A Retrospective Review of COVID-19 Testing and Mitigation Strategies at Western Psychiatric Hospital and Subsequent COVID-19 Acquisition

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ABSTRACT

Background: Since the outset of the COVID-19 pandemic, certain medical conditions and healthcare settings were shown to be associated with an increased risk of severe illness from COVID-19. Much of the guidance provided by governmental organizations is specifically for congregate settings with no mention of behavioral health settings that serve similarly at-risk populations. Additionally, people with Severe Mental Illness (SMI) have higher rates of many of the risk factors for severe illness, in addition to having increased odds for poor health outcomes in general. Special considerations for this group should be made when developing mitigation strategies designed to prevent transmission of COVID-19.

Aims: To review the COVID-19 mitigation and testing strategies of University of Pittsburgh Medical Center Western Psychiatric Hospital (UPMC WPH) in Pennsylvania with patient outcomes from July 2020 to February 2021.

Methods: A quality improvement study with deidentified patient data from WPH and demographic information obtained from the Wolff Center at UPMC.

Results: During the study period, there were 3,694 total discharges and 3,229 unique patients at WPH. WPH cared for 86 (2.7%) patients who had a positive SARS-CoV-2 polymerase chain reaction (PCR) test results, up to 29 (33.7%) of which were determined to have potentially acquired the infection at WPH. A majority of the WPH acquired positive test results did not have a known index case (22/29, 75.9%). As for non-WPH acquired infection, the testing strategy identified 8 asymptomatic positive cases before they were admitted (8/86, 9.3%). Demographic characteristics and medical risk factors were all similar proportions in both the unique patient and positive test group, however, there was a higher proportion of people with schizophrenia spectrum disorders in the positive test group (12.8%) compared to the unique patient group (8.8%).

Conclusion: The testing and mitigation strategies at WPH had successes and gaps that were identified through this review. This review supports the need to tailor safeguards against infectious disease specifically to the populations being served and has strong public health relevance as it can be applied to any healthcare setting, better protecting patients from disease and ultimately improving quality of care and outcomes.

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1.0 INTRODUCTION

1.1 COVID-19

1.1.1 Brief Timeline

In late December 2019, reports of "pneumonia of unknown cause" were coming out of Wuhan, China ("Timeline of WHO's response to COVID-19," 2020). Sequencing of bronchial epithelial cells from patients in the original cluster of 27 pneumonia cases revealed the cause to be a novel coronavirus, then named 2019-nCoV (N. Zhu et al., 2020). It is now known as severe acute respiratory syndrome coronavirus 2, or SARS-CoV-2 and is the agent responsible for Coronavirus Disease 2019 (COVID-19). On March 11, 2020 the World Health Organization (WHO) officially characterized COVID-19 as a pandemic after spreading rapidly to 114 countries with over 118,000 cases reported (Adhanom Ghebreyesus, 2020).

The timeline of COVID-19 in the United States is somewhat less clear. At the time, it was understood that the first case was a recent traveler to Wuhan, China in Washington state who had presented with dry cough, nausea, and vomiting, and was confirmed to have COVID-19 via laboratory testing on January 20, 2020 (Holshue et al., 2020). Retrospective testing of serum from blood donations taken between December 2019 and January 2020 for anti-SARS-CoV-2 antibodies revealed that some samples from California, Washington, and Oregon contained antibodies as early as December 13, 2019 (Basavaraju et al., 2020). Due to the nature of antibody testing, none of the positive samples guarantee a prior COVID-19 infection, but further analysis of the samples using a highly specific assay analyzing binding units of the SARS-CoV-2 spike protein indicate that at least some of the donors had active or past COVID-19 infections. At the time, asymptomatic carriage of COVID-19 was not well understood, but retrospectively looking at samples allows for a more complete picture of what was happening in the United States during the early days of the pandemic.

As more cases were reported the federal government of the United States took actions such as travel restrictions from countries with increasing numbers of cases, screenings at select airports, development of COVID-19 tests, and approval of Federal Emergency Management Agency requests from states (Department of Defense, 2021; Holshue et al., 2020) Additionally, some states chose to take further action, including shutting down portions of the economy that were deemed nonessential and issuing mask mandates and social distancing guidelines. In the early period of the pandemic, scarcity of testing supplies made it difficult to clinically confirm cases and conduct contact tracing. Throughout 2020, the United States experienced multiple surges of COVID-19, with the timing and severity of these surges differing between individual states. The December 11th and 18th Emergency Use Authorization (EUA) of the two-dose Pfizer and Moderna COVID-19 vaccines was an important declining cases and hospitalizations.

1.1.2 SARS-CoV-2 Origin and Natural History of COVID-19

Many patients that were part of the initial cluster of 27 pneumonia cases in Wuhan, China had been to the Huanan Seafood Wholesale Market (B. Hu, Guo, Zhou, & Shi, 2020). This prompted suspicion that zoonotic transmission was responsible for the emergence of SARS-CoV-2 in humans. Genetic sequencing of SARS-CoV-2 revealed greater than 90% similarity in multiple *Rhinolophus* genus bat coronaviruses and one pangolin coronavirus, but scientists have yet to confirm an intermediate host (B. Hu et al., 2020). Bats were initially implicated due to their role as an animal reservoir in previous coronavirus epidemics, but also their host status to a litany of other viruses, due in part to unique ecological and biological traits (Calisher, Childs, Field, Holmes, & Schountz, 2006; Irving, Ahn, Goh, Anderson, & Wang, 2021). Civet cats and dromedary camels were also briefly considered because of their roles as intermediate hosts responsible for transmission in humans for SARS and MERS respectively (El-Sayed & Kamel, 2021).

Further study of SARS-CoV-2 also revealed a similar mechanism of action to SARS-CoV, both using spike proteins to bind to the angiotensin-converting enzyme 2 (ACE2) receptor in epithelial cells in the respiratory tract (B. Hu et al., 2020). Slight differences in the amino acid structure of the receptor binding domain of SARS-CoV-2 spike protein have provided insight into how it is more efficiently interacting with ACE2 receptors (Yan et al., 2020). After successfully binding to ACE2 receptors, SARS-CoV-2 begins the replication process. The virus is successful at evading the body's natural defenses due to a viral protein that blocks the activation of type I interferons—important regulators in the immune system (Konno et al., 2020). The alterations of amino acids in the spike protein and proteins expressed are explanations for the increased transmissibility of SARS-CoV-2 and play important roles in the clinical manifestation.

After exposure to SARS-CoV-2, the incubation period in nearly all people was observed to be between 2 and 14 days, with an average between 5 and 6 days before symptom onset (Backer, Klinkenberg, & Wallinga, 2020; Q. Li et al., 2020). Not all infected patients present with symptoms, but those that do most commonly experience a dry cough, fever, shortness of breath, or lethargy (Guan et al., 2020; Ortiz-Prado et al., 2020), and less frequently gastrointestinal illness (Ortiz-Prado et al., 2020). Loss of smell and taste is a symptom that was not identified in some of the early literature on clinical manifestations, but eventually was recognized as a characteristic sign of COVID-19 (Spinato et al., 2020). Further, some studies found that those experiencing loss of smell or taste had more favorable prognoses than those experiencing other symptoms (Aziz et al., n.d.).

The severity of COVID-19 is dependent on a variety of risk factors that will be discussed further in subsequent sections. It is estimated that between 40% and 50% of people infected with SARS-CoV-2 are clinically asymptomatic (Oran & Topol, 2020). Those who do present with mild symptoms typically recover within 2 weeks. (Ortiz-Prado et al., 2020). Even after recovery, some patients will develop Long COVID, where they experience prolonged symptoms for more than four weeks after the initial infection (The Centers for Disease Control and Prevention, 2021a). Multisystem Inflammatory Syndrome in Children (MIS-C) and adults (MIS-A) is a rare complication succeeding the initial infection that causes inflammation in various organs and tissues (Mayo Clinic, 2021). Long COVID and MIS-C/A have been linked to excessive mast cell activation and upregulation of inflammatory cytokines (Brodsky, Ramaswamy, & Lucas, 2020; J. Li, Liu, Yin, Li, & Wang, 2021).

COVID-19 pneumonia is common in both those with mild or more severe illness and can lead to Acute Respiratory Distress Syndrome (ARDS) as a complication from the patient's immune response rather than a symptom of the disease itself. Of patients that were hospitalized, approximately 29% of patients developed ARDS with 2% to 20% requiring mechanical ventilation (Singh et al., 2021). The decreased signaling of type-I interferons during the initial stage of infection can later results in increased levels of certain cytokines, triggering a cytokine storm that stimulates an uncontrolled immune response that can cause multi-organ failure and ultimately death (Gautret et al., 2020). The cytokine storm phase has been shown to occur approximately 8 days post symptom onset (D. Wang et al., 2020). The immune and vascular response triggered by the cytokine storm also increases clotting factors in the blood and can lead to pulmonary embolisms and deep vein thrombosis in some patients (Zuo et al., 2020). Symptoms can vary drastically from person to person, but certain pre-existing conditions and even demographic factors can make it more likely for someone to experience severe disease.

1.1.3 Medical Risk Factors for Severe COVID-19

Early studies out of China at the onset of the pandemic indicated that there were characteristics that might make it more likely for a person to become severely ill with COVID-19 and require hospitalization. The earliest known risk factor was age, and the first 26 deaths attributed to COVID-19 were all over 50 years old and some had other comorbidities (Gralinski & Menachery, 2020). Data looking at trends in the United States have confirmed this, with 80% of COVID-19 deaths and 45% of hospitalizations occurring in people greater than 65 years of age, while only accounting for 31% of cases (CDC COVID-19 Response Team, 2020). Age continues to be the risk factor associated with the most severe outcomes of COVID-19 and one of the reasons that many mitigation efforts focused on long-term care facilities (LTCFs).

There are other comorbidities that have shown association with risk of severe COVID-19, and the CDC has separated the risk factors into categories based on the amount and type of available literature to support its inclusion on their list. Comorbidities with significant association supported by meta-analysis and systematic review are cancer, cerebrovascular disease, chronic kidney disease, chronic obstructive pulmonary disease (COPD), Diabetes Type 1 and 2, obesity, heart conditions, pregnancy, and smoking. The second category is comorbidities that have shown increased risk for severe outcomes in observational studies, they are: children with certain underlying conditions, Down syndrome, Human Immunodeficiency Virus (HIV) infection, neurologic conditions, overweight, lung disease, sickle cell disease, transplant status (solid and stem cell), substance use, and use of corticosteroids or immunosuppressants. The third category is comorbidities supported only by case series or case reports, and they are Cystic Fibrosis and thalassemia. The CDC's final category of risk is comorbidities that have mixed evidence, some studies have shown increased risk while others found no association, those conditions are asthma, hypertension, immune deficiencies, and liver disease. A study looking at all hospitalizations in the United States from April to May 2020 found 79.7% patients who died had hypertension (Rosenthal, Cao, Gundrum, Sianis, & Safo, 2020), however, hypertension is a common pre-existing condition in many older adults and has not exhibited clear evidence that it is an independent risk factor (Savoia, Volpe, & Kreutz, 2021).

1.1.4 Psychiatric Risk Factors for Severe COVID-19

There is extensive literature to support the risks associated with medical comorbidities and COVID-19, but far less evidence regarding psychiatric risk factors. Intellectual disabilities in particular have been shown to be the independent risk factor aside from age with the strongest associations with contracting COVID-19, intensive care unit admission, and death (Gleason et al., 2021). A study comparing COVID-19 outcomes for those with intellectual disabilities in residential group homes and the general population of New York state confirmed those findings. Case rates for those with intellectual disabilities were 7,841 per 100,000, compared to 1,910 per 100,000 in the general population, with a case fatality rate of 15% and 7.9% respectively (Landes, Turk, Formica, McDonald, & Stevens, 2020). Though reporting out of residential care facilities was not consistent, this information provides evidence that additional considerations should be given to mitigation strategies for these populations.

There are not many studies looking at associations between behavioral diagnoses and COVID-19. A nationwide cohort study conducted in South Korea compared people with mental illnesses as characterized by the International Classification of Diseases (ICD) 10 and those without. The researchers found that those with mental illness did not have increased risk for testing positive for COVID-19, but there was a slightly increased risk for severe illness (Lee et al., 2020). A study in the United States found that those with attention deficit hyperactivity disorder (ADHD), bipolar disorder, depression, and schizophrenia have significantly higher odds of contracting COVID-19 than those without, even after adjusting for medical comorbidities (Q. Wang, Xu, & Volkow, 2021). Additionally, the study found higher rates of hospitalization and death among the population and a stronger effect size in those who had recently received their diagnoses. A case control study confirmed this, finding that having a psychiatric disorder was associated with a 57% increased risk of contracting COVID-19 in patients without any physical comorbidities and a 65% increased risk when physical risk factors were used to match (Taquet, Luciano, Geddes, & Harrison, 2021). There were minimal differences in associated risk when comparing different psychiatric diagnoses. Another study did find that after analyzing psychiatric conditions separately, schizophrenia spectrum diagnoses had 2.7 times the odds of mortality, even after adjusting for medical risk factors (Nemani et al., 2021). In this analysis, schizophrenia spectrum disorders were the second highest independent risk factor for mortality, behind only age. It is important that any associations between psychiatric diagnoses and COVID-19 continue to be explored so that governing bodies have the evidence they need to classify it as a risk factor.

1.1.5 Racial and Ethnic Disparities

Racial and ethnic disparities in disease have been an ongoing problem in the United States, and COVID-19 is no exception. Previous research has shown disproportionately high rates for many of the risk factors of COVID-19 in minority populations when compared to their non-Hispanic white counterparts. Some specific conditions include obesity (Lincoln, Abdou, & Lloyd, 2014), hypertension (Savoia et al., 2021), and diabetes (Peek, Cargill, & Huang, 2007). Beyond the conditions themselves, the life expectancy for black men in particular is lower than black women, white women, and white men, with 72.2, 78.2, 81.1, and 76.1 years respectively (Bond & Herman, 2016). Further, there are racial differences in socioeconomic status (SES) that add to the health disparities, but even with adjustment for SES, race alone still impacts health outcomes (Williams, Mohammed, Leavell, & Collins, 2010).

It was no surprise that early CDC morbidity and mortality reports identified race and ethnicity as risk for COVID-19, with 33% of cases identifying as Hispanic and 22% as black, even though these groups make up 18% and 13% of the population respectively (Stokes et al., 2020). Current CDC data estimates hospitalization rates for American Indian and Alaskan Natives, black, and Hispanic groups are 3.3, 2.9, and 2.8 times higher than their white counterparts with mortality rates are 2.4, 1.9, and 2.3 times higher when adjusted for age (Centers for Disease Control and Prevention, 2021f). Beyond the higher rate of death for COVID-19, minority populations are also dying younger than their white counterparts. Data from the CDC's surveillance efforts show 34.9% of Hispanic deaths and 29.5% of nonwhite deaths occurred in people less than 65 years of age, this is compared to 13.2% in white, non-Hispanic decedents (Wortham et al., 2020).

The COVID-19 pandemic has only amplified existing racial disparities in health in the United States, and it exemplifies how vital it is to rapidly address these issues. Racial and ethnic minorities are more likely to live in multigenerational households, have occupations that prevent them from sheltering in place, and use public transportation, increasing the likelihood of exposure to SARS-CoV-2 and infection (Lopez, Hart, & Katz, 2021). For these reasons, there have been pointed efforts to vaccinate minority groups and prevent serious outcomes and death. This is more difficult than it seems because it involves undoing decades of mistrust in healthcare institutions that stem from studies such as the Tuskegee syphilis experiments in addition to existing biases and institutional racism (Bunch, 2021). It is difficult to quantify the success of these attempts because all states are reporting race and ethnicity differently and at inconsistent rates.

1.1.6 Duration of Infectious Period and Asymptomatic Carriage

For those with mild and moderate COVID-19, studies have been unable to replicate virus in samples greater than 10 days post symptom onset (Centers for Disease Control and Prevention, 2021a), with some unable to cultivate a positive sample after 8 days (Bullard et al., 2020; Wölfel et al., 2020). This knowledge was able to be applied in a real world setting during a contact tracing study that failed to identify any infections occurring in exposures to cases that were greater than 6 days post symptom onset (Cheng et al., 2020). A study looking at more severe hospitalized patients with COVID-19 confirmed a median infectious period of 8 days post symptom onset, however, 5% of their sample continued to shed infectious virus 15.2 days post onset (van Kampen et al., 2021). One study observed infectiousness up to 4 months after symptom onset in three severely immunocompromised patients (Tarhini et al., 2021), while a review found the median infectious duration of 14 patients across 10 studies to be 71 days (Haidar & Mellors, 2021). This varying infectious period among immunocompromised patients could be more accurately estimated if more was understood about the different causes of immunodeficiencies.

Asymptomatic carriage was identified as early as January 2020 in China (Z. Hu et al., 2020) and demonstrated through contact tracing studies where the most plausible index case was someone not experiencing any symptoms (Bai et al., 2020). The outbreak on the Diamond Princess cruise ship provided a unique opportunity for quantitative analysis of asymptomatic transmission, finding that 46.5% of passengers with positive test results did not have symptoms at the time of testing (Moriarty et al., 2020). Not only did asymptomatic transmission complicate the ability to control and track the spread of COVID-19, but presymptomatic transmission also played a role. Presymptomatic transmission—or contagiousness before the onset of symptoms—has been estimated to occur between 1 and 4 days prior to symptom onset, but is generally accepted to be up to 2 days prior to symptom onset (Savvides & Siegel, 2020; Tindale et al., 2020).

It is difficult to ascertain the exact period of infectiousness for asymptomatic patients, but some studies have estimated it to be up to 9.5 days after the first positive test (Z. Hu et al., 2020). Regardless of symptomatic status, viral loads and infectiousness can vary from person to person, with some people being categorized as super spreaders who, for a variety of host and environmental factors, infect large numbers of people (P. Z. Chen et al., 2021). A study that created phylogenetic trees of super spreading events where as many as 328 individuals were infected used genome sequences to provide evidence that large proportions of the transmission came from one or a few individuals (Gómez-Carballa, Bello, Pardo-Seco, Martinón-Torres, & Salas, 2020). Regardless of how many individuals a single person can infect, recognizing the role of asymptomatic and presymptomatic transmission can help better guide testing strategies by making sure they are available to people who are not experiencing symptoms.

1.1.7 Modes of Transmission

In the early stages of the pandemic, evidence supported that the main mechanism of SARS-CoV-2 transmission was via respiratory droplets from an infected person (Chan et al., 2020; Q. Li et al., 2020). There was additional concern of transmission via fomites playing a role in the spread of COVID-19 due to early tests that showed SARS-CoV-2 could remain viable on a variety of surfaces for up 72 hours after application (van Doremalen et al., 2020). The Centers for Disease Control and prevention (CDC) and WHO accepted this as a route of transmission and made recommendations to disinfect surfaces as a method of preventing spread. Some scientists pushed back at this assertion, arguing that tests of survival in the lab often included extremely high viral loads and other experimental conditions that make it questionable to generalize to real world situations (Goldman, 2020). Swabs of inanimate surfaces in a healthcare setting with COVID-19 positive patients only yielded positive samples for continuous positive airway pressure (CPAP) helmets being used by infected patients, and those samples were unable to be cultured, suggesting the virus was no longer viable (Colaneri et al., 2020). As the body of evidence grew, the CDC also changed its stance on the role of fomites, stating that "current evidence strongly suggests transmission from contaminated surfaces does not contribute substantially to new infections" (Centers for Disease Control and Prevention, 2021d).

Another point of contention throughout the pandemic has been the role of airborne transmission via aerosols. Previous viral outbreaks such as norovirus, influenza, and seasonal coronaviruses have been shown that aerosols contribute to transmission (Tang et al., 2020). Additionally, the same study that established the long term viability of SARS-CoV-2 on inanimate surfaces also showed that it can survive in the air for 3 hours (van Doremalen et al., 2020). Epidemiologic investigations out of China comparing possible transmission methods in different

COVID-19 outbreaks provided evidence that aerosols were at least partially responsible for the spread (Shen et al., 2020; Tang et al., 2020). One caveat of the Shen et al. cohort study is that it occurred on a bus with air recirculation, which would impact the transmission dynamics.

Evidence exists for both respiratory droplet and aerosol transmission of COVID-19 in laboratory settings, but evidence for aerosol transmission in real world settings is less robust. This lead WHO and the CDC to put forth respiratory droplets as the most likely transmission route early on. However, a letter signed onto by over 200 scientists published July 2020 in Clinical Infectious Disease urged governments, international bodies, and the healthcare community to evaluate existing evidence and recognize the role of aerosols in transmission of COVID-19 (Morawska & Milton, 2020). Coincidentally, WHO released a brief later that month stating that "short-range aerosol transmission…cannot be ruled out," but it was not until April 2021 that they edited the transmission page on their website to say "a person can be infected when aerosols or droplets containing the virus are inhaled or come directly into contact with the eyes, nose, or mouth" (Chamary, 2021). The CDC was also slow to recognize the role of aerosols in transmission, claiming "limited, uncommon circumstances where people with COVID-19 infected others who were more than 6 feet away" in October 2020 (Centers for Disease Control and Prevention, 2020), but it was not until May 7th, 2021 that published "inhalation of very fine respiratory droplets and aerosol particles" as the principle way COVID-19 is spread (Centers for Disease Control and Prevention, 2021d).

This aerosol versus respiratory transmission debate is not unique to COVID-19 and has also divided scientists when considering the modes of transmission for influenza. A review of randomized control trials comparing N-95 respirators to surgical masks did not show a lower risk of influenza associated with use of the N-95 (Long et al., 2020). This suggests that, at least in the case of influenza, aerosol transmission plays a smaller role in real world situations than laboratory evidence would suggest. Studies continue to come out about COVID-19 transmission, and it is important to consider the most up to date scientific information on transmission methods is vital when considering how best to mitigate spread.

1.1.8 Mitigation Tactics

Ways to mitigate the spread of COVID-19 can be put into two categories—government action and individual action. The initial mitigation strategy put in place by the United States federal government was the previously discussed restrictions on travel for non-residents, which used screening questions that asked about symptoms and known contacts. Due to the variety of symptoms experienced by those who test positive and the role of asymptomatic transmission, this strategy proved to be ineffective (Dollard et al., 2020). The second method, used by states and local health departments, was the testing and contact tracing of cases and subsequent isolation and quarantine protocols for those who were exposed, however, this became difficult when the volume of cases exceeded public health capacity and index cases were unable to be identified. The roles of asymptomatic and presymptomatic transmission became better understood, and mitigation tactics, including contact tracing, needed to look beyond clinically recognizable symptoms. For this reason, testing became recommended for all people with an exposure—regardless of their symptomatic status. The new testing guidance became an important piece of contact tracing but could not be successful unless those identified through these efforts quarantine to prevent further transmission. Additionally, community mitigation strategies such as the cancellation of events with super spreader potential, social distancing, travel restrictions, and quarantine of household contacts (Ebrahim, Ahmed, Gozzer, Schlagenhauf, & Memish, 2020) were all proposed to combat this. Individual states put a variety of these measures and mask mandates into action with different metrics such as hospitalization rates and daily case counts indicating when it would be safe enough to remove them.

The mitigation strategies for individuals recommended by WHO, the CDC, and other governing bodies were largely based on the understanding that respiratory droplets were the main mode of transmission for SARS-CoV-2. The difference in how aerosols and droplets behave—the former staying in the air for hours and the latter spending less time airborne before landing on objects in the environment—inform how to best prevent the spread of COVID-19. With respiratory droplets considered to be the main mode of transmission, recommendations from WHO and the CDC relied on social distancing, disinfecting surfaces, and hand hygiene in order to combat the perceived risks that contamination on fomites posed. The recommended 6 feet of distance accounted for the 1-2 meters respiratory droplets travel, but not the tens of meters aerosolized particles can travel (Morawska & Milton, 2020). As far as hand hygiene was concerned, it is recommended to wash all parts of the hand with soap and water for 20 seconds and to use hand sanitizer when soap and water are not available.

Addressing the role of transmission via aerosols could be more difficult than just increasing cleaning protocols to mitigate surface transmission. In October 2020, the CDC began to recognize the role of aerosolized particles in the spread of COVID-19 and updated guidance on ventilation in buildings as a way to decrease the concentration of viral particles indoors. Eventually, they would recommend as variety of to improve ventilation, including no cost options such as opening windows and inspecting existing exhaust ventilation systems, slightly more costly interventions like adding fans and high efficiency particulate air filters, and costly measures such as adding ultraviolet germicidal irradiation systems (Centers for Disease Control and Prevention, 2021b).

What would ultimately be one of the most widely used individual mitigation tactics is the use of cloth and surgical masks in public places. Early mask guidance published on January 29, 2020 by WHO stated that “a medical mask is not required, as no evidence is available on its usefulness to protect non-sick persons” and further, “cloth (e.g. cotton or gauze) masks are not recommended under any circumstance (World Health Organization, 2020). The CDC took a similar stance and in a briefing in early February 2020 and confirmed that they did not the use of face masks for the general public, just those that were experiencing symptoms (Messonnier, 2020). It is likely that organizations took this stance in order to prevent the stockpiling of masks and shortage of personal protective equipment for healthcare workers. At the time, there was evidence supporting some degree of protection from pathogens with the use of cloth masks (Lai-yam Chan, Leung, Lam, & Cheng, 2020) and eventually studies recognizing asymptomatic and presymptomatic spread. This led to the recommendation of face coverings, including those made of cloth and other non-surgical options, for all persons in the community, regardless of their infection status.

Combinations of government and individual mitigation strategies were used by healthcare settings to prevent and slow transmission within their facilities. The adoption of universal masking was done earlier than in the general public, as it was already a common practice during flu season. N-95 respirators would also be used in situations where there was a higher risk of airborne transmission. Asymptomatic and symptomatic testing, cleaning protocols, social distancing, screening procedures, and isolation of patients were other commonly used strategies.

1.1.9 Available Testing

Timely testing would prove crucial for slowing the spread, but this was difficult in the early days of the pandemic when few tests were available and reserved only for those who were experiencing symptoms and had direct contact with someone else who had COVID-19. Available tests fall into two categories—antibody tests which detect SARS-CoV-2 antibodies present in the body and diagnostic tests that detect viral RNA or specific proteins.

After the full genome sequence was made available by Chinese scientists in early January 2020, scientists across the world raced to develop diagnostic tests. Within two weeks, German scientists had developed a real-time reverse transcriptase polymerase chain reaction (RT-PCR) test to detect the presence of SARS-CoV-2 RNA in respiratory samples (Corman et al., 2020); this test was adopted and distributed by WHO. The United States opted to forgo the WHO test and the Federal Drug Administration (FDA) had issued and EUA to the CDC's own Real-Time RT-PCR Diagnostic Panel to be used only at CDC approved labs on February 4, 2020. This was the only test that was approved until mid-March and was not effective, as defective batches of tests gave inconclusive results, making it difficult for testing to meet the demand (Temple-Raston, 2021). Relaxed standards and expedited reviews of EUAs approved by the U.S. Congress for diagnostic tests allowed non-CDC labs and private companies to develop their own diagnostic tests and receive approval sometimes within a day of application (Hahn, 2020). This was crucial in the effort to meet the demand of testing to detect the sharply increasing daily case counts. The RT-PCR test would become the clinical standard for the duration of the pandemic, though it was not without its own set of problems.

Detection of RNA is an imperfect means of testing because a positive test cannot identify whether it is a residual positive and the person is not actively suffering from infection, a true asymptomatic infection, or if the person is presymptomatic and will eventually experience symptoms. The RT-PCR tests simply detect the presence of SARS-CoV-2 RNA/genetic material but cannot ascertain if it is an intact virus able to replicate and cause infection in others. This has been one difficulty with developing isolation and quarantine guidelines and why they cannot be determined by testing alone. To further complicate matters, studies have shown the presence of viral RNA in some patients for up to months after infection (Agarwal et al., 2020; Marx, 2021) and would not be able to determine if the RNA was from the initial infection or the person was reinfected. There are few cases of reinfection, but they have been confirmed by differences in the viral genomes. However, genetic sequencing is difficult to implement on a large scale (Ledford, 2020).

The other diagnostic test used to detect COVID-19 infection is the antigen test, which uses antibodies to bind to viral proteins. Advantages to this test are that results can be obtained within minutes, it is less expensive, and generally, it does not require additional reagents and equipment as the tests are self-contained. The main disadvantage to antigen tests is their sensitivity when compared to the RT-PCR tests. The FDA requires a minimum sensitivity of 80%, but false negative results in 20% of the tests mean that antigen tests cannot be relied on as a sole method of determining infection (Service, 2020). A performance review of the Sofia antigen test showed sensitivity of 80% in symptomatic persons, but only 41.2% in asymptomatic persons, while specificity for both groups was over 98.9% and 98.4% respectively (Pray et al., 2021). Though not perfect, antigen tests can be a useful to in quickly identifying positive cases, particularly in low-resource settings.

The second type of test is the antibody test, which cannot be used to diagnose an active infection, but is a useful tool to try to determine prevalence by detecting immune responses to a prior infection. Because symptomatic people without known exposures and asymptomatic people with known exposures were unable to get RT-PCR tests early in the pandemic, antibody tests became an important tool to more accurately ascertain how many people have been infected. Antibody tests detect the presence of different combinations of immunoglobin (Ig) G, IgM, and IgA antibodies in the blood, which are produced to by the immune system to target SARS-CoV-2 spike proteins and nucleocapsid proteins. Studies have shown the detection of IgM and IgG around the same time, but IgG typically remains present in the blood for longer periods of time (Iyer et al., 2020; Shah et al., 2021). For this reason, sensitivity of antibody tests can vary based on the timing of when the person had COVID-19, and it is important that panels test for both IgM and IgG in order to achieve a higher sensitivity (M. Chen et al., 2021). One difficulty antibody testing faced when it was first introduced was cross reactivity with other human coronaviruses. Through a variety of studies, test developers were able to identify which antigen combinations yielded the least cross reactivity and highest specificity and sensitivity (de Assis et al., 2021). Currently, vaccination has also altered how antigen tests and seroprevalence can be interpreted. Vaccinations in the United States contain only spike proteins, and antigen tests identifying only anti-spike antibodies indicate that someone has been vaccinated or had a previous infection, while the identification of anti-nucleocapsid antibodies indicates a previous infection. Some states used a combination of the two, which means their seroprevalence data is a combination of both previous infections and vaccinations (Centers for Disease Control and Prevention, 2021e).

All tests serve important roles, whether it be understanding prevalence of COVID-19 in communities that did not have adequate access to testing or identifying active infections and breaking the chain of transmission through previously identified mitigation strategies. The FDA's recent authorization of over-the-counter and at-home test kits will further the ultimate goal of preventing transmission.

1.1.10 Death Tolls, Infection, and Vaccination Rates

Infection rates of COVID-19 varied greatly between countries throughout the pandemic, but the differences in government response and testing capacities seen in the early stages made it difficult to calculate the number secondary infections caused by an infected individual in a susceptible population, known as the basic reproduction number (R_0) (Dietz, 1993). Initially, WHO estimated R_0 of COVID-19 to be between 1.4 and 2.4 (Achaiah, Subbarajasetty, & Shetty, 2020), but more recent analyses have narrowed the range to somewhere between 2.2 and 2.7 (To et al., 2021). Even with more consensus on R_0 estimates of COVID-19, it is still highly variable based on mitigation measures and virus variants, with some SIR models of retrospective data calculating an R_0 as high as 4.5 in completely vulnerable populations with no control methods (Katul, Mrad, Bonetti, Manoli, & Parolari, 2020). In addition to the impact of mitigation efforts, the asymptomatic transmissibility of COVID-19 also makes an accurate R_0 value difficult to ascertain. To contextualize the R_0 of COVID-19, the R_0 of seasonal influenza is typically between 1.19 and 1.37 (Biggerstaff, Cauchemez, Reed, Gambhir, & Finelli, 2014), and the R_0 for Measles is estimated between 12 and 18 in a susceptible population (Guerra et al., 2017).

R_0 is a useful tool to better understand infectiousness of a disease but looking at actual case counts is also important. As of May 15, 2021, there have been 163,252,673 million confirmed cases of COVID-19 and 3,381,168 deaths, however, due to testing capacity and reporting differences it is likely that both numbers are underestimated (Johns Hopkins University, 2021). The United States alone accounts for 32,942,520 of the cases and 585,978 deaths, with a case fatality ratio of 1.8%. There have been 178.52 deaths per 100,000 in the United States—the fifth highest in the world compared to 0.53 per 100,000 in New Zealand, a country that was much more successful at mitigating spread (Johns Hopkins University, 2021).

Even within the United States infection and death rates vary state by state and states and local areas experienced unique timing and severity of infections. This difference in growth can be partially explained by the policies implemented in counties and states across the country. There was a 0.5% decrease in daily case growth rates 1-20 days after implementation of a mask mandate and a 0.7% decrease in daily death growth rates; this decrease became more pronounced 100 days post mandate with 1.8% and 1.9% daily case and death growth respectively (Guy et al., 2021).

The first surge of COVID-19 in the United States is considered by many to be the period from March to May 2020 when community transmission was happening more frequently and there was exponential growth in the number of new daily cases. During the first surge, there was a peak of almost 36,000 new daily cases in mid-April 2020. There was a slight decrease in daily number of new cases during June of 2020, which prompted a relaxing of mitigation strategies and the opening of restaurants and non-essential businesses, leading to a second surge in July 2020 with a peak of almost 76,000 new daily cases. New daily cases began to decrease slightly in August, but never to below the first surge's peak. Again, cases began to steadily increase in October 2020, ushering in the beginning of the third surge that would last into January 2021. The severity and longevity of the third surge is likely a result of travel for the Thanksgiving and Christmas holidays, where airports screened approximately 1 million travelers per day leading up to Christmas (Muntean, 2020). Two weeks later on January 8, 2021, the third surge hit its peak of 311,067 new daily cases (The Centers for Disease Control and Prevention, 2021b). New daily cases began to decrease again coinciding with the end of the holiday season and the beginning of vaccine distribution after the emergency use authorization of both Pfizer and Moderna in December.

New daily deaths also fell into three distinct stages, however, the first stage saw a higher peak than the second summer surge with a 7-day average peak of approximately 2,200 per day—double the peak of 1,100 during the summer surge (Johns Hopkins University, 2021). This is likely due to the limited test capacity, underestimating the number of cases in the first stage, and the uncertainty as to best practices in treatment of COVID-19. The third stage proved to be the most deadly the US faced, seeing the 7-day average of daily deaths jump to 3,200 during the peak. Even as cases increased slightly in the spring of 2021, prompting fears of a fourth stage, deaths remained constant and continue to decrease, with only 404 deaths reported on May 18, 2021.

The steady decrease in deaths despite an increase in new daily cases is in part due to the success of the vaccine rollout, but also improved treatment practices and therapeutics such as remdesivir, monoclonal antibodies, anticoagulants, and corticosteroids (Kip et al., 2020). In addition to the Pfizer and Moderna two-dose mRNA vaccines, on February 27, 2021 the single-dose adenovirus Johnson & Johnson COVID-19 vaccine received its Emergency Use Authorization. As of May 18, 2020 over 1.5 billion vaccines have been administered worldwide with 252 million in the United States alone. Of the 252 million doses, 124.5 million people in the United States are fully vaccinated (Centers for Disease Control and Prevention, 2021e). The approval of the Pfizer vaccine for use in children 12-15 on May 10, 2021 will further the United States' goal of vaccinating as many citizens as possible.

1.2 DISEASE CLUSTERS IN CONGREGATE SETTINGS

1.2.1 Risks in Congregate Settings

Congregate settings have long been known to play important roles in disease transmission, and though it has slightly varying definitions, it is an environment where groups of people from multiple households meet for short or long periods of time (Virginia Department of Health, 2021). There are more temporary congregate settings such as schools, employers, and gatherings including churches and concerts, but also places that fall into a more residential category such as cruise ships, college dormitories, detention facilities, shelters, and long-term care facilities (LTCFs), with hospitals existing as combination of both. The risk with many congregate settings stems from the high number of contacts in close proximity, which can make it easy for certain diseases to spread and make it difficult to break the chain of infection without proper mitigation. Hospitals and other healthcare facilities utilize group activities as an important element of patient care, increasing the duration of contacts when compared to other settings. The knowledge that putting people together in close quarters could increase the incidence of disease has driven policies for centuries, even if the science behind it was not fully understood. The village of Eyam in Derbyshire, England famously quarantined itself in 1666 when it was hit by the plague, not participating in face to face trade with neighboring villages and holding outdoor church services (Whittles & Didelot, 2016). In more recent history, during the 1918 Spanish Influenza Pandemic, many schools across the United States opted to close in an attempt to slow the transmission (Stern, Cetron, & Markel, 2009).

For some congregate settings, such as prisons and LTCFs, the risks are increased due to the existing social inequities for many of the individuals (Nijhawan, 2016). It is important that with any infectious disease, specific guidance and considerations be implemented for these at-risk populations.

1.2.2 Examples of Outbreaks in Congregate Settings

Certain pathogens have a history of spreading efficiently in congregate settings and have existing policies in place to guide mitigation. Seasonal influenza is a recurring concern, but three pandemic influenza strains in 1957, 1968, and 2009 each required more strict methods of mitigation, specifically with schools. Children have been shown to shed more influenza virus for longer periods of time than adults, and it is estimated that 75% of seasonal influenza cases in children and 35% of cases in adults are the result of transmission through school children (Carlo & Chung, 2009). A review of non-pharmaceutical intervention policies in different countries during the H1N1 pandemic observed school closure as the most important factor driving differences in transmission (Cauchemez et al., 2014). School closure policies in the United States can vary by state and even by school district. Some closures are more reactive in nature, closing only when a threshold of absences is met, and others proactive, closing before widespread transmission is observed. An example of a reactive closure would be the 9-day closure of a Queens, New York high school with 2686 students after an outbreak of H1N1 in 2009. Ultimately, 115 students had confirmed cases with another 694 suspected cases of influenza like illness (Lessler et al., 2009). This outbreak illustrates just how quickly respiratory illnesses can spread in congregate settings.

Measles vaccination rates in the United States have hovered around 90% for the past decade, but can be lower in certain communities, leaving them vulnerable to potential outbreaks (National Center for Health Statistics, 2015). Multiple measles outbreaks have occurred at churches in the last two decades. One in Indiana in 2005, when the unvaccinated index case returned from a trip abroad and attended a 500 person church event, infecting 16 of the 50 unvaccinated attendees and was ultimately linked to 34 cases (Parker et al., 2006). Another example of a measles outbreak linked to church attendance was in 2013 in Texas, where there index case had traveled abroad and infected 21 people (Tanne, 2013). Though measles is highly contagious, its spread in congregate settings illustrates transmission potential for other airborne diseases and the importance of vaccination.

There are even greater risks for widespread transmission of disease in residential congregate settings. College dormitories are notorious for outbreaks of meningococcal disease, with 10 occurring from January 2013 to May 2018. These outbreaks resulted in 37 cases and 2 deaths, all but 1 were unvaccinated, and the vaccinated case had only received the first dose of the MenB vaccine 6 days before symptom onset (Soeters et al., 2019). This is another instance that exemplifies the vital role of vaccines in preventing disease transmission, but also the impact that close proximity living situations can have on the spread of diseases. Prisons are another congregate setting where a variety of diseases can spread rapidly, made worse by the sanitary conditions of the facilities, the social inequities experienced by the populations, and low vaccination rates. Influenza outbreaks in correctional facilities have been observed across the world: Canada (Besney et al., 2017), Australia (Awofeso et al., 2009), and the United States (Centers for Disease Control and Prevention (CDC), 2012). Beyond influenza, tuberculosis, varicella, measles, mumps, adenovirus, and now COVID-19 outbreaks have also been observed in correctional facilities in high income countries (Beaudry et al., 2020). A review of interventions for disease outbreaks in correctional facilities found that testing, contact tracing, and isolation were the most applicable strategies to prevent transmission (Beaudry et al., 2020). In order to protect people who are incarcerated, clear, up to date guidance on how to manage outbreaks needs to be regularly communicated to these facilities. Additionally, there should be an emphasis on ensuring that they are up to date on all available vaccinations.

Another congregate setting frequently housing at-risk populations are LTCFs, a vulnerability that has been highlighted by the ongoing COVID-19 pandemic. LTCFs tend to house those over 65 years of age and those with developmental disabilities. Both of these groups commonly have comorbidities that not only make it difficult to identify symptoms that may be associated with a disease outbreak, but also put them at a greater risk for contracting diseases and experiencing poor outcomes. Attack rates for outbreaks of seasonal influenza in LTCFs range between 20% and 70%, leading to complications such as pneumonia and even death (High et al., 2009). Other respiratory viruses, skin and soft tissue infections, and gastrointestinal illnesses such as *Clostridioides difficile* have all been observed to cause outbreaks in LTCFs, and should be managed through communication with clinicians and timely testing (High et al., 2009). A 2002 norovirus outbreak in a LTCF resulted in 52% of the 246 residents and 46% of the 181 employees developing gastroenteritis (Wu et al., 2005). The mitigation strategies utilized in this outbreak included hand hygiene reinforcement, contact precautions, mask use, and the stay-at-home orders for symptomatic employees until they experienced 48 hours without symptoms.

With older age as COVID-19's greatest risk factor, it is no surprise that it became a significant threat to LTCF and other congregate settings. An outbreak in February 2020 at a long-term care facility in Washington state resulted in death for 34% of residents who had confirmed cases of COVID-19, the median age was of all patients was 83 (McMichael et al., 2020). It was an early indication that COVID-19 would pose a unique challenge to LTCFs across the United States. State governments implemented a variety of policies which included quarantine guidance for staff and residents, whole house testing, and personal protective equipment use in an to mitigate the spread. Despite these precautions, LTCF residents make up 64.9% of COVID-19 deaths, but only 3.5% of cases, illustrating how important it is to take aggressive action to prevent residents from becoming infected in the first place (Gmehlin & Munoz-Price, 2020). Prioritizing the vaccination of older adults and LTCF residents has proven to be a successful strategy and has coincided with falling infection, hospitalization, and death rates of these populations. Vaccination of the personnel in these facilities is also vital to preventing infection. A Kentucky skilled nursing facility experienced an outbreak originating from an unvaccinated, symptomatic personnel member in March 2021 where 90.4% of residents were fully vaccinated, but only 52.6% of the 116 personnel members were fully vaccinated. Though 18 of the 26 resident cases occurred in fully vaccinated individuals, the attack rate was only 25% compared to the 75% attack rate for unvaccinated residents (Cavanaugh et al., 2021). It has been known that the vaccine is not 100% effective at preventing infection, but this outbreak illustrates the importance of vaccinating both residents and staff at LTCFs and continuing to follow COVID-19 guidance.

1.3 RISK FOR DISEASE IN THOSE WITH PSYCHIATRIC DIAGNOSES

1.3.1 Poor Outcomes

A greater incidence of poor outcomes and mortality for a variety of health conditions has been noted in patients with SMI. These associations are not isolated to single country and have been observed worldwide and in countries of varying development. A study out of Denmark found that excess death rate ratio for heart disease was 2.9 in people with SMI, which they defined as a diagnosis of bipolar disorder, schizoaffective disorder, or schizophrenia (Laursen, Munk-Olsen, Agerbo, Gasse, & Mortensen, 2009). A cohort study out of England and Wales looking at the same disorders found higher standardized mortality ratios (SMRs) than the general population for suicide (7.65, 95% CI 6.43-9.04), unnatural causes (4.01, 95% CI 3.34-4.78), respiratory disease (3.38, 95% CI 3.4-3.74), cardiovascular disease (2.65, 95% CI 2.45-2.86), and cancer (1.45, 95% CI 1.32-1.6) (Das-Munshi et al., 2017). Though the rate ratios differed when separating ethnic groups, they all remained higher for those with SMI. For excess cardiovascular mortality, it can be partially attributed to the previously mentioned issues in quality of care. Patients with heart disease and SMI had lower rates of prescription for common heart disease management drugs, with schizophrenia specifically having the lowest likelihood (Woodhead et al., 2016). A meta-analysis looking at associations between SMI and diabetes, hypertension, and dyslipidemia indicated a pooled risk ratio of 1.7 (CI 1.21-2.37) for schizophrenia-like illness and diabetes, but inconsistent results for other SMI diagnoses and metabolic conditions (Osborn et al., 2008). Mental illness diagnoses have also shown associations with COPD, even after adjusting for smoking status (Rapsey et al., 2015). It is not only chronic illnesses that have been observed to have higher rates in people with psychiatric diagnoses, but also viral diseases. Diagnoses of bipolar disorder, schizophrenia, depression, and anxiety were associated with higher risk ratios for pneumococcal disease (Seminog & Goldacre, 2013).

Many of these comorbidities associated with SMI have been indicated as risk factors for severe illness due to COVID-19. Additionally, the barriers to care and societal inequality faced by people with SMI put them further at risk. This is a group that has a history of vaccine hesitancy, with influenza vaccination rates as low as 25% (Smith, Lambe, Freeman, & Cipriani, 2021). While it may be difficult to address decades of systemic inequalities for people with SMI as a way to prevent COVID-19, action can be taken now to reduce vaccine hesitancy to improve health outcomes for this group moving forward.

1.3.2 Reasons for Poor Health Outcomes

Some studies have indicated an increased risk of COVID-19 for those with psychiatric diagnoses, but there is a body of evidence supporting that these diagnoses are also associated with increased risks for comorbidities and poor health outcomes. This can partly be explained by a history of health inequities and reduced access to care experienced by people with severe mental illness (SMI) (Reilly et al., 2015). Additionally, people with mental illness have been observed to have significantly higher inadequate health literacy levels than the general population with 50% and 26% respectively (Clausen, Watanabe-Galloway, Bill Baerentzen, & Britigan, 2016). This is notable because low health literacy levels, regardless of any psychiatric diagnoses, have been associated with poor health outcomes and increased health care utilization (Baker et al., 2002; Marrie, Salter, Tyry, Fox, & Cutter, 2014; Sudore et al., 2006). Certain health behaviors also impact health outcomes, and smoking specifically has been linked to cardiovascular illness, respiratory illness, and cancer. This is problematic because people with mental disorders have rates of smoking that are almost twice as high when compared to those without mental disorders (Lawrence, Mitrou, & Zubrick, 2009).

Even if someone with psychiatric diagnoses had excellent health literacy and behaviors, there are outside factors that create barriers to care. Discrimination against people with mental illness in health care is a pervasive problem that can lead to poorer quality of care for these already at-risk patients (Knaak, Mantler, & Szeto, 2017). The stigma can impact the patients themselves and reduce their likelihood of seeking care in general (Corrigan, Druss, & Perlick, 2014). Beyond quality of care and reluctance to seek care, the separation of mental health care and physical health care has also been attributed to the poor outcomes experienced by people will mental illness (Lawrence & Kisely, 2010). Further creating barriers to treatment is the association between mental illness and low socioeconomic status (SES), which can make them 2 to 3 times more likely to have a mental disorder than those of higher SES (Kim & Cho, 2020). Addressing not only the stigma associated with mental illness itself, but also societal inequities are both important factors in the attempt to improve health outcomes for this group.

1.4 COVID-19 IN BEHAVIORAL HEALTH SETTINGS

1.4.1 Existing Literature

Much of the existing literature discussing COVID-19 in behavioral health focuses on mitigation strategies and the increased risks faced by people with psychiatric diagnoses rather than the patient population itself. An outbreak of COVID-19 at a psychiatric hospital in China in February 2020 explored precautions that were put in place and explained why this population is more at risk than those receiving care at a medical health center (Y. Zhu et al., 2020). This was one of the first articles published looking at COVID-19 in a behavioral health setting, but it does not give exact counts for how many patients in staff were infected and does not give any demographic information about the patients. Shanghai Mental Health Center, a facility with more than 2400 inpatient beds, outlined the management strategies they employed to avoid any infections as of April 7, 2020 (Shao, Shao, & Fei, 2020). With no infections occurring, it does not provide any insight into management infected patients, which is an extremely important piece of mitigation for many facilities. A New York psychiatric hospital cared for 47 COVID-19 positive patients between March and April 2020 and outlined their screening, testing, isolation, and treatment policies during that time (Brody, Parish, Kanellopoulos, & Russ, 2020). It features an easy-to-read flowchart about these strategies but fails to give information about the patient population and demographics. A review of the testing and mitigation strategies at NYU Langone Health includes information on patient demographics and psychiatric diagnoses, number of tests, and on-unit transmission of staff and patients (Zhang, LeQuesne, Fichtel, Ginsberg, & Frankle, 2020). It is more robust than other literature but focused on two psychiatric units totaling 57 in-patient beds where 238 patients were seen during the period of March 1- May 1, 2020 and did not include information about medical comorbidities.

1.4.2 Gaps in Knowledge

More literature about the strategies for testing and treatment in psychiatric facilities can provide evidence-based guidance and ultimately lead to improved patient care. There is a lack of information on outbreaks in these facilities, preventing a full understanding on the successes and gaps of different testing and mitigation strategies. Further, it is known that those with SMI diagnoses have higher risks for poor outcomes in a number of diseases, but this is not recognized as a risk for COVID-19 and lacks guidance indicating that this population should have additional considerations when developing treatment plans. Additionally, the relationship between psychiatric diagnoses and physical comorbidities in the risk for COVID-19 is not well understood. Inclusion of this patient information when reviewing testing and treatment strategies provides context that can better inform other facilities when they are developing policies in the future.

1.4.3 Public Health Significance

Providing real world data illustrating the success of certain mitigation and testing strategies at a psychiatric hospital adds to the body of evidence that hospital policy makers can refer to when implementing their own strategies. Cost can be prohibitive to implementing certain policies but proving that targeted testing strategies can prevent hospital acquired infections makes it more likely that facilities can justify additional costs that may be associated with increased testing. By tailoring safeguards against infectious disease specifically to the patients they serve, healthcare facilities can better protect their patients and ultimately improve patient quality of care and outcomes.

2.0 OBJECTIVES

This review was done to describe the successes and failures of COVID-19 mitigation and testing procedures at a psychiatric hospital, as well as described how medical conditions and psychiatric diagnoses are distributed between the entire patient population and those who tested positive for SARS-CoV-2. The information provided by this review will be used to better inform strategies implemented in behavioral health settings for COVID-19 and other infectious diseases.

3.0 METHODS

3.1 WESTERN PSYCHIATRIC HOSPITAL

3.1.1 Facility Description

University of Pittsburgh Medical Center Western Psychiatric Hospital (UPMC WPH) is a facility in Western Pennsylvania with 263 inpatient beds and a network almost 60 community-based programs. Some of these services provided on-site include transitional care, acute inpatient services, 24-hour emergency services, outpatient treatment, and telepsychiatry. Some of the community-based programs in WPH's network provide long term service release, off-site residential programs, school programs, and the Resolve mobile crisis team. WPH treats a variety of conditions in both children and adults, such as addiction, ADHD, anxiety disorders, dementia, developmental disabilities, mood disorders, psychosis, eating disorders, obsessive-compulsive disorder (OCD), and schizophrenia. Annually, WPH sees approximately 14,000 patients per year with only 35% being admitted for inpatient treatment, the others being referred to one of WPH community-based programs.

Units are separated by diagnosis and age, with all having private or semi-private patient rooms, shared locked bathrooms, a locked treatment room, a locked kitchen area where prepared meals are eaten, and a common area. The exception is the Transitional Recovery Unit, which has full access to a kitchenette and refrigerator. Milieu therapy is an important part of recovery for all WPH patients, and it was important to have mitigation measures in place to allow its continued use throughout the pandemic. WPH has a neighboring acute care medical facility, UPMC

Presbyterian Hospital, where patients could be easily transferred if they require more specialized medical care.

3.1.2 COVID-19 Mitigation Strategies

COVID-19 mitigation strategies at WPH for the time period were guided by existing WPH protocols for other infectious diseases, the CDC, and Pennsylvania Department of Health (PA DOH). The experience with transmission-based precautions and contact tracing varicella zoster virus (chicken pox, shingles) and respiratory viruses were important in quickly implementing similar strategies to prevent transmission of COVID-19 in patients and healthcare workers (HCWs). Testing and mitigation guidance from the CDC and PA DOH was specifically made for LTCFs and skilled nursing facilities (SNFs), as those have been previously identified groups with high risk for severe disease from COVID-19. WPH's geriatric unit has similar risk factors as those groups, between age, existing comorbidities, and living in a congregate setting.

All of the listed practices were in place throughout the study period of July 2020 to February 2021 and indicate changes from pre-pandemic policies:

1. Staff facing and patient facing signage about handwashing, how to properly wear a mask, and when to wear a mask
2. Hand sanitizer was kept on the workers' person and at nurses' stations. 72% alcohol wipes were available to patients most patients with castile wipes available to units treating substance use and those with autism who have aversions to certain smells or materials. Ligature reduced soap dispensers were installed in patient bathrooms.
3. High touch surfaces were cleaned hourly, a change from the previous policy of twice per day.

4. There was reduced support person visitation, only one per patient. In-person visitation was reduced from any day to Tuesdays, Thursdays, and Saturdays, with virtual or phone visitation on the other days. Support persons visiting in person were required to wear a mask at all times and have their temperature taken and answer screening questions before entry.
5. Group therapies had assigned seating with patients 6 feet apart and required that patients wear masks. If the patient did not want to wear a mask or was medically unable to, they could attend group therapy virtually or choose to do one-on-one therapy.
6. Mealtimes would be staggered and done in smaller groups with social distancing and cleaning in between groups.
7. Cloth masks were provided to patients and encouraged to be work in the communal spaces, but not mandatory.
8. Electroconvulsive Therapy was moved to UPMC Presbyterian Hospital where it was done in an operating room. Patients were tested preprocedural and it was not done on any patients in the yellow or red zones until they returned to their normal unit.

3.1.3 Patient Testing Strategy and Isolation Protocols

The testing strategy from March 20, 2020 to July 2020 was to test only symptomatic patients or those with a known close contact. On June 29, 2020 WPH began testing asymptomatic admissions from communal settings (if the patient did not have a test within 48 hours) in addition to all discharges to communal settings. After an outbreak in a geriatric unit, additional test reasons were added to the existing strategy. From July 2020 onward there were six reasons a patient would be tested asymptomatically:

1. A positive screen upon arrival to the WPH Emergency Department (yes to one of the following questions):
    i. Have you been tested for COVID-19 in the past 30 days because you were having symptoms consistent with possible COVID-19 infection?
    ii. Do you have fever plus either a cough or shortness of breath?
    iii. Have you had close contact with a person suspected or confirmed to have COVID-19?
2. Admission directly to WPH from a congregate setting such as a LTCF, SNF, prison, or jail
3. Admission directly to WPH into a geriatric unit or the Center for Autism and Developmental Disorders (CADD)
4. Transfer from another facility through PsychCare+, a system that allows facilities to see real time bed availability statewide and works with social workers and doctors to find the best facility for a patient, when a patient has been admitted between 2 and 14 days at their facility
5. Post exposure after a confirmed positive contact while admitted
6. Upon discharge from WPH to a congregate setting

Figure 1 outlines when a patient would be tested at admission and how they can ultimately be admitted to the appropriate unit. A positive screen indicates that they are asymptomatic and have a known contact or they were experiencing symptoms upon admission. COVID (+) or (-)

PsychCare+ indicates that the patient had a positive or negative PCR test no more than 48 hours prior to admission. Testing would also be done on patients after admission if they begin experiencing symptoms. If they were exposed to a known positive but tested negative, they would be moved to a yellow zone, and if they tested positive, they would be moved directly to a red zone.

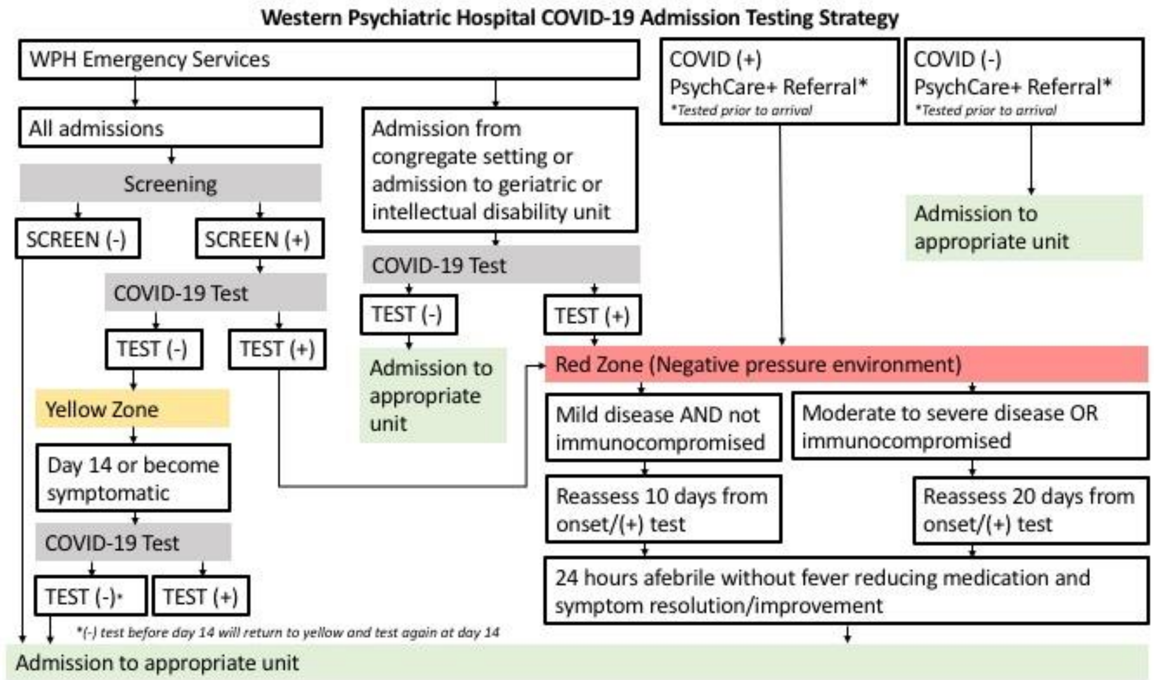

Figure 1: Western Psychiatric Hospital Testing and Isolation Flowchart

Yellow and Red Zones were created as needed throughout the study period. Group therapy was held with all patients in each zone regardless of their diagnosis. Additionally, these patients could participate virtually in group sessions with the appropriate unit. Yellow zones had droplet contact protocols where staff would wear surgical masks with face shields or goggles and gowns during high contact care activities and activities where they anticipated splashes and sprays. Red zones were negative pressure environments where staff always wore face shields or goggles, N-95 masks, and gowns. If a patient had an increased oxygen requirement of greater than or equal to 6 liters-per-minute or became medically complicated, they would be transferred to UPMC

Presbyterian. In some instances, patients would be discharged directly from the Red Zone or Yellow Zone without ever being cleared to transfer to their appropriate unit.

3.2 DATA CLEANING AND STATISTICAL ANALYSIS

This is a quality improvement study looking at all discharges from WPH from July 2020 to February 2021. There were 3,694 total discharges, with 3,229 being unique patients. A total of 382 patients had between two and six admissions during the study time period. Demographic characteristics of sex, race, ethnicity, and zip code were provided by the Wolff Center at UPMC, and medical and psychiatric risk factors were taken from discharge chart information.

Many patients had multiple psychiatric diagnosis, but unless it was ADHD, bipolar disorder, depression, or schizophrenia, only the primary diagnosis was included. This is due to the existing literature on increased risk of severe illness from COVID-19 for diagnoses of ADHD, bipolar disorder, depression, and schizophrenia (Q. Wang et al., 2021). Medical risk factors for severe illness were put into two categories of "Increased Risk" and "Maybe Increased Risk" based on the groupings of evidence available to the CDC, shown in ***Table 1*** (Centers for Disease Control and Prevention, 2021c). At the time that the risk factors were coded from the discharge charts, cerebrovascular disease was not a noted risk factor and therefore is not included in this review. Statuses of overweight, obesity, and severe obesity were determined using body mass index values indicated in the chart information of 25.0 to <30, 30.0 to <40, and >40 respectively. Severe obesity and obesity were combined in the analysis.

The races of “CHINESE,” “INDIAN (ASIA),” “KOREAN,” “OTH/ASIAN,” and “VIETNAMESE” were all reclassified as “ASIAN.” Discharge unit was also recoded from the physical location to the type of unit. **Table 2** shows the new unit codes and the unit descriptions. Psychiatric diagnoses of Adjustment, Conduct, Oppositional Defiant, and Intermittent Explosive Disorder were all classified as behavioral disturbances.

Table 1: Medical Conditions Associated with Risk of Severe COVID-19

Increased Risk for Severe Illness	Maybe Increased Risk for Severe Illness
Age	Asthma
Cancer	Cystic Fibrosis
Cerebrovascular Disease	Hypertension
Chronic Obstructive Pulmonary Disease	Neurologic Conditions (Dementia)
Down Syndrome	Liver Disease
Heart Conditions	Overweight
Kidney Disease	Pulmonary Fibrosis
Obesity and Severe Obesity	Thalassemia
Pregnancy	Transplant Status (Solid and Marrow)
Sickle Cell Anemia	
Smoking	
Type I and II Diabetes	

Patients with positive test results were epidemiologically investigated by the WPH infection preventionist to determine if it was the result of nosocomial transmission. Positive test results were considered potentially acquired at WPH if the patient was admitted to inpatient treatment more than 2 days prior to the positive test and did not have a known community exposure.

The statistical analysis was done using R version 4.0.5 with packages tidyverse, lvplot, hexbin, dplyr, and epiDisplay. Binary variables of each individual medical and psychiatric risk factor were created, and age was calculated using date of birth and the patient admission date. R was used to calculate the frequencies and proportions then input into excel to create tables.

Table 2: Western Psychiatric Hospital Unit Names and Descriptions

UNIT	DESCRIPTION
ACABs	Adolescent and Adult Bipolar Unit
ATRIUM	Adult Trauma Recovery Inpatient Unit
CHILD	Child and adolescent unit treating children from ages 3-18
COVID	COVID-19 flex units used as yellow and red zones
CED	Center for Eating Disorders
CRS	Comprehensive Recovery Services, specializing in psychotic illnesses such as Schizophrenia
DUAL	Adult substance abuse and psychiatric treatment unit
GER	Integrated Health and Aging Program, the Geropsychiatric unit
CADD	Center for Autism and Developmental Disorders
TRU_CRU	Transition to Recovery Unit (TRU) and Comprehensive Recovery Unit (CRU), treating people with severe and persistent mental illness in an acute phase with support for reintegration

4.0 RESULTS

4.1 STUDY POPULATION

Between July 2020 and February 2021 there were 3,694 discharges and 86 (2.32%) positive test results. Demographic information for unique patients (n = 3229) during the study time frame and patients with ≥1 positive test result can be found in **Table 3**. A total of 1,654 (51.2%) of the unique patients and 43 (50%) of those who had positive test results were female. The average age for the unique patients was 33.2 years (sd 18.8) and 41.5 (sd 21.7) for those with positive test results. A total of 248 of the unique patients were over age 65 (7.7%) compared to 17 of those who tested positive (19.8%). White was the most commonly identified race for both the unique patients (2149/3229, 66.6%) and those with positive test results (60/86, 69.8%) and black as the second most common for both (870/3229, 26.9%; 16/86,18.6%). Non-Hispanic was the most common ethnicity identified by the unique patients (2395/3229, 74.2%) and those with positive tests (65/86, 75.6%). There were similar proportions of unknown ethnicities for both the unique patients (802/3229, 24.8%) and those with positive tests (20/86, 23.3%).

Table 3: Demographic Characteristics of Patients Discharged from Western Psychiatric Hospital between July 1 2020 and February 28 2020

Characteristic		Unique Patients N = 3229 n (%)		Patients with ≥1Positive Test Result N = 86 n (%)	
Age	Mean	33.2	(sd 18.8)	41.5	(sd 21.7)
	Min	4.6		11.7	
	Max	95.2		92.4	
	>65	248	(7.7)	17	(19.8)
Sex	Female	1654	(51.2)	43	(50)
	Male	1575	(48.8)	43	(50)
Race	White	2149	(66.6)	60	(69.8)
	Black	870	(26.9)	16	(18.6)
	Declined	78	(2.4)	6	(7)
	Not Specified	56	(1.7)	3	(3.5)
	Asian	47	(1.5)	1	(1.2)
	American Indian	24	(0.7)	0	(0)
	Other Pacific Islander	3	(<0.1)	0	(0)
	Alaska Native	2	(<0.1)	0	(0)
Ethnicity	Non-Hispanic	2395	(74.2)	65	(75.6)
	Unknown	802	(24.8)	20	(23.3)
	Hispanic	32	(1)	1	(1.2)

4.2 DISTRIBUTION OF COVID-19 RISK FACTORS

Table 4 shows the frequencies and percentages of the different CDC-identified risk factors for both the unique patients and those who tested positive. A total of 1667 of the 3229 (51.6%) unique patients and 44 of the 86 patients with positive tests (51.2%) did not have any of the risk factors associated with increased risk for severe illness. However, 367 of the unique patients (11.4%) and 11 of those with positive tests (12.8%) had multiple risk factors associated with increased risk of severe illness. Smoking was that most common risk factor among both groups, with 882 unique patients (27.3%) and 19 patients with positive results (22.1%) denoted as having smoked cigarettes. Obesity and severe obesity together were the second most common risk factor for the unique patients (565/3229, 17.5%) and patients with positive tests (11/86, 12.8%).

Table 4: Distribution of Medical Conditions Associated with Risk of Severe COVID-19 in Unique Patients Discharged from Western Psychiatric Hospital between July 1 2020 and February 28 2020

Risk Category	Condition	Unique Patients N = 3229 n (%)	Patients with ≥1 Positive Test Result N = 86 n (%)
Increased Risk	Cancer	34 (1.1)	1 (1.2)
	COPD	82 (2.5)	1 (1.2)
	Diabetes	215 (6.7)	0 (11.6)
	Down Syndrome	1 (<0.1)	0 (0)
	Heart Disease	79 (2.4)	5 (5.8)
	Kidney Disease	87 (2.7)	1 (1.2)
	Obesity (BMI ≥ 30)	565 (17.5)	1 (12.8)
	Pregnancy	21 (0.7)	2 (2.3)
	Sickle Cell Anemia	14 (0.4)	0 (0)
	Smoking	882 (27.3)	19 (22.1)
	No Conditions	1667 (51.6)	44 (51.2)
	Multiple Conditions	367 (11.4)	11 (12.8)
Maybe Increased Risk	Asthma	383 (11.9)	5 (5.8)
	Cystic Fibrosis	1 (<0.1)	0 (0)
	Dementia	93 (2.9)	10 (11.6)
	HIV	19 (0.6)	0 (0)
	Hypertension	468 (14.5)	19 (22.1)
	Overweight	45 (1.4)	1 (1.2)
	Liver	2 (<0.1)	0 (0)
	Transplant Status	5 (0.2)	0 (0)
	No Conditions	2320 (71.8)	55 (64.0)
	Multiple Conditions	106 (3.3)	5 (5.8)

A majority of both the unique patients and patients with positive test results did not have any risk factors that may by associated with increased risk of severe illness from COVID-19

(2320/3229, 71.8%; 55/86, 64.0%). Only 106 of the unique patients (3.3%) and 5 patients with positive results (5.8%) had multiple risk factors that may be associated with severe illness. Of those who did have at least one of the "maybe" risk factors, hypertension was most common with 468 unique patients (14.5%) and 19 of the patients who tested positive (22.1%) having hypertension noted in their charts.

4.3 DISTRIBUTION OF PSYCHIATRIC DIAGNOSES

Psychiatric diagnoses were present in the chart information for 98.8% of the unique patients (3191/3229) and 97.7% of patients who tested positive (84/86). The frequencies and percentages of the different psychiatric diagnoses for both the unique patients and patients with positive test results can be found in **Table 5**. The most common diagnosis for both groups was depression, with 1271 of the unique patients (39.4%) and 35 of the patients with positive tests (40.7%) having the diagnosis noted in their chart. For the unique patients, behavioral disturbances were the second most common diagnosis (432/3229, 13.4%). Bipolar disorder was only marginally lower in the unique patients, with 398 (12.3%) having the diagnosis. For those with positive test results, bipolar disorder was the second most common diagnosis (13/86, 15.1%).

Table 5: Distribution of Psychiatric Conditions in Unique Patients Discharged from Western Psychiatric Hospital between July 1 2020 and February 28 2020

Diagnosis	Unique Patients N = 3229 n (%)		Positive Test Results N = 86 n (%)	
ADHD*	231	(7.2)	2	(2.3)
Bipolar Disorder*	398	(12.3)	13	(15.1)
Depression*	1271	(39.4)	35	(40.7)
Schizophrenia*	179	(5.5)	4	(4.7)
Anxiety	42	(1.3)	1	(1.2)
Autism	91	(2.8)	1	(1.2)
Behavioral Disturbance	432	(13.4)	5	(5.8)
Personality Disorder	43	(1.3)	1	(1.2)
Psychosis	199	(6.2)	2	(2.3)
Schizoaffective Disorder	106	(3.3)	7	(8.1)
Substance Use	56	(1.7)	3	(3.5)
Suicidal Ideations	26	(0.8)	0	(0)
No Psychiatric Diagnosis	38	(1.2)	2	(2.3)
Other	58	(1.8)	2	(2.3)
Recent Diagnosis	889	(27.6)	17	(19.8)

**Higher odds of contracting COVID-19 observed in Q. Wang et al* (Q. Wang et al., 2021)

4.4 TEST RESULTS AND ATTRIBUTION/ACQUISITION

Of the 86 positive test results, 29 (33.7%) were considered potentially WPH-acquired based on the criteria. In total, 55 of the positive tests (64.0%) were done on patients who were asymptomatic, with the remaining 31 (36.0%) of patients experiencing at least one symptom consistent with COVID-19. **Figure 2** shows the reasons for the test by the patient's symptom status. The most common reason for testing was for transfers from other facilities that bypassed the emergency services (n = 38, 44.2%), with 27 (71.1%) of transferred patients being asymptomatic. The second most common reason for testing was if a patient had contact with a known positive while at WPH; this accounted for 31.4% of positive tests (n = 27). Fifteen (55.6%) of the patients who had a post exposure test were asymptomatic. A community exposure indicates a positive test from a patient who found out that they had a known positive contact after they had been admitted. There were seven patients that tested positive (8.1%) who fall into the community exposure category.

Positive screens, preadmission from, and preadmission to categories represent patients who came directly to WPH for admission. There were 14 patients who fall into this category (16.3%). There were seven patients with positive screens, six (85.7%) of whom answered yes to the screening question about symptoms upon arrival, and one (14.3%) who was symptomatic but had contact with someone who was a known positive (1/7, 14.3%). “Preadmission from” means that the patient came from a congregate setting such as a SNF, LTCF, jail, or prison and was admitted directly to WPH. This accounted for four of the 86 tests (4.7%) with all of them being asymptomatic. Two of these admissions came from a SNF (50.0%) and two came from a jail (50.0%). The final category, “preadmission to” means that the patient would have screened negative and was asymptomatic, but because they were being admitted to the geriatric floor or CADD, they were also tested. This test reason accounted for three of the total tests (3.5%), and all three were meant to be admitted to the geriatric floor.

Table 6 shows the number of patients with either WPH acquired or non-WPH acquired COVID-19 by symptomatic status. The majority of both WPH acquired infections and non-WPH acquired infections were asymptomatic (17/29, 58.6%; 38/57, 66.7%).

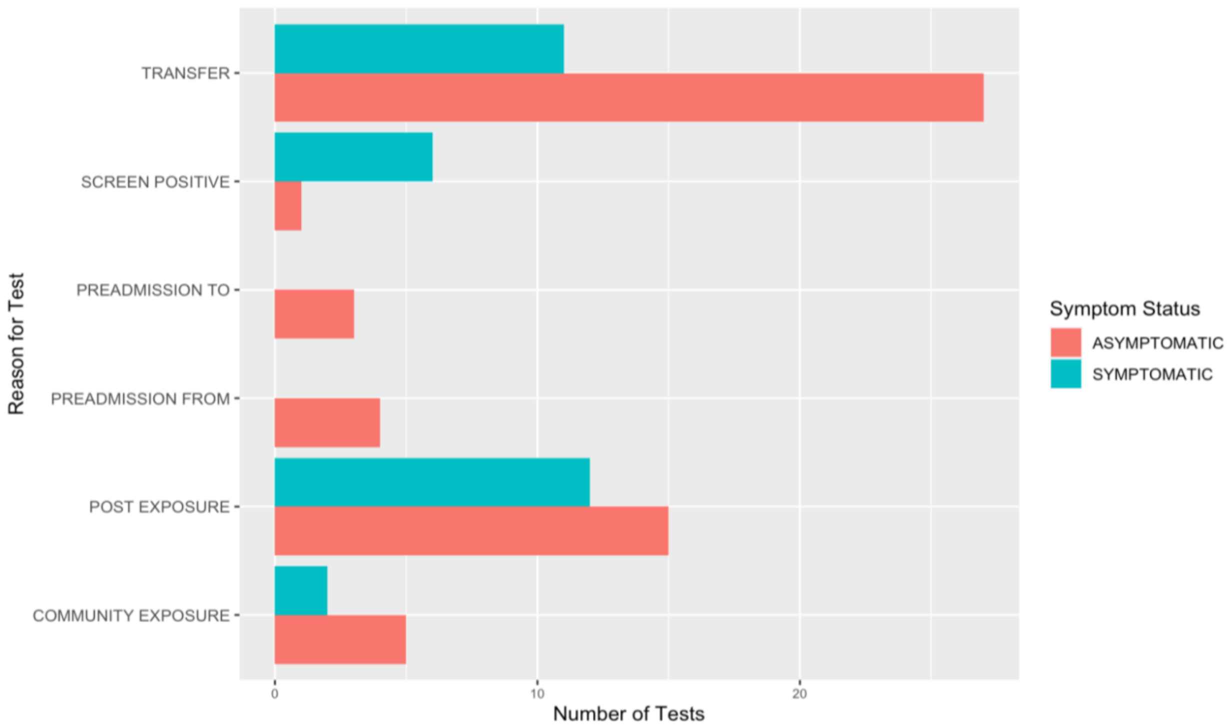

Figure 2: Reason for SARS-CoV-2 Test by Symptom Status

Table 6: Western Psychiatric Hospital SARS-CoV-2 Acquisition by Symptomatic Status

	POTENTIALLY WPH ACQUIRED	NON-WPH ACQUIRED	TOTAL
ASYMPTOMATIC	17	38	55
SYMPTOMATIC	12	19	31
TOTAL	29	57	86

5.0 DISCUSSION

5.1 PATIENT RISKS

Among 3,694 total admissions, 86 patients had positive test results (2.3%), and of those 86 patients, 55 were asymptomatic (64.0%). By identifying these asymptomatic infections, the patients were able to be isolated and prevent further transmission. Outlining the testing strategy at WPH and including patient data to support it provides evidence for the use of asymptomatic testing as part of a successful mitigation strategy that has not yet been quantified in the literature.

Demographic characteristics represent similar proportions in both the unique patients group and those who tested positive. The average age for the group that tested positive was 41.5 years old, slightly higher than the average for the unique patients of 33.2 years old. This could be explained by nosocomial transmission in the geriatric unit in July 2020. During this outbreak, six positive results were genetically linked to an index patient who was suspected to have contracted it from either a healthcare worker or unknown patient at WPH. This was the first case of an inpatient at WPH testing positive for SARS-CoV-2 and only symptomatic patients were being tested at the time. Beyond age, the sexes and ethnicities all make up similar proportions in both groups. Identified race of white was similar in both groups, but the group with positive test results had a slightly lower percentage of people identifying as black (18.6%) compared to the unique patients (26.9%).

Both groups had similar percentages of patients with none of the conditions associated with increased risk (51.6% of unique patients; 51.2% of positive tests) and also with multiple conditions (11.4% of unique patients; 12.8% of positive tests). The proportions varied for many of the conditions between groups. Diagnoses of smoking, obesity (including severe), COPD, kidney disease, and sickle cell anemia were all higher in the unique patients group. Heart disease, pregnancy, and diabetes all had proportions of diagnoses that were approximately twice as high as the unique patients. Based on existing literature, the expectation was to see higher proportions of each of these conditions in the group that tested positive, due to their identification as risk factors for severe illness (Centers for Disease Control and Prevention, 2021c). Many of the conditions were diagnosed in less than 2.7% of the unique patients, which would represent 87 patients. With only 86 total positive test results, it is not unexpected that proportions for these diagnoses would be lower than in the group of unique patients. The small number of positive test results means that the proportions of risk factors in that group cannot be generalized to the population at large and does not indicate that these are not risk factors for contracting SARS-CoV-2.

Some conditions that were maybe associated with an increased risk of severe illness were also lower in the positive test group. Diagnoses of asthma and overweight were both lower in the test group, and there were no patients with transplants (bone marrow or solid organ), Cystic Fibrosis, HIV, or liver disease in positive test result group. 11.6% of the positive test result group had dementia (n = 10), compared to 2.9% of the unique patients (2.9%). This is another discrepancy that can be attributed to nosocomial transmission at WPH. Four of the 10 patients with dementia who tested positive (40.0%) were determined to have acquired COVID-19 at WPH. Hypertension was also higher in the group that tested positive, with 19 of the positive test results (22.1%) compared to the unique patients (14.5%). This is another situation where nosocomial transmission was driving up the proportion, as four of the 19 positive patients with hypertension had WPH acquired COVID-19 (21.1%). Three of those four patients were part of the aforementioned July 2020 outbreak.

The four diagnoses this review focused on was ADHD, bipolar disorder, and schizophrenia because of existing literature that showed people with these diagnoses having significantly higher odds of contracting COVID-19 than those without, regardless of pre-existing medical conditions (Q. Wang et al., 2021). In the WPH data, there were only two patients with ADHD that tested positive for SARS-CoV-2 (2.3%), compared to 7.2% of the unique patients. Diagnoses of bipolar disorder and depression were both slightly higher in the group with positive test results, representing 15.1% (n = 13) and 40.7% (n = 35) respectively. This is compared to 12.3% (n = 398) patients having diagnoses of bipolar disorder and 39.4% (n = 1271) having diagnoses of depression in the unique patients group. Schizophrenia alone has a higher proportion of diagnoses in the unique patients group (179, 5.5%) compared to the group that tested positive (4, 4.7%). While the Wang study only looked at Schizophrenia, another study found schizophrenia spectrum diagnoses having higher odds of mortality (Nemani et al., 2021). Though this study did not report mortality, combining diagnoses of schizoaffective disorders and Schizophrenia in the contact of positive test results does provide additional insight. 8.8% of the unique patients were diagnoses with a schizophrenia spectrum disorder (n = 285) compared to 12.8% of the patients who tested positive (n = 11). This does not necessarily represent any kind of increased risk of contracting COVID-19 in people with schizophrenia spectrum disorders, but it does support the inclusion of schizoaffective disorder when analyzing psychiatric risk factors for COVID-19.

5.2 TESTING STRATEGY SUCCESSES AND GAPS

As previously discussed, seven of the 29 potentially WPH-acquired positive tests (24.1%) were the result of the July 2020 outbreak before WPH tested asymptomatic individuals. The ultimate goal of the testing strategy is prevent further transmission and subsequent infection in the hospital. Seventeen of the 29 (58.6%) WPH acquired positive test results occurred in December 2020 at the height of the third surge, but only 1 had a known index case. Without a known index case for the other 16 December cases, it is possible that some of the patients contracted COVID-19 from exposure to a positive healthcare worker. Additionally, two of the WPH acquired cases had exposures in the emergency department before they were admitted (6.9%). Asymptomatic patients could be in the emergency department for up to 48 hours while awaiting a test result, however, the average was 6 to 8 hours. For this reason, expedited testing for admissions to the geriatric floor and CADD.

The greatest success of the testing strategy is illustrated in the eight asymptomatic positive cases that were identified before admission to the appropriate unit (9.3% of all positive test results). Five of these eight cases would have been admitted to the geriatric unit had the strategy not been in place, with later admitted to CRS, and the final two being discharged directly from the COVID-19 flex unit. The July outbreak proved how infectious COVID-19 was on this unit, and it can be assumed that preventing these five additional positive cases from admission directly to the unit reduced the number of WPH acquired cases. One of the eight asymptomatic positive cases is a result of a positive screening, meaning they had a known close contact with someone who tested positive for COVID-19. This case in particular shows that simple screening questions can be effective at preventing transmission. Additionally, it is a mitigation strategy that has no cost to the hospital. It is important to note, however, that the other 7 asymptomatic positive cases likely would have been admitted directly to the appropriate unit had only the screening been utilized. This illustrates that the asymptomatic testing piece of the mitigation strategy was crucial to WPH's success.

5.3 LIMITATIONS

A limitation of the mitigation strategies employed was the lack of testing for healthcare workers. The workers were tested by WPH if they had a known contact or were symptomatic but could also elect to be tested elsewhere. In December 2020, the percent positivity reached 16.2% for the state of Pennsylvania with substantial transmission in all counties (Pennsylvania Department of Health, 2020). Staffing shortages due to absences during this time also led to some healthcare workers having to work in both yellow and red zones in addition to green zones. A limitation related to testing is the amount of time that some patients had to spend in the emergency department while awaiting results. Not only did this create potential exposures that resulted in two known cases, but it also prevented them from getting timely care. In a population that already faces care disparities, it is vital there are not additional barriers to care. This was eventually addressed through the expedited testing for the most at-risk patients.

It is not known if there were patients that decided to forgo seeking care at WPH because they tested positive, but it could have increased the proportion of positive test results. Another factor that likely impacted the number of positive tests was those that tested positive prior to a transfer but were unable to be admitted to WPH. This would have decreased the total number of positive cases and also impacted the quality of care that patients were receiving.

A limitation in the data itself is the lack of information on symptom severity for those who did experience symptoms. It would have been insightful to be able to describe the proportions of psychiatric diagnoses for the different levels of severity, something that has an observed association in the literature. Additionally, the reason for testing was not accurately recorded in patients that tested negative for SARS-CoV-2, which prevented this study from quantifying how many tests were done overall and making comparisons to those who tested positive. Finally, this study is solely descriptive and did not test for statistical significance in the differences between unique patients and those with positive test results.

Finally, the delimitation used to classify if a case was potentially WPH-acquired was a positive PCR result after day 2 with a known index or greater than 14 days after admission with or without a known index. Due to the incubation time of COVID-19, it cannot be said with certainty if the cases occurring in patients admitted for less than 14 days were the result of hospital acquired transmission. For this reason, it is likely that the number of potentially WPH-acquired positive test results is inflated.

5.4 STRENGTHS

Of the few existing studies reviewing mitigation and testing strategies in behavioral health settings, there is also limited information about their patient populations and positive SARS-CoV-2 tests. In the study by Zhang et al that included information about patient demographics, they did not stratify by positive test results or include medical diagnoses that would increase risk for COVID-19 (Zhang et al., 2020). This study compares all of the unique patients with those who tested positive and included not only psychiatric diagnoses, but also medical conditions. Further, it quantifies the success of the outlined mitigation strategy by providing the reasons that the positive tests were performed.

Though relationships that may exist between different risk factors and positive tests cannot be generalized to other facilities or patients with those diagnoses, it provides new insight into how testing strategies can impact transmission in a facility. By presenting the strategies with patient data collected during a novel public health crisis, this review can better inform future policies.

5.5 RECOMMENDATIONS

One difficulty in deciding on what mitigation strategies to employ was the lack of guidance for behavioral health settings from the CDC and Pennsylvania Department of Health (PA DOH). These settings have similar risks of other congregate settings specifically listed such as jails, SNFs, and LTCFs, in addition to psychiatric diagnoses that make it even more difficult to prevent transmission. After lobbying from the WPH infection preventionist, it seems that the PA DOH is beginning to include similar facilities in their recommendations, but the CDC is not specifically naming behavioral health settings. It is important for the government and other overseeing bodies to include these facilities in their recommendations. Some of the testing and mitigation strategies can be expensive, so without official guidance hospitals and facilities may choose not to adopt all of the practices.

The importance of timely testing was illustrated by this review, and it is important that patients getting tested for any infectious disease, not just COVID-19, be tested rapidly so they can be appropriately isolated to prevent transmission. Rapid testing also allows for care to be administered quickly. Surveillance testing of asymptomatic healthcare workers during the height of transmission in December 2020 could have prevented nosocomial transmission of COVID-19 at WPH. Cost is a consideration when testing asymptomatic health care workers. Advancements made in antigen tests for SARS-CoV-2 make them a cost-effective option that could potentially identify asymptomatic cases should transmission levels increase again. Specifically, if community percent positivity reaches a predetermined threshold, asymptomatic HCW testing should be initiated.

PCR testing alone cannot inform the source of a positive result. In instances where large amounts of positive results cannot be linked through case investigation, whole genome sequencing should be utilized. This can better inform how the cases spread and potential sources, providing evidence that can better guide future mitigation and testing strategies.

WPH patients face many barriers to care due to not only their psychiatric diagnoses, but also socioeconomic factors and homelessness. While they are receiving care at WPH there should be efforts to vaccinate patients and discuss any vaccine hesitancy they may be experiencing. Not only will this help reduce transmission at WPH should they be readmitted, but it will also provide protection once they are discharged. Beyond COVID-19, having discussions about vaccine hesitancy with peers and healthcare workers could strengthen their trust in the medical field overall.

Ultimately, this review shows that characteristics and diagnoses of the patients should be considered in the design of methods to prevent transmission of infectious disease in behavioral health settings when compared to other healthcare facilities. This approach of tailoring safeguards against infectious disease specifically to the populations being served has strong public health relevance as it can be applied to any healthcare setting, better protecting patients from disease and ultimately improving quality of care and outcomes.

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