Coronavirus disease 2019 (COVID-19) is a global pandemic that has affected 188 countries as of the time of this writing. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative virus of this disease, has the potential of causing a fatal severe respiratory distress syndrome. The initial reports from hot spots such as China and Italy indicate that about 15% of affected patients will develop severe pneumonia requiring hospitalization and that 5–6% will require intensive care (1).

The exponential spread of this virus in major metropolitan areas has led to escalating health care use, thereby placing a massive burden on acute care resources, including hospital beds, personal protective equipment (PPE), and ventilators (2). An equally distressing problem is a shortage of trained medical personnel who are capable of treating the surge of patients requiring intensive care, especially as more healthcare workers become infected, quarantined, or hospitalized. Containment has been difficult in the United States, and the magnitude of community spread is unknown. Restrictions on travel and everyday life have been imposed in an attempt to curb the infection rate, but the number of patients requiring hospitalization and intensive care is predicted to be high.

In anticipation of a surge in hospitalizations, it is paramount for every medical center in the United States to rapidly establish contingency plans to accommodate increased demand. Concurrently, hospitals need protocols as well as training to minimize healthcare worker exposure and ensure proper active and reserve staffing. Logistical deficiencies can stress a healthcare system, but with adequate preparation, we hope to reduce COVID-19 mortality by ensuring that the standard of care is preserved despite the increase in healthcare use. Meanwhile, efforts to reduce the possible spread of COVID-19 to patients, visitors, and essential healthcare providers through early detection, isolation, and triaging need to be emphasized. In the perspective article, we report our institution’s plan for addressing these challenges.

**Staffing/Training**

Temple University Hospital is a 722-bed academic medical center located in urban North Philadelphia. Our hospital is centered within a medically underserved residential region of the city. Temple has approximately 50 available intensive care unit (ICU) beds during normal operations. These beds are often filled at close to 80–90% capacity during normal operations.

Staff training on safety and precaution measures was initiated immediately after the outbreak. A designated hospital committee on infection control drafted pertinent protocols on PPE. Live in-service programs were conducted to educate healthcare providers in techniques to safely don and doff PPE. Simulation exercises in advanced cardiac life support and rapid response were conducted to garner familiarity with the time-consuming process of wearing PPE.

All staff were required to report symptoms via an online application and to undergo aural temperature monitoring before and after shifts. A daily departmental teleconference with involved staff has been integral in maintaining a uniform and consistent stream of evolving information. In addition, daily updates have kept remote individuals effectively informed of new protocols and contingencies.

**First Screening**

On the basis of experiences of Wuhan, China, we instituted a screening protocol to classify patients into low-, intermediate-, and high-risk groups based on exposure history and clinical signs/symptoms. The goal of this risk stratification was to identify high-probability patients to minimize transmission risk. Individuals were considered low risk if they presented with afebrile viral prodromes and/or unilobar...
pneumonia of fewer than 5 days’ duration since symptom onset. The intermediate group included febrile viral prodromes, hypoxemia, and unilobar pneumonia of more than 5 days’ duration since symptom onset. The high-risk group included a recent history of travel to level III countries (i.e., China, Italy) or U.S. areas with community transmission, those with known contact with a patient with confirmed COVID-19, healthcare workers with unexplained lower respiratory tract infection, or individuals with unexplained multifocal pneumonia with hypoxemia. As the infection spread in the community, our protocol changed to include only clinical signs, symptoms, and radiographic signs. Travel history was discarded from the algorithm because community spread was assumed to be the primary vector of disease.

Regarding inpatients, any reports of a viral prodrome, changes in oxygen requirement, or imaging results suspicious of viral syndromes were considered as criteria for screening. Any rapid responses or cardiac arrests that had suspicion of COVID-19 were immediately transferred to the COVID-19 unit for screening to avoid staff contamination in the non–COVID-19 hospital.

Initially, all SARS-CoV-2 tests were sent to a third-party diagnostic company that had a 4–5-day turnaround time. This resulted in an inappropriate use of PPE, delay of discharge of patients without COVID-19, and ultimately an increase in our total census. We eventually developed our own in-house testing that yielded results within 5–10 hours. Once faster testing became available, we were able to effectively triage and discharge our patients efficiently. Table 1 highlights the algorithm we have used since the point-of-care test became widely available.

### Units

Containment of individuals with suspected COVID-19, inadvertent contamination of noninfected healthcare workers, and sequestering those critically ill due to COVID-19 are paramount. In lieu of a widely available vaccine, the neutralization of COVID-19 is achieved through isolationist practices and eventual viral extinction. Within our institution, this effort was exercised through temporary designated units, stratified by the following parameters: COVID-19 positivity, probability of COVID-19 infection of those awaiting test results, and overall traditional clinical illness parameters.

We determined that three hospital units were necessary. First, an isolated unit in a building separate from the main hospital was created. The unit comprises two floors with a total of 14 medical-surgical and 10 intensive care beds on each floor. All medical-surgical beds have the capability to be turned into ICU beds if necessary. This unit was designed for patients with intermediate to high probability of COVID-19 and is staffed only by pulmonary faculty and fellows.

The second unit was designated for patients with low probability of COVID-19. This 100-bed unit has been managed under the medicine service. As our census increased, we converted all floors of this building into a COVID-19 medical-surgical unit. We have also arranged extra beds in the lobby and operating areas if necessary. This entire building has a capacity of 250 total

### Table 1. Coronavirus disease 2019 severity stage protocols

| Stage | COVID-19 Status | Presence and Degree of Symptoms | Symptom Description | Triage |
|-------|----------------|---------------------------------|--------------------|--------|
|       |                |                                 | Symptoms           | CXR/HRCT | Respiratory Support | Hemodynamic Support | Triage |
| 0     | +              | None                            | None               | Normal   | None                | None               | Home   |
| I     | +              | Mild                            | $T_{\text{max}} < 38.3^\circ\text{C}$, sore throat, nasal congestion cough, chest tightness, myalgias, body aches, fatigue, diarrhea | None | NC < 3 L O$_2$ | None | Home   |
| II    | +              | Moderate                        | Stage I plus SOB, RR 20–25 breaths/min, HR < 110 beats/min, $T_{\text{max}} < 38.3^\circ\text{C}$ | GGO or peripheral lobar consolidation | NC > 4 L O$_2$, rest | None | COVID-19 ICU floor unit |
| III   | +              | Severe                          | Stage I plus $T_{\text{max}} < 38.3^\circ\text{C}$, RR > 25 breaths/min, HR > 110 beats/min | GGO, “crazy paving,” or multifocal lobar consolidation | O$_2$ > 40%, HFNT, BiPAP | One vasopressor | COVID-19 ICU |
| IV    | +              | Very severe                     | Stage I and/or encephalopathy, hypotension, SBP < 90 mm Hg | Diffuse infiltrates resembling ARDS | Mechanical ventilation, ECMO | Two or more vasopressors | COVID-19 ICU |

**Definition of abbreviations:** ARDS = acute respiratory distress syndrome; BiPAP = bilevel positive airway pressure; COVID-19 = coronavirus disease 2019; CXR = chest x-ray; ECMO = extracorporeal membrane oxygenation; GGO = ground-glass opacities; HFNT = high-flow nasal therapy; HR = heart rate; HRCT = high-resolution computed tomography; ICU = intensive care unit; NC = nasal cannula; O$_2$ = oxygen; RR = respiratory rate; SBP = systolic blood pressure; SOB = shortness of breath; $T_{\text{max}}$ = maximum body temperature.

The table displays the clinical characteristics of a COVID-19–positive patient.
beds. Once patients are ruled out for SARS-CoV-2 infection, they are transferred to a general medicine service or discharged.

Because of increased demand for computed tomography (CT) in assessment of suspected COVID-19 cases, we established a dedicated CT scanner in the same building as the unit described earlier. This kept patients and staff from asymptomatic transmission. The staff at this radiology unit have been instructed to take maximal PPE precautions as well as perform appropriate equipment sanitation. We also took measures to reduce the frequency of unnecessary physical patient–healthcare provider contact. Unnecessary blood draws and portable imaging have been discouraged in clinically stable patients. In-room tablets are available primarily for non–English-speaking patients so that in-room translation can be facilitated without using phones, which may lead to contamination. As with other institutions, it has been difficult to find an available tablet for every patient who needs it.

Last, a third unit functioned as an outpatient COVID-19 screening unit. Established outpatients are screened via preclinic telephone encounters using a COVID-19 symptom questionnaire. Any patient suspected of having COVID-19 receives a referral to the COVID-19 screening unit. Moreover, all patients triaged at the emergency department main entrance with mild symptoms suspicious of COVID-19 are also referred to this clinic using a separate main hospital entrance.

Contingency Plans

If the inpatient surge overwhelms existing facilities, backup units should be designated. We arranged an additional 27 ICU-capable rooms. These rooms are located in the operating room, postanesthesia care unit, and neurosurgical ICU located in the same building as our intermediate–high-risk unit.

We have mobilized ventilators from our smaller satellite campuses. Since nonemergent procedures have been held, we have been able to relocate ventilators from operating rooms from these hospitals. A few local long-term acute care facilities have also provided extra ventilators.

To prevent staff shortages in the event of the inevitable occurrence of medical personnel infection, staff members who are not on essential inpatient services are asked to remain at home on reserve to make up for these staffing shortages. Several contingency plans were put in place to use healthcare workers in other departments in case of a severe staffing shortage. We developed a model in which several teams work together in a shift-based model with remote help. This applied to all essential departments, such as physicians, nurses, and respiratory therapists. This strategy helps minimize staff exposure and PPE use. Nonurgent procedures have been tentatively postponed to reduce hospitalizations and to maintain operating room and ICU vacancy.

Because of the high risk of contamination of family members and visitors, a strict no-visitor policy is enforced at our hospital. However, to keep family members updated, nurses and physicians spend time daily in updating families. We have incorporated remote physicians who are responsible for daily updates. Tablets for virtual visits between family and patients would be very helpful and is a goal we are striving toward.

Conservation of PPE has been a major priority at our institution. Employees in the COVID-19 unit receive one N95 mask and one surgical mask per shift. They also receive a protective face shield that they can reuse with specific instructions on doffing. Each of our nursing units has an ultraviolet light disinfection box for solid objects such as phones, glasses, and pens.

Admission Protocols

We created a COVID-19 admission order set inclusive of isolation precautions, specimen collection, imaging, and laboratory testing. Once admitted, patients are maintained in airborne/droplet and contact isolation until SARS-CoV-2 is ruled out or an alternative diagnosis is made. High-risk patients are maintained using airborne precautions, whereas low- and intermediate-risk patients with abnormal CT findings are maintained according to droplet precautions. If they have a positive test result for SARS-CoV-2, patients are maintained in airborne and contact isolation until they clinically improve and their SARS-CoV-2 polymerase chain reaction (PCR) test result is negative. If patients’ symptoms resolve but their PCR test result remains positive, they are discharged to home quarantine with daily telemedicine checkups. Patients’ home quarantine is continued until their PCR test result is negative.

Discharge

In a public health crisis, discharge follow-up becomes an important measure of epidemic mitigation. Most patients admitted to our unit will not need inpatient care shortly after testing is performed. These patients should therefore self-quarantine at home and await their test results. These patients should be reliable enough to respond to phone follow-up and have home infrastructure in place in case of worsening symptoms. A family member should be spoken to so that the discharge plan can be reinforced. Written information on contingency plans should be provided in the patient’s preferred language. The responsibility of communicating negative or positive test results is performed by our microbiology laboratory with mandatory reporting to the state public health department.

Because of limitations with testing supply, we commonly do not retest patients before discharge. We work with our case managers and social workers to ensure that each discharged patient can self-isolate in a room away from family members or roommates. Patients are asked to wear a mask at all times after discharge. In addition, at discharge, patients are also provided with social support as needed for food, housing, and other day-to-day needs in conjunction with the health department.

At discharge, COVID-19–positive patients are provided access to an online portal, where they are required to log in daily and report their symptoms. In addition, the patients are asked to perform mandatory quarantine for 14 days after discharge. The online symptom log is followed by a remote physician on a daily basis. Any worsening in clinical status is dealt with promptly by the physicians.

If patients continue to improve, an initial follow-up call is made within 48 hours after discharge. The outpatient follow-up is performed in 1-week, 2-week, and 1-month intervals from the date of discharge. On a case-by-case basis, the need for liver and renal function tests, sputum and stool PCR tests, imaging, and lung function tests is determined. Follow-up phone calls are also made at 3 and 6 months after discharge.

Outpatient Care

At our high-volume lung center, we perform 33,000 outpatient visits, 7,000 pulmonary
function tests, 2,500 sleep studies per year. We converted all scheduled in-person outpatient appointments to telemedicine visits. All nonemergent pulmonary tests/procedures were canceled.

Telemedicine facilitated a practical solution allowing us to evaluate the symptoms of our established outpatients while keeping those who are well away from unnecessary risks of illness. Office staff called patients to confirm their appointments and to obtain consent for a telephone visit. At that time, all patients were asked COVID-19 risk screening questions. All phone calls were documented in the medical chart, similarly to a face-to-face visit. Our information technology team has been developing a simple web-based application that can be used to detect symptoms of patients, healthcare personnel, and family members. Our bronchoscopy suite policies were revised to perform only urgent procedures with appropriate PPE.

Trainee Experience and Education

Our institution is one of the largest pulmonary disease and critical care hospitals whose aim is to balance clinical training with academic training. Program leadership and fellows work together to continue lectures, conferences, and research meetings remotely through teleconferencing. Similarly to the 1980s acquired immunodeficiency syndrome pandemic, with COVID-19 as a newly described and rampant illness, trainees learned to adapt to the evolution and volume of COVID-19 cases. Moreover, the international response generated a deluge of literature and research. Trainees faced the task of reviewing, interpreting, and applying the expanding compendium of COVID-19 data.

Generally, public health and its logistical aspects is not a focal point throughout training. Of necessity, trainees receive dedicated education on proper PPE use, reporting guidelines, and self-screening for illness and work readiness.

Clinically, the shortage of healthcare workers have forced trainees to assume more responsibilities than before, functioning as surrogate care providers. This clinical experience is highlighted by its autonomy and acuity, accelerating trainee proficiency/skillfulness. The unique experiences gained from this global event will be invaluable to any trainee’s education.

Conclusions

The major disease outbreak of COVID-19 calls for urgent healthcare workflow restructuring. Essentially a call to arms, infrastructure adjustments were made to achieve the following principles: identify and triage patients with suspected COVID-19, optimize and reconfigure hospital operations to match needs to confront the current pandemic, curb worldwide viral spread, and avoid excessive exposure to immunocompromised patients. All institutions should have protocols and measures to mitigate the transmission of the novel SARS-CoV-2 while also using available resources appropriately. We understand that all institutions do not have the same capabilities or resources. It is imperative, however, that an action plan be prepared to face the outbreak. With our protocols, we aim to provide a roadmap for other institutions in the United States to deal with this crisis optimally.

Author disclosures are available with the text of this article at www.atsjournals.org.

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