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IMPLEMENTATION OF DRIVE-THROUGH TESTING FOR COVID-19 USING AN EXTERNAL EMERGENCY DEPARTMENT TRIAGE

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Abstract—Background: During the coronavirus disease 2019 (COVID-19) pandemic, healthcare systems in many regions of the country were being overwhelmed by large numbers of patients needing care. In this paper, we discuss use of an external emergency department (ED) site by a hospital system based in Charlotte, North Carolina to address concerns of a local surge similar to those seen around the country. Objective: Demonstrate how expansion of ED facilities can increase efficiency of care for patients while also improving safety for clinicians, staff, and non-infected patients. Methods: We describe development and implementation of our external ED drive-through testing sites during the COVID-19 pandemic. We collected data from three external ED sites in the Atrium Health system between March 15th and April 15th, 2020. Patients were included if they were seen at one of the sites and tested for COVID-19. There were no exclusion criteria. We analyzed the data to identify any differences in patient demographics between sites. Results: We saw 580 patients across the three sites, 302 of whom met criteria for COVID-19 testing. The majority of patients tested were Caucasian females. The majority who tested positive, however, were males. Thirteen patients were redirected into the hospital ED for further medical evaluation. Conclusions: External expansion of the ED is an important strategy that can allow hospitals to accommodate potentially infectious patients while maintaining appropriate isolation and rapid throughput. Proper implementation of the right system to meet hospital-specific needs can prove effective for the healthcare system. © 2020 Elsevier Inc. All rights reserved.

Keywords—COVID-19; drive-through testing; external emergency department; infectious diseases; triage

INTRODUCTION

Since the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19) arrived in January 2020 in the United States, it has rapidly spread, causing problems in all aspects of the country and its population. COVID-19 is a novel, highly infectious pathogen with a reproduction number (R0) of 2–3, about twice that of seasonal influenza (1). The COVID-19 disease is primarily transmitted via respiratory droplets and typically presents with a constellation of symptoms, including fever, cough, shortness of breath, chills, and the loss of sense of smell or taste (2). The reported aggregate mortality of COVID-19 infections is 1.3% (3). Patients suffering with COVID-19 and comorbid illness are more likely to need intensive care unit care than those with no comorbidities, and the more comorbidities they have, the greater likelihood of a poor clinical outcome (4). As clinical experience matured, many organizations recommended that people without requirements for acute care hospitalization related to COVID-19 remain home and isolate from family and friends to decrease the risk of disease spread (5).
As the COVID-19 pandemic progressed, many communities in the United States have seen substantial increases in the numbers of patients with confirmed or suspected COVID-19 disease (6). As hospitals filled, the U.S. Centers for Disease Control and Prevention (CDC) recommended screening, evaluating, and testing patients before they physically enter the emergency department (ED) or hospital to reduce virus transmission within health care facilities (7). Globally, several strategies emerged to safely manage patient surge without requiring patients to enter the hospital. In London, systems are experimenting with in-home testing followed by a telemedicine screening by a provider (8). In Italy, Paganini et al. demonstrated several approaches used to respond to increased patient load by expanding the ED footprint within and external to the physical structure (9). Internally, waiting rooms, hallways, and other traditionally nonclinical areas can be adapted for patient care. Paganini et al. also demonstrated the use of tents and other temporary structures built outside the ED to serve as valuable additions to the expansion effort (9).

The purpose of this paper is to present an assessment of our external ED drive-through (EXT ED) testing sites during the COVID-19 pandemic. In 2010, Weiss et al. modeled a drive-through testing system to evaluate for efficacy in the case of a pandemic (in that case, influenza-H1N1), determining that emergency physicians could rapidly evaluate and determine appropriate management of patients with influenza-like illness (ILI) in a drive-through setting (10). Drive-through testing at a hospital ED allows for physical distancing, isolation from the fixed facility ED, increased capacity of the hospital to evaluate patients during mass casualty or patient surge situations, and effective cohorting of patients. We discuss how our team was able to implement an EXT ED drive-through triage and testing system during the COVID-19 pandemic. We describe the types of patients, symptoms, and operational dynamics of our particular program’s system.

**METHODS**

**Development**

Atrium Health is an integrated health care delivery system in the southeastern United States with approximately 2.3 million patient visits per year. In early March, the Atrium Health Incident Command tasked hospital EDs with establishing a mechanism to expand their ED footprints to 1) safely isolate COVID-19 assessments from the brick and mortar hospital structure, and 2) conduct rapid screening, evaluation, testing, and disposition of patients. Institutional review board approval was acquired for this project before obtaining any information from patients of organizations. Our system had to be capable of dealing with all severity of patients, and quickly and efficiently dispositioning stable patients who only required screening, testing, and discharge. The primary EXT ED site (“main EXT ED”) is at a quaternary care center and level 1 trauma center with an average total ED volume of 115,000 annual visits (85,000 adult and 30,000 pediatric patients) (11). Two additional EXT ED sites (“community 1 EXT ED” and “community 2 EXT ED”) were established, both of which are affiliated with community hospital EDs in urban settings. Annual patient volumes at these 2 EDs are approximately 60,000 patients per year.

Initial planning assumptions were: 1) a majority of COVID-19–related visits would be low acuity and best managed at home; 2) large volumes of COVID-19 patients would overwhelm the existing ED infrastructure (e.g., waiting rooms) and create an elevated nosocomial transmission risk; 3) the system would adhere to existing ED regulations and laws (e.g., Emergency Medical Treatment and Active Labor Act [EMTALA]); and 4) we could safely screen and disposition patients outside the walls of the traditional ED. Before the pandemic there was no formal guidance from the health care system in terms of how to expand on-site ED functionality.

**Implementation**

**Patient selection.** Patients who presented via private vehicle were initially stopped at an external screening tent staffed by a paramedic who determined eligibility to be seen at the EXT ED. Inclusion criteria for EXT ED included chief complaint consistent with ILI or concern for COVID-19 plus clinical judgment that the patient was stable. There were no age-specific restrictions for entry. No vital signs were taken at point of entry into the EXT ED process. Patients who did not meet inclusion criteria or did not present by vehicle were directed to the main ED. Eligible patients were instructed to drive ahead a short distance to the drive-through tent.

Patients at the main EXT ED received an in-person or virtual physician evaluation. Community 1 EXT ED used either advanced practice providers (APPs) or physicians to assess patients, while community 2 EXT ED used only APPs. Patients who met the most current testing criteria were then offered nasopharyngeal (NP) swab testing. Patients who needed additional evaluation in the ED (at the discretion of the evaluating physician) were referred into the physical ED. Patients who did not meet current testing criteria and had no emergency medical condition identified were discharged with home isolation guidelines.

**Location.** The ED EXT sites took advantage of the hospitals’ well-known locations to the public to provide
focused evaluation for patients with suspected COVID-19 disease. Appendix A includes details regarding the ED EXT infrastructure. The main EXT ED was constructed near the ED footprint beyond the ambulance bay on the hospital’s main campus. The main EXT ED primarily operated from 11 AM to 7 PM on weekdays, with a start date of March 15, 2020. The community EXT ED 1 operated from 1 PM to 5 PM. Previous work showed that higher volumes of patients presented to external drive-through and triage systems between noon and midnight (10). Community EXT ED 2 had intermittent hours of operation because they only activated it when a certain ED bed capacity was exceeded.

As shown in Appendix B, community 1 EXT ED was established in the parking lot between the community hospital and its medical office building. Patients were directed toward the tent by security, where they received an EMTALA-mandated medical screening examination by either a physician or an APP on-site. Patients remained in their vehicle and were evaluated by the provider according to the triage criteria shown in Appendix B.

Community 2 EXT ED was established in front of their hospital and activated when the ED met a predetermined room occupation threshold. As shown in Appendix C, patients were processed through a prescreening clinician and security, registration, clinical triage and medical screening station, and finally the swab and discharge instruction station.

**Staffing.** We were able to use staff from other parts of the main (internal) ED because of low patient census. During pilot trials of main EXT ED, staffing and physical build-out of the drive was adapted to daily demands. The drive-through triage team would consult and get final approval from the EXT Triage and Surge Team Lead each day regarding changes or requests. Initial staffing was provided by on-site nursing and physician personnel, who normally worked in the internal ED. Later, this was transitioned to a combination of on-site nursing personnel, virtual ED providers, and volunteer resources. ED providers were redeployed from a previous provider-in-triage position to a virtual EXT ED position. The initial triage tent typically only required a minimum of 1–2 nurses or ED paramedics to direct patients who presented to the hospital. The main EXT ED evolved to be operated by 3 nurses, 1 virtual provider, and 1 registration employee. Community 2 EXT ED, of note, did the opposite by only activating the drive-through and pulling staff from the ED when census was elevated.

The providers (physicians and APPs) were tasked with evaluation and triage of the presenting patients. Nurses and medics performed several key tasks, including recording vital signs, triaging patients at the front tent for meeting EXT ED criteria, swabbing patients for COVID-19, and escorting patients to the internal ED when necessary. The registration staff eventually were able to indirectly register patients through the phone rather than in person.

**Evaluation, testing, and documentation.** All patients who presented to an EXT ED received an EMTALA-mandated medical screening examination (Appendix A). Nurses wore appropriate personal protective equipment per system recommendations to assess vital signs and the usual triage information. A physician then interviewed and examined the patient. During the initial stages, this physician evaluation was in-person at our main campus. This was transitioned to a virtual physician encounter shortly after program launch. To help minimize exposure and improve efficiency, patients remained in their car for the entire encounter. The virtual provider determined the need for COVID-19 testing based on virtual evaluation and current infectious disease recommendations. Patients with abnormal vital signs or significant comorbidities or other provider concerns were referred to the internal ED for additional evaluation. Otherwise, patients were offered COVID-19 NP swab testing when appropriate and discharged in their vehicles from the EXT ED. The nurse/medic who was assigned to test that day would then perform the NP swab and take the test swabs to the hospital laboratory for processing within 30 min of the test being performed. All patients with ILI were given return precautions on discharge and instructions on how to obtain their test results (Appendix B). Patients were able to follow-up on their swab result online but also received the result via phone call by Atrium Health staff.

**Scalability.** The EXT ED initially began primarily as a drive-through triage system for screening ILI patients and determining who needs testing. It was then expanded to increase surge capabilities with the addition of an external ED triage wing that has 13 triage beds capable of seeing noncritical patients. This expansion system was also able to be successfully replicated and adapted at multiple hospital sites.

**Analytic Methods**

Data from the 3 EXT ED sites were evaluated retrospectively between March 15, 2020 and April 15, 2020. Patient characteristics noted in supplemental data were collected from our electronic medical record system and each one subdivided into their proper category by our research team. We used SAP Business Objectives (SAP America, Newtown Square, PA) as our analytics program. Patients were included for this report if they were seen at one of these sites and underwent testing.
for COVID-19. There were no exclusion criteria. Data were tabulated and analyzed to evaluate for differences between patient demographics presenting to each testing facility. They are reported here without additional statistical analysis.

**RESULTS**

Between March 15, 2020 and April 16, 2020, our EXT EDs saw 580 patients, 302 of whom met criteria for testing (Table 1). The other 278 patients did not meet criteria for testing and were discharged without testing but were still given return precautions. The mean age of patients tested was 43.5 years with a standard deviation of 15.9. Ages seen ranged from 6 months to 91 years. Most patients who were considered persons under investigation and tested for COVID-19 were female (n = 155; 51.3%). Whites made up the largest percentage of individuals tested, followed by African Americans (55.3% and 26.5%, respectively). The majority identified their ethnicity as non-Hispanic (77.5%).

A total of 25 (8.3%) patients tested were COVID-19–positive by NP swab polymerase chain reaction (PCR) test (Table 2), which were sent to the core laboratory to be run on the Roche 8800 and Luminex platforms. The average age of patients who tested positive was 47.9 (± 17.4), with the majority being male (64%). Thirteen patients seen also required transport into the internal ED for further medical evaluation.

**DISCUSSION**

Our EXT ED sites are part of an overall health system strategy to expand evaluation and testing of patients with suspected COVID-19 while protecting staff and other patients from possible exposure. We were able to evaluate, test, and discharge 302 patients home without having to enter the internal ED. The percentage of COVID-19–positive patients in our population tested was lower than the CDC’s recent report of 18.4% (12). We are not aware of any incidental infectious exposures to clinical or nonclinical staff operating these sites. Other components of the system’s strategy include an ED triage tent, which was built on-site, and an expansion tent, which will expand the ED capacity to house approximately 30 patients with COVID-19 who need ongoing inpatient care. Additional steps taken by the health care system aimed at slowing the spread of COVID-19 in our community include remote, off-campus testing sites staffed by community paramedics.

Many hospitals upscaled their capacity to be able to handle a potential surge of infectious patients, similar to those seen in Italy (9). Our hospital system did see a decrease in the number of overall patients presenting to the ED. While the cause for this decline remains to be determined, there is thought it could be the result of several factors, including social distancing and other mitigation methods slowing the spread, less patients seeking care out of fear of infection at hospitals, other unknown causes, or a combination of all. Further studies will be needed to determine the cause for this decrease, as well as if external triage systems (like ours) are contributing to the decrease in patients presenting to hospital EDs.

**Limitations and Recommendations**

Throughout this pandemic, there have been recurrent reports of insufficient stores of personal protective equipment and testing kits. Our system was able to avoid any severe shortages both because of supply shortage mitigation strategies and because COVID-19 infection levels did not significantly surge in our metropolitan area. We

Table 1. Baseline Characteristics of Persons Under Investigation at Presentation External Emergency Department

| Patient Characteristics | EXT ED, N = 580 (PUI, n = 302) |
|-------------------------|---------------------------------|
| Mean age, years (SD)    | 43.5 (15.9)                     |
| Age range               | 6 months to 91 years            |
| Male, n (%)             | 147 (48.7)                      |
| Race, n (%)             |                                 |
| White                   | 167 (55.3)                      |
| African American        | 80 (26.5)                       |
| Asian                   | 6 (2.2)                         |
| Native American         | 3 (1.1)                         |
| Pacific Islander        | 0 (0)                           |
| Non-Hispanic ethnicity, n (%) | 234 (77.5)                   |

EXT ED = external emergency department; PUI = persons under investigation; SD = standard deviation.

Table 2. Baseline Characteristics of COVID-19–Positive Patients at Presentation External Emergency Department

| COVID-19–Positive Patient Characteristics | EXT ED, n = 25 |
|------------------------------------------|---------------|
| Mean age, years (SD)                     | 47.9 (17.4)   |
| Age range, years                         | 15–84         |
| Male, n (%)                              | 16 (64.0)     |
| Race, n (%)                              |               |
| White                                    | 7 (28.0)      |
| African American                         | 11 (44.0)     |
| Asian                                    | 0 (0)         |
| Native American                          | 0 (0)         |
| Pacific Islander                         | 0 (0)         |
| Declined to report                       | 7 (28.0)      |
| Non-Hispanic ethnicity, n (%)            | 18 (72.0)     |

COVID-19 = coronavirus disease 2019; EXT ED = external emergency department; PUI = persons under investigation; SD = standard deviation.
had approximately 2600 total confirmed cases in Mecklenburg County from March to April compared with approximately 192,600 cases in New York City and the 5 counties it encompasses (New York County, Kings County, Bronx County, Richmond County, and Queens County) (12). This allowed our team to avoid the limitation of not being able to test certain people because of shortages of supplies. Other health care systems that were not as well supplied or that saw much larger numbers of patients would potentially have difficulty being able to assess high volumes of patients. These points emphasize the importance of proper supply and staffing when planning to implement an EXT ED system.

The relatively low volume of patients we saw during this period compared with harder hit regions of the country represents another limitation. We saw 580 patients over 33 days, which is an average of 6 patients per site per day. While some sites were open intermittently, our operation did not get tested against a large volume of patients overall. This does not mean our operational design does not work; however, further investigation is warranted if the opportunity to trial during a higher patient surge presents. This may occur during the winter months of 2020 when we anticipate flu season and COVID-19 together will increase cases of ILI and its complications, leading to potentially increased patient numbers.

Staffing an EXT ED can drain essential staff from other sections of the ED and increase costs to the hospital. Operational costs must be balanced against the needs to continue these and related processes based on patient volume. We were able to staff the EXT ED in the beginning primarily with medics and nurses from the pediatric ED on campus because of significantly lower volumes. This prevented nurses from being called in with the increased cost of incentive pay for overtime work. The pediatric staff were able to integrate easily into the system despite most patients being adults. If the volumes continue to remain low, pulling staff from that section will continue to be a viable option. Our system was also able to successfully staff our main EXT ED site with volunteer medical personnel from the disaster response volunteer organization “Team Rubicon.” They were able to fill in almost all positions that did not require direct electronic medical record access without increasing costs to the health care system. These are the ways we were able to solve the issue of staffing an expansion of the ED without increasing costs.

During the entire process, we sought feedback from all team members to take advantage of every opportunity for improvement. The primary concerns voiced by staff centered around personal protective equipment and protocols. Many staff were initially concerned that we did not have enough N95 masks for everyone. The physician and nurse who swabbed and interacted directly with patients in their vehicles were given priority for the N95 masks. As more supplies became available, everyone staffing the operation was allotted an N95. There was also concern about operating during inclement weather. Staff were provided water, food, and air-conditioned facilities in the adjacent building for rest at all times. If the temperature became too cold, heating lamps were also placed outside to be used. During mild rainstorms, operations were still able to proceed under the tent; however, if the rain became heavy or had associated thunder/lightning, then the drive-through operation was stopped until weather improved or the shift ended.

We identified ambulance and potential high-volume traffic flow routes at the EXT ED as choke points that could have caused issues if there had been a large volume of drive-up patients at one time. While this issue will be unique to each hospital’s design, we were able to coordinate with security to correct this problem by moving emergency medical service stand-by zones away from the EXT ED entrance. By creating a drive-through tent on the hospital grounds, system designers must account for increased traffic this will bring and congestion it may cause.

**CONCLUSION**

External expansion of the ED is an important strategy that can allow hospitals to accommodate potentially infectious patients while maintaining appropriate isolation and rapid throughput. Proper implementation of the right system to meet the specific needs of the hospital can prove effective for all aspects of the health care system. Our system showed how expanding the ED’s facilities can create more efficient care for patients while also improving safety for the rest of the hospital staff and other patients who do not have COVID-19.

**SUPPLEMENTARY DATA**

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jemermed.2020.09.037.

**REFERENCES**

1. Rettner R. How does the new coronavirus compare with the flu?. Available at: https://www.livescience.com/new-coronavirus-compare-with-flu.html. Accessed May 14, 2020.
2. U.S. Centers for Disease Control and Prevention website. Clinical questions about COVID-19: questions and answers. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/faq.html. Accessed May 20, 2020.
3. Ellison J. COVID-19: UW study reports “staggering” death toll in US among those infected who show symptoms. Available at: https://www.washington.edu/news/2020/05/18/covid-19-uw-study-reports-staggering-death-rate-in-us-among-those-infected-who-show-symptoms/. Accessed May 27, 2020.
4. Guan W-J, Liang W-H, Zhao Y, et al. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. Eur Respir J 2020;55:2000547.

5. U.S. Centers for Disease Control and Prevention website. Daily life and coping. Available at: https://www.cdc.gov/coronavirus/2019-ncov/daily-life-coping/index.html. Accessed May 20, 2020.

6. CDC COVID-19 Response Team. Geographic differences in COVID-19 cases, deaths, and incidence - United States, February 12-April 7, 2020. MMWR Morb Mortal Wkly Rep 2020;69:465–71.

7. U.S. Centers for Disease Control and Prevention website. Interim infection prevention and control recommendations for patients with suspected or confirmed coronavirus disease 2019 (COVID-19) in healthcare settings. Available at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Finfection-control%2Fcontrol-recommendations.html. Accessed May 20, 2020.

8. Mahase E. Coronavirus: home testing pilot launched in London to cut hospital visits and ambulance use. BMJ 2020;368:m621.

9. Paganini M, Conti A, Weinstein E, Della Corte F, Ragazzoni L. Translating COVID-19 pandemic surge theory to practice in the emergency department: how to expand structure. Disaster Med Public Health Prep 2020. [Epub ahead of print].

10. Weiss EA, Ngo J, Gilbert GH, Quinn JV. Drive-through medicine: a novel proposal for rapid evaluation of patients during an influenza pandemic. Ann Emerg Med 2010;55:268–73.

11. Atrium Health website. Emergency medicine residency program > Medical & clinical education. Available at: https://atriumhealth.org/education/graduate-medical-education/physician-residencies/emergency-medicine. Accessed May 20, 2020.

12. U.S. Centers for Disease Control and Prevention website. COVID-View: a weekly surveillance summary of U.S. COVID-19 activity. Available at: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/index.html. Accessed May 20, 2020.
ARTICLE SUMMARY

1. Why is this topic important?
   The safe management of patient surge during a highly infectious disease pandemic is critical for current and future emergency department (ED) operations. Novel practices, such as external ED triage systems, can offer safe solutions that limit disease transmission and preserve acute care bed space if they are aligned with existing clinical operations, health care regulations, and infection prevention best practices.

2. What does this study attempt to show?
   This study shows how a drive-through triage system similar to ones used during past infectious outbreaks can be effectively applied during the COVID-19 pandemic in a safe and rapid manner, while also being integrated into a broader system-wide medical response plan.

3. What are the key findings?
   Our team demonstrated that we were able to safely and efficiently triage and evaluate potential patients with COVID-19 outside of the physical ED. We were also able to protect staff and other patients who were not presenting for concern of COVID-19 infection from being exposed to the patients seen in our external ED drive-through triage system.

4. How is patient care impacted?
   The drive-through triage teams were able to provide efficient and safe care for patients by expediting their care and reducing exposure to other patients presenting to the ED. It also reduced numbers of patients presenting to the main ED for COVID-19 concern and prevented the potential for worsening ED crowding and congestion. Finally, patients who did not meet criteria for our COVID-19 drive-through triage system were able to avoid exposure to COVID-19 patients who would have otherwise needed to come in to be seen in the physical ED with them.