Quality Improvement for Rapid Development and Scale-Up of COVID-19–Related Screening Processes

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abstract

BACKGROUND: In March 2020, Ohio strongly recommended temperature and health screening for coronavirus disease 2019 symptoms in all businesses to reduce the spread of infection.

METHODS: We used multiple plan-do-study-act cycles and workplace efficiency techniques iteratively to develop 12 intervention components required to effectively screen employees and visitors across all locations. We used run and control charts to summarize our performance over time.

RESULTS: Over the course of 20 days of rapid testing, we increased from 0% to 100% of locations successfully screening. The volume of people undergoing screening peaked during employee shift change. Employee positive screen results decreased by >50% after the first 7 days of screening, whereas family positive screen results remained stable throughout the study period.

CONCLUSIONS: An empowered, multidepartmental steering team, disciplined use of rapid cycle quality improvement processes, and explicit, standardized training processes enabled rapid successful scale-up of standard screening and masking process for employees and patients during the coronavirus disease 2019 pandemic. This approach can assist hospitals in adapting screening processes to evolving evidence.
METHODS

Context

The CCHMC is a large tertiary and quaternary care academic medical center. It has nearly 16,000 employees across clinical, research, and academic missions, >700 inpatient beds, and >1 million outpatient and emergency department visits in the 2020 fiscal year. Efforts to implement temperature screening for all visitors and employees began on March 15, 2020. The CCHMC had instituted a telecommuting policy for all nonessential employees and limited clinical encounters to emergency or essential visits only. As a result, the volume of people entering the institution was significantly reduced.

Improvement and Analytic Approach

Leveraging existing institutional quality improvement (QI) expertise, the CCHMC used a methodologic QI approach to developing the COVID-19 screening program. Workplace organization concepts further informed design and ensured efficient flow. The CCHMC improvement science methodology is based on the Model for Improvement developed by Associates in Process Improvement.3 We established that our overall goal was to establish an effective universal screening program. The SMART Aim of the work was to establish a universal temperature and symptom screening process at 100% of CCHMC screening stations by April 5, 2020 (Fig 1). Small-scale plan-do-study-act (PDSA) testing4 was done to establish the effectiveness of the design. This method gave the team the opportunity to quickly make small changes in an area, and then study the results to determine the next actionable steps on the basis of direct observation. The team was able to learn at a fast rate without adversely impacting performance and adapt the change to a variety of conditions. Successful testing results were followed by an iterative scale-up across increasing numbers of screening stations in the main hospital and satellite locations. Data collection of volumes of individuals screened informed design and evolution. A key driver diagram (Fig 1) was used to make visible our theory and the actions needed to
meet our aim. There are 5 key drivers related to the safety of patients, families, and employees, efficiency (especially reducing waiting) and patient, family, and employee experience. Run charts were initially used to show data over time followed by control charts when more data were available, and standard run and control chart rules were used to determine changes in the centerline.

**Interventions**

The interventions tested and ultimately implemented to address those drivers are summarized in Table 1 and detailed below.

1. Assembly of a cross-functional steering team: A cross-functional steering team included leaders from all areas predicted to be critical to the program’s success. These included: patient services, family relations, supply chain, protective services, and the hospital QI center. Other departments were added ad hoc. The team, initially, met daily for updates and problem solving to drive timely resolution of issues and nimble evolution of processes and screening station design. Also, in these meetings, the impact of changes to the Centers for Disease Control and Prevention and Ohio Department of Health guidance was considered.

2. Strategically located screening stations: Screening stations were located near or adjacent to the main flow of incoming hospital pedestrian traffic. Stations were not situated at the entrances themselves to allow incoming families to orient themselves and for employees and families to queue inside of the facility. Signage visible beyond entrances provided direction to the closest screening station and explained the reason for screening.

3. Standardized approach to screening station design: A key focus in designing the screening stations was to standardize design elements as much as was appropriate. This included standardized roles, training, signage, flow, etc. As a result, a standard screening station setup and flow was designed and used as the building block for all stations (Fig 2).

4. Standard screening protocol: Everyone screened was tested for fever by using a touchless, handheld thermometer and asked a series of questions regarding symptoms. An algorithm was developed that outlined appropriate follow-up action.

5. Responsiveness to evolving clinical guidance: The screening process evolved over time as additional guidance was issued by the Centers for Disease Control and Prevention and the State of Ohio. One notable addition was the implementation of universal masking as the first part of the screening process.

6. Sufficient qualified screening staff: Each week ~100 employees from multiple departments and hospital campuses staffed the 5 main campus screening stations, with smaller numbers of additional employees staffing the other 18 screening stations. The total number of shifts per week when the process was fully functional was slightly over 400.

<table>
<thead>
<tr>
<th>TABLE 1 Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Following Interventions and Program Design Principles Are Considered to Be the Keys to Success in Establishing a Temperature Screening Program</td>
</tr>
<tr>
<td>1. Assembly of cross-functional steering team</td>
</tr>
<tr>
<td>2. Strategically located screening stations</td>
</tr>
<tr>
<td>3. Sufficient qualified screening staff</td>
</tr>
<tr>
<td>4. Standard screening protocol</td>
</tr>
<tr>
<td>5. Standardized approach to screening station design</td>
</tr>
<tr>
<td>6. Responsiveness to evolving clinical guidance</td>
</tr>
<tr>
<td>7. Greeter role</td>
</tr>
<tr>
<td>8. On-site supervisor orientation before each shift</td>
</tr>
<tr>
<td>9. Standard work and TWI</td>
</tr>
<tr>
<td>10. Centralized scheduling</td>
</tr>
<tr>
<td>11. Supply chain and materials management</td>
</tr>
<tr>
<td>12. Signage</td>
</tr>
</tbody>
</table>
7. Greeter role: A greeter role was established to facilitate flow through the screening station, reinforce procedures, and verbally support a positive and welcoming environment.

8. On-site supervisor orientation: An on-site supervisor familiar with current process and requirements designated as the “shift captain” briefed oncoming screeners and greeters before each shift.

9. Standard work and Training Within Industry (TWI): TWI emphasizes learning by doing with a job instruction that breaks down the steps of the job and the key points. Training documentation (see Fig 3 for greeter example; full documentation for all roles is available from the first author on request) with key points and illustrations was created for screeners, greeters, and shift captains.

10. Centralized scheduling: Screener staffing schedules for all stations were coordinated a week in advance to ensure that shifts were filled. By contrast, the greeter role was filled by employees who volunteered to serve and organized by using a free online scheduling application.

11. Supply chain and materials management: Close coordination with and support from supply chain and materials management staff was critical to ensuring supplies were provided in a timely manner. Initially, the supplies (thermometers, disinfectant wipes, and stickers showing the date to be worn by anyone screened) were assembled in plastic bins and placed at each screening station by the team directing the screening efforts. After the addition of universal masking and the need for increased supplies (masks and sanitizer), the supply chain team assumed responsibility for restocking.
supplies on a nightly basis on the basis of par levels established as a result of supply monitoring during the first few weeks.

12. Informational and directional signage: A critical element in screening station flow and experience was effective informational and directional signage guiding visitors and employees to and through screening stations. This included floor cues to help maintain 6-ft spacing in screening lanes and information on their role and responsibilities.

Data Collection

The data used to generate measures were collected as manual counts at each station and included the volume of individuals screened (Fig 4) and number of screens flagged because of symptoms.

Additional information was collected via direct observation by QI staff and began during the initial setup in the first station. QI staff were present as each additional location opened up to observe the flow of people through the station and assess where backups were taking place.

The data used to calculate the cost of supplies for the screening stations were enabled by the creation of a new department code specifically associated with the COVID-19 pandemic. Weekly reports were generated to include the number and cost of each supply item and then totaled for the initial 8 weeks. The staffing costs were calculated on the basis of the number of shifts at each screening station and average salary for the employee roles that staffed the screening stations and totaled for the initial 8 weeks (Fig 5).

A daily huddle call was held for the first few weeks to gather immediate feedback and address identified concerns among the steering team. The call frequency was eventually reduced to twice weekly and ultimately once weekly as the process became more standard and stable.

Human Subjects Protection

This initiative met CCHMC Institutional Review Board guidelines for QI projects that did not involve human subjects research.
RESULTS

We measured the percent of total screening stations that were functioning effectively. This was our SMART Aim measure and, initially, was plotted on a run chart. Eventually, a control chart was used as the overall system became more stable. Special cause was indicated twice by 8 consecutive points above the centerline, and the centerline was shifted to reflect these statistically significant changes to the system (Fig 4). Hand-collected volume data for each screening location helped the team identify the peak time of heavy traffic, along with the proper staffing of the Screener and greeter roles (Fig 6). Through direct observation, the wait time for an individual to complete the screening process was no more than 5 minutes during the peak time. We also measured the number of COVID-19-positive employee and visitors (patients, families, and others, such as contractors) who were flagged for positive symptoms each day at the largest volume stations (Fig 7). Employee positive screen results declined, from a median of 8 per day in the first week of screening to a median of 2 per day thereafter. Visitor positive screen results remained stable, at a median of 3 per day throughout the study period.

For each intervention, an initial concept was laid out and tested by using hand-collected data from observations and the volume of people passing through the screening station. This concept was quickly adapted and scaled to 50% of the hospital-wide screening station locations within 2 weeks. In the first and second week of implementation,?

<table>
<thead>
<tr>
<th>Screening Station Costs</th>
<th>March 23 to May 16 (8 wk)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Screening supplies:</strong></td>
<td><strong>Cost</strong></td>
</tr>
<tr>
<td>Supplies stocked at screening stations (includes hand sanitizer, masks, goggles, disinfectant wipes, thermometers, etc)</td>
<td>$17,816</td>
</tr>
<tr>
<td>Stanchions (line control)</td>
<td>$2,835</td>
</tr>
<tr>
<td>Posters (information and directions)</td>
<td>$1,840</td>
</tr>
<tr>
<td>Miscellaneous office supplies (storage bins, scissors, tape, laminating sheets, and labels)</td>
<td>$400</td>
</tr>
<tr>
<td><strong>Subtotal supplies</strong></td>
<td><strong>$22,891</strong></td>
</tr>
<tr>
<td><strong>Staff costs for screening</strong></td>
<td></td>
</tr>
<tr>
<td>Senior administrative leadership (oversight)</td>
<td>$80,000</td>
</tr>
<tr>
<td>Pt Svcs employees (screeners)</td>
<td>$171,000</td>
</tr>
<tr>
<td>Protective services (screeners)</td>
<td>$95,680</td>
</tr>
<tr>
<td>Anderson Center staff (greeters, direct traffic, process improvement)</td>
<td>$101,850</td>
</tr>
<tr>
<td><strong>Subtotal staffing</strong></td>
<td><strong>$448,530</strong></td>
</tr>
<tr>
<td><strong>Notes:</strong></td>
<td></td>
</tr>
<tr>
<td>* The staffing costs listed above were not incremental costs to the hospital.</td>
<td></td>
</tr>
<tr>
<td>* Staff that were not performing their regular duties because of decreased clinical volumes were engaged in screening activities.</td>
<td></td>
</tr>
<tr>
<td>* The hospital did not furlough any staff and all staff received 100% of their normal compensation during the initial 8 wk of COVID-19 screening.</td>
<td></td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td><strong>$471,421</strong></td>
</tr>
</tbody>
</table>

**FIGURE 5**
Screening Stations Costs. Pt Svcs, patient services.

**FIGURE 6**
Example of screening volumes by hour of the day. A, Employees flagged for symptoms at base screening stations. B, Visitors flagged for symptom at base screening stations.

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A PDSA cycle was taking place nearly every day in every location, and adaptations were made on the basis of learnings from each area. These PDSA cycles are summarized in Table 2. As new challenges emerged and barriers were identified during scale-up, the interventions continued to be the key to implementing the best solution (see Fig 8). When masking was added on the basis of new Centers for Disease Control and Prevention guidance, new supplies had to be added to the screening stations, increasing the complexity and time to complete the process. A large focus of PDSA testing was during shift change, to optimize the flow of people and supplies while maintaining social distancing. A high volume, space-constrained entrance from an employee garage was used to test and improve layouts and roles to manage the shift change volume. On the basis of those learnings, we rapidly spread to other locations, maintaining a standard overall screening process, while adapting the layout of each station to optimize the physical space and daily flow of people. TWI documents were created to capture the best practices, key points, and illustrations of each step of the process and be a reference to new employees staffing these positions (see Fig 3).

The emergence of the COVID-19 pandemic has made many people wary of leaving their self-quarantine at home for any reason. Patient and family experience data gathered during the time frame of the study support this concern. During May 2020, when families were surveyed and asked the question “Did you feel safe in the environment provided by the hospital/facility?” 74% responded “Yes, definitely” (Fig 9). One parent commented “I felt as though Children’s has taken every precaution possible to keep everyone safe and healthy.” The establishment of the screening process helped drive the overall feeling of safety and confidence in our patients and families.

Given the new process, there were a number of less common concerns and process exceptions that had to be identified and addressed. As they were identified, they were raised with the steering team and, as needed, with the larger hospital COVID-19 steering team, to ensure alignment on the

![Graph A](image_url)

**FIGURE 7**
TABLE 2 Evolution of Screening Station Area and Workspace to Include Station Design and Flow, Screening Process, and Signage

<table>
<thead>
<tr>
<th>PDSA Ramps</th>
<th>PDSA Cycles</th>
</tr>
</thead>
</table>
| **Screening station layout** | 1. The initial setup involved 3 tables and directional markers (blue tape used on the floor) implemented at a single screening station for a period of 8 h to observe flow, while maintaining social distance.  
2. Added stanchions to create roped off lane separation as individuals waited to be screened after reaching the tables.  
3. Scaled to a second station and observed from 6:00 AM to 8:00 PM.  
4. Scaled to 3 additional screening stations within the same week.  
5. Introduce the role of a greeter assigned at each screening station to direct traffic to the appropriate lane.  
6. In areas heavily trafficked by employees, continuous minor adjustments were made to the layout of the tables and stanchions to reduce backups and maintain social distance.  
7. A standard layout diagram was then established for each screening station, with minor variations necessary to accommodate building design and space limitations.  
8. Supply tables were organized and labeled, with tape designating the intended location of necessary supplies to ensure these were set up consistently each day and in adequate supply. This setup allowed everyone to know the quantity of items that should be placed in each section and could easily identify when an item needed to be replenished. |
| **Screening station flow of process steps** | 1. Before universal masking, individuals being screened entered a designated screening lane, had their temperature taken, and were asked questions related to symptoms of the virus. Individuals who passed the screening process received a sticker indicating the day of the week screened. The screeners followed an algorithm for individuals who did not pass the screening process.  
2. After the implementation of universal masking, those who passed the screen had to, additionally, sanitize their hands with a pump-bottle sanitizer and then pick up a mask and disposable bag, in addition to a screening sticker.  
3. After a family concern that the sanitizer was too close to the masks, a PDSA cycle was completed with an additional table added to each screening lane to space out the sanitizing and masking steps from the screener taking temperature.  
4. After multiple PDSA test cycles, in the final process, individuals entered a designated screening lane, sanitized their hands with a pump-bottle sanitizer, picked up a mask and placed it over their nose and mouth, had their temperature taken, while being asked symptom questions, and, lastly, picked up a screening sticker and bag for their mask. |
| **Social distancing** | 1. Initially, screeners stood behind a podium taking an individual’s temperature.  
2. Podiums were switched out for long rectangular tables to make it easier to take temperatures via forehead scanning, with screeners standing on one side of the table and those being screened on the other.  
3. Blue tape was added to mark the floor, indicating where the screener should stand while going through all the screening steps.  
4. Verbal cues from greeters to incoming pedestrian traffic reinforced social distancing, along with directional markers on the floor. |
| **Visual identification of screening process completion** | 1. Initially, a large rectangular sticker was handed by the screener to each person after they “passed” screening. The sticker displayed the date as an abbreviation (mm/dd/yyyy) and was worn on the outermost layer of clothing.  
2. With multiple off-site locations implementing the screening process, stickers were changed from a large rectangular sticker to a small dot sticker, with a different color for each day. During this PDSA cycle, employees were asked to place the dot sticker on employee badges, and patients and families were given the color dot sticker on a larger blank white sticker to be worn on clothing.  
3. A distinct sticker marked “Patient Family” was created for any parent or guardian who presented with a fever or responded yes to symptomatic questions to alert clinical staff that they had not passed the screening. |
| **Role of the greeter** | 1. Initially greeters were 91 trained employees able to observe the process and conduct small-scale PDAs at their screening station to optimize flow. Responsibilities included welcoming the individual to be screened, directing them to the appropriate screening lane, and providing social distancing reminders.  
2. During the first 2 wk of the screening process, 5 greeters staffed two 7-h volunteer shifts from 6:00 AM to 1:00 PM and, then, from 1:00 PM to 8:00 PM across 5 screening stations.  
3. On the basis of hand-collected volumes at each screening station, a PDSA was conducted with volunteer shift durations reduced to 3 h during the peak volume (from 8:00 AM to 9:00 AM) each day of the week. One greeter was additionally assigned to the employee parking garage area for 2 h in the evening (from 8:00 to 10:00 PM) each day of the week during peak hospital shift change time.  
4. As the process evolved, the greeter continued to facilitate the elements of the process with verbal instructions. |
| **Signage** | 1. Initial signage was created as needed and limited to printed, laminated items (such as line numbers and screening questions) requests to stop and sanitize, and directional arrows made of blue tape, etc.  
2. The second phase of signage included large poster board signs that listed screening questions and, eventually, masking protocol information. The key messaging of the signage was rewritten as the number of staff, patients, families, and vendors entering the hospital facilities continued to increase. Input from design, construction and space management, child life, plant services and safety was included.  
3. The final PDSA cycle for signage involved professionally designed, consistent, and engaging graphics. |
response and practice changes. These decisions are summarized in Table 3.

From the outset of this project, our team was involved in the screening activities and provided continuous review of screening operations and data to identify workflow improvements. The hospital was able to, initially, use available clinical and nonclinical staff who were not assigned to normal duties because of decreased census and outpatient volumes. Consequently, there was no incremental cost to the hospital for those staff who were functioning as screeners because they were already being paid (Fig 5). Site specific coordinators were identified to facilitate screening operations and communications at each individual site location. Because of the magnitude of this expansion and to ensure the sustainability of the screening operations, standard processes became part of the routine practice.

**FIGURE 8**
Intervention strategy versus specific implementation challenges.

**DISCUSSION**

We used improvement methodologies to rapidly develop, improve, and, then, scale-up a universal screening and masking process during the COVID-19 pandemic that was well received and minimized bottlenecks, which was key to optimizing safety.

Positive symptom screen results declined among employees after the first week of screening, suggesting that employees with symptoms were now electing to stay home, as had been previously recommended. Although the screening process fulfilled the state guidance and, once optimized, did not create substantial wait for screening even during change of shift, we lack causal data as to whether the screening and masking process actually reduced viral transmission in the hospital. In addition, numerous other interventions, such as social distancing and telecommuting, were also in place during this time. However, a limited random sample testing program using COVID-19 polymerase chain reaction technology of over 5000 employees who had just passed the screening process (ie, were without symptoms) found no cases of asymptomatic infection. Although the evidence for the effectiveness of masking has grown since this project was undertaken, there remains little evidence for the effectiveness of

**FIGURE 9**
Patient family experience data: May 2020.

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The image contains a table titled "Resolving Key Challenges With Interventions in PDSAs" and a diagram titled "Intervention strategy versus specific implementation challenges." The table summarizes the interventions and specific implementation challenges, while the diagram illustrates the relationship between interventions and challenges.
The steering team began with daily huddles during the testing and roll out of this model across the institution much simpler. Regarding possible spread to other institutions, we identified key success factors, which are likely relevant to others undertaking similar programs. These included the steering team with broad knowledge and ability to make decisions. This is especially important, given the evolving evidence regarding both COVID-19 spread and the efficacy of methods to reduce spread during this pandemic. The steering team began with daily huddles during the testing and roll out the first 2 weeks. The team then moved to a huddle rhythm of 2 times per week. This team included key stakeholders that could make decisions in real time and remove barriers hindering the process. Second, we undertook intensive testing and process development at the main campus; the lessons learned were then quickly spread to other campus locations, including a smaller inpatient site as well as the psychiatry campus, community outpatient practices, and nonclinical (research and business) sites. Each site adapted the details of the process to meet local needs (such as physical space), while maintaining the core components of the process. A third key factor was the use of simple, visually explicit training materials. These made it feasible for large groups of rotating employees to staff the process with minimal training.

There were a number of limitations to this project. Although we report the success of the process of screening and masking, we cannot know whether the process actually reduced viral transmission. We received a number of unsolicited positive comments from employees and families regarding the screening process, and multiple families responded on the standard post visit experience survey that the screening process made them feel safe. However, we were not able to systematically survey either group to determine their experience with the process. Similarly, we lacked resources to do formal time studies regarding the length of the screening process. Rather, we relied on observations from QI team members and feedback from screeners and greeters. Thus, we may have missed times and situations in which there were bottlenecks in the process. At this early stage, there are a number of unanswered questions regarding the future of the process. As in all QI work, sustainability is a critical question. Staffing the stations will become more challenging as employees whose usual work had been suspended, making them available to staff the screening stations, return to their usual roles. It may not be financially sustainable if the pandemic requires the process to continue over an extended time period. For employees, it may be possible in the future to use self-screening and reduce the overall cost of the screening process.

These factors will require our screening model to continue to evolve. We believe our empowered steering team combined with standardized but flexible processes and willingness to resume iterative testing will be important facilitators of successful adaptation in the future. The clear mandate to keep our patients and families and our employees safe during this pandemic help ensure that we will not lose that critical priority and focus and sustain the gains achieved.

ACKNOWLEDGMENTS

We gratefully acknowledge the skilled work of all the other members of the COVID-19 screening steering team, Dawn Nebrig, Mark Potticary, Jim Whitaker, the staff of the James M. Anderson Center for Health Systems Excellence who supported the project (Cheri Cole-Jenkins, Michelle Coleman, Christina Ewers, Setenay Kara, Brandy Seger Jennifer Sexton, Rhonda Wagenlander), and Karen Fahlgren and Kim Smith for assistance with article preparation.

**TABLE 3** Emerging Questions and Policy Decisions

<table>
<thead>
<tr>
<th>Emerging Challenge</th>
<th>Practice Modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female visitors wearing burkas</td>
<td>Screen on destination unit</td>
</tr>
<tr>
<td>Visitors wearing cloth masks</td>
<td>Will be encouraged at the screening stations to wear a CCHMC face mask but will not be required to do so if they prefer a cloth mask</td>
</tr>
<tr>
<td>Children &lt;2 y of age refusing to wear mask</td>
<td>Will not be required to wear mask</td>
</tr>
<tr>
<td>No. visitors accompanying or visiting patient</td>
<td>Limited to 2</td>
</tr>
<tr>
<td>Visitors staying over night</td>
<td>Will be required to be rescreened after 5:00 AM</td>
</tr>
<tr>
<td>Employees with allergic reaction to masks</td>
<td>Another option available from supply chain</td>
</tr>
<tr>
<td>Non–English-speaking visitors</td>
<td>Signs translated into Spanish and Arabic and screeners call virtual translation services</td>
</tr>
</tbody>
</table>

**ABBREVIATIONS**

CCHMC: Cincinnati Children’s Hospital Medical Center
COVID-19: coronavirus disease 2019
PDSA: plan-do-study-act
QI: quality improvement
TWI: Training Within Industry
REFERENCES


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