vaccination completion and the number of vaccinations completed per hour over the first week of vaccinations.

We provide count data with associated percentages and central tendencies as mean and standard deviation for normally distributed variables and median and interquartile range for nonnormally distributed variables.

Results

We allotted vaccines for 13,753 employees. Employees without access to our EHR patient portal were first sent an e-mail that asked them to sign up for portal access to receive a vaccine appointment. Ultimately, 10,662 employees had or added portal access and received a vaccination invitation.

Prioritization

During the allocation phase, we categorized 2,473 employees (18%) into the highest priority (phase 1a.1). The majority were providers and nurses, but ancillary clinicians and administrative staff (e.g., unit clerks) were also included (►Table 1). While the phase-1a.2 cohort had a similar distribution, the phase-1a.3 cohort had 649 facility and food workers and 996 administrative staff. Invitations were sent by phase to the employees asking them to schedule their vaccinations. As we write this manuscript, invitations had been sent only to groups 1a.1 to 1a.4. A large number of responses to invitations resulted in server bandwidth issues and delayed pending invitations and acceptances for phases

Table 1 Distribution of gender, age, and phases by employee type in phases 1a.1 to 1a.4

	Administration	Ancillary clinicians	Facility/food services	Nursing staff	Providers	Research staff	Total
Total allocated (% of row)	1,942 (14)	3,842 (28)	658 (5)	2,695 (20)	4,116 (30)	500 (4)	13,753
Sex *n* (% of col)							
Female	1,266 (65)	2,914 (76)	468 (71)	2,312 (86)	2,158 (52)	347 (69)	9,465 (69)
Male	633 (33)	906 (24)	190 (29)	377 (14)	1,894 (46)	148 (30)	4,148 (30)
Unknown	43 (2)	22 (1)	NA	6 (0)	64 (2)	5 (1)	140 (1)
Mean age (SD)	37.8 (13.3)	39.9 (11.9)	41.3 (14.1)	40.3 (11.9)	41 (11.8)	38.9 (12.4)	40 (12.2)
Phase *n* (% of col)							
1a.1	249 (13)	411 (11)	1 (0)	735 (27)	1,066 (26)	11 (2)	2,473 (18)
1a.2	108 (6)	387 (10)	1 (0)	393 (15)	313 (8)	32 (6)	1,234 (9)
1a.3	996 (51)	1,435 (37)	647 (98)	1,033 (38)	1,665 (40)	75 (15)	5,851 (43)
1a.4	589 (30)	1,609 (42)	9 (1)	534 (20)	1,072 (26)	382 (76)	4,195 (31)

Abbreviations: NA, not available; SD, standard deviation.

1a.3 and 1a.4 by several hours; however, "word of mouth" communication allowed a portion of our employees to schedule their immunization prior to receiving the official invitation in the mobile version of the patient portal, which was not constrained by bandwidth issues.

Invitation

Out of 10,662 employees receiving an invitation, 6,483 (61%) scheduled an appointment and 6,251 (59%) were immunized in the first 7 days of vaccination availability. Employees varied significantly by type. About 66% of invited providers were vaccinated in the first 7 days. In contrast, only 41% of facility/food service employees received the first dose of the vaccine ($p < 0.001$) in the first 7 days. Clinical research staff and providers had the highest uptake (68 and 66% respectively, $p = 0.97$) followed by nurses (►Table 2). Vaccination status for all employees is displayed in ►Fig. 1 stratified by job category and phase. Phases 1a.3 and 1a.4 have seemingly lower vaccine uptake; however, this may be a function of a shorter observation period from invitation to time of data extraction.

Scheduling

Providers were the fastest group in scheduling their vaccines in every phase with median time of 92 minutes (►Fig. 2). The longest to schedule were facility/food service employees (588 minutes). (►Supplementary Table S1, available in the online version). Notable is that, for some employees, the time from invitation to scheduling was negative. The portal server problem resulted in delayed e-mail invitations and employees figured out scheduling was already available in the mobile patient portal.

Table 2 Employees invited, scheduled, arrived at vaccination site, and immunized

Employee type	Invited	Scheduled	Administered
Administration	1,147	625 (54%)	600 (52%)
Ancillary clinical	3,159	1,746 (55%)	1,677 (53%)
Facility/food services	449	197 (44%)	184 (41%)
Nursing staff	2,377	1,494 (63%)	1,441 (61%)
Providers	3,095	2,119 (68%)	2,053 (66%)
Research staff	435	302 (69%)	296 (68%)
Total	10,662	6,483 (61%)	6,251 (59%)

Vaccine Administration

Times from arrival at the vaccination site to vaccine administration are shown in ►Table 3. On the first day, the wait time was the longest with 6.8 minutes declining over time. On average, employees waited 5.6 minutes (interquartile range [IQR]: 3.9–8.3) to vaccination (►Table 3). Early morning wait times were longer due to employees arriving early to their appointments (►Supplementary Fig. S1, available in the online version). While employees were able to check in at

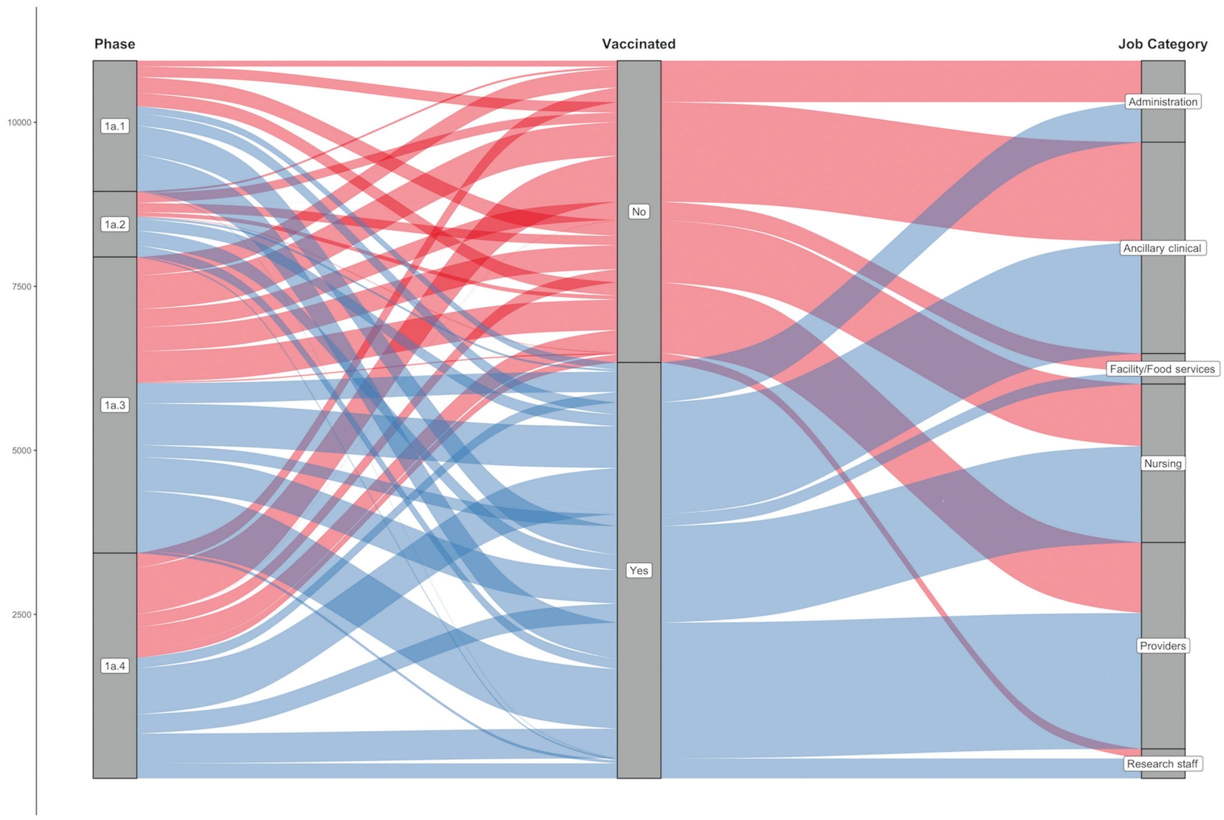

Fig. 1 Flow from invitation by phase to vaccination status segmented by employee groups. Red represents unvaccinated employees and blue vaccinated employees.

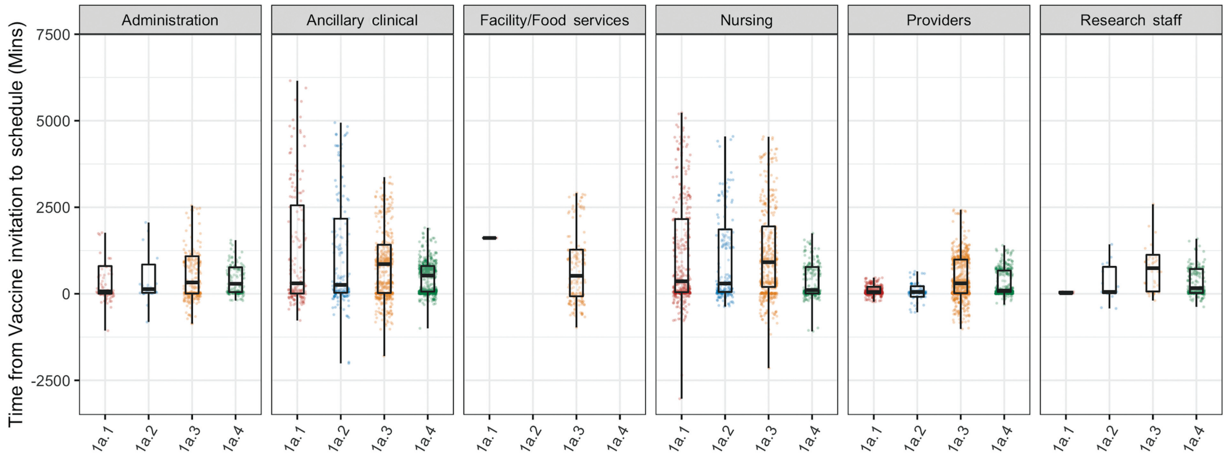

Fig. 2 Time from invitation to scheduling of the vaccination by phase. The colored dots represent the distribution in each phase.

Table 3 Time from arrival to vaccination

Date of administration	Total vaccinations	Average hourly vaccinations Mean (SD)	Time from arrival to vaccination (mins) Median (IQR)
Total	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.

arrival, they had to wait until the vaccine administration commenced. Cohorts scheduled later in the day had substantially shorter wait times. From December 16 to 18, around 5 p.m., we experienced a mismatch between employees seeking vaccination and personnel available to perform vaccinations leading us to later increase the personnel scheduled in the evenings.

Because of the initial slow vaccination uptake by facility and food service employees, hospital leadership scheduled several town hall events with these employees with subsequent increased uptake in scheduling and immunizations (►**Supplementary Fig. S2**, available in the online version).

Discussion

We offer early insights into the performance of our health system's vaccine administration efforts and staff's interest and acceptance of the COVID-19 vaccine.

The development of highly efficacious vaccines by Pfizer/BioNTech and Moderna[12,13] and the FDA EUA for the vaccines have shifted attention from vaccine readiness to vaccine delivery and acceptance. Despite a high death toll from COVID-19 in the United States with over 300,000 deaths by mid-December 2020,[14] there remain concerns about the willingness of the population to be vaccinated.[15] A 19-country survey, published in June 2020, showed only 71.5% would be very or somewhat likely to take a COVID-19 vaccine.[16] A U.S. Gallup survey from December 2020 showed that 63% were willing to be immunized against COVID-19, up from 50% in September.[17]

The historically short interval from vaccine development to authorization, the politicization of the pandemic and pandemic measures,[18] the paucity of accurate data throughout the pandemic,[10] as well as historic distrust of the medical establishment in minority communities,[19] are reflected in preliminary surveys that suggest many Americans are reluctant to "roll up their sleeves" to be vaccinated.[20] While at time of drafting this manuscript, it is still relatively early in the immunization process, these survey data contrast with the high demand from health care workers, we saw in the first 7 days of vaccine availability within our health system. Despite the start of the holiday season, we found an interest among health care workers to receive the vaccination at the earliest possible opportunity. One can assume that our clinical employees had a bias to receive the vaccine because of their scientific training, their experience of the COVID-19 pandemic and its impact on our health system, the perceived risk of infection treating patients with COVID-19, and their first-hand knowledge of its associated morbidity and mortality. We also attribute active rounding by nursing and physician leaders on the floors, educating staff on how to sign up for the vaccination, and answering questions about the risks and benefits to an increase in vaccine adoption once the vaccine was available.

Vaccine Adoption

A large proportion of our employees were interested in signing up for and receiving the vaccination. Even though some invitations were delayed, some employees realized that scheduling was available to them in the mobile patient portal and word spread quickly to others. Notably, this phenomenon was mainly observed among providers who often practice in close-knit, stable groups that easily disseminate information.[21]

The example set by our health care workers may convince larger segments of the general population to seek out vaccination despite significant unfavorable sentiments on social media.[22] We noticed a stark difference in the willingness to be vaccinated by different employee groups. There was a high uptake of the vaccine by providers, ancillary clinicians, and nurses, but less so by the nonclinical staff.

Not every employee invited to receive a vaccine elected to do so at UTSW. Many providers who received vaccine invitations from UTSW were also eligible for vaccines at affiliated hospitals (especially in later phases). Individuals were encouraged to be vaccinated at the location where they spend the majority of their clinical time. Therefore, the actual provider uptake is likely underestimated by our numbers due to some providers being vaccinated at independently operated affiliated hospitals. There was a decline in vaccination rates among all employee groups through the progression of phases 1a.1 to 1a.4. Employees in the later phases were more likely to have received a vaccine invitation from the affiliated organizations.

UTSW had instituted a work-from-home policy for those without direct patient care or facility responsibilities at the time (e.g., physician on service). As invitations were delivered shortly before the winter holidays, many employees, and students, who were in the first phase groups, already had left for the holidays or were working from remote locations (like one of the authors) resulting in barriers to early vaccination.

On days 3 and 4 of the vaccination effort, our Chief Medical Officers and Chief Quality Officers held five town halls/preshift huddles for environmental services and food services employees that were likely responsible for the bimodal distribution in vaccine uptake in the non-clinical population suggesting that vaccine reluctance at least in part is modifiable by intervention (►**Supplementary Fig. S2**, available in the online version).

While the effect of the town hall interventions could be appreciated in the uptick of immunizations, facility and food service employees had the lowest uptake in vaccinations with 41%, raising concerns about the willingness of the general public to become immunized. We can only speculate to the reasons for this divergent uptake, as employee demographic data were not available to us. However, our results may corroborate a nascent distrust in immunization by communities of color who have been "peripheral, not central actors in the pursuit of COVID-19 vaccines."[23] There may also be technologic barriers to engaging an electronic scheduling system in populations with limited access to the internet or smart devices. To eliminate other barriers, supervisors were instructed (after data collection for this manuscript had ended) to provide 15 to 30 minutes of free time to these employees to allow for scheduling during work hours.

We suspect that our observations of limited vaccine uptake will hold true for other institutions. On December 29, 2020, the CEO and President of the Vanderbilt University Medical Center sent a plea to Vanderbilt employees asking them to "make the case for immunization" and to "to engage our communities" to achieve herd immunity through vaccination, suggesting that there might be reluctance to immunization.

Prioritization

UTSW elected to prioritize its employees at highest risk for the COVID-19 infection for the vaccine administration as an investment into the wellness of the workforce and a reward for everyday heroism.[24] Over 90% of nurses and ancillary clinical employees were part of phase 1a compared with only 76% of providers. Unlike other institutions that saw objections about perceived inequities and strikes against the local vaccine prioritization,[25] we did not experience any protests or complaints at UTSW.

Scheduling

UTSW had instituted a policy early in the pandemic that restricted those in the highest risk groups, over the age of 65 years or immunocompromised, from direct COVID-19 patient care.[26] This rule affected physicians disproportionally and may explain why fewer providers were listed in phase 1a. Further, nurses' and ancillary clinical staff's workloads tend to be distributed evenly, whereas providers tend to batch work in "rotations" which results in diverse risk profiles over time. We believe that this "shift-work" also affected the time from invitation to scheduling as invitations were sent during daytime hours, when many nurses and ancillary clinicians who worked nightshift were sleeping.

Minimizing Risk during Vaccination

One of our goals was to minimize the risk for infection during the vaccination event. The dwell time for employees at the vaccination site was very short and improved to under 5 minutes (excluding observation) and all employees were required to wear masks and eye protection, thus rendering the risk for infection during the vaccination low.

We offer early data on vaccine prioritization, administration, and uptake in our institution with the intent of offering insight and a potential model for other health systems to adopt for not only employee vaccination but also a model that is scalable to vaccinate the general populous in an efficient and safe manner. The reported outcomes of our employee vaccination effort demonstrated over a 90% decrease in workforce-related isolation or quarantine and only 4 out of 8,121 SARS-CoV-2 cases among fully vaccinated individuals.[27] We hope that our findings are not a unique response within our health system and are instead a marker for not only other health systems but also the rest of the country.

Limitations

Our study has several limitations. First, we lacked data on employee race and socioeconomic status which limited our conclusion on why we experienced differences in vaccine uptake among the varying job types. Second, we looked at a very narrow window of time describing only the first 7 days of vaccine administration at UTSW limiting our ability to make more sweeping conclusion. Our limitation to a single hospital system also may have restricted our ability to draw general conclusions. At time of writing, we are still reconciling provider vaccinations that occurred at other health systems. Third, we recognize earlier scheduling of vaccinations among certain phased groups such as physicians may be a result of familiarity with patient portal technology and may not be truly reflective of vaccine interest. Fourth, given the server difficulties associated with messaging phases 1a.3 and 1a.4, we recognized that it may be difficult to make true conclusions from our data; however, it does highlight the need for other institutions who may adopt a similar framework to be cognizant of server and bandwidth issues. Finally, as we discovered in the early phases of the COVID-19 pandemic, we were significantly limited by the "Fog of War" that hinders active participants in a struggle to appreciate the complete picture. Lack of standardized processes for a mass immunization, the need to design our own priorities, and lack of reliable measures and standards for data submissions made data aggregation and analysis difficult and potentially error prone.

The media expressed significant concerns that vaccine distribution and deployment lagged behind the goal of 20 million doses administered by December 31, 2020. Based on our experience, some of the delay may be attributable to reporting problems of administered doses, a "Fog of War" on a larger scale. Time and more analysis will explain how successful we have been in our approach to bring life-protecting vaccinations to our employees.

Conclusion

We developed a system of early COVID-19 vaccine prioritization and administration in our health care system. We saw strong early acceptance but noticed significant difference in the willingness of different employee groups to receive the vaccine. By scheduling the vaccination process and matching the scheduled time to how long it took to administer the vaccine (~5 minutes), we kept dwell time of vaccine seekers to a minimum reducing risk of infection.

Clinical Relevance Statement

The use of a patient portal to optimize prioritization and administration of the COVID-19 vaccine can offer unique insights into vaccine acceptance of employees at an academic medical center; a trend that may be reflective of the general population. Furthermore, using this framework allows for opportunities to capture metrics that facilitate assessment of the vaccine process, such as efficiency and dwell time, two important features in minimizing risk of infection. These processes can be easily adapted for postpandemic processes such as yearly influenza vaccination campaigns or other required immunizations.

Multiple Choice Questions

1. The prioritization framework for employee COVID-19 vaccination was based on:
   a. Seniority
   b. Employee category
   c. Race and ethnicity
   d. Exposure risk to SARS-CoV-2

   Correct Answer: The correct answer is option d. To provide equitable and fair administration of the COVID-19 vaccine, a multidisciplinary team comprised of providers and administrators including medical ethicists created a stepwise framework with those at increased risk of COVID-19 having first priority to receive the vaccine irrespective of stature within the organization, job category or race/ethnicity.

2. Using the patient portal linked to the institution's electronic health record instead of an employee based occupational health software facilitated collection of what data:
   a. Vaccine type
   b. Job type
   c. Appointment, arrival, and administration times
   d. Employee demographics

   Correct Answer: The correct answer is option c. Using the patient portal associated with the electronic health record facilitated capture of traditional metrics of clinic efficiency including throughput (e.g., appointment, arrival and administration times). Vaccine type, job type, and employee demographics are data that can be typically captured through any traditional occupational-based software.

Protection of Human and Animal Subjects

This study was formally reviewed and approved as quality improvement by the UT Southwestern Medical Center Human Research Protection Program and deemed not to require Institutional Review Board oversight.

Conflict of Interest

S.M. and R.J.M. report research grants from the Centers for Disease Control and Prevention (Grant U01CK000590). S. M., M.A.B., and R.J.M. report research funding from the

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