

CASE STUDY

Developing a Large-Scale Covid-19 Surveillance System to Reopen Campuses

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To open campuses safely, the University of Pennsylvania (Penn) and its health system (UPHS), with six hospitals and hundreds of outpatient practices, needed to develop an early warning system to identify the infected and exposed among Penn and UPHS campus members — 70,000 faculty, staff, and students who were at risk of transmitting severe acute respiratory syndrome coronavirus 2, or Covid-19. This warning system would help to minimize future spread by preventing individuals with concerning symptoms or recent exposures from coming into contact with others and, when necessary, streamline access to testing, self-isolation guidance, contact tracing, and medical care. The authors describe the challenges in designing, implementing, and continuously improving PennOpen Pass and the Red Pass Management System, a part-digital, part-human screening system. The lessons learned while developing and implementing PennOpen Pass provide key insights for the future of innovations in health care as we move toward improving the health of communities long after the pandemic.

KEY TAKEAWAYS

- » Complex organizations with diverse missions (e.g., educating undergraduates and caring for patients) can overcome challenges by unifying around common goals, being transparent in their communications, and nimbly adapting.
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- » Programs that screen essential workers for Covid-19 must balance their ability to identify concerning symptoms or exposures against the demands to staff essential services supporting the daily operations of an organization or clinical care.
- » Automation can substantially increase efficiencies in a system that otherwise would have required extensive human-to-human interaction.
- » How organizations have made decisions under the pressures of the pandemic can illustrate potential strategies for advancing innovation and transforming health care in the future.

The Challenge

In May 2020, leaders at the University of Pennsylvania (Penn) and the University of Pennsylvania Health System (UPHS) were deliberating how to safely return nearly 70,000 employees, students, and others to campus during the Covid-19 pandemic. While social distancing, handwashing, and masking were enforced on our campuses, these behaviors were encouraged to varying degrees by policy makers in the three states where our campus members live or work (Pennsylvania, New Jersey, and Delaware), and individual compliance with these practices outside of our campuses was unenforceable and unobservable. Symptom and exposure detection emerged as an essential layer of protection for our campuses. At the time, temperature screening at building entrances had low sensitivity in detecting Covid-19 symptoms, did not screen for concerning exposures, created delays and crowds, and turned people away from campus without offering additional guidance or resources. We needed a virtual entryway to screen individuals before coming into contact with others on our campuses and, when necessary, we need to streamline access to testing, self-isolation guidance, contact tracing, and medical care.

The Goal

We needed to identify people with symptoms or exposures concerning for Covid-19. Without routine, frequent, rapid surveillance testing, our system had to rely on self-reporting while being scalable and adaptable. As a result, we focused on digital solutions complemented by existing clinical staff who could determine when individuals with concerning symptoms or exposures could return.

The Execution

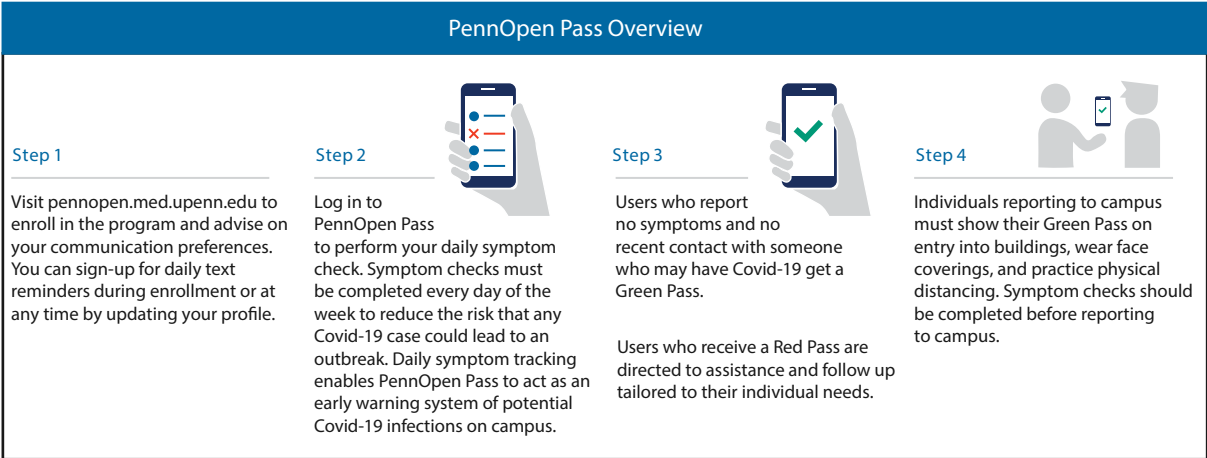
Overview

PennOpen Pass is a daily electronic symptom and exposure screening system that was developed and implemented in a phased approach over a period of several months to reduce community spread of Covid-19 and to manage those exposed or infected, with patient triage and care coordination based on clinical algorithms (Figure 1, Figure 2).

After a one-time enrollment process lasting approximately 5 minutes, end users are required to complete symptom and exposure checks each day in seconds with the use of a mobile-friendly

FIGURE 1

Overview of the of PennOpen Pass System



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FIGURE 2

Timeline and Phased Rollout of PennOpen Pass

UPHS = University of Pennsylvania Health System.

Phased Rollout					
Timeline	Phase 0: May-June 2020	Phase 1: July 2020	Phase 2: Sept. - Oct. 2020	Phase 3: Nov. - Dec. 2020	Phase 4: Jan. 2021
People	Pilots at the University and Health System	Implementation with University faculty, staff, visitors, vendors, and contractors	Implementation with UPHS staff, vendors, and contractors	Implementation with UPHS patients and visitors	Implementation with returning University students
Program	PennOpen Pass "beta" version symptom and exposure screening	PennOpen Pass symptom and exposure screening application and call center	Red Pass Management System application and expanded clinical team	UPHS patient and visitor version, kiosks, travel notices	Surveillance testing tegration, postvaccine guidance

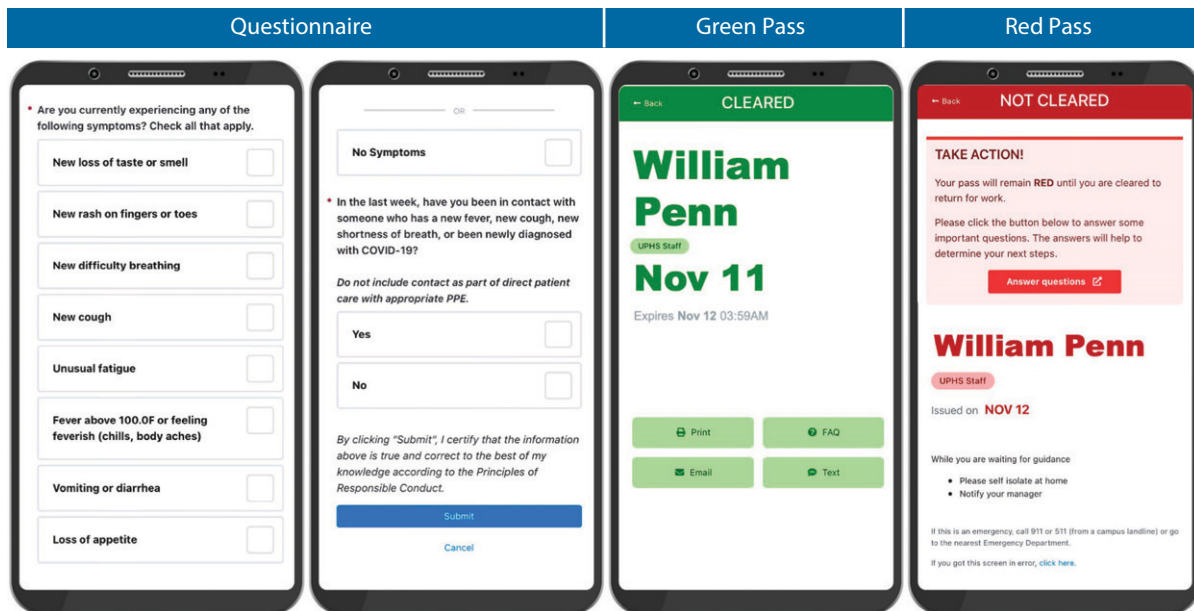
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Web application (Figure 3). Users receive a green pass if they do not report either concerning symptoms or recent contact with someone with suspected or confirmed Covid-19. Users with concerning symptoms or exposures receive a red pass and are guided through the Red Pass Management System (RPMS), an automated evaluation process backed by a team of trained clinicians who determine the user’s next steps, tailored to their situation. Intake questions adjudicate whether they should truly retain a red pass or if they should be cleared to a green pass because their situation is less concerning (Figure 4). Even if users do not complete all

FIGURE 3

Screenshots of the Daily Survey, Green Pass, and Red Pass

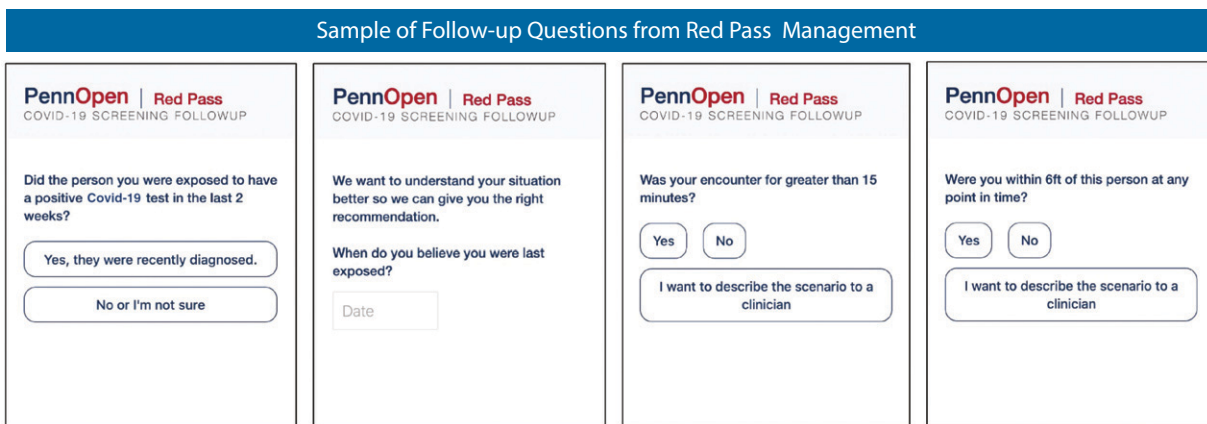
PPE = personal protective equipment.



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FIGURE 4

Sample of Follow-up Questions from the Red Pass Management System



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FIGURE 5

Detailed View of the Red Pass Management System’s Web-Based Dashboard

CPUP = Clinical Practices of the University of Pennsylvania, Post-Doc = post-doctoral student, PUI = person under investigation, Qs = questions, SARS CoV 2 = severe acute respiratory syndrome coronavirus 2, UPHS = University of Pennsylvania Health System.

The screenshot displays the Red Pass Management System interface, divided into two main sections: 'Web-based Dashboard' and 'Workflow Management Tool'.

Web-based Dashboard: This section contains a table with the following data:

School or Center	Red pass issued	Red Pass Reason	Timing
Perelman School of Medicine Hospital of the University of Pennsylvania (HUP) and Penn Presbyterian Medical Center (PPMC)	1/30 21:07 1 minute ago	Made red by red pass handling app This person has not started the intake	
UPHS	1/30 20:53 16 minutes ago	Failed screening: Vomiting or diarrhea, Loss of appetite	
UPHS Hospital of the University of Pennsylvania (HUP) Clinical	1/30 17:15 about 4 hours ago	Failed screening: Cough	Sxes started 2021-01-28
UPHS Outpatient CPUP practice	1/30 13:57 about 7 hours ago	Failed screening: Cough, Fatigue, Contact	Sxes started 2021-01-30

Workflow Management Tool: This panel provides detailed information for a selected individual, including:

- Personal Information:** Faculty/Post-Doc, Perelman School of Medicine, Self-selected locations: Hospital of the University of Pennsylvania (HUP) and Penn Presbyterian Medical Center (PPMC), Tel +###-###-####.
- Status:** This person is in the red state (locked). Change this person to green and change status to cleared to return.
- Clearance Options:**
 - Self-clearance:** This person cannot self-clear. Self-clearance is a process in which a user goes back to Open Pass and answers the screening questions in a way that normally gives a green pass.
 - Auto-clearance:** This person is NOT eligible. Auto-clearance is when a symptomatic user self-reports a negative Covid-19 test and is given clearance questions through the app, potentially changing to green without speaking to a person.
- Red pass reasons (select all that apply):**
 - Symptoms
 - Exposure
 - +SARS CoV 2
 - Noncompliance with surveillance testing
- Current red pass status:** PUI: intake not finished.
- Additional Notes:** Upon reporting a symptom or exposure on Open Pass, some groups of people are asked to complete further questions (otherwise known as intake). The people in this bucket did not finish intake, or did not start at all.
- Clearance Settings:**
 - Covid-19 test recommended on:** None
 - Earliest return to campus date:** None
 - Auto change to green on the return to campus date
 - Email screening Qs 1 day before, and if pass then auto change to green on the return to campus date

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intake questions, their data populate a Web-based dashboard and workflow management tool, critical for care coordination and contact tracing support (Figure 5). Our communities are highly interconnected geographically, with many people routinely crisscrossing our clinical and university campuses. Creating a centralized management tool that facilitated coordination and provided a uniform response to screenings was critical.

The PennOpen Pass/RPMS user-facing teams included: (1) a centralized call center staffed from 4 a.m. to 10 p.m., 7 days a week to provide technical and logistical support to users; (2) a team of registered nurses, cross-utilized from other telemedicine programs, to provide clinical support to PennOpen Pass users and to finalize the determination of a green versus red pass in situations of clinical uncertainty; and (3) a diverse and large team of personnel from Penn (including representatives from Student Health Service and Campus Health as well as contact tracers) and UPHS (including representatives from Occupational Medicine and Infection Control and Prevention) who were already dedicated to mitigating Covid-19 risks on our campuses.

Contact tracing was conducted at two levels. First, workplace contact tracing was conducted by Penn contact tracers and UPHS infection control teams. Second, community contact tracing was conducted by a team led by Penn’s Center for Public Health Initiative. The PennOpen Pass teams were tightly linked to both groups of contact tracers.

PennOpen Pass Design and Implementation

We wanted our solution to be usable on mobile devices and capable of producing an instantly understandable visual pass to display at building entrances. Early in the process, we ruled out developing an iPhone and Android mobile app because of potential adoption barriers. Instead, we built a mobile-friendly Web application that facilitated mobile or desktop symptom surveys so that daily passes could be printed or shown on screens like an airplane boarding pass (Figure 3). To accommodate campus users without phones or easy access to the Web application, verbal attestation signs were developed at entryways so that users could acknowledge the absence of concerning symptoms or exposures to entry personnel, modeled after “Nothing to Declare” pathways for customs inspection. To date, the verbal attestation process has been used by 0.5% to 5% of users per day.

“ *The time urgency required us to “fix the plane while flying it,” rolling out PennOpen Pass to our UPHS campuses while prototyping and iteratively redesigning RPMS despite all of the clinical protocols and software specifications that still needed refinement and testing at the time of launch.* ”

PennOpen Pass was built by our internal software development team, despite the fact that the team was facing many other pandemic-related challenges. Given that many organizations faced similar challenges, it might seem that identifying a close-enough external solution would have been more efficient. If a screening functionality was the only requirement, outsourcing would have made sense. However, to create a unified and coordinated approach that accounted for the diverse populations across hospital, ambulatory, and university settings, frequent design iterations were needed from a team who understood and was willing to work through the operational complexities of all of our campuses. Using internal resources for this task allowed us to adapt to rapidly evolving public health guidance and specific campus needs. This flexibility was essential for widespread stakeholder buy-in. Although a daily survey could have been created in a third-party system, there were numerous features that required customization and integration, such as the ability to prevent a person with a red pass from completing a new screening until clinically cleared. In addition, using internal software teams gave us complete flexibility to integrate complex logic and PennOpen Pass within other enterprise systems.

Our product team followed an Agile software-development process to rapidly iterate the Web application and quickly test concepts through small-scale rapid-cycle pilots.¹ In June 2020, we ran a 2-week pilot to evaluate adoption, user experiences, clinical workflows, and operational requirements.

Design issues with the questionnaire initially led to a high rate of user errors in generating red passes, accounting for 80% of red passes and resulting in an unnecessary burden on the teams who were managing red passes as well as on the users themselves, who were delayed in being able to enter campus buildings. Accordingly, we applied user-centered design principles by modifying the questionnaire design (e.g., simplifying the language used in the screening questions and response

choices to improve interpretability), improving the user-centered design (e.g., enhancing the usability of on-screen buttons to minimize click errors), and giving users a grace period to retake their questionnaire if they generated a red pass by mistake. These changes decreased the red pass rate from 1.5% during the pilot to 0.8%, but they did not decrease the total number of symptoms or exposures reported in the days soon after. Questionnaire redesign also resulted in faster survey completion, reducing the average completion time from 36 to 13 seconds. We also removed friction from the log-in process on the basis of user feedback, such as the removal of daily dual-factor authentication for the majority of user groups.

With these design improvements, the team completed the first step in a phased rollout to more than 30,000 Penn faculty, staff, and students by July 2020. With a small implementation team facing a 12-school university campus with different needs, we leveraged local operational groups from each school (e.g., law, engineering, design, medicine, etc.). We developed a detailed implementation toolkit with templated workflows, standardized communications, and held virtual office hours to answer questions and foster peer-to-peer learning and dissemination (Figure 6). In July 2020, each of Penn’s 12 schools went live in a three-step, month-long process of: (1) preparing for go-live, (2) enrolling users, and (3) mandating usage for building access. Starting in September 2020, the same model was used to deploy the program across the health system.

FIGURE 6

Example of Content from the Implementation Toolkit

ID = identification, TSA = Transportation Security Administration.

Implementation Toolkit Example Content

PennOpen Pass fast lane
The PennOpen Pass fast lane is for individuals who have completed their symptom check and have a Green Pass from PennOpen Pass.

Access checkpoint
Staff responsible for clearing individuals to enter should be positioned at a checkpoint in between the fast lane and the verbal attestation lane. Staff should call individuals forward for review from the fast lane first (asking how TSA PreCheck works in an airport) as they get priority check-in. Individuals in the verbal attestation lane will be called forward once the fast lane is cleared.

Verbal attestation lane
The verbal attestation lane is for individuals who do not have a mobile phone or did not complete their symptom check on PennOpen Pass.

Hand sanitizing and face coverings
Upon entrance, individuals should have access to hand sanitizer and face coverings.

Directions for staff at active screening locations

Directions for staff facilitating verbal attestation at building entrances
Individuals who could not or did not complete their symptom check on PennOpen Pass can complete verbal attestation to gain entry to buildings.

Directions for facilitating verbal attestation

1. Ask the individual to show their ID.
2. Ask the individual, "Do you meet any of these criteria?"
When asking this question, point to the [verbal attestation sign](#) for the individual to review.
3. If the individual answers no, they received "green status" and you can grant them access to the building with a hard copy Green Pass. For each individual approved for entry, please fill in their name, role, and the date, and initial the top of the pass.
 - a. [Hard copy Green Pass](#)
4. If the individual responds yes, that they do meet criteria on

Communication recommendations and resources
Communication will be key to ensure the success of your PennOpen Pass launch. Communication plans will vary at the local level. Use these recommendations & resources to develop, customize, & execute on your approach.

Week 2, Day 1 - Announce program

- [Announcement message](#) goes out from leadership of school, center, or entity to faculty, students, postdocs, and staff
- Supervisors [send emails](#) to direct reports to promote enrollment
- [Email](#) goes out to visitors, vendors, and contractors

Week 2, Day 5 - Enrollment reminders

- [Reminder to enroll](#) email goes out from school, center, or entity to faculty, students, postdocs, and staff
- Supervisors [send emails](#) to direct reports reminding them to enroll by the deadline
- [Reminder emails](#) goes out to visitors, vendors, and contractors

Week 3, Day 5

- PennOpen Pass is fully operationalized with rollout participants at your location

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Fixing the Plane While Flying It

In the time between the Penn and UPHS rollouts, we developed and implemented the RPMS to enhance scalability as we prepared to enroll an additional 40,000 health system employees. While there had been a lull in cases in the Philadelphia region over the summer in 2020, we recognized the urgent need to implement PennOpen Pass at our health system by the early fall of 2020, as national case counts were rapidly rising. The time urgency required us to “fix the plane while flying it,” rolling out PennOpen Pass to our UPHS campuses while prototyping and iteratively redesigning RPMS despite all the clinical protocols and software specifications that still needed refinement and testing at the time of launch. A daily workgroup of staff from the PennOpen Pass call center, nursing leadership, occupational medicine, and infection control reviewed clinical scenarios and technical problems to adapt RPMS into a functional, end-to-end red pass screening system that could be used throughout UPHS and by the small number of Penn students, faculty, and staff who were working on campus during the fall of 2020.

FIGURE 7

Stakeholder Map for Program Development and Implementation

Note: Penn Medicine and the University of Pennsylvania Health System are synonymous. EHRS = Environmental Health and Radiation Safety.

Stakeholder Map for Program Development and Implementation		
Function	Group	Membership
Owner/Driver	Core Workgroup	Penn Medicine Center for Health Care Innovation (CHCI), Penn Medicine Information Services (IS), and the Center for Health Incentives and Behavioral Economics (CHIBE)
Sponsor	Program Sponsors	Penn Medicine Chief Medical Officer (CMO), University Chief Information Officer, Penn Wellness Chief Operating Officer
Advisory	Leadership Partners	University Recovery Planning Group and Penn Medicine Executive and Entity Leadership
	Clinical and Public Health Advisory Group	Penn Medicine CMO, Penn Medicine Infection Control, Penn Medicine Occupational Medicine, University Campus Health, University Student Health, University Environmental Health and Radiation Safety, and the Center for Public Health Initiatives (CPHI)
	Privacy, Legal, and Human Resources Advisory Group	University and Penn Medicine Chief Privacy Officers, Office of General Counsel, University and Penn Medicine Human Resources
	Faculty, Staff, and Student Advisory Groups	Faculty Senate, Penn Professional Staff Assembly, Penn Weekly Paid Professional Staff Assembly, Undergraduate Assembly, Graduate and Professional Student Assembly
Workgroups	Technical Teams	Penn Medicine IS, Penn Medicine CHCI, and University Information Services & Computing
	Data Reporting Workgroup	University Information Services & Computing (ISC), Penn Medicine IS, Penn Medicine CHCI
	Communications Workgroup	University Communications, Penn Medicine Communications
Red Pass Management	Open Pass Call Center	Penn Wellness, University ISC
	Testing and Scheduling	Hospital of the University of Pennsylvania Occupational Medicine, Penn Medicine Testing Operations, Penn Medicine Access Center
	Clearance for Return	Hospital of the University of Pennsylvania Occupational Medicine, University Campus Health
	Contact Tracing	University EHRS, CPHI, University Campus Health, Penn Medicine Infection Control, PennVet
Rollout	Implementation Team	University ISC, Penn Medicine IS, Penn Medicine Strategic Operations, Penn Medicine Center for Connected Care, Penn Medicine CHCI, University School and Center Operational Owners, Penn Medicine Entity Operational Owners

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Hurdles

Organizational Considerations

The major hurdles during design and development were more organizational and human than technical. PennOpen Pass and RPMS touched every part of the university and health system, requiring extensive discussions, stakeholder engagement, and buy-in for decision-making (Figure 7). Visual mapping, prototyping, and pilots helped inform decision-making, achieve alignment, and identify requirements and workflows that would meet the needs of our diverse campus.

The core workgroup centralized change-control decisions that had been largely decentralized until that point, coordinating and prioritizing stakeholder requests and input while drawing on local experts for guidance. For example, a privacy, legal, and human resources advisory group helped develop the program's publicly available [privacy policy](#), which outlined the purpose of PennOpen Pass, the information that would be collected from users, how the data would be used, and who would have access to the data. In addition, the privacy policy made clear that users' digital location and contact data would not be collected or used and that user information would be made available only to those engaged in health and safety functions, such as contact tracers and clinicians. Additionally, we worked closely with a clinical and public health advisory group to develop clinical algorithms that could be used to guide testing, to facilitate contact tracing, and to determine when users could return to work or school.

Clinical Considerations and Staffing Needs

PennOpen Pass and RPMS needed to balance adequate detection of concerning situations (essential for keeping the campus and health system safe) against overdetection and running the risk of unnecessary strains on staffing for essential campus and health system roles. We convened infectious disease physicians, epidemiologists, and operational leaders to join our core workgroup and provide expert guidance on how to achieve this balance. We also trained registered nurses with a designated nurse lead and medical director. The clinical leads were responsible for disseminating and implementing institutional guidelines related to testing and quarantining, which evolved as public health guidance shifted.

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To determine which symptoms PennOpen Pass should screen for daily, we referred to Covid-19 symptoms outlined and updated by the Centers for Disease Control and Prevention.² The

FIGURE 8

Algorithm Used to Trigger a Red Pass

Questionnaire Component	Logic for Triggering a Further Evaluation
Contact	Any contact
Symptoms	
New cough	1 or more of these symptoms
New difficulty breathing	
New loss of taste or smell	
Fever above 100.0° F or feeling feverish	
Vomiting or diarrhea	2 or more of these symptoms
Loss of appetite	
Unusual fatigue	
New rash on fingers or toes	

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tension between adequate detection and overdetection was felt acutely when considering which symptoms (either individually or as part of a cluster of symptoms) should trigger a red pass. Our greatest challenge was the limited evidence available to guide our decision-making process.³ Many symptoms associated with Covid-19, such as sore throat, are nonspecific. Symptoms of other communicable diseases, such as fever and newly developed cough, were concerning enough for Covid-19 that they warranted immediate testing and self-isolation. Symptoms that have become almost pathognomonic for Covid-19, such as loss of taste and smell, were easier to include as individual red pass triggers. The finalized algorithm and list of symptoms triggering a red pass and further evaluation are included in Figure 8.

Given that approximately 30% of people capable of transmitting the disease were asymptomatic,^{4,5} we emphasized identifying, quarantining, and testing individuals with concerning exposures, in addition to those with symptoms. Classifying exposures was more challenging than classifying symptoms, reflecting not just the mechanism of exposure, but also uncertainty about the contact’s own risks. A substantial proportion of our campus members resided in poor and largely minority neighborhoods that were disproportionately burdened by the pandemic. While we needed a screening process that would be sensitive enough to detect concerning exposures, we also had to back it up with human-centric contact to account for the needs of individual users and the communities in which they resided. We recognized that we might need to rely on PennOpen Pass for the foreseeable future and hoped to gain the trust and long-term acceptance of our users.

The Challenges and Value of Integrating Automation

Initial projections indicated that \$3.8 million would be required to manage users with red passes for 12 months using a manual, human-staffed program. That figure, already daunting, was made even less attainable because few staff could be reallocated to this task, a hiring freeze had

limited new personnel, and the pandemic had already caused a financial strain. Automating much of the process, from identification to management to clearance for returning to work, was immediately recognized as a key requirement. RPMS provided the in-house capability to test and validate processes that were hypothesized to be automatable while ensuring the flexibility to adapt to user feedback, stakeholder requests, and the changing evolving nature of the pandemic. However, the constantly changing landscape and multiple user demands were challenging.

First, we faced internal barriers to the concept of automation itself. Many members of our team defined their roles as providing essential human touch and hard-to-replicate expertise in the context of emotionally sensitive conditions. Acceptance of the role of automation became easier as the impossibility of supporting manual approaches became more apparent with experience.

Second, the timeline to a minimum viable product was short. Our “fix the plane while flying it” approach acknowledged that critical learning would occur along the way, but hiccups experienced by users during the early stages of development created lingering perceptions among users that the program was ineffective or unreliable. Overcoming these challenges required a level of transparency, vulnerability, and rapid responsiveness to concerns at a scale that many of us had not previously experienced.

Third, while we initially believed that assessing exposures could be largely automated with the use of a set of follow-up questions from RPMS, we quickly learned that users’ exposure scenarios were too nuanced and idiosyncratic to fall into simple patterns. Individual stories evolved over time as users progressively recalled details or gained collateral information from their contacts in the subsequent hours or days. We transformed RPMS questions to gather basic information, such as when an exposure occurred and whether or not individuals wore a mask.

Fourth, while the initial intake process was variable from person to person, we learned that the process of clearing individuals for returning to work could be largely automated. For those with symptoms, we followed public health guidance after receiving their test results. For exposures, we designed RPMS to conduct time-based follow-up to determine if users remained asymptomatic or, in alignment with public health guidance later in the pandemic, if they had followed test-based strategies for returning to campus at 10 days instead of waiting the full 14 days. We also leveraged RPMS to flag individuals with more complicated situations such as household exposures, reserving those individuals for a more hands-on, clinician-managed process.

Adaption and Expansion

Evolving public health guidance necessitated a flexible, ongoing implementation process and in-house software development to keep us nimble. For example, PennOpen Pass was adapted to reinforce travel warnings during the winter holidays, and its quarantining or self-isolation recommendations have been adjusted for users who have been vaccinated. The program has experienced a number of expansions. First, it has been expanded to support symptom and exposure screening of patients and their visitors prior to entering our health care facilities. Second, the success of PennOpen Pass in the fall of 2020 generated confidence among leaders at Penn that the Penn community members who returned to university campus could be safely monitored and cared for when Covid-19 concerns arose.

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From June 2020 through February 2021, more than 75,000 campus members enrolled in PennOpen Pass. During that time, the program supported 4,183,462 daily surveillance checks and the PennOpen Pass and RPMS teams issued and managed 25,117 red passes.

In January 2021, campus was “reopened” to allow more than 3,000 students to live on campus as well as to reintroduce an increased number of in-person activities (e.g., opening athletic facilities for student athletes and opening dining halls) for thousands of students living both on and off campus. PennOpen Pass checkpoints were integrated into all buildings, including dormitories and common spaces. That same month, PennOpen Pass was integrated with a Covid-19 surveillance testing program that tested all undergraduates twice per week, all graduate students once per week, and certain Penn community members (i.e., those who accessed campus grounds or facilities 4 or more hours per week) once per week. If individuals received a positive test or did not comply with scheduling a screening test, their pass would automatically be converted to a red pass. The surveillance testing program and the PennOpen Pass system were seen as complementary. One program could detect asymptomatic infections, and the other provided an effector arm for implementing public health mitigation techniques through the red pass system and PennOpen Pass’ team of contact tracers and clinicians.

The Team

A core workgroup was assembled to develop PennOpen Pass and the RPMS from the Penn Medicine Center for Health Care Innovation, Penn Medicine Information Services, the Center for Health Incentives and Behavioral Economics, and executive leaders from Penn and UPHS. After university-wide implementation, the core workgroup managed a transition of the program to the current operational structure under the Penn Medicine Center for Connected Care (Figure 9).

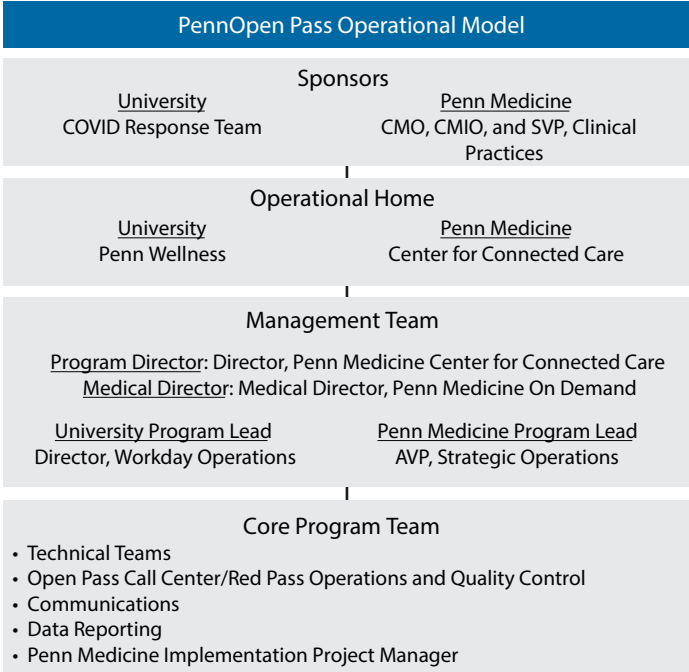
Metrics

From June 2020 through February 2021, more than 75,000 campus members enrolled in PennOpen Pass. During that time, the program supported 4,183,462 daily surveillance checks and the PennOpen Pass and RPMS teams issued and managed 25,117 red passes. Exposures accounted for 54% of red passes. The most common symptoms triggering red passes triggered were cough (18%), fatigue (16%), and fever (15%). Among the 37,034 UPHS employees who enrolled in PennOpen Pass —users who were most likely to receive testing through the health system when they triggered a red pass — 1,276 positive tests occurred. To provide context, in the five southeast Pennsylvania counties surrounding Philadelphia during the December 2020 surge, the median number of new cases per 100,000 in the last 7 days was 53.7 (range, 44.7 to 64.8). By comparison, the median number of new cases per 100,000 in the last 7 days among UPHS employees who enrolled in PennOpen Pass in December was 63.3 (range, 44.6 to 72.3). Among those who tested positive, 44% attested to symptoms, 11% attested only to exposure, and 45% attested to both symptoms and exposure.

FIGURE 9

The PennOpen Pass Operational Model

Note: Penn Medicine and the University of Pennsylvania Health System are synonymous. AVP = Associate Vice President, CMIO = Chief Medical Information Officer, CMO = Chief Medical Officer, SVP = Senior Vice President.



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Through automation and iterative improvements, the final PennOpen Pass system resulted in reductions in the median time of red pass clearances from a peak of 45 hours in mid-November to 27 hours by the end of December 2020. The cost of administering PennOpen Pass with our current staffing model combined with technology costs is projected to be \$0.9 million over a 12-month period. This figure is substantially less than the initial \$3.8 million projected for a PennOpen Pass system without automation.

Where to Start

During the process of developing and implementing PennOpen Pass, we learned several key lessons for the future of innovations in health care:

- 1. A shared common mission can be a motivating force to drive new initiatives forward.**
While the pandemic was an experience that many of us would not want to repeat, it brought people from disparate and siloed parts of our campuses together with a sense of extreme urgency to achieve a common goal. As the pandemic wanes, we need to identify strategies for how to identify future shared missions and work toward achieving those goals together.

2. **Delivery challenges in health care can be overcome.** Often in health care, solutions to challenges are plagued by pessimism about what is not legally possible, a reimbursement structure that is not ready, or situations in which the technology does not exist. The development of PennOpen Pass and RPMS demonstrated the feasibility of crafting a new approach that required working through a variety of legal and data-privacy challenges without a reimbursement model and of building a customized technological solution when none existed. The pandemic has taught us that we can overcome seemingly insurmountable challenges with ingenuity, imagination, and collaboration.
3. **Trust is a critical two-way street that flows through successful innovations.** On one hand, we had to learn to trust our users, as PennOpen Pass is an honor system. On the other hand, stakeholders had to learn to trust PennOpen Pass and the development team. We had to build that trust by delivering meaningful results (e.g., successful implementation of an expedited testing process, contact tracing, and follow-up of red passes); by making purposeful choices in our policies, communications, and design (such as our privacy policy and protection of identified red pass data); and by maintaining openness with operational leaders during implementation.
4. **Automation can be integrated into care, and health care will not lose its humanity.** Initially, automation of the red pass system was met with hesitation, even among our own team. However, as we opened the PennOpen Pass system to 70,000 users, it became clear that the estimated 0.5% daily red pass rate would require a substantial amount of work to process users with symptoms and/or exposures and to efficiently return individuals to work. This work could largely be done in an algorithmic fashion. Automating routine tasks helped our clinicians focus on providing humane care to those who needed it the most: the worried and the clinically complex. The PennOpen Pass system provides a technological, operational, and clinical backbone that can be retooled after the pandemic for more efficient, large-scale health and safety-screening initiatives such as postoperative follow-up or population health-management approaches for other conditions for which the early detection of clinical decline is critical.

Our experience with Penn OpenPass and the RPMS demonstrated that the technical challenges that defined our initial solution sat alongside even larger, often time-consuming, organizational challenges of stakeholder management and operational implementation. Yet we were motivated by the importance of stemming the pandemic, keeping our campus safe, and helping our campus members feel safe. While PennOpen Pass was created under the pressures of the pandemic, the lessons we learned will help us advance health care innovations in the future.

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