

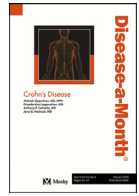


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COVID – 19 case study in emergency medicine preparedness and response: from personal protective equipment to delivery of care

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“May you live in interesting times”-
English expression of Purported Chinese Curse

Introduction

In late 2019, a novel new virus appeared in China with reports of a cluster of pneumonia cases in the large city of Wuhan. Current epidemiological theories trace the virus's first appearance to a seafood market in the city. It is there the virus was thought to have passed from animals to humans. Hundreds and then thousands of Chinese nationals developed high fevers, body aches, and pneumonia-like symptoms. Testing to determine cause revealed it wasn't SARS, the coronavirus that spread around the country in 2002, or the deadly Middle East Respiratory Syndrome, MERS; nor was it influenza, bird flu, or the adenoviruses that cause respiratory symptoms.⁴⁹ All this was unfolding just before China's biggest holiday, Spring Festival, a time when hundreds of millions of Chinese travel to celebrate and be with family.²⁰

Over the ensuing months, this new coronavirus spread across the globe. By February 11, 2020, this virus was given an official name severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by the International Committee on Taxonomy of Viruses. On that day the World Health Organization announced the official name of the virus, there were 42,708 confirmed cases reported in China and 1017 deaths in that country, mostly in Wuhan's Hubei province. Outside of China, there were 393 reported cases in 24 countries and 1 death.⁶⁹ In the months following that day, many millions have gotten sick and hundreds of thousands have died. As for nomenclature, the illness that this virus causes became synonymous with the virus itself: COVID 19.

In the United States, the first COVID case was reported on January 21, 2020.³¹ In the weeks that followed, an additional 53 cases were reported and many public health officials hoped the viral spread was limited but containment measures were haphazard and based on a rapidly de-

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veloping knowledge base about viral transmission. The federal government barred entry of most foreign nationals with recent travel to China, but not US residents who had been to China. Little viral testing was available or done to screen people entering the US. Given low official numbers of cases that month, social gatherings were not restricted. Voluntary self-quarantine measures and hand hygiene recommendations were the mainstays of response at that time.⁴²

By late February, reports of positive cases outside of China with no recent travel history indicated a rise in community transmission and hinted at pandemic spread. Cruise ships were particularly vulnerable to the spread of COVID with their crowded common areas, travel to new areas, and limited medical resources.⁵³ Italy and Iran were also seeing a rapid increase in cases, foreshadowing the effects of widespread transmission and prompting concerns over upcoming holiday and religious pilgrimage travel.³²

On February 29th, authorities in Seattle reported the first American death from COVID; later reports indicated the earliest COVID death in the United States was in early February in Santa Clara County in the San Francisco Bay area.⁶⁶ Ongoing community spread, attendance at professional and social events, introduction into facilities and settings prone to amplification, and the lack of viral testing contributed to rapid increase in transmission in March in the United States. Large social events such as Mardi Gras, spring break vacation travels, and attendance at international professional conferences were held as planned. Directly linked increases in cases related to events like these prompted state-led restrictions in gatherings and travel.⁶ A funeral in Albany, Georgia was attended by more than 100 people. Later, Dougherty County, Georgia, the small rural county that includes Albany, reported the highest cumulative incidence of COVID (1630/100,000) in the country at the time.⁶⁵ Areas particularly impacted at this time were long-term care facilities and high-density urban areas. Other factors increasing COVID spread included confluence with influenza and pneumonia season, continued importation of virus from other areas via travel, and undetected transmission among presymptomatic or asymptomatic individuals.

By mid-March, transmission had become widespread and state and federally mandated measures to contain spread and protect health care capacity were initiated. Federal travel bans expanded to include Italy, South Korea and many European countries. Nearly all states were under some form of stay-at-home orders with closures of school and nonessential workplaces and cancellation of sporting events and all group gatherings to try to “flatten the curve.” Most lockdowns began between late March and early April. California was the first state to issue lockdown orders on March 19th, following the lead of San Francisco three days prior.⁵⁸ Restrictions on international travel were put in place, and a No Sail Order from the Director of the CDC was issued on March 14th, suspending travel on US waters.⁶⁵ On March 26th, the United States became the country hardest hit in the world by coronavirus with 81,321 confirmed infections.⁵¹ That trend continues today.

COVID in Illinois

Spread of coronavirus and the challenges inherent in pandemic circumstances were similar in the state of Illinois. Its index case was the second detected case in the United States: a woman traveling from Wuhan, China in mid-January who returned home to Illinois and was hospitalized a week later with pneumonia.⁷ Her spouse tested positive as well the following week which was the first recorded case of local transmission in the United States.²⁶ Early screening and positive cases in Illinois were connected to travel histories such as recent travel to high risk areas as with Illinois' first case or recent travel on a cruise ship.³⁶

Nationally, retrospective analysis of surveillance data from this time period suggests that limited community transmission likely began by early February after initial importation from travelers from China and Europe.⁴³ This could not be tracked until late February to early March via emergency department syndromic surveillance data as evidenced by an increase in emergency department visits for COVID-like illness demonstrated increased incidence (Fig. 1). This data represents a critical indicator, given limitations in widespread testing at that time.

By March 10th, the first cases of coronavirus were being reported not only outside Cook County but also in individuals with no identifiable risk factors such as recent travel or known

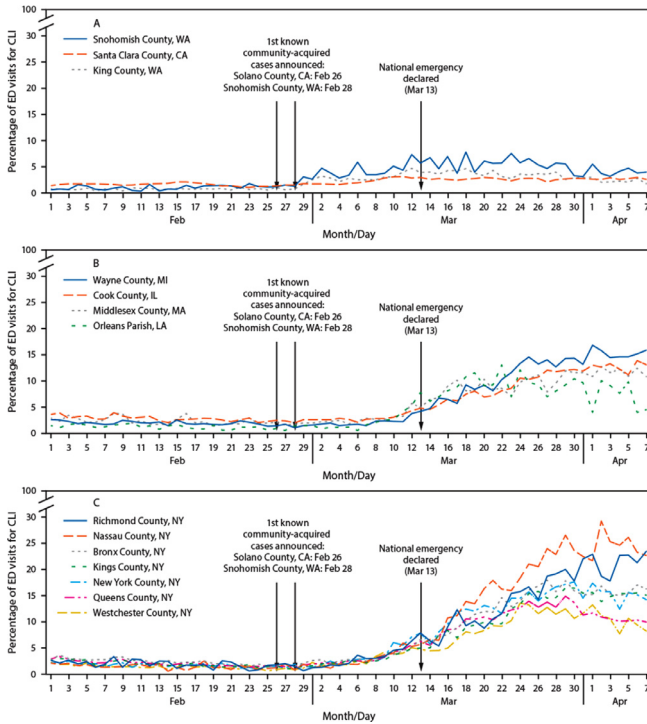


Fig. 1. Percentage of emergency department (ED) visits for COVID-19-like illness (CLI),* in 14 counties†,§ (three in California and Washington [A]; four in Illinois, Louisiana, Massachusetts, and Michigan [B]; and seven in New York [C]) – National Syndromic Surveillance System,¶ February 1–April 7, 2020. Source: https://www.cdc.gov/mmwr/volumes/69/wr/mm6922e1.htm?s_cid=mm6922e1_w#F1_down

Legend:

Abbreviation: COVID-19 = coronavirus disease 2019.

* Fever and cough or shortness of breath or difficulty breathing or presence of a coronavirus diagnostic code.

† California: Santa Clara County; Washington: King County, Snohomish County; Illinois: Cook County; Louisiana: Orleans Parish; Massachusetts: Middlesex County; Michigan: Wayne County; New York: Bronx County, Kings County, Nassau County, New York County, Richmond County, Queens County, Westchester County.

§ King County, Washington includes Seattle; Cook County, Illinois includes Chicago and many of its suburbs; Wayne County, Michigan includes Detroit and many of its suburbs; Orleans Parish includes New Orleans; Kings County (Brooklyn), Queens County (Queens), Bronx County (Bronx), Richmond County (Staten Island), and New York County (Manhattan) are all within New York City.

¶ From the subset of emergency departments in each county that participates in the National Syndromic Surveillance Program.

sick contacts.³⁷ Retrospective analyses have confirmed the deadly nature of community transmission like the above case in Albany, Georgia: Chicago Department of Public Health (CDPH) investigated a large, multi-family cluster of COVID positives and presumed positive cases. This cluster investigation and tracing demonstrated transmission to non-household contacts and family gatherings after one index patient attended funeral events that triggered a chain of transmission that included 15 other confirmed and probable cases of COVID and ultimately three deaths.²⁵

Long term care facilities (LTCF) became a particular area of focus and monitoring. The first resident of an Illinois long term care facility that tested positive during this time spurred testing of the entire facility and resulted in 21 positive cases including 17 residents and 4 staff members, confirming the fears of public health officials both of the inherent risky nature of congregate living and the vulnerability of congregate living residents.³⁸ Increased guidance from IDPH for nursing homes included restrictions on all visitors, volunteers, and non-essential health care personnel (e.g., barbers), cancellation of group activities and communal dining, and active

symptom monitoring for both residents and staff. As one congregate living resident summarized during his emergency room visit at the time: "I haven't been allowed to leave my room and they bring all my meals to my door and leave it there. My family can't visit me."

By the time that Illinois Governor Pritzker issued stay-at-home orders on March 21st, Illinois had 585 confirmed cases across 25 counties, including 163 recently diagnosed new cases and a death toll of five.³⁹ The directive prohibited socializing in-person with people outside your household and gatherings larger than 10 people. Playgrounds were closed and selective green spaces were used with 6 feet of social distancing. Only essential travel was permitted and essential services continued. At the time, Illinois was joining California, New York and Connecticut, states with three of the largest cities in the country, to enforce strict sheltering measures. Illinois remains one the states with stricter sheltering measures in the country and subsequent reopening guidelines currently.

COVID in the emergency department

The approach to the coronavirus pandemic in our emergency department focused on identification and isolation of infected individuals, adequate protection of staff, reporting of positive cases to the health department, effective treatment, and education of patients and families. Protocols for triaging, use of PPE (personal protective equipment), environmental services and cleaning, even the types of tests we ordered were adjusted to maximize protection. Use of telemedicine technologies helped mitigate risk and exposure. Care for these patients was pared down to the most essential personnel to minimize staff exposure, especially given a worst case scenario that predicted temporary loss of staff due to illness and quarantining. Staff was re-allocated to essential areas such as the ED, ICU, home health, and nursing homes to help test and care for COVID patients. Other staff were recruited from outpatient areas with less volume to assist in the ED in anticipation of higher volumes and unanticipated staff absences due to illness.

The physical space of the emergency room was re-evaluated to best triage and isolate COVID patients. Protocols for cleaning and sanitizing rooms and common diagnostic areas (radiology, CT scanners) were formulated to balance the need to turnover spaces efficiently but safely. A trauma or stroke patient cannot be imaged in a CT scanner that just minutes before accommodated a confirmed COVID positive patient, so protocol for use and cleaning had to be developed. These were but a few of the many challenges that pandemic conditions present to an emergency room and to a hospital.

The NorthShore University HealthSystem (NorthShore) had to be dynamic, informed, and innovative in its approach in order to provide effective care with minimal risk of exposure to both patients and staff. NorthShore is headquartered in Evanston, IL and includes 5 hospitals—Evanston, Skokie, Glenbrook, Highland Park and Swedish—on the north side of Chicago and its suburbs. These ED's are busy—seeing a combined total of over 170,000 visits annually.³⁴ The integrated nature of the hospital system means that NorthShore can be dynamic and responsive to the needs of the community while also having the resources to be effective.

Advanced Practice Practitioner (APPs) is a term used to represent Physician Assistants and Nurse Practitioners. APP's have traditionally been widely used in the NorthShore system and are utilized in a variety of clinical areas from outpatient to inpatient roles. APP's are used in nearly every service area, evaluating patients, ordering tests, formulating treatment plans, and educating and advising patients and families. The NorthShore ED APP group consists of 31 full-time, part-time, and resource team APP's. We work all the ED pavilions in both fast track and main room areas. APP's assist by seeing patients alongside and in addition to the physicians, dispersing responsibilities and providing more complete care. With the advent of COVID, we have worked to adjust our role along with the rest of the ER team. APP's within NorthShore have had to alter their usual role to adapt to COVID, many temporarily relocating to the ED, Immediate Care, inpatient floor, ICU, and as part of the nursing home testing outreach team.

APP's who participated in these roles were able to alleviate the demand placed on these departments and provide access to on-site testing. APP's in the Immediate Care have played a

crucial part in caring for COVID patients and providing access to testing within their clinical sites. APP's in the ICU have been critical in helping fill the gaps where additional staff were needed to care for COVID patients, make calls to update family members, and provide input for treatment protocols. We, the authors of this article, work as APP's within the NorthShore emergency department. The following is a detailed description of our perspective on how NorthShore, one hospital system in the US, adapted to respond to the demands of the COVID pandemic. In writing this paper, we interviewed people across the system to help capture some of the changes our hospital system underwent to respond to COVID.

Hospital communication during COVID

Communication throughout the COVID response faced many challenges and growing pains. The landscape of understanding and response to the virus changed so radically over this year that clear and constant communication was vital for healthcare workers. Challenges arose with social distancing and sheltering at home guidelines restricting large meetings that posed a threat of transmission, yet it was essential to maintain a clear understanding of clinical and operational guidelines to ensure safe and effective care.

These efforts occurred on many levels. Early on, NorthShore set up an online COVID resource center to update staff. The site was divided into protocols, updates, and specific service line guidelines (such as surgery, vascular lab, or psychiatry admissions). Also included in updates and education were common procedures performed in caring for COVID patients such as intubation, donning and doffing protocols, updated testing guidelines, and proper nasopharyngeal swabbing technique.

NorthShore's internal COVID website also included the most recent recording of the weekly physician update for the hospital system. These meetings were conducted by COVID response team leaders in the NorthShore system who drew on their expertise in their clinical areas to update and educate physicians across the system and other NorthShore employees on particular aspects of COVID and NorthShore's response to the pandemic. Representatives included NorthShore's leaders including Dr. Mahalakshmi Halasyamani, Chief Quality and Transformation Officer, Dr. Tom Hensing, Chief Quality Officer, and Dr. Kamaljit Singh, Director of Microbiology and Infectious Diseases Research. Each offered updates including testing and laboratory data, hospital protocols, and clinical research trials. The weekly meeting also offered a forum for addressing meeting attendees' questions, some of which were particular to their own specialty but also arose from general curiosity about NorthShore's COVID response.

NorthShore's CART (COVID Analytics Research Team) maintained a real time data resource accessible through Epic, NorthShore's electronic medical record system. This page included current operational COVID census within the hospital system as well as total testing outcomes. Through the hard work of this team, data was analyzed by age, end outcome, and other markers. More recently, CART has begun analyzing and presenting early data from NorthShore's COVID antibody testing.

Within the ED, our division chief Dr. Ernest Wang hosted bi-weekly call-in meetings open to physicians, APP's, nurses and ED staff. Those meetings focused on ED workflow and covered a variety of topics. He also invited feedback and discussion as well as contributions from directors of each of the individual ER locations. Given the information deluge that has characterized COVID, physicians in our group worked hard to stay up-to-date themselves and shared important information within the ED group using group chat platforms. It seemed like nearly daily there were important new understandings of COVID and our team worked hard to share, interpret, and discuss this information. Our ED APP manager, Sue Bednar, APN, also held call-in meetings to field questions and concerns as well as sent out regular email updates. All these efforts were appreciated by staff because shared knowledge is important not only for personal safety but also for efficient and effective patient care.

With our group trying to stay informed on ED workflows in several different ED pavilions, it was important that we received guidance and information from one central source. Sue Bednar, Dr. Wang, and all the other physician leaders in our group worked tirelessly to keep us safe

and informed. Their work ensured that we felt calm and prepared for challenging shifts, that we understood PPE use and rationale and ED testing and treatment protocols, and that we had knowledge of current areas of stress in the system and measures to address these challenges and bottlenecks in daily workflow. All this reinforced the message that we were valued members of the organization.

PPE use and availability

As the first case of COVID was confirmed in the United States in January, hospitals, clinics, and essential businesses across America started to think about how they were going to protect their employees. There was scarcity of equipment like standard surgical masks, N95 masks, and gloves for not only essential businesses but the general public as many rushed to protect themselves and their loved ones. In addition, hospitals needed to ensure that they had sufficient gowns, face shields, shoe coverings, and hair coverings so healthcare workers could safely do their jobs, not just in the days but also the weeks and months to come. Having adequate PPE and training proved to be the most important means of enforcing workplace safety and preventing viral transmission to healthcare workers. Reports of high healthcare worker infection rates out of countries badly hit by COVID like China and Italy, worried healthcare workers in the US.⁷⁵

Hospital employees everywhere were questioning if their employers had the resources to protect them as the number of COVID cases grew and if the PPE would be effective. Surrounding communities stepped up to help by donating any extra PPE they had. Despite shortages elsewhere, NorthShore has been fortunate to be able to provide adequate PPE for all employees that came in contact with COVID patients.

Prior to the COVID pandemic, most employees hadn't worn N95 masks often and most hadn't been recently fit tested for proper N95 mask size. At each NorthShore hospital, fit testing was offered as hundreds of employees lined up to be refitted for appropriate sizing of N95 masks. As the months progressed, employees were retested for appropriate fit as the hospital ran out of certain sizes of N95 masks and alternatives were provided.

In addition to the need for N95 mask fit testing, NorthShore had to also reeducate employees on proper use of PPE. On March 11th, NorthShore released their first statement regarding PPE use, drawing from WHO (World Health Organization) and CDC (Center for Disease Control) guidelines. NorthShore recommended full PPE when caring for confirmed COVID or PUIs in Immediate Care, ED, and hospitalized settings. NorthShore also had to address concerns of improper PPE donning and doffing procedures that could inadvertently expose staff: Kang et al.⁴⁴ demonstrated that healthcare personnel contaminated themselves in almost 80 percent of videotaped PPE simulations. This was especially apparent during the Ebola virus outbreaks from 2014 to 2016.^{46,23} In early March 2020, there were concerns about PPE shortages that created a tension between appropriate use and unnecessary waste. CDC guidelines at the time did not recommend wearing masks when not around COVID patients, nor did they recommend masks for people without symptoms. It goes without saying that we all felt confused about PPE usage and what resulted were inconsistent practices within hospitals and also between hospitals.

By mid-April every employee and visitor was required to be screened by taking temperatures and answering questions about symptoms or exposure prior to entering any NorthShore facility. With a negative screen, everyone entering the hospital was given a mask to wear throughout their visit. Distribution of masks was limited initially in efforts to preserve supply, but as the hospital recognized the difficulty of socially distancing at work to prevent spread of infection, universal masking became standard. As of early June, NorthShore's positivity rate among employees is 13 percent, an improvement since enforcing universal masking and eye protection. It's unclear how many of these positive employees contracted COVID at work or at home, but the decrease in positivity rate is a testament to the effectiveness of proper implementation of PPE.

As NorthShore was able to increase COVID testing, PPE protocols became more regulated. Full PPE was required when interacting with patients with confirmed or suspected COVID including N95 mask, goggles or face shield, hair covering, plastic or cloth gown, and gloves. NorthShore

Doffing PPE for COVID-19

Inpatient

In Patient Room

STOP & FOCUS on each step

- 

1 Remove Gown and Gloves

 - Untie straps at front of gown
 - Pull gown away from torso, rolling away from you keeping the exterior safely wrapped
 - Remove gloves as you roll sleeves off, keeping gloves safely wrapped
 - Discard
- 

2 Hand Hygiene

 - Use alcohol-based hand gel
- 

3 Hand Hygiene

 - Use alcohol-based hand gel or wash with soap and water for at least 20 seconds
- 

4 Hand Hygiene

 - Use alcohol-based hand gel or wash with soap and water for at least 20 seconds
- 

5 Remove Face Shield or Goggles

 - Remove and disinfect face protection
 - Place in large bag labelled with your name
 - Do not seal the bag completely
- 

6 Remove N95 Mask

 - Remove N95 mask and place in second bag
 - Do not seal the bag completely
 - Place bag with N95 mask into larger bag
 - Do not seal the bag completely
- 

7 Remove Gloves

 - Remove gloves careful not to touch outside
 - Discard
- 

8 Hand Hygiene

 - Use alcohol-based hand gel or wash with soap and water for at least 20 seconds

EXIT to Hallway

Donning PPE for COVID-19

Inpatient

In Hallway

STOP & FOCUS on each step

- 

1 Hand Hygiene

 - Use alcohol-based hand gel
- 

2 Gown

 - Obtain clean gown from isolation cart
 - Fully cover torso and wrap around back
 - Ensure thumbs are through thumb holes
 - Cross straps in back and tie in front
- 

3 Gloves

 - Obtain clean gloves from isolation cart
 - Extend to cover wrist of gown
- 

4 N95 Mask

 - Remove N95 Mask from your labelled bag
 - Secure bands around head and neck
 - Adjust for snug fit around nose and face
 - Perform fit-check. No air should escape sides of mask
- 

5 Remove Gloves

 - Remove gloves careful not to touch outside
 - Discard
- 

6 Hand Hygiene

 - Use alcohol-based hand gel or wash with soap and water for at least 20 seconds
- 

7 Gloves

 - Don clean gloves for patient care
 - Extend to cover wrist of gown
- 

8 Face Shield or Goggles

 - Remove face protection from your bag
 - Place over face and eyes and adjust to fit

ENTER Patient Room

Donning PAPR for COVID-19

An MASH® PAPR / Emergency Department

In the Hallway or Anteroom

STOP & FOCUS on each step

- 

1 Remove Mask & Badge

 - Remove mask
 - Remove and set aside phone and ID badge
 - Remove and set aside watch, jewelry, pens
- 

2 Hand Hygiene

 - Use alcohol-based hand gel
- 

3 Inner Gloves

 - Obtain clean gloves
 - If available, use long-cuffed gloves
 - Extend to cover wrist or higher
- 

4 PAPR - Belt Pack & Hose

 - Confirm the pack is fully charged
 - Insert hose into belt pack using the end of the hose with the pins. Turn to "click"
 - Press and hold the power button to turn on PAPR
 - Feel for airflow
 - Put on the belt pack and adjust for a snug fit
- 

5 Gown

 - Obtain clean gown
 - Fully cover torso and wrap around back
 - Ensure thumbs are through thumb holes
 - Cross straps in back and tie in front. Ensure the straps go over the belt and motor housing.
- 

6 PAPR - Hose & Hood

 - Connect the hose to the hood. Listen for "click"
 - Don the hood
 - Ensure head band is in front of your head like a crown
 - Pull the elastic bottom under your chin
 - You should feel the airflow in the hood
- 

7 Outer Gloves

 - Don second pair of gloves
 - Extend cuffs to cover wrists

ENTER Patient Room

Doffing PAPR for COVID-19

An MASH® PAPR / Emergency Department

In the Patient Room

STOP & FOCUS on each step

- 

1 Hand Hygiene

 - Use alcohol-based hand gel on your outer gloves
- 

2 Gown & Outer Gloves

 - Untie straps at front of gown
 - Pull gown away from torso, rolling away from you keeping the exterior safely wrapped
 - Remove outer gloves as you roll sleeves off, keeping gloves safely wrapped
 - Discard
- 

3 Hand Hygiene

 - Use alcohol-based hand gel on your inner gloves
- 

4 PAPR

 - Unbuckle belt pack
 - Place hand between outer and inner layers of hood and remove hood
 - If available, hand PAPR to your helper. Otherwise, place PAPR onto designated "dirty" area
- 

5 Gloves

 - Remove inner gloves slowly careful not to touch the exterior of the gloves
 - Discard gloves
- 

6 Hand Hygiene

 - Use alcohol-based hand gel
- 

7 Hand Hygiene

 - Locate sink
 - Wash with soap and water for at least 20 seconds
- 

8 Disinfect PAPR

 - If available, helper will disinfect PAPR. Otherwise, don clean pair of gloves to disinfect PAPR
 - Disconnect hose from belt pack and hood
 - Disinfect the hose
 - Disinfect the belt pack and belt
 - Disinfect the inside of the hood, in between outer and inner layers of hood, and outside of hood
 - Once disinfected, place all parts in the "dirty" area
 - Disinfect the "dirty" area
 - Remove gloves and perform hand hygiene
 - After dry, store and charge PAPR (or return to the ED)

EXIT to Hallway

Fig. 2. Donning and Doffing PPE and PAPR.

and ED management worked hard to disseminate instructions on when and how to properly use PPE via handouts, emails, and videos. This was especially important for employees that needed to review how to use a PAPR and proper decontamination after performing an aerosolizing procedure like intubations (Fig. 2). Patients considered PUIs were flagged by the triage nurse and placed in a room with both contact and airborne precaution signs on the door, indicating need for full PPE. Patients that were not flagged as PUIs were not placed on COVID precautions, and

providers interacting with these patients were only required to use standard precautions and a surgical mask.

Other ways in which NorthShore worked to protect its staff working directly with COVID patients was offering the opportunity to shower at work post-shift and providing hospital-issued scrubs for shift use rather than wearing personal scrubs that must be laundered at home. Although robust literature about the use of hospital-issued scrubs to minimize exposure is lacking, most experts don't believe laundering scrubs at home poses an infection control problem. Regardless, Neysa P. Ernst, RN, MSN, a nurse manager in the Biocontainment Unit at Johns Hopkins School of Nursing notes "COVID-19 is so novel that 'psychological safety' is extremely important... For many frontline providers, changing in and out, and wearing hospital-laundered scrubs reduces concerns about bringing COVID home."²¹ Although hospital scrub use was put up as optional to use at first, quickly all ED employees took advantage of this opportunity to prevent the spread of COVID to home.

In addition to what was provided by NorthShore, ED employees also shared amongst themselves strategies for mask storage and eye protection, shoe changing/storage, and social distancing precautions. When N95 mask resources were limited, it became routine to wear a surgical mask over the N95 to further prevent contamination of valuable N95 masks. A few physicians and APP's referred to evidence published online regarding use of UV light or moist oven heat to decontaminate materials, some even buying personal portable UV lights to use on masks between patients.⁸ Items that were once kept at desks in the ED were now confined to a locker, phones were kept in plastic bags, and hair kept in scrub caps to prevent exposure. Providers also referenced online resources that discussed strategies to prevent contamination at work and home through FOAM (Free Open Access Meducation) online resources like EMCRI, EMRAP, and Emergency Medicine Cases.

From the beginning, NorthShore collaborated with employees to align with CDC recommendations, preserve resources, and create an environment in which employees felt safe and supported.⁹ Each hospital employee also had to take into account their own level of comfort, some going so far as to isolate themselves from their family completely, sleeping in separate houses or hotel rooms at the height of the pandemic. When it came down to it, COVID presented many new challenges that hospitals across the nation will continue to navigate as we move through the pandemic.

Testing and admission criteria

As we learned more about the nature of the virus and the reality of an imminent pandemic set in, America scrambled to find a widely available means of diagnosing COVID. In mid-February, Illinois became the first state in the United States to use a nasopharyngeal swab to test for COVID.³⁵ According to the FDA, the sensitivity of the COVID rt-PCR test is 95% with a specificity of 100%, but Illinois was only producing about 12 swabs a day for the entire state.^{30,48} At that time, testing was extremely restricted and controlled entirely by the state which posed difficulties in both meeting the community's testing needs as well as incorporating testing into hospital protocols.

The rapidly changing recommendations for COVID testing in Illinois were reflected at NorthShore as we struggled to keep up with the daily changes in testing supplies, requirements and best use. On January 21st, NorthShore released their first statement regarding screening of patients under investigation (PUIs) including symptoms of cough, shortness of breath, and/or fever with either recent travel in China or contact with a COVID positive patient within the past 14 days. This was in accordance with CDC guidelines. Initially, tests were only available by request from the IDPH, leaving NorthShore dependent on state guidelines and resources for testing.

When caring for a PUI patient, providers were advised to isolate the patient in a negative pressure room, wear PPE, and contact NorthShore Infection Control for further guidance. Additionally, the guidelines for PUI's identification continually expanded to match viral spread throughout the world and our local community. By early March, PUI's were considered to be

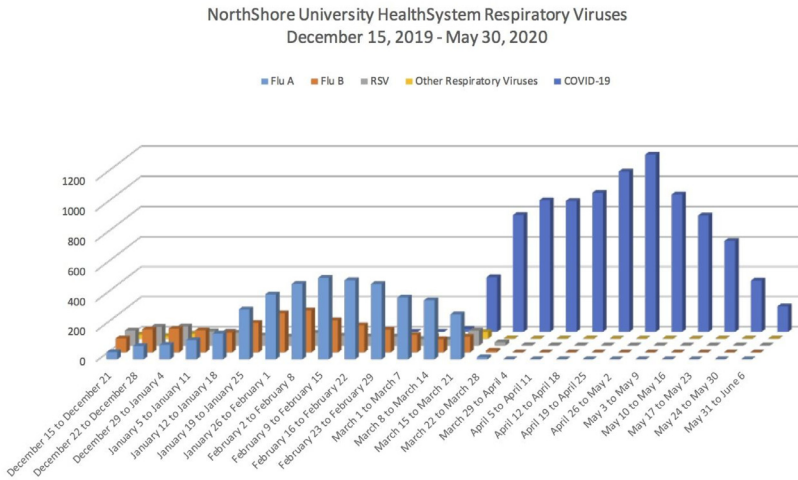


Fig. 3. Respiratory Virus Testing from December 2019 to June 2020.

those with cough, shortness of breath, and fever and had recently returned from Italy, Korea, Iran, or China, or patients who had come in contact with a known positive person in the past 14 days. While there were many cases already confirmed in California and Washington State and the first few COVID cases emerging within Chicago, PUIs at this time continued to be limited.

Recognizing the danger of limited testing, in late February the FDA relaxed policies regulating development of COVID testing kits to help achieve more rapid testing capacity nationally.²⁴ This was in response to the CDC's failure to develop a test under the emergency use authorization granted by the FDA that prohibited other laboratories from having the same freedom to fast track testing products. The CDC's initial test was distributed among states but problems with state testing sites and reagents yielded equivocal and unreliable test results.⁶⁴ At a time when the government was unable to provide adequate tests with prompt results, hospital systems across the nation were faced with the task of developing their own test as quickly as possible. By March 12th, NorthShore became the first local community hospital in the Chicago area to develop their own test for COVID with the capacity to run 400 tests daily. NorthShore's 24 to 48 h test turnaround time was impressive, given this was during a time when much of the rest of the country's COVID testing took almost two weeks to result.

COVID also emerged in the midst of the influenza season, further complicating the approach to a diagnosis. Testing protocols early on mandated ruling out flu/RSV prior to initiating a COVID test and halting further viral testing with a positive influenza/RSV swab. At that time, the possibility of co-infection of COVID with other respiratory viruses was thought to be unlikely. To simplify testing protocol, ED providers were given a flowsheet on how to approach patients with respiratory symptoms (Fig. 4). By late March, the decision was made to remove flu/RSV testing. The flu/RSV test was set up with a reflex to test for COVID if negative. By late March, the majority of the flu-RSV tests had resulted as negative, while many were reflexively resulting positive for COVID (Fig. 3). It was determined that continuing to test for flu/RSV was a misuse of resources, and it would be best if the step was eliminated from the protocol.

By mid-March the screening criteria for COVID was expanded to include patients with recent travel to Japan and anywhere in western Europe, domestic travel to the cities of Seattle, Boston, San Francisco, Los Angeles, New York City and the surrounding suburbs, or patients that had attended large gatherings such as conferences or sporting events in the past 14 days. This came at a time when the virus continued to spread within the community. In an article published in *The Daily Northwestern* "there were 55 confirmed cases in Evanston. 1865 Illinois residents have tested positive for the virus, and 26 have died as of Thursday (03/26) at 2:30 p.m., according to the state's Coronavirus (COVID-19) Response webpage."²⁹ Despite the virus's rapid

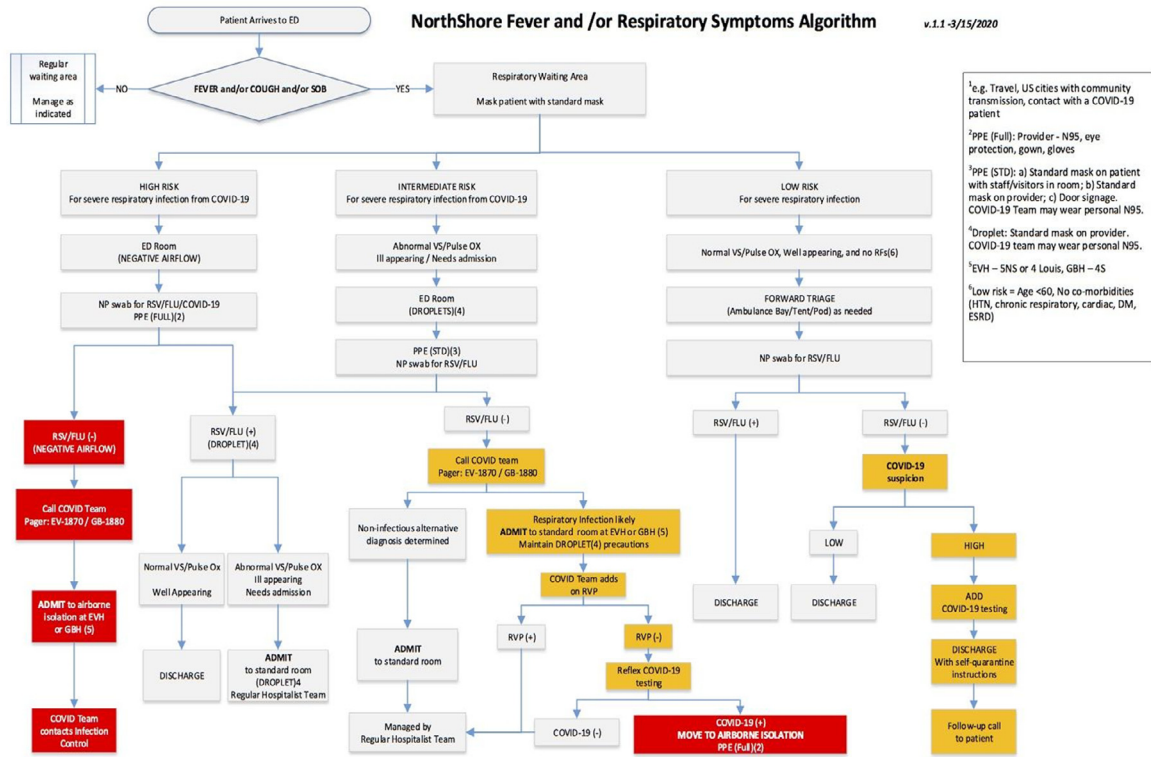


Fig. 4. ED Fever and Respiratory Symptoms Algorithm from 03/15/2020

spread, NorthShore and IDPH worked to match the testing protocol with the demand within the community.

By early April, COVID had spread widely within the NorthShore population, significantly impacting surrounding nursing homes, independent living facilities, and other congregate living arrangements. Eventually, community spread was so prominent and recent national or international travel rarer that history of travel became less emphasized in testing criteria. As NorthShore further increased their ability to perform in-house testing and we learned more about the virus, the threshold for COVID testing continued to be lowered. The testing criteria as of April 11th is listed below:

Cough, shortness of breath, and lower respiratory symptoms
 Unexplained hypoxemia (discordant exam)
 Fever/chills and no alternate diagnosis
 Myalgias
 Anosmia/ageusia
 GI symptoms including N/V/D
 Radiologic findings consistent with COVID (i.e. ground glass interstitial infiltrates)
 Admission from nursing home w/ or w/o known positive cases
 Known positive contact within the past 14 days
 New onset of severe headache
 New onset of labs suspicious for COVID infection: leukopenia, atypical lymphocytes of lymphopenia, thrombocytopenia, and elevated LFTs

Although the screening criteria is much the same as of time of writing in early June, it continues to expand as more discoveries are made and findings disseminated across the globe. There seems to be a clear relation between COVID and vascular findings, with a study published on May 21st showing that alveolar capillary microthrombi were 9 times as prevalent in patients with COVID as in patients with influenza.¹ A COVID patient's initial presentation may be a catastrophic vascular event such as a stroke, mandating changes to stroke care that included early COVID screening to protect staff.¹⁶ Another example lies in pediatric populations frequently seen in the ED: the last few months, there have been minimal findings in the young otherwise healthy population, with a death rate of essentially 0% in those ages 0–17 in the Chicago area.⁶² However, as of late May, NorthShore pediatricians have alerted providers of COVID-induced Kawasaki syndrome as well as Multisystem Inflammatory Syndrome in Children.²⁸ Along with COVID toes, limb ischemia, and COVID-induced hepatitis, clinicians are still in the process of discovering the full effects of this virus and the symptoms that align with it.

COVID disposition from the ED

Management of COVID patients from the ED requires complex decision-making and coordination. NorthShore's protocols took advantage of its unique systems-based and multi-hospital set up in its management of COVID patients. Patients that were stable enough to go home were notified of their results via phone call or online medical record portal. Their discharge instructions included strict self-quarantining while waiting the 24 to 48 h for test results but this was only a small inconvenience compared to test turnaround times of up to two weeks in other parts of the United States.

For patients who required inpatient admission, several factors in their presentation were taken into consideration. Need for admission mostly weighed on the patient's vital signs, specifically tachypnea and SpO₂ on room air as well as the need for supplemental oxygen. Providers also took into account radiographic findings, medical history, living situation, and other significant test findings.

Biomarkers for COVID were included in the work up and were used to help predict a positive test or severity of illness including CRP, LDH, hepatic enzymes, and the presence of leukopenia or lymphopenia. For example, a patient with a CRP of greater than 200, a chest x-ray with infiltrates consistent with COVID, and a marginal oxygen saturation were much more likely to be admitted to the hospital than someone without these findings. In addition, these inflammatory

biomarkers were helpful while waiting for the results of a COVID PCR test to assist in inpatient placement.

Determining the disposition of a COVID patient or PUI required a reevaluation of the admission process. Aside from patients that were considered stable enough to be discharged to quarantine at home, NorthShore had to create a protocol for patients too sick to be discharged that utilized the unique systems-based approach to COVID. Two of the four NorthShore hospitals offered a COVID floor and ICU: Evanston and Glenbrook Hospitals. Anyone who was swabbed for COVID was then admitted to a COVID floor or ICU as they awaited the results of their test. Skokie Hospital was no longer admitting patients as pre-pandemic, during its transition to becoming primarily an orthopedic facility. The fourth NorthShore pavilion, Highland Park, was designated as COVID-free and would admit only patients non-concerning for COVID. All COVID rule out cases were transferred to either Glenbrook or Evanston Hospital. With a negative test result, these patients were immediately transferred to a non COVID floor. While initially Glenbrook admitted both COVID and non COVID patients, eventually the hospital was chosen as the COVID only hospital and all other patients were transferred to one of the two other admitting hospitals. Glenbrook's choice to be the main COVID hospital was logical, given the layout of the newer emergency room as it was built with the potential to become completely negative pressure. This made it easier for the ICU to overflow into the ED rooms at Glenbrook as they reached capacity in the inpatient areas. Therefore, the majority of the ICU patients were transferred to Glenbrook for admission.

By the end of March an inpatient COVID hospitalist team was formed to determine which patients being admitted required testing and to manage the COVID rule-out and known positive patients on the inpatient side. With this new team, the ED physician or APP discussed the patient with the COVID hospitalist first and the need for testing. Once the hospitalist agreed to admit the patient, the ED provider could place the order for the COVID test and the patient would be admitted to the COVID team either at Evanston or Glenbrook.

The COVID hospitalist served an important role when placing patients in the appropriate setting was more important than ever. ED providers worked in collaboration with the hospitalist to determine which patients needed to be tested for COVID. It was the physician's responsibility to protect both the inpatient population and the patient to be admitted from unnecessary exposure in the interim before the results of the COVID test were known. Ultimately, they were the ones who made the testing and admission decisions. For example, consider the admission of an elderly patient with a history of COPD, lung cancer and new respiratory symptoms. Admission to a unit with COVID positive patients puts that patient at risk for infection but admission to a general med surg floor can risk exposure of other patients if he does have COVID. It was important to have a team in charge of determining what was best for the patient under review, other patients in the hospital, and the staff caring for them. As the rapid antigen test becomes more accessible the admission process will continue to change.

Rapid antigen swab

On May 8th, the Food and Drug Administration granted Emergency Use Authorization to the nation's first antigen test, the Sofia SARS Antigen FIA.²⁴ NorthShore's utilization of the Cepheid Xpert Xpress rapid antigen test, made it possible to know if a patient is COVID positive in a matter of 30 min as opposed to the 8 to 24 h it would take with the regular COVID PCR test.¹¹

The addition of the antigen rapid COVID swab changed the admission process further by making it easier to rule out COVID in patients where the diagnosis was unclear or wasn't the primary admission diagnosis. This was for patients that had not had a known positive COVID exposure, had a history of living at a congregate living facility with positive cases, or didn't have lab markers or chest x-ray or CT findings consistent with COVID. For patients who had symptoms consistent with possible COVID but the diagnosis was in question, the rapid test was able to provide a direction for admission within an hour.

By late May, hospitals struggled to maintain an adequate supply of the antigen tests. This meant COVID Hospitalists and ED providers had to work together to determine which cases

would benefit the most by using a rapid test. The admission protocol continues to change as NorthShore works to obtain a consistent supply of rapid antigen tests.

The decision to intubate

The COVID pandemic forced the ED to face a troubling dilemma: how to deliver oxygen and respiratory support to a COVID-positive patient or PUI in respiratory distress without placing unnecessary risk to the patient or placing staff at increased risk of exposure.

Decisions to intubate are never taken lightly but factors like the high patient mortality rates of COVID patients once intubated and the potential staff exposure during intubation also were now being taken into consideration.

Additionally, conventional means of oxygen delivery and treatments for respiratory distress such as noninvasive positive pressure ventilation (NPPV) modalities like BIPAP, high flow oxygen devices, and nebulized albuterol treatments became questionably dangerous tactics in a world where transmission was measured by aerosolization, degree of exposure and distance from source.

Reports out of China and Italy, other countries hard hit by coronavirus, were also alarming in the high proportions of health care workers testing positive for coronavirus, presumably due to occupational exposure.^{13,75} The rationale behind early intubation was perceived to be giving the patient necessary ventilator support and also protecting staff from unnecessary airborne and droplet exposure due to the closed nature of the ventilator system.

There has been an evolving understanding of the precise mechanism by which COVID is spread such that we lacked consensus as to whether COVID is a droplet or airborne spread disease.⁵⁹ This is where the term “aerosol generating procedure” gained new weight due to the increased risk of exposure to health care workers within the vicinity of the patient during these events, especially with prior evidence of increased viral particle spread with other viruses like influenza.⁶⁷ These events include: coughing, sneezing, NPPV with poorly fitting masks, nebulized medications via simple mask, bag mask ventilation, CPR prior to intubation, and tracheal suctioning. All of these events could be part of treatment for a severely hypoxic COVID patient.

Early in the pandemic in the US, providers approached the problem of respiratory support based on experiences of other countries hit hard by the pandemic.

Experiences from Italy advised early intubation to provide support for the hypoxic patient in ways that avoided the typical aerosol generating strategies like high flow oxygen and NPPV and to prevent a chaotic emergency intubation that can unnecessarily expose staff.⁴ Early on, we treated COVID like acute respiratory distress syndrome (ARDS) and mechanical ventilation was one of the mainstays of treatment.

This approach was supported by reports from China expressing concern that delayed intubation led to worse outcomes.⁵² Even transfer to another area of the hospital with the potential exposure to staff during transport and the safety of patient and staff during inter-hospital transport become important when considering intubation: can a patient safely be transported to the proper intensive care unit without being intubated first?

Meng et al.⁵² emphasizes “timely, but not premature, intubation” but, early on, we lacked the evidence and experience with COVID to make these decisions. At times, the decision to intubate was clear: hypoxemia, tachypnea, work of breathing, increased fatigue, radiographic findings of severe illness, agitation and altered mental status and rate of clinical deterioration made intubation a necessary intervention.

Yet the knowledge that once a COVID patient is placed on a ventilator, their mortality rate rises significantly also weighed heavily on the decision: many studies quote mortality rates of 50 to 90% after intubation for COVID-related respiratory distress.^{70,61,3}

As one ER/ICU doctor stated in an April interview with the *New York Times*: “You have a disease that you don’t understand, that is very deadly... with patients that are scared and staff that are scared... and on top of that, it does not appear that we have a good treatment strategy other than a ventilator. We are not sure when to put a breathing tube in ... the crux of it is we don’t want to put a breathing tube in to someone who doesn’t need it knowing there’s a 70% chance they will die and we don’t want to not put it in to someone too late.”⁵⁷

Over the months of the epidemic, experience has given medicine a different, if still small-cohort and case-based, understanding of COVID's effects on the lungs and body. Despite continued debate and more updated contributions to the discussion, understanding that COVID affects lungs differently has grown.

The phenomenon of the "happy hypoxemic" puzzled many: many COVID patients were presenting with hypoxia without other markers of respiratory distress such as shortness of breath, tachypnea and fatigue. After intubation, these hypoxic patients weren't displaying the decreased lung compliance of ARDS and instead showed a pure hypoxemia without stiffness or evidence of end organ damage.⁵⁰ Clinicians began to consider other strategies than intubation such as high flow oxygen delivery devices and awake or self proning.

Many providers noted that these hypoxic patients actually did not "tire out" and require dangerous "crash intubations" and instead slowly improved over time. Others noted these patients became more hypoxic without signs of distress but then noted worsening bradycardia and cardiac arrest.⁶⁰ Another physician noted a story of "a patient satting 61% room air with a heart rate of 135, and tachypneic. He was talking and sitting up, signing consent to let us take pictures. We proned him and started high-flow. 2 h later, his sats were in the 90s".⁶⁰

All these stories are anecdotes, stories of a single or small number of patients; medicine is based on large volume, evidence-based strategies. As one ICU doctor summarized for the *New York Times* in April: "Within the last two weeks, what has been unacceptable has become very acceptable. Some of these patients don't need to be intubated. You watch them carefully, you make sure their oxygenation is adequate and they can recover."⁵⁷ As another contributor stated about his experience with COVID in an emergency medicine blog post: "The patient will teach us about the disease, but we have to really listen and watch to see how he responds to treatments".⁶⁰ This is the predicament of changing knowledge and treatment recommendations for intubation and oxygen support over the COVID pandemic.

The intubation process

As a potentially highly transmissible aerosol generating procedure (AGP), the intubation process was reevaluated and standardized in the ED. Close proximity to the patient's airway, necessity of removing the patient's mask to intubate, coughing and vomiting, and patient agitation from hypoxia and respiratory distress are but a few of many potential modes of transmission.⁴ In addition, physicians had to become comfortable with intubating adeptly while wearing bulky PAPR devices and using intubation equipment and barriers that often changed glottic views and required different techniques. In a situation where swift action means limited exposure for the intubator and the staff in the room, it was important that physicians felt comfortable with the new protocols.

Dr. Joanna Davidson organized several in-situ simulation training sessions to help staff get comfortable with new COVID protocols. At each NorthShore ED pavilion, she created simulation scenarios involving both intubation and cardiac arrest of a mannequin substitute for a COVID patient that increased physician, nurse, respiratory therapy, and other ED staff familiarity and comfort. Her work allowed staff to practice unfamiliar tasks, gain muscle memory and facilitate experiential learning and teamwork. Topics included PPE donning and doffing, intubation protocols, communication barriers, and equipment organization. She also sought to standardize protocols across the four ED pavilions as well as identify and remedy knowledge gaps to ensure staff and patient safety.

Intubation protocols were standardized and reviewed for safety of both staff and patient. Intubations were performed in negative pressure rooms with doors closed. All staff in the room wore PPE advised for AGPs: undergloves, PAPR devices covering head and shoulders, gown or bunny suit, overgloves.² The donning and doffing of PPE dictated proper layering to maximize protection.¹⁰ Roles were pared down to essential personnel only in the room to minimize exposure: one intubator, one respiratory therapist to assist and manage the ventilator, and one nurse to administer medications and monitor vital signs during the procedure (Fig. 5). Early on, it was recommended that the most experienced physician intubate to minimize attempts and

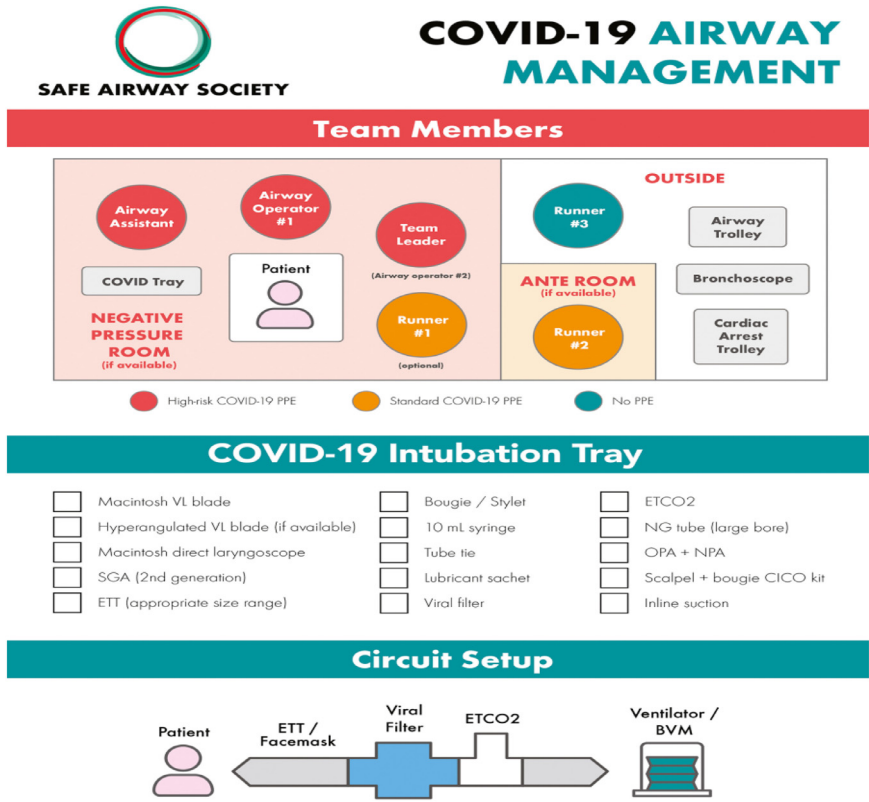


Fig. 5. Safe Airway Society COVID Airway Management.

exposure.² Supply lists were standardized including a specialized COVID intubation tray with equipment and a disposable medication bag with rapid sequence intubation medications. Equipment had to be readily available and in a convenient location in the ER.

The intubation tray was equipped for both video laryngoscopy and also alternative scenarios such as direct laryngoscopy and airway adjuncts like laryngeal mask airways.² As well, the medication bag was securely stored and contained the most commonly used medications for intubation such as sedation for example propofol and etomidate, paralytic agents including succinylcholine and rocuronium and vasopressors. By having all agents in one bag, you can ensure that medications are quickly available in a high stress, time sensitive situation (Fig. 6).

Communication during these procedures inside a closed, negative airflow room was critical not only between staff in the room wearing PPE but also between those in the room and staff outside the room. Over the months that we cared for patients, staff utilized many resources including hands free phones on speaker settings as well as secure chat messaging within our EMR. Even simple communication like hand signals and writing on glass doors with markers helped overcome some barriers and allowed staff to quickly communicate a need for additional supplies or assistance.

The intubation process itself also became more standardized to minimize or eliminate minor aerosolizing steps such as ventilating the patient using a bag valve mask (BVM) or the patient coughing without a surgical mask in place with the intubator or other staff nearby. These recommendations came both from guiding societies' general recommendations and also from shared knowledge in emergency medicine practice during this time.^{2,63} Use of viral filters in line with BVM minimized exposure if bagging was done peri-intubation. Often bagging was not done in favor of passive oxygenation. Disconnection of oxygen delivery circuits was done with knowl-

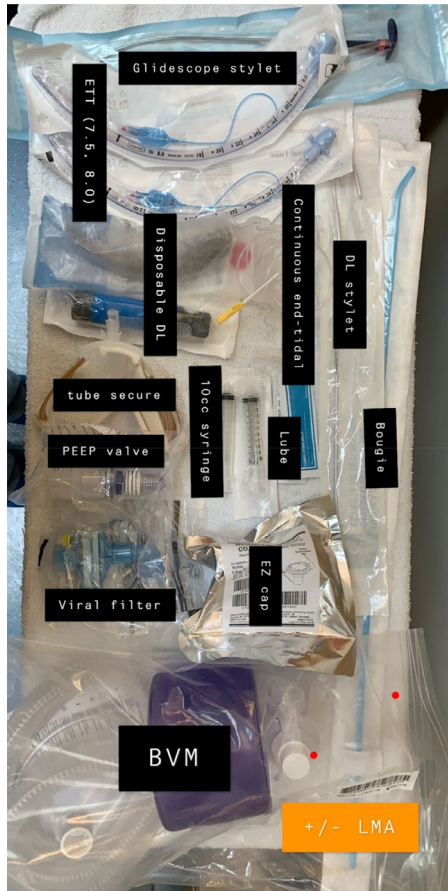


Fig. 6. NorthShore COVID Intubation Tray Set Up

edge of where the viral filter was in the system and using the filter as a protective layer. Even the traditional “C-E” technique of bag valve mask use in BLS training was re-evaluated to emphasize improved mask seal and prevent aerosolization (Fig. 7). Certain groups recommended an alternative vice (V-E) grip to maximize face mask seal and minimize gas leak after induction.⁴ In other cases, preoxygenation was done by passive strategies only such as nasal cannula.

Rapid sequence intubation was preferred using therapeutic doses of longer acting paralytic agents such as rocuronium to prevent coughing and vomiting during intubation as well as prolonged time to start sedative medications to minimize vent intolerance and optimize patient comfort. Even wait times from administration of paralytic medication to intubation pass were advised to be a 60 s window to maximize paralytic medication effects. Videolaryngoscope intubations with indirect visualization using a video screen view (such as CMAC or Glidescope) were preferred over direct visualization to increase the intubator distance from the patient’s face. After placement, inflation of the cuff of the endotracheal tube prior to administering the first ventilated breath via BVM provided a seal to further prevent aerosolization.¹² Viral filters were also applied to ventilator tubing prior to initiating mechanical ventilation.

Other potential situations were considered as part of intubation protocols. Increased oral secretions could be managed by administering atropine prior to intubation due to the risk of aerosolization by oral suctioning. Some physicians elected to use an “aerosol box,” a clear hard plastic box placed around the patient’s face to protect the intubator from aerosolized particles.⁵



Fig. 7. "V-E" grip for BVM. Source: Safe Airway Society.

Every step of an already detailed intubation process was examined for risk. This careful preparation ensured that both patients and staff were kept safe during this life-saving procedure.

Other modes of oxygen delivery

As our experience and understanding of COVID patients increased, our treatment strategies evolved as well. With less early intubation, we pursued oxygen delivery strategies with minimal risk of transmission and staff exposure.

ED physician Dr. Ben Feinzimer researched aerosolization risk and alternative oxygenation strategies and formulated new algorithms for respiratory distress for all 4 ED pavilions. We learned that some previously prohibited strategies were not as risky as previously implied. Simple nasal cannula at 1–6 L per minute with a surgical mask in place supported many patients. When this was not enough support, NorthShore algorithms suggested a non-rebreather (NRB) mask at 15 L be placed over the nasal cannula, also with surgical mask cover over the NRB mask (Fig. 8).

When greater support than a nasal cannula at 6 L was required, we initially were turning to intubation as the next intervention given the need to avoid aerosolizing forces of NPPV such as BIPAP. Over time and learning lessons from the pandemic over the past few months, we began utilizing other forms of oxygen delivery such as the Heated High Flow Nasal Cannula (HHFNC). If not already in a negative pressure room, these patients were moved and HHFNC therapy was initiated. This device has larger bore nasal prongs and tubing that delivers high-velocity nasal insufflation that flushes the anatomical dead space of the upper airway, thereby creating a fresh, oxygenated, CO₂-depleted gas reservoir that facilitates both oxygenation and ventilation.⁷¹ Titrations of the device involve both liter flow rate (40 to 60 liters per minute) and fraction of inspired oxygen (FiO₂) management.

By flushing the upper airway of carbon dioxide-filled expiratory gasses and replacing it with warmed, humidified, highly concentrated oxygen, the HHFNC can noninvasively support a hypoxic and hypercarbic patient. The device can also assist with work of breathing by providing positive end expiratory pressure to maintain alveolar and airway opening. A patient who continues to have tachypnea and increased work of breathing despite conventional nasal cannula or NRB oxygen delivery often experienced decreased work of breathing after transitioning to HHFNC. Small studies using HHFNC showed decreased mortality and intubation rates.⁷²

The device also protects against mucosal damage to the upper nasopharyngeal space by warming and humidifying gas even at high oxygen concentrations. The combination of positive pressure and high concentration of inspired oxygen means that it offers more support than the conventional nasal cannula. Studies have found that it is noninferior to NPPV.¹⁸ In addition, HHFNC is often better tolerated than NPPV by the patient as they can talk, drink and eat while

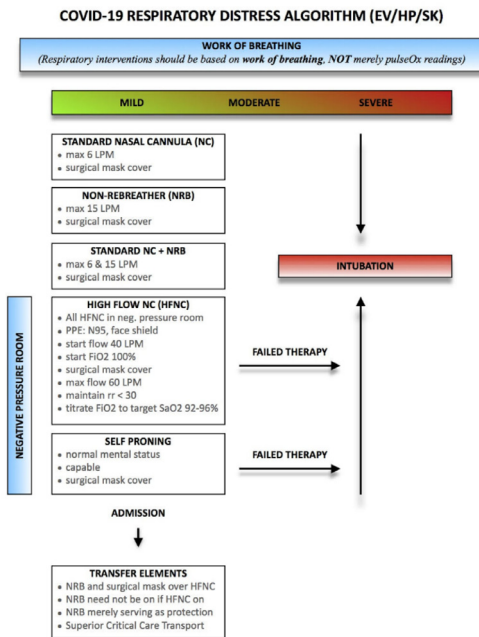


Fig. 8. NorthShore COVID-19 Respiratory Distress Algorithm.

wearing the cannula which cannot be done easily with NPPV. This becomes especially important when you're anticipating days to weeks of oxygen support while the patient recovers.

Lastly, early expert opinion that questioned the aerosolization of these modalities such as HHFNC and NPPV and associated exposure of staff has been found to not be as significant as initially thought. Modifications were made to NPPV devices like BIPAP to ensure good interface fitting and tubing that does not create widespread dispersion of exhaled air⁷³. Several studies show that droplet dispersion rates are actually much lower than initially feared and the addition of a surgical mask over the oxygen device also minimizes viral spread.^{33,47} Concern about CO2 trapping behind the mask worn on the patient's face can be significantly offset by increasing the amount of gas liter flow of the HHFNC to increase CO2 washout as well as continuous CO2 monitoring. NPPV like BIPAP has gained greater acceptance in treatment of hypoxia in COVID patients.

Oxygen saturation

Oxygen saturation goals have also been debated over the last few months. With the goal of end organ damage in mind, many "happy hypoxemic" patients confounded typical measures of end organ perfusion.

New strategies of targeting SpO2 goals of >80% with careful monitoring of other measures of respiratory distress such as work of breathing, fatigue, and altered mental status have been successfully utilized both in the emergency room and in the inpatient setting. Clinical trajectory was also an important measure of level of intervention: a patient with a rapidly increasing oxygen requirement over the hours they were monitored in the ED often required more interventions including intubation over a patient with a stable oxygen requirement. Tobin⁶⁸ points out the complexity of assessing respiratory status, noting that an increased respiratory rate does not in itself indicate distress; instead, respiratory muscle use, sensation of air hunger, or fatigue can be more accurate measures (p. 1319).

He also points out that hypoxia does not equate to end organ damage: evidence of end-organ damage is difficult to demonstrate in patients with PaO2 above 40 mm Hg (equivalent to

oxygen saturation of 75%) in patients with adequate oxygen carrying capacity and cardiac output (p. 1320). This more detailed understanding allows emergency medicine clinicians to avoid knee jerk responses to hypoxia without taking into consideration other measures of respiratory status.

Prone positioning

Another strategy to improve oxygenation in these patients included use of prone positioning to improve oxygenation. Previous studies have shown prone positioning in severe ARDS intubated patients improved oxygenation but had not been recommended in mild to moderate disease and in non-intubated patients.⁵⁶ One small study of early prone positioning combined with HHFNC or NPPV in ARDS (not COVID positive) patients showed improvement in oxygenation which was hypothesized to help avoid intubation.¹⁷ Prone positioning decreases lung compression by displacing the weight of the heart and mediastinum off the lungs, allowing for greater aeration. It also supports more homogenous ventilation as evidenced by more homogenous distribution of transpulmonary pressures in the ventral-to-dorsal axis.²⁷ This theoretically can improve VQ mismatch and alveolar recruitment.

Contrary to prone positioning in an intubated patient, self or awake proning of a non-intubated patient requires less staff and less risk as long as the patient is cooperative, protecting their airway, and keeping the surgical mask in place. This may also mobilize secretions and allow for greater airway clearance. Some expert opinion even notes shifting of position from side to side rather than proning can make a difference in oxygenation, yet all of these suggestions are purely anecdotal.²² When we are practicing at the bleeding edge of a viral pandemic that didn't exist 6 months ago, practitioners are often forced to work with less than robust data sets.

Infection prevention and environmental services in ED

Infection prevention and control are cornerstones to a pandemic response. COVID dramatically changed the nature of infection prevention and control both within the hospital setting as well as in the community. Testing delays meant PUI-related care required precious and at times scarce PPE just as much as confirmed positive patient care. As well, room turnover and equipment use related to COVID had to be carefully considered in order to balance urgent need with safety and minimal exposure. This was important not only to support staff trust and feelings of safety but also to guarantee safety to our patients as well.

Efficient treatment room turnover in the ED even during non-COVID times is paramount to smooth ED throughput. With COVID, many questions arose regarding this workflow and how to protect not only direct care staff and the next patient using the room but also the environmental services staff tasked with cleaning the room. CDC guidance about when to enter a room after the patient has vacated takes into account ventilated air exchanges to remove potentially infectious particles, also known as air changes per hour (ACHs).^{7,76} NorthShore was in line with these national recommendations as increased inpatient volume has stressed workflows in areas with direct COVID patient care. ACHs and room type (standard versus negative airflow room) were evaluated and Environmental Services protocols followed the time recommendation for the number of ACH's required to ensure 99.9% removal of potentially infectious particles in that room. In a standard ED patient room, this was 70 min; in an airborne isolation room with negative airflow, this wait time to enter and clean was reduced to 35 min due to the increased rate of ACHs. While this slowed room turnover, it assured that patients and staff were protected from viral transmission.

As well, these protocols were applied to common areas such as radiology. These protocols became particularly important when considering areas like CT scanners which must be available at a moment's notice for trauma or stroke patients. A CT scanner goes "out of commission" for several hours after scanning a COVID positive patient due to the cleaning process of equipment and room. This can be disastrous for a critically ill patient presenting with massive trauma

or stroke. Our radiology technologists worked tirelessly to ensure adherence to these infection control guidelines while also preserving as efficient workflow as possible.

Measures to limit movement of patients through the hospital were also adopted. Two view PA and lateral chest x-rays were deferred in favor of portable AP chest x-rays that could be done in the patients' rooms.⁴¹ In addition, NorthShore's radiology technologists utilized innovative techniques to limit PPE use and staff exposure: the portable x-ray unit was placed outside the patient room with the tube directed through the glass of the isolation room window. The AP chest x-ray that is shot through the glass is of diagnostic quality. As part of modifications to workflows developed during the 2014 Ebola outbreak, the University of Washington showed that this can be done through wire-reinforced glass, through opened metal venetian-style blinds, and even 10 to 15 feet away from the patient across an isolation antechamber room into an isolation room.⁵⁴ The patient is placed upright in the bed or in a wheelchair and a staff member (often a PPE-clad nurse) in the room places the double-bagged x-ray cassette behind the patient just prior to the x-ray. After the x-ray is done, the only equipment decontamination required is the cassette. Using this technique, PPE is reduced, less equipment decontamination is required and staff exposure is reduced.

Physicians and staff in the ED sought to minimize exposure without compromising patient care. Providers used cell phones and iPads to update patients and clarify treatment plans and also minimize the number of times the provider entered the room. In return, patients appreciated the ease of communication.

Use and management of the physical space of the ED

By early March, NorthShore anticipated that many areas of its healthcare system would be stressed by the pandemic. NorthShore worked both with state and national authorities to analyze data and trends to best anticipate needs of the community. It was anticipated early on that screening and testing would be an integral part of the services we could provide the community. This could include any patient from a "walking well" who had mild symptoms or a history of exposure or travel to a critically ill and hypoxic patient. NorthShore had to be prepared to handle extremely high volume and variety, triaging effectively and moving patients through spaces that kept them safe but also served their needs.

Early on, discussions on how to convert spaces to isolate, evaluate, and test "walking well" populations centered on providing excellent care isolated from other patients in the department. Two hospitals, Evanston and Northbrook, began building out areas in the ambulance bay to create a space distant from the main ED rooms but convenient for staff to operate. While the space was being built, well-appearing patients with stable vital signs were evaluated by staff in a tent adjacent to the Evanston ED to best isolate potential COVID positive patients. Within weeks, this quickly expanded to a physical space encompassing the entire ambulance bay at Evanston Hospital that could manage dozens of patients at once. Patients were socially distanced in both triage and evaluation areas of this part of the COVID bay. The area included computers, phone lines, portable bathrooms, even an area for chest x-rays. Data analytics was crucial at this time, often working to analyze how well these patients appeared and what level of care required: testing, interventions, hospital admission versus discharge home from ED, etc.

Using this data, NorthShore was able to see that most of the patients tested were well enough to go home with strict isolation protocols and that only a small percentage required further evaluation or hospital admission. APP's were extremely helpful in the triage of these patients in this COVID tent space. Adequate staffing of these areas often required additional staff and many APP's from other areas of the hospital system stepped in to help. The decrease in surgeries and outpatient visits allowed NorthShore to increase resources in areas stressed by the pandemic such as the ED. These APP's were quickly trained to work in areas directly treating COVID patients including triage, evaluation, and testing. An APP could evaluate a patient presenting to the COVID bay for COVID testing and help determine whether further evaluation was needed: for example, a patient complaining of shortness of breath and fevers but also reporting leg swelling would need more resources than the test space could provide. For those patients

requiring further evaluation in the ED, transfer into a negative airflow room in the main area using proper PPE and isolation protocols was done.

Despite the constant possibility of a patient needing more testing and intervention than the COVID bay could provide, the majority of the patients seen in this area were well served by the dedicated resources and testing done there. These patients were triaged, tested and educated on self-quarantine measures and symptoms to seek medical care prior to discharge from the ED. So much so that the decision has been made at this time to keep these areas open and prepared for other potential surges in cases later this year.

The immediate cares of NorthShore

The Immediate Cares (IC) of NorthShore were integral to NorthShore's COVID response and one of the most heavily utilized resources for COVID testing in the community. The Immediate Cares were re-designed to accommodate large volumes of mildly ill patients with symptoms of COVID. A combination of an online COVID portal for triaging patient complaints, nurse phone lines, telehealth visits, drive thru testing, and designated Immediate Care testing sites enabled the NorthShore system to meet the needs of the community while also ensuring that other areas of the system, such as the emergency department or primary care offices were not overwhelmed. Their efforts were an incredible success at triaging and addressing these populations who were able to manage their COVID illness in an outpatient setting or at home.

Early on, certain IC's were chosen to be dedicated COVID testing centers. These sites were chosen both for their location in the community as well as their physical separation from clinical areas seeing non infected patients such as primary care offices. Many of these sites took over adjoining family and internal medicine offices to increase the quantity of treatment rooms given the necessary time it took to turn over rooms related to ventilation and cleaning protocols similar to inpatient environmental services protocols. Through these modifications, a 4-room immediate care setting very quickly became a 25-room COVID-focused testing center. With these modifications, one IC location saw and tested up to 200 patients daily in its busiest weeks.

By dedicating staff and space to COVID testing, IC staff quickly became proficient in PPE protocols and testing. Fewer IC staff across the system were exposed to COVID given the efforts to triage patients and direct them to designated testing centers. This contributed to their extremely low COVID testing positivity rates among staff. With less staffing hours lost to illness and greater staff comfort and confidence in COVID management, patients also received the best quality care. Of course, the occasional walk-in patient with COVID-like symptoms was seen in an IC outside these four dedicated IC's, but even these scenarios were tightly protocolized. These scenarios included instructions to patients directing them to one of the designated IC testing sites or immediate rooming of patients to minimize time the patient is in a common waiting area, use of telephones in room to complete registration by staff outside the room, and use of proper PPE to protect staff at that site.

One of the many striking aspects of IC triage algorithms is the acknowledgement of the early period of COVID illness when PCR testing was more likely to yield false negative results. These algorithms advise a "watch and wait" approach if a patient is in the first three days of symptoms and managing their symptoms safely. Similar approaches were also applied to patients presenting without symptoms but with positive exposures. Studies have shown a high false negative rate if a patient is tested too early due to a variety of factors.⁴⁵ This results in missed diagnosis, false reassurance given to patients, in appropriate discontinuation of self-isolation protocols, and waste of valuable COVID testing swabs.

Similarly, clinically severe or worsening conditions were addressed effectively. Red flag symptoms such as fevers combined with shortness of breath, resting or ambulatory hypoxia or chest pain had much different workflows than an asymptomatic patient with concern for exposure. The good working relationship between the IC's and ED's of NorthShore facilitated seamless communication about the patient's condition and work up thus far: patients forwarded to the ED could be addressed promptly. The goal of medical workflows is to get the patient the most appropriate care by the most expeditious route possible: the IC was an excellent example of

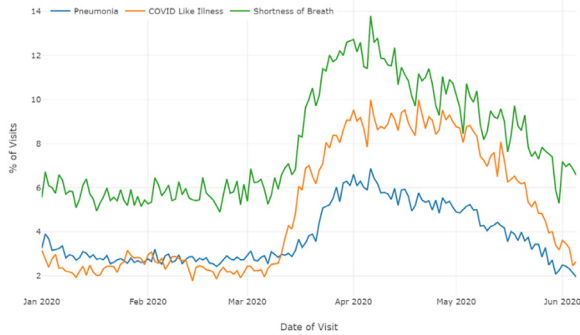


Fig. 9. IDPH COVID-19 Syndromic Surveillance Daily Percentage of Emergency Department Visits. Source: Source: <https://www.dph.illinois.gov/covid19/syndromic-surveillance> on June 21, 2020.

this effort. Based on the presence or absence of symptoms, duration of symptoms, and history of comorbidity or pregnancy, a patient could be adeptly directed to monitor symptoms at home with close follow up, towards drive thru testing with minimal exposure of all parties, or to an IC visit, an OB visit if pregnant, or the ED.

Conclusion

As of early June, there are over 7 million documented cases of COVID worldwide. Approximately 2 million of those were diagnosed within the United States, which far outweighs the amount of cases in any other country in the world. Illinois continues to rank high among all states for COVID cases, with nearly 130,000 positive cases so far.¹⁴ Daily positive cases continue to oscillate in frequency over the past few weeks but the general trend has been a decline since early May. Illinois has begun the process of 'Phase Three' of reopening Chicago and the state, which includes the opening of non-essential businesses like restaurants (outdoor dining only), personal services (barbershops and salons), and retail.¹⁵ Throughout this process, health officials continue to stress the importance of hand hygiene, mask use, and social distancing to prevent the occurrence of a surge in cases. The number of positive cases within the NorthShore system nears 8720 patients with nearly a 24% positive rate of the total 36,347 tested.⁷⁷ As part of the reopening plan, NorthShore has begun to reinstate certain outpatient/non-emergent services.

Emergency department visits within Illinois for shortness of breath, COVID-like illness, and pneumonia continue to decline daily⁴⁰. This figure has been compiled from Illinois' Syndromic Surveillance System and shows a decreasing percentage of visits to the emergency department for a chief complaint of pneumonia, COVID-like illness, or shortness of breath (Fig. 9). NorthShore's own ED census decreased over the early months of the pandemic, mirroring national trends in emergency rooms. As the state has started reopening, emergency department volumes for non-COVID complaints as a whole have begun to steadily climb as tensions abate.

Immediate Care Clinics continue to be a vital component of the ongoing battle with COVID, with nearly 25,500 COVID SuperSite ICC visits and 6900 drive thru visits to date. They continue to utilize their APPs to triage patients, complete telehealth visits, and see patients in the clinic. As we move further into the summer, ICCs will reevaluate the distribution of resources and continue to adjust to demand.

NorthShore is processing thousands of RT-PCR tests a day, accommodating testing for several other non-NorthShore affiliated clinics and hospitals. NorthShore continues to follow a similar testing criteria as what was established in April, but have begun to expand testing to asymptomatic individuals with positive exposure, pre-surgical candidates, and labor and delivery. The hospital system continues to struggle with achieving reliable supply of rapid antigen tests. As NorthShore is able to secure a steady supply, the admission protocol is likely to evolve once again.

PPE supply continues to remain adequate in most areas of the country as many companies have ramped up PPE production. ED personnel continue to wear full PPE for every PUI and confirmed positive, although the number of these encounters have steadily decreased in frequency. We continue to use hospital-provided scrubs every day, wear a surgical mask through our entire shift, and pass through temperature and symptom screening every day. We continue to participate in bi-weekly ED COVID conferences and weekly NorthShore COVID physician updates.

Although the number of patients requiring this isolation has significantly decreased, the tents remain open in anticipation of another possible surge. As Chicago moves into subsequent phases of reopening, it's impossible to know if cases will spike. In the meantime, the tents stay open to accept stable patients that present for testing. In addition, NorthShore services like SNF COVID Swab teams continue to operate in congregate living facilities to evaluate and test symptomatic patients. As well, outpatient areas like primary care offices continue to do what they can to support their patients and keep them out of the emergency room and the hospital. Physicians, APP's, nurses, and office staff have triaged countless phone calls, telemedicine messages, and in person visits to keep patients as healthy and able as possible.

NorthShore continues to adjust screening criteria, admission protocols, and staffing as we learn more about the virus and attempt to prepare. However, changes are happening at a rapid rate and it's difficult to predict what the future will bring. As we move into the summer months, there are many factors that will affect transmission with the possibility of warmer weather making a difference. A study out of Mount Auburn Hospital found that, "while the rate of virus transmission may slow down as the maximum daily temperature rises to around 50° (F), the effects of temperature rise beyond that don't seem to be significant." This indicates that it is unlikely that disease transmission will slow dramatically in the summer months from the increase in temperature alone.⁵⁵ The study also found that the transmission rate is highest in months where the temperature is below thirty degrees Fahrenheit, meaning the rate of positive COVID cases will most likely increase as we move back into fall and winter. This will coincide with increased rates of several other respiratory viruses, including influenza and RSV, and we will need to consider to possibility of co-infection.⁷⁴ This challenge will allow us to reconsider how we approach triage and testing for respiratory complaints.

In the meantime, NorthShore has started to provide 'COVID Kits' to positive patients that are able to remain at home or those that have been discharged after admission. This kit includes masks, hand sanitizer, gloves, and most importantly—a pulse oximeter. Patients are given the ability to monitor their oxygen levels at home. This will help catch the "happy hypoxic" patients who have low oxygen saturation but don't feel short of breath enough to present to the ED themselves. Catching these patients early would theoretically prevent patients from presenting to the ED when their pulse oximeter is dangerously low with significant respiratory distress. The positive patients are followed by a designated outpatient team until their infection has cleared. This is an indispensable resource to those that don't have a primary care doctor to turn to when questions arise.

With resources like antibody testing coming into play, we question when we will be able to achieve herd immunity to COVID. As of late May, only a small portion of the population has built up antibodies to the virus. Antibody testing has given us the ability to detect a history of the virus in those that may have been asymptomatic. In the area hit hardest by the pandemic within the United States, New York City, only 19.9% of the population has positive antibody status. In order to achieve herd immunity, it is necessary that 70 percent of the population show positive antibody status. "This implies that over 200 million Americans would have to get infected to reach this threshold. Even if the current pace of the COVID pandemic continues in the United States – with over 25,000 confirmed cases a day – it will be well into 2021 before we reach herd immunity. If current daily death rates continue, over half a million Americans would be dead from COVID by that time".¹⁹ Attaining significant herd immunity would play a huge role in slowing down transmission rates. The majority of the Chicago area population remains susceptible to the virus, but according to the data collected by NorthShore's team, around 5.17% of the NorthShore population has positive antibody status. This is a far cry from the 70% neces-

sary for herd immunity, but immunity status can perhaps be improved with the availability of an effective vaccination.

We continue to learn more about the virus as we search for ways to slow its spread and effectively treat its complications. Many of the changes already made are likely here to stay, but the circumstances will almost certainly evolve as we navigate 2020 and another respiratory virus season. This article sought to describe one ED's response to the pandemic, given changing understanding of both the disease, its spread, and its complications. We understand that our experience is different from other ED's nationally and internationally in staffing, utilization of APP's, social demographics, and resources. We believe that knowledge sharing is key to effective action and hope that this article is both informative and interesting. As we move forward, we approach reopening with caution and reiterate the importance of safe social distancing and mask usage. NorthShore's ED team remains vigilant and prepared to take on whatever the future may bring.

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