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Case Report

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Automation of mass vaccination against COVID-19 at an academic health center

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ABSTRACT

As vaccines against COVID-19 became available for distribution, the University of Miami addressed several challenges to facilitate vaccine allocation to the highest risk employees, patients, and students. Advanced use of technology allowed for the automation of key processes in the mass vaccination effort, which expedited vaccine outreach and scheduling, while maintaining routine delivery of healthcare services. The University's employees were initially prioritized for vaccination; employees who opted in were stratified into 5 vaccine administration phases. A similar process was implemented for students. When the state of Florida mandated expansion of vaccine allocation to include individuals aged 65 and older, an algorithm for patients was designed, taking into account age, comorbidities, date of last visit, and presence of an activated patient portal account. Innovative use of technology allowed for 19 000 vaccines to be administered within the first 37 days, which comprised 100% vaccine allotment, without wasting a single vaccine dose.

Key words: mass vaccination, COVID-19, automation, algorithms, delivery of health care

Lay Abstract

As vaccines against COVID-19 became available for distribution, the University of Miami addressed several challenges to facilitate vaccine allocation to the highest risk employees, patients, and students. Advanced use of technology allowed for the automation of key processes in the mass vaccination effort, which expedited vaccine outreach and scheduling, while maintaining routine delivery of healthcare services. The University's employees were initially prioritized for vaccination; employees who opted in were stratified into 5 vaccine administration phases. A similar process was implemented for students. When the state of Florida mandated expansion of vaccine allocation to include individuals aged 65 and older, an algorithm for patients was designed, taking into account age, comorbidities, date of last visit, and presence of an activated patient portal account. Innovative use of technology allowed for 19 000 vaccines to be administered within the first 37 days, which comprised 100% vaccine allotment, without wasting a single vaccine dose.

INTRODUCTION

Several months after Florida's first reported coronavirus disease-19 (COVID-19) case, the University of Miami appointed a Chief Medical Officer for COVID-related initiatives and established several committees: Testing and Tracing, Therapeutics, Supply Chain, Workforce Resiliency, and later a Vaccine Advisory Committee (VAC). The VAC was specifically established for the efficient and equitable roll out of vaccines, and membership consisted of infectious disease experts, internists, pediatricians, medical ethicists, clinical informatics specialists, and administrators. The main challenges addressed by this committee were prioritizing the most vulnerable groups given limited and uncertain vaccine supply, targeting outreach of the appropriate populations, and scheduling. The latter provided multiple challenges including minimizing human resources to handle high volumes of appointment requests which had reportedly paralyzed the information technology infrastructure at other centers, maximizing vaccine utilization given the limited shelf life, coordination of scheduling for multidose vials as to not to waste the precious resource, and scheduling the second vaccine dose without human resources. This report details our coordination for a successful vaccine distribution plan with heavy reliance on technology and can serve as a framework for similar challenges that will be faced for the booster rollout.

To understand our outreach strategy, it is important to explain the University of Miami's structure. The University has three campuses: Coral Gables, medical, and marine. The Coral Gables campus provides on-campus housing, while both the marine and Coral Gables campuses offer virtual and in-person learning to undergraduate and graduate students. The medical campus consists of the Leonard M. Miller School of Medicine and clinical services under the University of Miami Health System (UHealth), including 3 hospitals and more than 30 outpatient facilities, which continued to provide non-COVID-related medical and surgical services throughout the pandemic.

EMPLOYEE AND STUDENT RECORD CONVERSION PROCESS

At the beginning of the pandemic, employee records on all campuses were converted to patient records in Epic, UHealth's electronic medical record, to ensure appropriate medical care during peak COVID periods could be provided. Employees could opt-out of the record conversion process. To create the patient record, employee demographics were sent from the employee management software, Workday, to the Epic database. Statistical algorithm was used with assigned weights to determine the probability of a match, and if the probability was low, we added more data fields to the match process to increase the probability of a match.[1] If an employee was an existing patient in Epic, that patient record was tagged with their unique employee identification number. If an employee did not have a patient record, a new patient record was created using the employee's demographics. The HIPAA Privacy Rule protects employees' personal health information from being shared with their employers. To be compliant, we created filters that restricted access to employee medical information during the vaccine administration process.[2] We replicated the patient record conversion process for students utilizing the student database software, PeopleSoft Campus Solutions.

OPT-IN PROCESS AND VACCINE PHASE PRIORITY

Before the COVID-19 vaccine release, a customized question was created in Workday to opt into the vaccination process. An employee's opt-in status remained "unknown" until the employee responded to the question, and they could opt in or out of vaccination at any time. Multiple modes of communication, from emails to virtual town halls, were used to inform employees of the new vaccine opt-in process. In addition, each employee was assigned a COVID vaccine administration phase. The VAC determined employee "essential" or "nonessential" operational classification in the database would not be factored into vaccine phase eligibility, as it did not take into account risk of COVID-19 exposure. These new vaccine phases were created based on several factors, including job title, work location, and risk of work-related exposure to COVID-19 positive patients or students. Employees were then stratified into 5 vaccine administration phases, which were added to their Workday record and viewable to them. In order to keep Epic up-to-date, an automated extract, transfer, load process was set up to securely send opt-in status and phase data from Workday to Epic multiple times per day. We replicated the same processes for students within the student database software (Table 1).

SCHEDULING

As each vaccination phase was activated, the database was queried to pull all employees who opted in and were eligible to receive the vaccine, capturing anyone who recently changed their opt-in status. Next, an automated process checked for an active patient portal account. If an employee's account was active, an SMS and personalized scheduling email were sent, inviting them to self-schedule their vaccine appointment through the patient portal. For those employees without an active patient portal account, the email automatically generated the individual patient portal activation link. Once in the

Table 1. Employee and student vaccine phases

Phase	Description of groups included	Total
1	Emergency Department (All Personnel), COVID Units (All Personnel), COVID Testing Site Personnel, Food Services, Patient Access, Providers of Aerosol Generating Procedures, Laboratory and Pharmacy Staff, Infection Control, Employee Health	3560
2	Clinical Faculty, Medical Tier 1 Essential Staff, Medical Students, Nursing Students on Clinical Rotations, Physical Therapy Students on Clinical Rotations, Procedural Staff	5423
3	Medical Tier 2 Essential Staff, Clinical Research Faculty and Staff, University of Miami Police Department, Voluntary Faculty, Employees and Students with Comorbidities, Employees who met Age Requirement set by the State	2162
4	Coral Gables and Marine Campus Tier 1 Essential Staff, On-Campus Residential Housing Support Staff, Community Healthcare Providers, Employees who met Age Requirement set by the State	924
5	Graduate and Undergraduate Students on Campuses who Age Met Requirement by the State, Medical Campus Volunteers	13 426

Table 2. Medical conditions associated with increased risk of severe COVID-19 (before March 29, 2021)

Cancer
Chronic kidney disease
Chronic obstructive pulmonary disease
Down's syndrome
Heart conditions (heart failure, coronary artery disease, or cardiomyopathies)
Immunocompromised state from solid organ transplant
Body mass index (BMI) of 30 kg/m^2 or higher
Sickle cell disease
Smoking
Type 2 diabetes mellitus

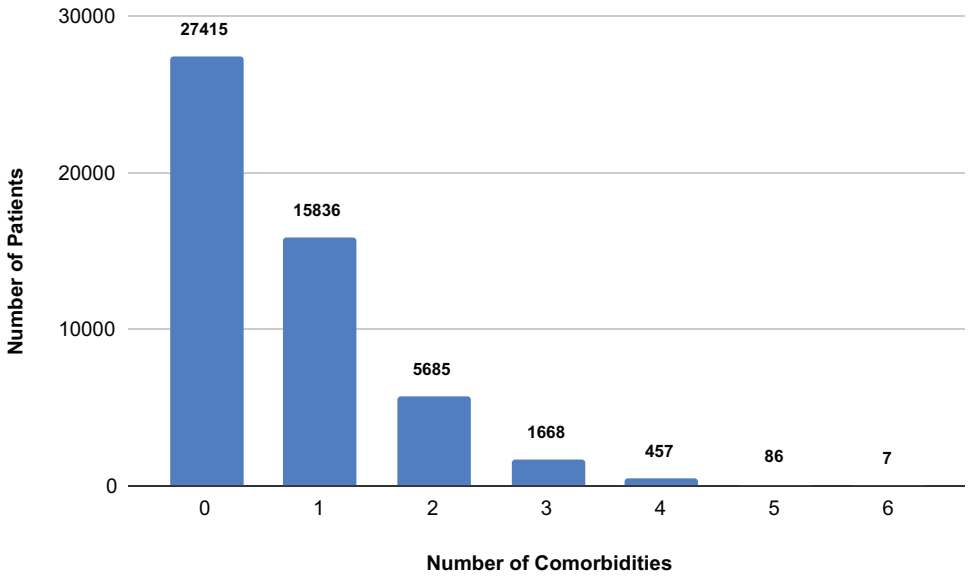

Figure 1. Patient stratification based on number of comorbidities.

patient portal, each employee selected a "COVID Vaccine" button, answered several questions, and scheduled their appointment for the first dose of the vaccine. After self-scheduling the appointment, they completed the check-in process and signed the consent through the patient portal without human intervention. When an employee arrived for their appointment, the system automatically generated an order for the vaccine. Employees were scheduled in an employee-specific department that had restricted access to their medical information in order to respect employee privacy regulations.[3] After vaccine administration, they received an electronic notification to schedule their second vaccine appointment during the 15-min post-vaccine observation period. Logic was created to ensure that the minimum interval between the first and second vaccine doses was 21 days for the Pfizer-BioNTech COVID-19 Vaccine and 28 days for the Moderna COVID-19 Vaccine. Students self-scheduled their vaccine appointments in the same manner. With advanced use of technology to fully automate key processes, the health system was able to redeploy resources for active administration of the vaccine, rather than for scheduling and outreach.

EXPANSION TO PATIENTS

Only 1 week into the deployment of the COVID-19 vaccine for healthcare workers, Florida mandated expansion of vaccine distribution to include anyone 65 years-of-age and older.[4] There was an urgent need to modify the vaccine rollout plan, because scheduling websites and phone systems within the healthcare industry were becoming overwhelmed. Given the uncertain vaccine supply and the prospect of opening scheduling to an enormous patient population, UHealth leveraged the initial success of the employee vaccination effort, quickly pivoting to include this new massive population by analyzing data to create a targeted, phased approach to patient vaccination.

We initially set out to determine the appropriate patient population given the limited vaccine availability. Using discrete patient data within Epic, we identified 121 168 patients aged 65 and older with an active patient portal account, a number that was far too large for outreach. Adding the criterion that the patient must have been seen by office or telemedicine visit within the past 3 years yielded 91 014 patients, a number that still exceeded supplies. We then created an algorithm to best determine the patient outreach methodology, informed by the underlying principles of the Digital Divide. The algorithm took into account the patient's age, comorbidities, date of last visit, and if the patient had activated a patient portal account. The final cohort consisted of 51 154 patients aged 65 and older with an active patient portal account, who had been seen within the past year by office or telemedicine visit. These patients were stratified into phases by the number of comorbidities

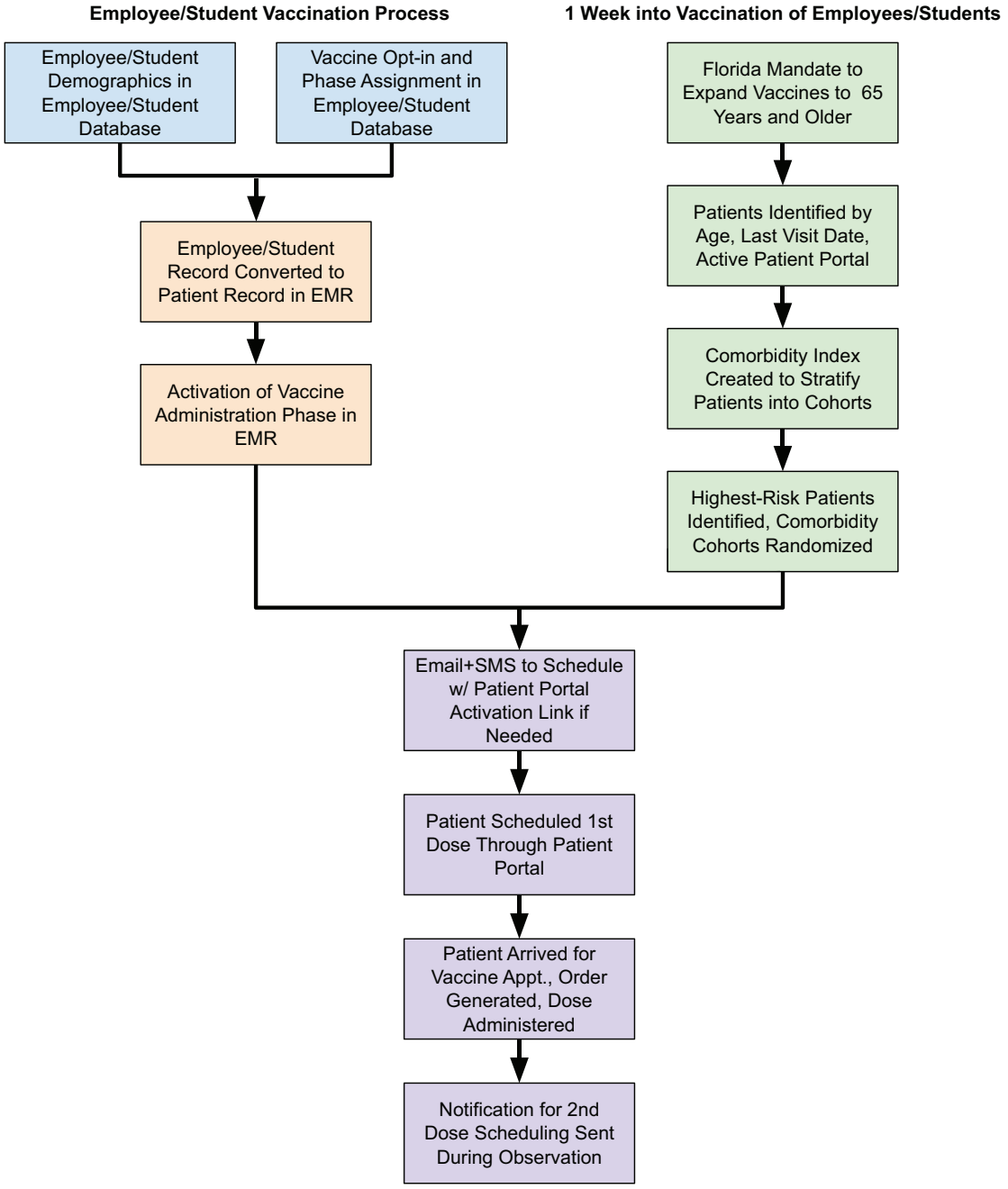

Figure 2. Flowchart of UHealth's COVID-19 vaccination process.

within their problem lists that placed them at increased risk of severe COVID-19, as outlined by the Centers for Disease Control (Table 2).[5]

Each comorbidity was given equal weight, and the final score assigned to the patient was the sum of all the patient's comorbidities, a value between 0 and 6 (Figure 1). Patients were informed of their priority score if they called to schedule vaccination.

Once the comorbidity score identified the highest risk patients with 4 or more comorbidities, they were immediately contacted to self-schedule for the vaccine through multi-channel communications. Patients received the same initial personalized scheduling email as employees in addition to a text message notifying them of their eligibility. If an employee was an existing patient, they were assigned an employee vaccine phase as well as a patient comorbidity score. They would have 2 opportunities to schedule vaccines depending on which phase was activated first. The VAC met twice weekly to review the percent scheduled from each outreach and demographics breakdown to determine when to advance to the next priority group. Once the next cohort was activated, we randomized the remaining larger cohorts into groups of 1000 for multi-channel outreach given the limited vaccine supply. These smaller groups were activated multiple times per day. To outreach those without internet access, we initiated phone calls for scheduling. Over time, logic was added to query the Florida state immunization registry to exclude previously vaccinated individuals from outreach. Thirty-seven days into the vaccination effort, enabled through the innova-

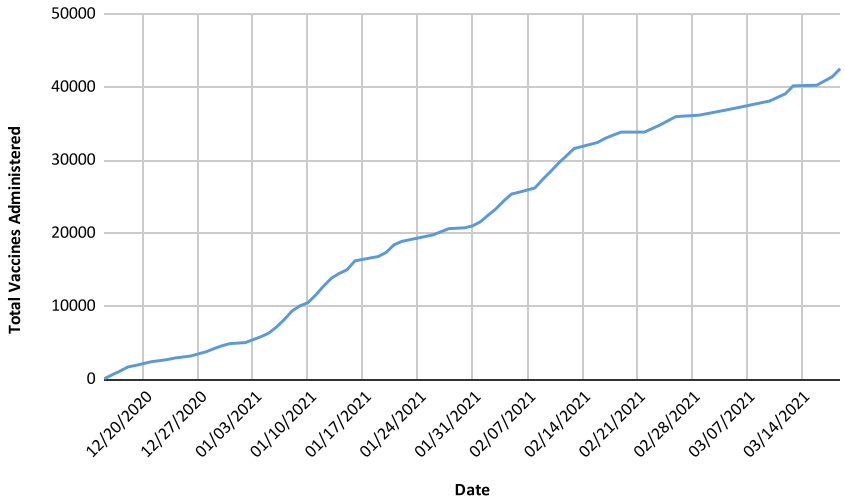

Figure 3. Cumulative number of COVID vaccines administered from December 15, 2020 through March 19, 2021.

tive use of novel technology, we were able to administer approximately 19 000 vaccines without wasting a single vaccine dose, and 99.9% of individuals self-scheduled through the patient portal. A summary of the process is outlined below (Figure 2).

OBTAINING ZERO-WASTE VACCINE ADMINISTRATION

Challenging the vaccine rollout was the uncertainty of vaccine shipments, which varied in quantity and frequency. The State was responsible for vaccine distribution to health centers, and there was no predictable schedule. Despite this uncertainty, we established a process for the immediate and complete use of vaccines without wastage. We carefully created schedules based on the number of vaccine doses received and opened scheduling blocks to maximize appointment slot utilization. When vaccine doses were received from the State, the schedule template was created with 30 appointments every 15 minutes. Initially, only the morning session was activated for scheduling. Once 80% of the morning session was booked, the afternoon session was activated. Working in collaboration, the vaccine site manager and pharmacy reviewed the schedule for the next day to determine the number of vials needed for vaccination. If too many vials were taken out, we opened an additional vaccination day. Although our initial no-show rate was zero, over time the no-show rate grew to 2%. To overcome the small no-show, the final 2 hours of each afternoon session were key to ensure zero waste. A waiting list was created outside of Epic, consisting of walk-ins who could arrive at the vaccine center within 20 minutes. Staff would call from the list during the final 2 hours of each day to notify individuals if there were any no-shows. Once those walk-ins arrived at the site, the pharmacists would puncture a vial when enough people arrived for their appointments to utilize the entire vial, ensuring that all doses from each vaccine vial were used.

State mandates for vaccine administration frequently changed, requiring modification of our vaccine eligibility algorithm, including Florida resident status, profession, and updated age requirements. As of March 19, 2021, by leveraging technology while maintaining current medical practice at our health center, we have been able to administer a total of 42 272 vaccines with a maximum daily throughput of 1200 vaccinations (Figure 3).

CONCLUSION

Organized on both the medical campus of an academic health center and its cognate University campuses, this mass vaccination effort targeted employees, students, and patients, prioritizing those who were at the highest risk of contracting severe COVID-19 illness. Rapid, equitable and efficient distribution of COVID vaccines during the pandemic could not have been accomplished without a coordinated effort and heavy reliance on workflow automation for identification, phasing, and scheduling of employees, students, and patients. We hope that our efforts to overcome the challenges of mass vaccination while continuing to provide medical care to our patients can serve as a framework for the appropriate utilization of resources to organize large-scale outreach and automate healthcare delivery.

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AUTHOR CONTRIBUTIONS

MS and AB were the primary authors of this manuscript. RW, DR, JR, RA, and DF also contributed substantially to the manuscript. DR and RA particularly contributed to the technical details of the manuscript. GP and MS conceived the original design of this project. RA contributed significantly to the design and implementation of this project. GP supervised the project. AB analyzed the data. All authors contributed to the intellectual content, commented on the manuscript, and approved the final content of this manuscript.

CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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