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

Psychiatry Research 298 (2021) 113776

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Epidemiology, Infection Prevention, Testing Data, and Clinical Outcomes of COVID-19 on Five Inpatient Psychiatric Units in a large Academic Medical Center

Luming Li [a,*], Scott C. Roberts [b], William Kulp [a], Angelina Wing [c], Todd Barnes [c], Nicole Colandrea [c], Beth Klink [c], Frank Fortunati [a], Richard Martinello [b]

[a] Department of Psychiatry, Yale University, New Haven, CT, United States
[b] Infectious Disease, Yale New Haven Hospital, New Haven, CT, United States
[c] Yale New Haven Health, Yale New Haven Hospital, New Haven, CT, United States

ARTICLE INFO

Keywords:
infection prevention
COVID-19
inpatient psychiatry
observational study

ABSTRACT

Inpatient psychiatric facilities can face significant challenges in containing infectious outbreaks during the COVID-19 pandemic. The main objective of this study was to characterize the epidemiology, testing data, and containment protocols of COVID-19 in a large academic medical center during the height of the COVID-19 outbreak. A retrospective cohort analysis was conducted on hospitalized individuals on five inpatient psychiatric units from March 1st to July 8th, 2020. Demographic data collected include age, race, gender, ethnicity, diagnosis, and admission status (one or multiple admissions). In addition, a Gantt chart was used to assess outbreak data and timelines for one unit. Testing data was collected for patients admitted to inpatient psychiatric units, emergency room visits, and employees. 964 individuals were hospitalized psychiatrically. The study population included ethnically diverse patients with various mental illnesses. We also describe infection prevention strategies, screening, and triage protocols utilized to safely continue patient flow during and beyond the study period with a low patient and employee infection rate. In summary, our study suggests that early implementation of triage, screening, extensive testing, and unit-specific interventions can help prevent and contain the spread of COVID-19 in inpatient psychiatric units and help facilitate safe delivery of care during a pandemic.

1. Introduction

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) is the virus known to cause the coronavirus disease 2019 (COVID-19), which spread globally within months of identification and has been declared a pandemic by the World Health Organization. In the northeast U.S., following the first case in New York City on March 1, 2020, the first case in Connecticut was identified on March 8, 2020 (Dyal, 2020, Governor Lamont 2020). As of October 12, 2020, Connecticut has had a total of 61,377 lab-confirmed COVID-19 cases, and 4,532 COVID-19 associated deaths (COVID-19 Update 2020). Health systems have had to adapt to continue providing optimal patient care in the setting of surging COVID-19 cases while ensuring both patient and healthcare worker protection through evolving infection prevention strategies.

Psychiatric inpatient settings present potential concern for COVID-19 transmission for multiple reasons. Psychiatric units are structurally formatted in an open layout allowing for interaction as part of treatment (Lyons, 2020). Patients have close contact due to rooming together and participation in milieu and group therapies. Patients may have difficulties adhering to infection prevention guidelines, such as masking, due to acute psychiatric symptoms, altered mental status, and/or cognitive limitations (Yao et al., 2020). Psychiatric units can also be located in

Location of Work: Yale New Haven Psychiatric Hospital, Yale New Haven Health System, 184 Liberty St, New Haven, CT 06511.**Previous Presentation**: This paper has not been presented elsewhere and not in consideration for publication elsewhere.

* Corresponding author at: Luming Li, MD, 184 Liberty Street, New Haven, CT, 06511.
E-mail addresses: Luming.li@yale.edu (L. Li), scott.c.roberts@yale.edu (S.C. Roberts), William.kulp@yale.edu (W. Kulp), Angelina.Wing@YNHH.ORG (A. Wing), todd.barnes@ynhh.org (T. Barnes), nicole.colandrea@ynhh.org (N. Colandrea), beth.klink@ynhh.org (B. Klink), frank.fortunati@yale.edu (F. Fortunati), richard.martinello@yale.edu (R. Martinello).

https://doi.org/10.1016/j.psychres.2021.113776
Received 12 November 2020; Accepted 28 January 2021
Available online 2 February 2021

freestanding hospitals, with limited access to testing and hospital-based medicine (Koerth, 2020, Benson et al., 2020). Additionally, psychiatric patients are more vulnerable to contracting infectious disease in the community due to the adverse impact of social determinants of health, including homelessness, living in residential facilities, and frequent lack of social support which may all be further exacerbated in a pandemic (Conrad et al., 2020). Thus, infection prevention practices targeting the containment of COVID-19 transmission in psychiatric inpatient settings are critically important (Benson et al., 2020).

A pandemic does not reduce the need for acute psychiatric inpatient care, and patients continue to require intervention for illness, such as in cases of acute mania, suicidality, severe depression, and acute psychosis, that cannot be achieved through mitigation efforts implemented in non-psychiatric medical settings such as telemedicine and rescheduling (Kozloff et al., 2020, Vindegaard and Benros, 2020). Prior reports in several states, including Connecticut, New York, and Washington, have illustrated the unique burden of COVID-19 in psychiatric settings that resulted in outbreaks leading to patient morbidity and mortality (D'Agostino et al., 2020, Kim, 2020, Bellisle, 2020, Connecticut Valley 2020, John et al.). Previously, attempts to address COVID-19 transmission in psychiatric settings have largely centered on outpatient practices with the widespread implementation of telehealth, or on patient and staff safety in settings where patients are uncooperative or cannot adhere to infection prevention protocols (Ji et al., 2020, Xiang et al., 2020, Zhu et al., 2020, Chen et al., 2020, Fukuta and Muder, 2013). However, to our knowledge, only one study has previously characterized COVID-19 transmission and prevention strategies in inpatient psychiatry units at a state hospital (John et al.). In this retrospective cohort study, we describe the epidemiology, infection prevention strategies, and subsequent outcomes, including successful containment of an outbreak, in five psychiatric units that can serve as a model for optimizing future inpatient care during a pandemic wave.

2. Methods

2.1. Study Site and Study Population

The study sites included five inpatient units in a combined 118-bed psychiatric hospital located in across two campuses in an academic medical center in New Haven, Connecticut. The units include one adolescent unit (ages 13-17) named Liberty Village-2 (LV2), one young adult unit (ages 18-25) named Washington Square-3 (WS3), one older adult (ages 55+) unit named Celentano-5 (C-5), one adult unit for primarily mood disorders named Washington Square-2 (WS2), and one adult unit for primarily psychoses and dual-diagnosis treatment named Celentano-1 (C-1). LV2, WS2, and WS3 are located within a standalone psychiatric hospital adjacent to the Yale New Haven Hospital (YNHH) York Street Campus. C-1 and C-5 are located within the Yale New Haven Hospital Saint Raphael Campus. The facilities are approximately 1 mile apart. In calendar year 2019, the psychiatric hospital (both campuses) had 3,327 admissions, with an average length of stay of 12.5 days.

The study population included all inpatients hospitalized on March 1, 2020 across the five units, and all new patients admitted between March 1 and July 8, 2020. Data were obtained through the electronic medical record (EMR, Epic; Epic Systems Corporation, Verona, Wisconsin), which was used to obtain census and demographic information on the patients in each unit. This quality improvement project received a waiver of exemption for consent through the Yale University institutional review board.

Patients admitted more than once during the study period were counted as multiple admissions and categorized based on their initial admitting unit for primary diagnosis and unit location. Primary diagnosis and unit locations were applied to the first admission for data analysis.

The study period ranged from March 1 to July 8, 2020 and was divided into 3 periods relative to the implementation of an inpatient psychiatric COVID unit: (1) March 1 – April 27, 2020 – pre-COVID-19 unit; (2) April 28 – May 30, 2020 – COVID-19 unit; and (3) May 31 – July 8, 2020 – post-COVID-19 unit.

During period 1, COVID-19 was starting to penetrate into the northeast US. In the psychiatric hospital, all five units were operational and continued to receive patients. As the number of COVID-19 positive patients who met the requirements for acute psychiatric admission but did not need medical hospitalization increased, a COVID-19 specific psychiatric unit was created to facilitate care of COVID-19 positive psychiatric (or behavioral health) patients. Period 2 was the time when the COVID-19 specific psychiatric unit was in operation. During this period, two usually independent psychiatric units were merged into one on WS3 (adolescent and young adult), and LV2 became the COVID-19 unit. The 23-bed unit was modified to become an 11-bed COVID-19 unit. As the prevalence of COVID-19 decreased in Connecticut, the need for a COVID-19 psychiatric unit diminished and was closed (Period 3).

Prior to the implementation of the COVID-19 psychiatric unit, and after it was decommissioned, patients who tested positive were moved (or transferred) to the main hospital for inpatient medical care with support from the psychiatry consult service.

2.2. Testing Data

COVID-19 status was identified by SARS-CoV-2 RT-qPCR on nasopharyngeal swab specimens performed at the YNHH Clinical Virology Lab using FDA approved platforms. Test results were analyzed per encounter where an encounter was defined as the time between patient presentation and ultimate discharge back into the community. Individual patients may have had multiple tests and encounters across the study time periods. Test results were grouped by indication; 1) symptom-based (temperature >100.4 F, dyspnea, cough, anosmia and dysgeusia, or a positive travel history until community spread became prevalent in Connecticut) or 2) exposure-based (staff members or patients with a high-risk exposure to a positive person, defined as an interaction occurring less than 6 feet apart for greater than 15 minutes without appropriate personal protective equipment [PPE]). Individuals who underwent symptom-based or exposure-based testing were denoted as Persons Under Investigation (PUI) and were placed in a separately designated room within an inpatient unit. If staff developed symptoms, they were removed from the workplace, encouraged to obtain testing and worked with the Occupational Health to determine when they may return to work. Employee data were collected to track staff who tested positive.

Beginning April 23, 2020 all patients admitted to inpatient care across YNHH were tested, regardless of whether they were a PUI, prior to inpatient placement. Interventional psychiatric procedures continued throughout the study period (i.e. electroconvulsive therapy [ECT], esketamine), and COVID-19 testing was required within 72 hours of any ECT treatment. Finally, a number of post-hospitalization facilities mandated one or two negative COVID-19 tests prior to accepting patients for residential -care or housing programs. All COVID-19 tests were categorized according to the location of the test (emergency, inpatient medicine or inpatient psychiatry setting) and the reason for the test (person under investigation or disposition-related clearance tests).

In addition, encounter and testing data were collected from patients who were seen in psychiatric emergency services (PES), specifically assessing patients who were tested and diverted from inpatient admission or directly discharged. In the PES, patients were tested for COVID-19 based on the results of a travel/exposure and symptom screen. If determined to be high risk by a positive screen, then patients were tested and, if positive, admitted to the medical unit and/or COVID psychiatry unit during Period 2. PES-based screening occurred until preadmission testing was implemented for all inpatient hospital admissions.

A Gantt chart and epidemic curve was constructed to visually analyze the data and identify potential clusters of COVID-19.

2.3. Patient and Staff Safety Interventions

A series of interventions were implemented throughout the study period, many prior to the initiation of the COVID-19 specific psychiatric unit. The interventions were compiled into a timeline (See **Supplemental Data 1**), and included specific educational, operational, and clinical changes. The timeline includes two sections: 1) a section on system-wide YNHHS guidelines developed based on the Centers for Disease Control, CT Department of Public Health, and national professional society guidance, and 2) a section on psychiatry-specific interventions developed by Psychiatry in collaboration with YNHHS Infection Prevention. Escalation algorithms were used to guide staff on appropriate decision-making and transfer protocols (See **Supplemental Data 2**).

3. Results

3.1. Descriptive Demographic and Clinical Findings

During the 17-week study period, a total of 964 unique individuals were hospitalized with 824 patients (85.5%) experiencing a single admission. Demographic and clinical information are detailed in Table 1. The median age of the cohort was 33.0 years (interquartile range 22.0-51.0) with 129 (13.4%) adolescents and 132 (13.7%) geriatrics. Women comprised 465 (48.2%) of the cohort. 224 (23.3%) were Black, and 145 (15.0%) identified as Hispanics/Latinos. In addition, the COVID-19 psychiatry unit admitted 15 patients, 9 with mood disorders (60.0%), 3 with psychotic disorders (20.0%), 1 with a childhood disorder (6.7%), 1 with a substance-related disorder (6.7%), and 1 with a disorder classified as other (6.6%).

During the study period, patients continued to be admitted to the inpatient psychiatric units without any disruption to care delivery. However, the hospital operated at a reduced census compared to prior years (30-40% fewer inpatients during peak COVID weeks), due to fewer patients presenting to the emergency room and cancellations of elective procedures. The acute care hospital continued to admit patients to COVID-19 medical units and the highest community transmission period occurred between March 29 and May 30, 2020 when the inpatient medical COVID-19 hospitalized patient census was consistently above 150 patients per day and peaked at a total of 445 COVID positive inpatients on April 18th. The peak inpatient psychiatric hospital census was 115 on March 17th (see **Supplemental Data 3).**

The cohort of patients who received psychiatric inpatient care throughout the study period in any psychiatric setting (inpatient psychiatry units including the psychiatry-specific COVID-19 unit) did not require escalation of care nor transfer to medicine for acuity due to COVID-19. Patients did not need intensive care treatment, nor had pulmonary symptoms warranting medical consultation.

3.2. COVID-19 Testing and Patient Flow

Among the 964 individuals in the cohort, 1035 tests were performed and 61 (5.9%) were positive (Table 2). COVID-19 testing was performed for a variety of reasons including; suspicion for COVID-19 (PUI), disposition testing to transfer to another facility, preadmission testing, pretransfer testing (from inpatient medicine to inpatient psychiatry), or prior to a procedure such as ECT. Excluding tests conducted on known positive individuals within the COVID-19 psychiatry unit, there were 6 (10.2%) of 59 patients who tested positive while being suspected as a person under investigation for COVID-19, including 5 young adults and

Table 1
Demographics across Psychiatric Units, March 1, 2020 to July 8, 2020.

Variable	Total (N = 964)		C-1 (N = 224)		C-5 (N = 132)		WS-2 (N = 216)		WS-3 (N = 248)		LV-2 (N = 129)		COVID Unit[a] (N = 15)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	37.2	18.2	40.3	9.4	66.6	8.8	45.1	14	22.9	4.8	16	1.4	32.1	15.3
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Gender														
Female	465	48.2	63	28.1	67	50.8	128	59.3	116	46.8	82	63.6	9	60
Male	499	51.8	161	71.9	65	49.2	88	40.7	132	53.2	47	36.4	6	40
Race														
White	601	62.4	125	55.9	101	76.5	152	70.4	132	53.3	81	62.8	10	66.7
Black	224	23.2	61	27.2	28	21.2	42	19.4	61	24.6	29	22.5	3	19.9
Asian	22	2.3	7	3.1	0	0	2	0.9	12	4.8	1	0.8	0	0
Other	107	11.1	28	12.5	3	2.3	19	8.8	40	16.1	16	12.4	1	6.7
Unknown	10	1.0	3	1.3	0	0	1	0.5	3	1.2	2	1.5	1	6.7
Ethnicity														
Hispanic/Latino	145	15	40	17.9	4	3	20	9.3	46	18.5	34	26.4	1	6.7
Non-Hispanic	811	84.1	183	81.7	128	97	195	90.3	200	80.7	91	70.5	14	93.3
Unknown	8	0.9	1	0.4	0	0	1	0.4	2	0.8	4	3.1	0	0
Diagnosis [b]														
Alcohol-Related D/O	9	0.9	2	0.9	2	1.5	4	1.9	1	0.4	0	0	0	0
Anxiety D/O	52	5.4	7	3.1	2	1.5	9	4.2	19	7.6	15	11.6	0	0
Behavior D/O	6	0.6	0	0	0	0	0	0	2	0.8	4	3.1	0	0
Childhood D/O	2	0.2	0	0	0	0	0	0	1	0.4	0	0	1	6.7
Cognitive D/O	16	1.7	0	0	12	9.1	2	0.9	1	0.4	1	0.8	0	0
Development D/O	1	0.1	1	0.4	0	0	0	0	0	0	0	0	0	0
Mood Disorders	509	52.8	89	39.7	61	46.3	135	62.5	123	49.6	92	71.2	9	60
Personality D/O	26	2.7	6	2.7	0	0	5	2.3	12	4.9	3	2.3	0	0
Psychotic Disorders	278	28.8	91	40.7	51	38.6	45	20.8	78	31.5	10	7.8	3	20
Substance-Related D/O	50	5.2	26	11.6	2	1.5	14	6.5	5	2.0	2	1.6	1	6.7
Other	15	1.6	2	0.9	2	1.5	2	0.9	6	2.4	2	1.6	1	6.6
Admission [c]														
One Admission	824	85.5	189	84	115	87.1	186	86.1	213	85.5	113	87.6	8	61.5
Multiple Admissions	140	14.5	35	16	17	12.9	30	13.9	35	14.5	16	12.4	7	38.5

D/O = Disorders

[a] The COVID-19 psychiatry unit operated between 4/28-5/30, and only included patients who had an acute psychiatric condition requiring psychiatric hospitalization, and were positive for COVID-19 and medically stable.

[b] Diagnosis category groupings were based on a patient's principal hospital diagnosis.

[c] Patient unit locations were categorized based on the patient's first admission. If a patient were admitted directly to the COVID-19 psychiatry unit, the patient would be counted as part of the COVID-19 unit.

Table 2
COVID Testing Breakdown by Department of all patients from March 1, 2020 to July 8, 2020.

Unit	Category	Study Time Period 3/1 - 7/8		Pre-COVID unit 3/1 - 4/27		COVID Unit 4/28 - 5/30		Post-COVID Unit 5/31 - 7/8	
		Positive	Total	Positive	Total	Positive	Total	Positive	Total
COVID	Pre-Admission	5	5	0	0	5	5	0	0
	Pre-Transfer	12	12	7	7	5	5	0	0
	PUI Emergency	0	0	0	0	0	0	0	0
	PUI Inpatient	0	0	0	0	0	0	0	0
	Procedure Clearance	0	0	0	0	0	0	0	0
	Disposition Clearance	26	47	0	0	26	47	0	0
C-1	Pre-Admission	0	162	0	10	0	69	0	83
	Pre-Transfer	0	10	0	0	0	5	0	5
	PUI Emergency	0	10	0	10	0	0	0	0
	PUI Inpatient	0	4	0	3	0	0	0	1
	Procedure Clearance	0	6	0	0	0	6	0	0
	Disposition Clearance	0	16	0	0	0	4	0	12
C-5	Pre-Admission	0	71	0	3	0	35	0	33
	Pre-Transfer	0	21	0	3	0	10	0	8
	PUI Emergency	1	9	1	9	0	0	0	0
	PUI Inpatient	0	10	0	6	0	1	0	3
	Procedure Clearance	0	14	0	2	0	12	0	0
	Disposition Clearance	0	22	0	2	0	7	0	13
LV-2	Pre-Admission	0	89	0	4	0	32	0	53
	Pre-Transfer	0	3	0	1	0	1	0	1
	PUI Emergency	0	4	0	4	0	0	0	0
	PUI Inpatient	1	16	0	4	1	11	0	1
	Procedure Clearance	0	5	0	1	0	0	0	4
	Disposition Clearance	0	19	0	1	0	10	0	8
WS-2	Pre-Admission	0	111	0	9	0	55	0	47
	Pre-Transfer	0	21	0	5	0	6	0	10
	PUI Emergency	0	13	0	13	0	0	0	0
	PUI Inpatient	0	9	0	5	0	3	0	1
	Procedure Clearance	3	124	0	19	3	52	0	53
	Disposition Clearance	0	10	0	2	0	4	0	4
WS-3	Pre-Admission	1	118	0	0	0	48	1	70
	Pre-Transfer	4	17	3	7	1	5	0	5
	PUI Emergency	1	6	1	6	0	0	0	0
	PUI Inpatient	5	20	5	15	0	3	0	2
	Procedure Clearance	0	12	0	1	0	2	0	9
	Disposition Clearance	2	19	1	9	1	8	0	2
PUI Inpatient (Non-Covid Units)		6	59	5	33	1	18	0	8
Total Tests Performed		61	1035	18	161	42	446	1	428

PUI: Person under investigation (i.e. suspected for COVID due to symptoms or exposure). PUI Emergency: Any patient tested in the emergency room prior to April 23rd for symptom-based or travel history. Pre-admission Test: Test performed for all patients prior to admission on and after April 23rd. Pre-transfer Test: Test performed on the medical or surgical floors or another hospital's psychiatric unit prior to transfer to a psychiatric unit at the Yale New Haven Psychiatric Hospital (YNHPH). PUI Inpatient: Any patient with symptoms or vital signs meeting criteria for testing while in inpatient psychiatry. Procedure Test: Testing that was performed for psychiatric procedures (ECT, esketamine) or other medical procedures (i.e. dialysis). Disposition Test: Tests performed for placement post-discharge to another facility.

1 adolescent patient. All the positive tests were from patients on one inpatient unit, WS3, adolescent and young adult. While it was in operation, 15 unique patients were admitted to the psychiatry-specific COVID-19 unit after being deemed medically stable with COVID-19. At the time of admission, patients needed to be asymptomatic for at least 3 days and not require oxygen or respiratory therapy, have no

Table 3
SRC & YSC Psychiatric Emergency Unique Encounters, 3/1 to 7/8/2020.

Patient Status	Full Study Period: 3/1 to 7/8					3/1 to 4/22[1]					4/23 to 7/8[2]				
	Visits	Tested	Test Rate[3]	Positive	Pos Rate[4]	Visits	Tested	Test Rate	Positive	Pos Rate	Visits	Tested	Test Rate	Positive	Pos Rate
1. PES -> Discharge	1000	70	7%	3	4%	435	19	4%	0	0%	565	51	9%	3	6%
2. PES -> OBS -> Discharge	907	89	10%	1	1%	375	14	4%	1	7%	532	75	14%	0	0%
3. PES -> Inpatient Med/Surg	112	75	67%	15	20%	42	13	31%	9	69%	70	62	89%	6	10%
4. PES -> Inpatient Psychiatry	777	458	59%	1	0%	310	13	4%	0	0%	467	445	95%	1	0%
Total	**2796**	**692**	**25%**	**20**	**3%**	**1162**	**59**	**5%**	**10**	**17%**	**1634**	**633**	**39%**	**10**	**2%**

PES = Psychiatry Emergency Services; OBS = Psychiatry Observation Unit; SRC = St. Raphael's Campus; YSC = York St. Campus.
All testing was performed in the Psychiatry Emergency Services setting.
[1] Patients were tested in the emergency setting only if screened high risk for symptoms or exposure (3/1 to 4/22).
[2] All patients pending inpatient psychiatry admission were tested prior to admission (4/23 to 7/8).
[3] Test rate: Number of patients tested/number of patients seen.
[4] Pos Rate (Positivity Rate): Number of patients testing positive/number of patients tested.

significant medical co-morbidities, and be without dementia, delirium, or altered mental status due to the limited ability of a psychiatry unit to respond to medical emergencies. The average COVID-19 test turnaround time for inpatient units was 4 hours and 35 minutes.

Table 3 shows the number of patients tested in the two emergency rooms associated with the medical hospitals, and the disposition location of the patients who were tested. Early in the pandemic, when testing was less broadly available, 10 patients (16.9%) tested positive out of 59 tested based on symptom and travel risk alone. After implementation of universal preadmission testing, 10 patients (1.6%) of 633 patients were positive. Of the patients who tested positive in the emergency rooms, 15 patients were admitted to COVID-19 units on inpatient medicine, and 1 patient was directly admitted to the psychiatry-specific COVID-19 unit (as this unit was open for only a time-limited period). Five patients were transferred back to inpatient psychiatry after being hospitalized for COVID-19 in a medical unit and determined to no longer require isolation, but still required acute psychiatric hospitalization. The average test turnaround time was 3 hours and 21 minutes for COVID-19 performed for patients in the emergency room.

Staff were not universally tested but, rather, tested only if symptomatic or exposed to individuals who tested positive for COVID-19. Testing of the overall psychiatric staff found 11 of 93 (11.8%) to be positive for COVID-19 (Table 4). Among staff working on inpatient psychiatry units who became PUIs, 6 of 42 (14.3%) were positive for COVID-19.

3.3. Outbreak Data

The Gantt chart of outbreak data is detailed in Fig. 1. All patients who tested positive were physically located in one single psychiatry unit (WS-3), the young adult unit. The Gantt chart showed the first positive case of a patient on WS3 on April 9, 2020. The patient was discharged home for no longer requiring inpatient psychiatric hospitalization and did not need isolation after detection of COVID-19. Another patient who was considered high risk prior to admission (due to travel history, living in a residential facility, and having exposure to shelter/jail) initially tested negative on admission. However, this patient developed symptoms 10 days later and tested positive. Following the two positive test results, the entire unit of hospitalized psychiatric patients were tested on April 21, 2020. Of the 13 patients tested, 2 were found to be positive, the positive patient who was considered high risk at admission, tested in PES, and found to be negative at the time. Of note, one patient was not re-tested with the entire unit as he tested negative on April 20 (tested due to symptoms of cough that developed on April 19, 2020). In addition, one patient who was discharged on April 20, 2020 and re-presented to the PES 6 days later was found to be positive. This patient was admitted to the psychiatry-specific COVID-19 unit in order to minimize exposure to other units. After interventions; including transferring positive patients to inpatient medicine or the psychiatry-specific COVID-19 unit, unit-wide testing, and continued patient and staff screening, no further positives were detected on the WS3 unit for the duration of the study period.

Table 4
Testing of Employees Breakdown by Department from March 1, 2020 to July 8, 2020.

Area	Clinical Area	Tested	Positive	Rate
Administration	No	7	0	0.0%
Admissions	No	1	0	0.0%
Adol IOP	Yes	1	0	0.0%
Adult IOP	Yes	6	0	0.0%
C1	Yes	10	1	10.0%
C5	Yes	5	1	20.0%
Consult	Yes	2	0	0.0%
Dietary	No	2	1	50.0%
Interventional Psychiatry	Yes	1	0	0.0%
LV2	Yes	6	1	16.7%
PES – Observation Unit	Yes	6	1	16.7%
PES - SRC CIU	Yes	3	1	33.3%
PES - YSC CIU	Yes	7	2	28.6%
Social Work	Yes	15	0	0.0%
WS2	Yes	14	2	14.3%
WS3	Yes	7	1	14.3%
Total		93	11	11.8%
Total Staff on Inpatient Units		42	6	14.3%

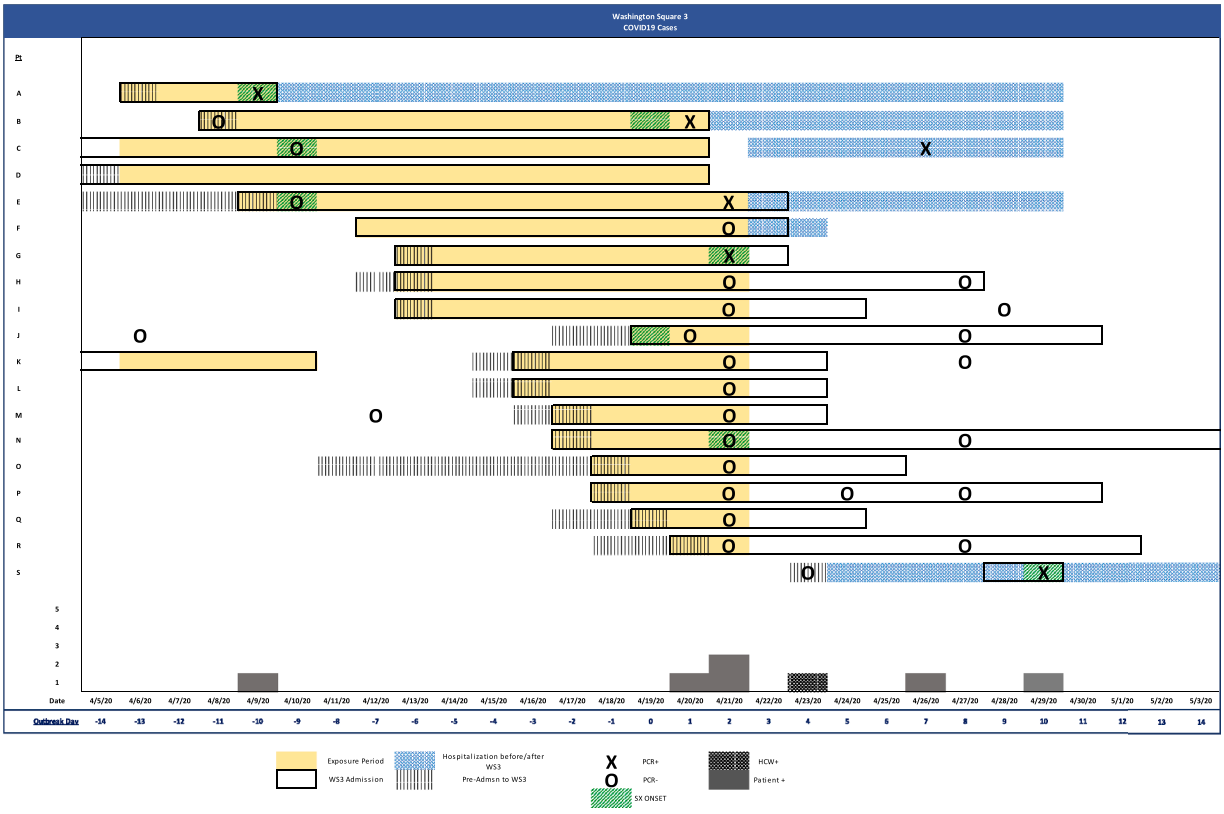
PES = Psychiatric Emergency Services.
Adol IOP = Adolescent Intensive Outpatient Program.
Adult IOP = Adult Intensive Outpatient Program.
YSC = Yale New Haven Hospital.
SRC = Hospital of St. Raphael.

4. Discussion

To our knowledge, this is the largest study describing the epidemiology, infection prevention strategies, and clinical outcomes of patients who required inpatient psychiatric hospitalization during the COVID-19 pandemic. We describe a cohort of 964 patients who were cared for between March 1 and July 8, 2020, through the peak period of the COVID-19 pandemic in Connecticut, and show both successful containment of an outbreak in an inpatient young adult psychiatric unit, as well as limited transmission across all inpatient psychiatry units through progressive employment of YNHH system-wide and YNHH psychiatry-specific infection prevention strategies while maintaining a stable inpatient census. We found that early risk factor and symptom screening in conjunction with universal pre-admission testing and enhanced staff and patient infection prevention interventions led to low spread of COVID-19 in inpatient psychiatric units. We found that patients requiring inpatient psychiatric level of care were able to be safely cared for even during the peak period of the COVID-19 pandemic.

Prior studies have described the high levels of transmission and mortality rates in inpatient psychiatric facilities, including Connecticut, New York, Washington, and internationally in Chinese and Korean psychiatric departments (D'Agostino et al., 2020, Kim, 2020, Bellisle, 2020, John et al., Ji et al., 2020, Xiang et al., 2020). These locations included state hospital facilities as well as government facilities internationally. In our study, we found that we had a low percentage of patients who tested positive in the inpatient psychiatric setting, despite one outbreak on the young adult unit that was successfully contained. No other healthcare associated transmission of COVID-19 was noted during the study period. In our cohort, the patients who tested positive were in the young adult unit, a population with a higher incidence of high-risk behaviors that can predispose them to greater rates of infection, including increased travel, social contact, and homelessness/housing instability, among others (Adams et al., 2020, Nagata, 2020, 10 Leading Causes of Death by Age Group 2017). Notably, patients who are considered high risk for COVID-19, including the geriatric population and those with serious mental illness (chronic schizophrenia and psychosis in the adult population), did not test positive once admitted, even though these patients were tested upon development of symptoms concerning for COVID-19.

A number of reasons may have led to a low rate of detected infection. Patients were triaged carefully in the emergency room and tested prior to admission if they either showed signs or symptoms concerning for COVID-19 or once universal testing for all hospitalizations was implemented. If found positive in the emergency room, the patient was not sent to inpatient psychiatry to prevent exposure and risk to other psychiatric patients. Other impactful interventions were introduced, including increased monitoring of vital signs and symptom review, to help with early detection of COVID-19 patients. Thus, even though there was an outbreak on one of the units where higher proportions of asymptomatic carriage in a young population can be seen, contact tracing and testing quickly identified positive patients and staff who were subsequently isolated off unit, effectively preventing further transmission. In addition, during the study period and beyond, staff and



SX ONSET = Symptom Onset
Post-Dischrg = Post-Discharge
Pre-Admsn = Pre-Admission
Pt = Patient
PCR+ = COVID Polymerase Chain Reaction Positive
PCR- = COVID Polymerase Chain Reaction Negative
HCW = Health Care Worker

Fig. 1. Gantt Chart of Psychiatry Unit Outbreak on WS3.
SX ONSET = Symptom Onset.
Post-Dischrg = Post-Discharge.
Pre-Admsn = Pre-Admission.
Pt = Patient.
PCR+ = COVID Polymerase Chain Reaction Positive.
PCR- = COVID Polymerase Chain Reaction Negative.
HCW = Health Care Worker.

patients had adequate access to PPE as well as hand hygiene supplies. Increased frequency of communication and educational trainings occurred throughout the period and reinforced the new interventions put in place. Training on the proper use of PPE and COVID-19 drills for inpatient PUIs may have contributed to the efficient prevention, identification and isolation of psychiatric patients. Social distancing was achieved by increasing use of telehealth on inpatient units, and a COVID-19 psychiatry unit became another means for isolation of positive patients.

Furthermore, as part of an academic medical center with internal testing capabilities, access to testing for psychiatric patients was likely better than in settings where access to testing capabilities is more limited. YNHH psychiatric patients were able to access rapid testing (<24 hours). In some circumstances, patients received test results within 4-6 hours, allowing for timely clinical management decisions. Interestingly, two patients who initially tested negative on admission then tested positive later in their hospitalizations, raising concerns about either healthcare acquisition or false negative results. Positive PCR testing is dependent on many factors, including viral loads and sampling technique and, with the longer incubation period of SARS-CoV-2, an initial missed diagnosis is possible and may have been the cause of the outbreak. Testing variability has been previously reported, and can be problematic for safe care delivery to patients in open-space hospital facilities and in congregate living settings (Koerth, 2020, Millard et al., 2020, Ghaffari et al., 2020). Repeated testing is one strategy that can help mitigate false negative results; however, this approach is contingent on adequate resources and increases the risk for false positive results. An alternative explanation is under-detection, and asymptomatic transmission was possible, especially without widespread pre-admission testing early in the pandemic. We also found an inpatient psychiatry staff infection rate of 14.3%, higher than the patient positivity rate at 8.8%; although, these incidence rates may not be directly comparable since staff testing was only based on symptoms, and some patients were tested asymptomatically based on exposure. In addition, staff may have self-isolated without official testing or received testing at alternative sites, which did not report to our system. Notably, the psychiatry-specific COVID-19 unit did not have any staff test positive.

There are several limitations to our study. Given the uncontrolled nature of clinical care delivery during the pandemic period, it is difficult to directly account for the impact of specific interventions utilized

during this time. For example, the impact of increased education and communication to staff is difficult to calculate and measure. We suspect that numerous quality improvement interventions were helpful for infection prevention during this period; although, the impact of each intervention could not be calculated. In addition, the study was conducted across two hospital campuses, which comprise an academic medical center. These findings may not be generalizable to other psychiatric units across the United States, particularly where the proximity and relationship with an acute care medical hospital are less close. While our facility struggled to ensure adequate provisions of testing and PPE, through several interventions to steward these resources, there was never a day when supplies were unavailable. This circumstance may not be the case for other facilities, particularly unaffiliated psychiatric hospitals, further affecting the generalizability of our results. Additionally, patients with psychiatric comorbidities may have been admitted medically for COVID-19 during this time period, and not for a primary behavioral health presentation. Similarly, even with strict methodology to categorize all the testing, including chart auditing and EMR data extraction, some test classifications could be misidentified, because test results required manual labeling. Finally, clinical outcomes were measured by test results and clinical status. While no patient cared for in psychiatry had morbidity or mortality, nor required escalation of medical treatment, due to COVID-19, a number of other clinical outcomes may have resulted from the virus, including longer term impacts such as subacute neuroinflammation that develops after hospitalization. Further study is needed to assess the impact on psychiatric care of this inpatient cohort during this period. Specifically, it would be important to follow this cohort to assess clinical status and outcomes in ambulatory settings, as well as track measures such as length of stay, readmissions, and inpatient psychiatry restraint use.

5. Conclusion

This retrospective cohort study assessed a group of patients cared for in inpatient psychiatry during and surrounding the peak period of COVID-19 in a geographic area with high community infectious spread. Numerous quality improvement interventions were utilized for infection prevention, and findings show that patients were safely cared for during the study period with low on-unit inpatient psychiatry transmission of SARS-CoV-2 to psychiatric patients.

CRediT authorship contribution statement

Luming Li: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Scott C. Roberts:** Conceptualization, Methodology, Visualization, Writing - review & editing. **William Kulp:** Conceptualization, Data curation, Validation, Formal analysis, Visualization, Writing - review & editing. **Angelina Wing:** Conceptualization, Formal analysis, Writing - review & editing, Data curation, Validation. **Todd Barnes:** Visualization, Data curation. **Nicole Colandrea:** Visualization, Writing - review & editing. **Beth Klink:** Conceptualization, Writing - review & editing. **Frank Fortunati:** Conceptualization, Resources, Supervision. **Richard Martinello:** Conceptualization, Writing - review & editing, Supervision.

Declaration of Competing Interest

Dr. Richard Martinello served on a scientific advisory panel for Genentech related to baloxavir. None of the other authors have disclosures to report. The authors declare that they have no competing interests to declare.

Acknowledgements

We thank all the staff who helped during the COVID-19 pandemic peak to keep our patients safe.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2021.113776.

References

Adams, S.H., Park, M.J., Schaub, J.P., Brindis, C.D., Irwin Jr., C.E., 2020. Medical Vulnerability of Young Adults to Severe COVID-19 Illness-Data From the National Health Interview Survey. J Adolesc Health 67 (3), 362–368.

Bellisle M. More Than a Dozen COVID-19 Cases at Psychiatric Hospital 2020. Available from: https://www.medscape.com/viewarticle/927841.

Benson, N.M., Öngür, D., Hsu, J., 2020. COVID-19 testing and patients in mental health facilities. The lancet Psychiatry 7 (6), 476–477.

Chen, J., Xiong, M., He, Z., Shi, W., Yue, Y., He, M., 2020. The enclosed ward management strategies in psychiatric hospitals during COVID-19 outbreak. Global Health 16 (1), 53.

Conrad, R.C., Baum, M.L., Shah, S.B., Levy-Carrick, N.C., Biswas, J., Schmelzer, N.A., et al., 2020. Duties toward Patients with Psychiatric Illness. Hastings Cent Rep 50 (3), 67–69.

Connecticut Valley Hospital Patient Dies of COVID-19 Complications: DHMAS NBCCT 2020 [cited 2020 7/16/2020]. Available from: https://www.nbcconnecticut.com/news/local/connecticut-valley-hospital-patient-dies-of-covid-19-complications-dhmas/2264026/.

COVID-19 Update October 12, 2020. Connecticut COVID-19 Data Tracker: 2020.

D'Agostino, A., Demartini, B., Cavallotti, S., Gambini, O., 2020. Mental health services in Italy during the COVID-19 outbreak. The lancet Psychiatry 7 (5), 385–387.

Dyal N.P. First Case of COVID-19 in NYC, First Death Reported in Washington State 2020. Available from: https://www.infectiousdiseaseadvisor.com/home/topics/respiratory/first-case-of-covid-19-in-nyc-first-death-reported-in-washington-state/.

Fukuta, Y., Muder, R.R., 2013. Infections in psychiatric facilities, with an emphasis on outbreaks. Infect Control Hosp Epidemiol 34 (1), 80–88.

Ghaffari, A., Meurant, R., Ardakani, A., 2020. COVID-19 Serological Tests: How Well Do They Actually Perform? Diagnostics (Basel) 10 (7).

Governor Lamont Announces First Positive Case of Novel Coronavirus Involving a Connecticut Resident. In: Connecticut So, editor.: The Office of Governor Ned Lamont; 2020.

Ji, H., Li, L., Huang, T., Zhu, Y., 2020. Nosocomial infections in psychiatric hospitals during the new coronavirus pneumonia outbreak. Eur J Psychiatry 34 (3), 177–179.

John W. Thompson J., M.D., , Amy J. Mikolajewski, Ph.D., Patricia Kissinger, Ph.D., Patrick McCrossen, M.D., Allison Smither, B.S., Govind Datta Chamarthi, M.B.B.S., et al. An Epidemiologic Study of COVID-19 Patients in a State Psychiatric Hospital: High Penetrance With Early CDC Guidelines. Psychiatric Services.0(0):appi.ps.202000270.

Kim M.J. 'It was a medical disaster': The psychiatric ward that saw 100 patients diagnosed with new coronavirus: Independent; 2020 [cited 2020 7/16]. Available from: https://www.independent.co.uk/news/world/asia/coronavirus-south-korea-outbreak-hospital-patients-lockdown-a9367486.html.

Koerth M. There Are Not Enough COVID-19 Tests. There Are Also Too Many COVID-19 Tests. FiveThirtyEight 2020. Available from: https://fivethirtyeight.com/features/there-are-not-enough-covid-19-tests-there-are-also-too-many-covid-19-tests/.

Kozloff, N., Mulsant, B.H., Stergiopoulos, V., Voineskos, A.N., 2020. The COVID-19 Global Pandemic: Implications for People With Schizophrenia and Related Disorders. Schizophr Bull 46 (4), 752–757.

10 Leading Causes of Death by Age Group 2017 10 Leading Causes of Death by Age Group, United States - 2017 CDC2017 [cited 2020]. Available from: https://www.cdc.gov/injury/wisqars/pdf/leading_causes_of_death_by_age_group_2017-508.pdf.

Lyons K. Lawsuit filed seeking to protect people in state-run psychiatric facilities from COVID-19: Hartford Courant; 2020 [cited 2020 7/16/2020]. Available from: https://www.courant.com/coronavirus/hc-news-coronavirus-psychiatric-facilities-20200501-l7gckolnmndg5pxv3mzd5xbuiq-story.html.

Millard, H., Wilson, C., Fortunati, F., Li, L., 2020. COVID-19 psychiatric patients: Impact of variability in testing on length of hospital stay and disposition back to congregate care settings. Psychiatry Res 292, 113324.

Nagata, J.M., 2020. Supporting Young Adults to Rise to the Challenge of COVID-19. J Adolesc Health 67 (2), 297–298.

Vindegaard, N., Benros, M.E., 2020. COVID-19 pandemic and mental health consequences: Systematic review of the current evidence. Brain Behav Immun. S0889-1591(20)30954-5.

Xiang, Y.-T., Zhao, Y.-J., Liu, Z.-H., Li, X.-H., Zhao, N., Cheung, T., et al., 2020. The COVID-19 outbreak and psychiatric hospitals in China: managing challenges through mental health service reform. Int J Biol Sci 16 (10), 1741–1744.

Yao, H., Chen, J.H., Xu, Y.F., 2020. Patients with mental health disorders in the COVID-19 epidemic. Lancet Psychiatry 7 (4), e21.

Zhu, Y., Chen, L., Ji, H., Xi, M., Fang, Y., Li, Y., 2020. The Risk and Prevention of Novel Coronavirus Pneumonia Infections Among Inpatients in Psychiatric Hospitals. Neuroscience Bulletin 36 (3), 299–302.