Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Redesigning emergency department operations amidst a viral pandemic

Tess Whiteside, BS, Erin Kane, MD, Bandar Aljohani, MD, Marya Alsamman, BA, Ali Pourmand, MD, MPH

Abstract

As shown by the current COVID-19 pandemic, emergency departments (ED) are the front line for hospital-and-community-based care during viral respiratory disease outbreaks. As such, EDs must be able to reorganize and reformate operations to meet the changing needs and staggering patient volume. This paper addresses ways to adapt departmental operations to better manage in times of elevated disease burden, specifically identifying areas of intervention to help limit crowding and spread. Using experience from past outbreaks and the current COVID-19 pandemic, we advise strategies to increase surge capacity and limit patient inflow. Triage should identify and geographically cohort symptomatic patients within a designated unit to limit exposure early in an outbreak. Screening and PPE guidelines for both patient and staff should be followed closely, as determined by hospital administration and the CDC. Equipment needs are also greatly affected in an outbreak; we emphasize portable radiographic equipment to limit transport, and an upstocking of certain medications, respiratory supplies, and PPE.

1. Introduction

The current pandemic caused by the rapid spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) demands urgent guidance for clinicians faced with the novel illness. Emergency departments (ED) are the front lines for hospital-and-community-based care, serving as the main points for triaging patients as infected versus non-infected and sick versus not-sick. EDs across the nation are overwhelmed with patient numbers at baseline. A review by the National Emergency Department Survey showed annual ED visits increased from 89.6 million to 139 million from 2006 to 2017 (an increase of 55.13%) [1] [2]. This issue of overcrowding has the potential to increase exponentially during times of viral outbreak. For example, during the H1N1/2009 pandemic, one study estimated that the rate of ED visits attributable to influenza increased to 1000 per 100,000, doubling the average annual rate of 500 per 100,000 population for seasonal influenza [3]. It is essential that strategic measures be taken to anticipate surges in ED patient visits, particularly during times of infectious disease outbreak.

EDs maintain order through structured workflow and careful departmental geographic planning. However, the typical organization must be largely disrupted when anticipating how to limit infectious spread and care for enormous patient volume. The main concern during such times is to maintain high quality and high efficiency care, with emphasis on patient and provider safety, when demand far exceeds capacity. Though many departments throughout the country have disaster preparedness protocols in place, individual outbreaks differ by severity of illness, route of transmission, and level of contagion, which dramatically alters the number of patients presenting to hospital facilities for screening and/or care. Thus a more general guideline, as presented here, will help address the overarching issues that will occur with any viral epidemic/pandemic. This paper will address some of the ways to adapt daily routines in the ED to better manage times of elevated airborne disease burden, specifically identifying areas of intervention to help limit crowding and spread during viral respiratory disease outbreaks.

2. Managing increased patient volume and adding capacity

Interventions that limit unnecessary patient visits during a respiratory disease outbreak are essential to mitigate infectious exposure and maintain expeditious ED workflow. A panel of expert emergency physicians placed highest priority on ED interventions that would alleviate high patient volume, with their greatest concern being ED crowding [4]. Specific interventions included triaging patients to the most appropriate care setting through a website or call center, then standardizing ED admission criteria for patients with respiratory symptoms. This
same panel felt disease severity was a lesser issue in the ED setting and more important for inpatient management [4].

Limiting patient inflow can be accomplished by triage points before and upon ED arrival. Before presenting to the hospital, patients can be directed to a telemedicine visit for triage. While some portion of these patients will ultimately require hospital-based care, many can be counseled and/or tested in the outpatient setting. Once at the hospital, diverting low-risk patients with respiratory symptoms to an alternate site of care, such as a medical tent, is a strategy to protect ED bed capacity. At George Washington University Hospital during the COVID-19 pandemic, a tent was set up outside the hospital and adjacent to the outpatient clinic building. Patients who arrived to the ED with concern for COVID-19 were directed to the tent and seen by an advanced practice provider (APP) if they met criteria for age, heart rate, and temperature. Patients who did not meet these criteria were deemed higher risk and triaged to a designated ED treatment space (Fig. 1).

Fig. 1. Clinical decision pathway.
ED directors should engage hospital leadership immediately to expand inpatient capacity, canceling elective surgeries and adding ICU and negative pressure rooms where feasible. With a reduced OR schedule, ED treatment spaces that typically would be occupied by ‘boarding’ patients can be recovered.

3. Identifying patients early

Triage is key to early recognition and rapid initiation of infection control precautions, which remain the most important strategies for controlling viral respiratory disease outbreaks [5]. However, as demonstrated with COVID-19, early identification can be difficult due to asymptomatic carriers and patients presenting with atypical symptoms, such as solely gastrointestinal complaints. Without immediate point-of-care tests, it is best to screen individuals through a balanced approach that incorporates clinical features and pertinent epidemiologic clues (including recent travel). This approach allows for the rapid identification of at-risk individuals while limiting the number of individuals who are tested or quarantined unnecessarily [5]. All patients who arrive in the ED with respiratory symptoms should be immediately masked with reinforcing signage posted in the waiting area.

4. Cohorting patients

With highly contagious viral disease that has both airborne and fomite transmission, a major problem is nosocomial transmission. Large healthcare systems may designate one hospital to serve as the primary hospital for infected patients. Within a single ED, there are no clear guidelines for the best organizational model, though it is clear that major adjustments must be made quickly when addressing highly contagious respiratory disease outbreaks. During the SARS outbreak, no decisions were made in the early stages about whether to cohort suspected and/or probable cases of SARS into a centralized section in EDs [6]. Thus, it is important to have collateral plans ready to put in place for when such viral outbreaks reoccur. One of the highest priority interventions should be to limit the number of staff and patients exposed by geographically cohorting patients with presumed or confirmed infection [4]. This operational approach must be implemented in the early stages of an outbreak as the efficacy declines significantly once an infection becomes widespread.

When cohorting patients it is most appropriate to designate a specific area of the department and establish a static geographic assignment model. In this model, providers and nurses are assigned specific rooms and automatically assigned patients who arrive in these rooms. When cohorting patients, the care team is assigned solely to the rooms in that cohort, thus limiting interaction with outside patients and staff. The providers and nurses may sit together at a workstation near the assigned rooms (Fig. 2) [7]. In terms of staffing these cohorts, it is most appropriate to use long shifts and overtime hours to limit the amount of staff turnover. Additionally, if possible, use staff who are immune (recovered) in these units and negative pressure rooms for these patients [8]. This operational plan must be flexible to change based on input from staff and the evolution of an individual outbreak situation. It is important to reinforce that cohorting is most effective in the early stages of an outbreak; there may come a point, depending on the level of contagion, where there are too many patients under investigation or confirmed positive to cohort them.

5. Infection control and environmental changes

Healthcare workers are particularly vulnerable to transmission of respiratory infections due to close proximity and department crowding, as highlighted during the 2003 SARS outbreak [9]. Currently, early data from Wuhan and Italy suggest a very high COVID-19 disease burden among healthcare providers [10]. Thus an important aspect of infection control is limiting patient-to-provider spread and provider-to-patient spread. A case-control study in five Hong Kong hospitals found that consistent practice of droplet and contact precaution significantly reduced the risk of infection in healthcare workers after exposures to patients with SARS [11]. Another study found that inadequate supply, and
inconsistent use, of personal protection equipment (PPE) when in contact with SARS patients were independent risk factors for SARS infection [12]. A case-control study of 254 hospital staff with documented exposure to SARS patients found that consistent droplet and contact precautions were adequate to significantly reduce the number of infections from patient exposures [11]. PPE can be a highly controversial subject with conflicting recommendations from different sources. Current COVID-19 guidelines from the Surviving Sepsis Campaign and the CDC recommend that any healthcare provider (HCP) performing an aerosol-generating procedure on a suspected or confirmed COVID-19 patient (including endotracheal intubation, open suctioning, NIPPV, and administration of nebulized treatment) wear fitted respirator masks, like N95 or FFP2, along with contact precaution and eye protection [10] [13]. In order to best preserve respirator masks for high-risk procedures, providers working with non-ventilated patients are recommended to wear surgical/medical masks. ED leadership should plan for, and obtain, an appropriate supply of PPE and establish allocation procedures. For instance, in case of shortage, each staff member may be given one N95 respirator per shift that is “checked out” rather than leaving boxes out in the open, with potential for anxious staff to use or take-home extra.

Additionally, although an initial face-to-face examination of the patient is typically required, subsequent interactions (updates, discharge instructions) may take place via phone or video-chat. Thus, EDs may wish to have smart phones or portable electronic devices (tablets or iPads) available for patients to communicate with staff who are outside the room.

New housekeeping protocols must be developed in conjunction with the Environmental Services director. Additional supplies will be needed. Additional staff may be added or diverted from other settings during times of peak room turnover. When the ED is seeing more than 100 persons under investigation (PIUs) per day, a 2-hour room clean time for contaminated rooms can devastate ED operations/flow and have real impact on patient care.

6. Staffing concerns and exposures

An essential aspect of infection control is testing and quarantining healthcare providers/staff as appropriate. Data from the COVID-19 pandemic in Italy suggests that EDs should be prepared to have at least 10% of staff become ill [8]. Thus, a conservative approach must be taken with strict guidelines for monitoring and testing HCPs.

Such exposures include prolonged close contact to COVID-19 patients without proper PPE or using a mask instead of a respirator during aerosol-generating procedures. Asymptomatic HCPs with low-risk exposures are able to work but should self-monitor with supervision from occupational health (or other hospital entity) for two weeks after last exposure. Low-risk exposures include most interactions with appropriate PPE. Self-monitoring includes making sure they are afebrile and asymptomatic before reporting to work [13]. This system collapses in communities with high rates of infection, where it is assumed that most HCPs have been exposed and must still work if asymptomatic and wearing appropriate PPE.

ED administration may consider implementing a system to evaluate staff for fevers and/or respiratory symptoms prior to starting work. Any HCP with fever or respiratory symptoms should immediately self-isolate. To mitigate impact on scheduling, EDs can have additional staff backup scheduled to cover in case a staff member calls out. Additionally, HCPs should be given priority for rapid-turnaround testing as this has enormous impact on available staff during a critical time.

7. Changes in medication stocking and supply

During a surge of a particular infectious disease, different formulations or quantities of medications may be required. Most importantly, metered-dose inhalers pose a smaller risk of infectious spread via respiratory droplet than nebulizers and are the preferred mode of delivery.
Table 1
Amendments to ED operations during viral respiratory outbreaks.

| Operation                        | Response considerations                                                                 |
|----------------------------------|------------------------------------------------------------------------------------------|
| Patient volume/ triage           | • Standardize ED admission criteria for patients with respiratory symptoms               |
|                                  | • Expand inpatient capacity: expedite discharges, cancel elective surgeries             |
|                                  | • Limit inflow by conducting initial patient evaluation via telemedicine                |
|                                  | • Triage low-risk patients with respiratory symptoms to an alternate site (medical tent) |
|                                  | • High risk patients to a designated ED treatment space                                  |
| Screening patients               | • Screen via clinical and epidemiologic clues                                            |
|                                  | • Current guidelines for COVID-19 testing include individuals with fever and/or symptoms of acute respiratory illness who: |
|                                  |   • are already hospitalized                                                             |
|                                  |   • are at high risk for poor outcomes                                                   |
|                                  |   • have been in close contact to a COVID-19 patient or travelled to high risk geographic area within 14 days of their symptom onset |
| Cohorting patients               | • Large healthcare systems can designate one hospital to be the primary hospital for infected patients |
|                                  | • Geographically cohort patients with presumed or confirmed infection                   |
|                                  | • Use long shifts and overtime hours to limit staff turnover in these units              |
| Infection control and            | • Any patient with respiratory symptoms must wear a mask at all times                    |
| environmental changes            | • Current COVID-19 guidelines recommend any HCP performing an aerosol-generating procedure on a COVID-19 patient wear a fitted respirator mask with contact precaution and eye protection |
|                                  | • Use negative-pressure rooms for such procedures                                       |
|                                  | • Establish new housekeeping protocols with Environmental Services (EVS)                |
|                                  |   • Add EVS staff during times of peak room turnover                                     |
| Screening/testing HCPs           | • Current CDC guidelines for COVID-19 testing among HCPs:                                |
|                                  |   • Asymptomatic HCPs with low-risk exposures are able to work but should self-monitor with supervision for two weeks after last exposure |
|                                  |   • HCPs with medium/high risk exposures should undergo active monitoring, including restriction from work until 2 weeks after last exposure. |
|                                  | • Implement a system to evaluate staff for fevers and/or respiratory symptoms prior to starting work |
|                                  | • Any HCP with fever or respiratory symptoms should immediately self-isolate.           |
| Staffing concerns                | • Have additional staff backup on the schedule to cover                                  |
|                                  | • HCPs should have priority for rapid-turnaround testing                                 |
| ED stocking and supply           | • Obtain an appropriate supply of PPE and establish allocation procedures                |
|                                  | • Increase inhaler and spacer stock                                                     |
|                                  |   • Instruct EMS/ED staff to preferentially use inhaler treatments                       |
|                                  | • Obtain additional stock of paralytics, induction agents, and medications for post-intubation sedation |
|                                  | • Confirm Pyxis availability                                                            |
| Radiography preparation          | • Use portable radiographic equipment whenever possible                                  |
|                                  | • Establish satellite radiography centers and dedicated radiographic equipment           |
|                                  | • If a suspected patient must be transported to the radiology department, that individual must wear appropriate PPE throughout transport/encounter |

Table 1 (continued)

| Operation                        | Response considerations                                                                 |
|----------------------------------|------------------------------------------------------------------------------------------|
| Respiratory support              | • COVID-19 patients are recommended for high-flow nasal cannula over NIPPV               |
|                                  | • Perform early endotracheal intubation when clinically indicated via video-guided laryngoscopy |
|                                  | • Mechanical ventilation should be managed similarly to other patients with acute respiratory failure |

intubation attempts [20]. COVID-19 patients who require mechanical ventilation should be managed similarly to other patients with acute respiratory failure, with special attention to settings that limit ventilator-induced lung injury as ARDS is a primary cause of death in many patients. A stock of disposable tape measurers for patient height and a wall reference with ideal body weights may help hard-wire appropriate initial settings.

The concerns about ventilator shortages must also be addressed. Many states having strategies in place to allocate ventilators during large disease outbreaks. For example, the New York Ventilator Allocation Guidelines uses the Sequential Organ Failure Assessment (SOFA) to evaluate mortality risk; this, along with exclusion criteria and timed trials, determine a patient’s priority level and length of access to ventilator therapy [21]. Hospitals anticipating a shortage may consider strategies to ventilate two patients using a single ventilator [22]. This concept remains highly complex and multifaceted with many ethical concerns (Table 1).

10. Limitations

Individual outbreak scenarios require unique responses. Strategies will vary largely based on hospital and department size, availability of staff, number of surrounding hospitals, community size, populations affected, and extent of disease spread. Additionally, the concerns addressed here are not exhaustive; they represent challenges to care in a viral respiratory disease outbreak and may not be applicable to other types of contagions. Finally, there is limited data with which to validate some of these interventions due to the recentness of the COVID-19 pandemic. There is a need for more formal evaluation of intervention quality and efficacy to further our understanding of the best response.

11. Conclusion

As the front-line for healthcare during a viral respiratory disease outbreak, EDs must be prepared to make expeditious operational adjustments to meet the expanding patient volume and limit infectious spread. The suggestions presented here limit unnecessary ED visits via establishment of a call-center, isolate patients through effective triage and geographic cohorting, mitigate viral spread with appropriate screening and PPE, and address equipment and medication stock concerns. While any viral outbreak requires an individualized response, sharing these suggestions for operational planning may assist in the development of emergency management protocol and better prepare departments during this pandemic and in the future.

Financial support

This is a non-funded study, with no compensation or honoraria for conducting the study.

CRediT authorship contribution statement

Tess Whiteside: Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. Erin Kane:
Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. Bandar Aljohani: Data curation, Formal analysis, Writing - original draft, Writing - review & editing. Marya Alsamman: Data curation, Formal analysis, Writing - review & editing. Ali Pourmand: Conceptualization, Data curation, Formal analysis, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors do not have a financial interest or relationship to disclose regarding this research project.

References

[1] Lin MP, Baker O, Richardson LD, Schuur JD. Trends in emergency department visits and admission rates among US acute care hospitals. JAMA Intern Med 2018;178(12):1708–10 Dec 1.
[2] FastStats [Internet]. [cited 2020 Mar 29]. Available from: https://www.cdc.gov/nchs/fastats/emergency-department.htm;2020.
[3] Schanzer DL, Schwartz B. Impact of seasonal and pandemic influenza on emergency department visits, 2003-2010, Ontario, Canada. Acad Emerg Med 2013;20(4):388–97 Apr.
[4] Dugas AF, Morton M, Beard R, Pines JM, Bayram JD, Hsieh YH, et al. Interventions to mitigate emergency department and hospital crowding during an infectious respiratory disease outbreak: results from an expert panel. PLoS Curr 2013;5.
[5] Jernigan JA, Low DE, Heftman RF. Combining clinical and epidemiologic features for early recognition of SARS. Emerging Infect Dis 2004;10(2):327–33 Feb.
[6] Chen W-K, Wu H-DI, Lin C-C, Cheng Y-C. Emergency department response to SARS, Taiwan. Emerg Infect Dis 2005;11(7):1067–73 Jul.
[7] Almulhim KN, Shesser R, Pourmand A, Whiteside T, Kane E. The relationship between staff teaming models and emergency department efficiency. The American Journal of Emergency Medicine [Internet] 2020;0(0):Mar 10 [cited 2020 Mar 30]. Available from: https://www.ajemjournal.com/article/S0735-6757(20)30157-1.abstract.
[8] Novel coronavirus – SARS-CoV-2 – COVID-19: an update what emergency clinicians need to know.Pdf [Internet]. Google docs. [cited 2020 Mar 27]. Available from: https://drive.google.com/file/d/1c2dVW8SUBkNbweUa5d8WM2RULxuXLEtI/view?usp=drive_web&usp=embed_facebook.
[9] Wilder-Smith A, Low JGH. Risk of respiratory infections in health care workers: lessons on infection control emerge from the SARS outbreak. Southeast Asian J Trop Med Public Health 2005 Mar;36(2):481–8.
[10] Alhazzani W, Møller MH, Arabi YM, Loeb M, Gong MN, Fan E, et al. Surviving Sepsis campaign: guidelines on the management of critically ill Adults with coronavirus disease 2019 (COVID-19). 101.
[11] Seto WH, Tsang D, Yung RWH, Ching TY, Ng TK, Ho M, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). Lancet 2003 May 3;361(9368):1519–20.
[12] Lau JIF, Fung KS, Wong TW, Kim JH, Wong E, Chung S, et al. SARS transmission among hospital workers in Hong Kong. Emerging Infect Dis 2004;10(2):280–6 Feb.
[13] CDC. Coronavirus disease 2019 (COVID-19) [internet]. Centers for Disease Control and Prevention. [cited 2020 Apr 3]. Available from https://www.cdc.gov/coronavirus/2019-ncov/hcp/index.html;2020.
[14] Amirav I, Newhouse MT. RE: transmission of Corona virus by nebulizer- a serious, underappreciated risk! [cited 2020 Mar 25]; Available from: https://www.cmaj.ca/content/re-transmission-corona-virus-nebulizer-serious-underappreciated-risk;2020 Mar 23.
[15] Hui DS. Severe acute respiratory syndrome (SARS): lessons learnt in Hong Kong. J Thorac Dis 2013;5(Suppl. 2):S122–6 Aug.
[16] Brocklebank D, Ram F, Wright J, Barry P, Cates C, Davies E, et al. Comparison of the effectiveness of inhaler devices in asthma and chronic obstructive airways disease: a systematic review of the literature. Health Technol Assess 2001;5(26):1–149.
[17] ACR recommendations for the use of chest radiography and computed tomography (CT) for suspected COVID-19 infection | American College of Radiology [internet]. [cited 2020 Mar 23]. Available from https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection.
[18] Rational approach | disinfection & sterilization guidelines | guidelines library | infection control | CDC [internet]. [cited 2020 Mar 23]. Available from https://www.cdc.gov/infectioncontrol/guidelines/disinfection/rational-approach.html.
[19] Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the chinese center for disease control and prevention. JAMA 2020.https://doi.org/10.1001/jama.2020.2648 [Published ahead of print].
[20] Lewis SR, Butler AR, Parker J, Cook TM, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation. Cochrane Database Syst Rev 2016(11) [Internet]. 2016 Nov 15 [cited 2020 Mar 25]. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6472630/.
[21] Zucker HA, Adler KP, Berens DP. Current members of the New York state task force on life and the law. 272.
[22] Neyman G, Irvin CB. A single ventilator for multiple simulated patients to meet disaster surge. Acad Emerg Med 2006;13(11):1246–9.