COMPARISON BETWEEN TELEHEALTH SERVICES AND TRADITIONAL IN-PERSON SERVICES FOR
OPIOID USE DISORDER TREATMENT DURING THE COVID-19 PANDEMIC

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ABSTRACT

The COVID-19 pandemic has stimulated the rapid growth of telehealth services. With the worsening of opioid overdose death and limited accessibility of opioid use disorder (OUD) treatments, the utilization of telehealth services for OUD treatments during the pandemic may be invaluable. We examined the patterns of such utilization and its relationship with the in-person treatment from April 1, 2020 to March 31, 2021 in a large health plan in southeast Michigan. First, the patients' socio-demographic and comorbidity characteristics were examined by the Pearson's chi-squared test for categorical variables and t-test for continuous variables between telehealth users and non-users. Next, we investigated whether the telehealth services were associated with the utilization of different levels of OUD treatments/cares by logistic regressions, adjusted by patient characteristics. Finally, we used a hurdle model to explore the factors associated with telehealth service use and the frequency of using the telehealth services. We found that patients were statistically different in most of their socio-demographic and comorbidity characteristics between telehealth users and non-users. Adjusted by covariates, telehealth users were more likely to take outpatient treatment, domiciliary partial residential care, behavioral therapy, medication for OUD, and buprenorphine for OUD treatment/care, while inpatient detoxification, intensive outpatient treatment, partial hospitalization, methadone and naltrexone had no statistically significant relationship with telehealth service use. Older patients had fewer telehealth visits compared to younger users, and patients living in the largest metropolis or more disadvantaged areas were less likely to use telehealth services. Telehealth services will be unlikely to replace in-person services, but may be a valued complement to in-person treatments during the COVID-19 pandemic.

ACKNOWLEDGEMENTS

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LIST OF ABBREVIATIONS

ADI: Area Deprivation Index

AHRQ: the Agency for Healthcare Research and Quality

ASAM: American Society of Addiction Medicine

AUD: Alcohol Use Disorder

BCBS: Blue Cross and Blue Shield

BCN: Blue Care Network

CCSR: Clinical Classifications Software Refined

CI: Confidence Interval

CMS: Centers for Medicare & Medicaid Services

COI: Childhood Opportunity Index

COVID-19: Coronavirus Disease of 2019

CPT: Current Procedural Terminology

DEA: Drug Enforcement Administration

ER: Extended-Release

FDA: U.S. Food and Drug Administration

HCPCS: Healthcare Common Procedure Coding System

HHS: Department of Health & Human services

HUD: U.S. Department of Housing and Urban Development

ICD-10-CM: International Classification of Diseases, 10th Revision, Clinical Modification codes

IOP: Intensive Outpatient Program

IRR: Incidence Rate Ratio

LOCs: Levels of Care

MOUD: Medications for Opioid Use Disorder

NB: Negative Binomial

NDC: National Drug Codes

OR: Odds Ratio

OTPs: Opioid Treatment Programs

OUD: Opioid Use Disorder

PM: Procedure Modifier

SD: Standard Deviation

SVI: Social Vulnerability Index

CHAPTER 1: INTRODUCTION

Due to the increased opioid medication prescription for pain relief and misuse of the prescribed or non-prescribed opioids or synthetic opioid drugs, the opioid overdose deaths have risen dramatically over the past two decades. More than half million people in the United States (U.S.) died from opioid overdose from 1999 to 2020.[1] There are three waves of opioid overdose death, shown in Figure 1 (Source[2]). The first wave was initiated by opioid medication increasingly prescribed for pain relief while ignoring the risk of addiction in the 1990s. The second wave of opioid overdose deaths started around 2010 due to heroin abuse, and the third wave began in 2013 caused by dramatically increased synthetic opioids misuse, especially due to the market of illegally manufactured fentanyl.[1,2] In 2007, the Department of Health & Human services (HHS) declared a public health emergency and a new five-point opioid strategy to fight this crisis from the five perspectives including treatment/care accessibility, available drugs for treatment, public health data surveillance, advanced research and pain management. [3,4]
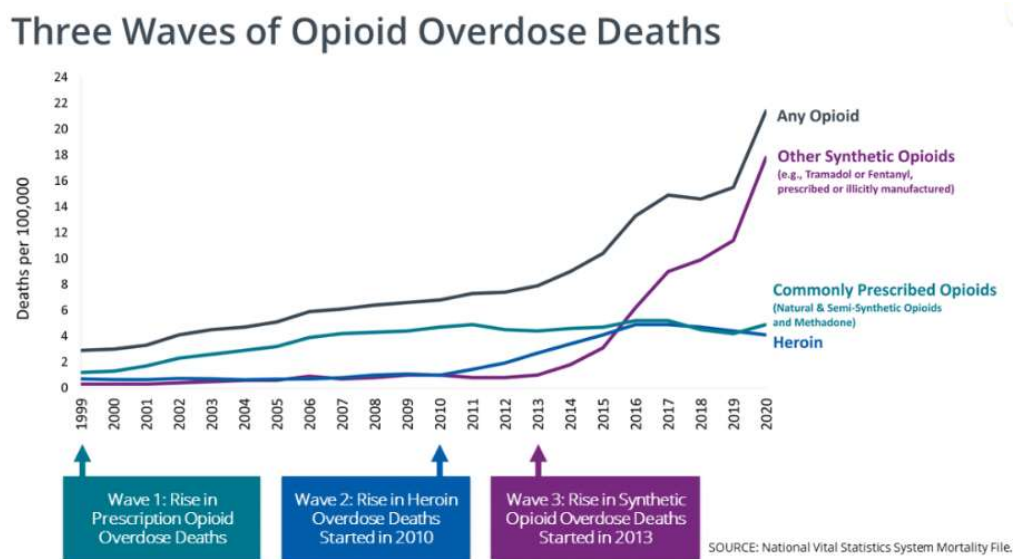
Figure 1. Three Waves of Opioid Overdose Deaths (Source [2]).

There are three primary medications to treat opioid use disorder (OUD), methadone, buprenorphine combined with naloxone, and naltrexone.[5] Methadone was approved by the U.S. Food and Drug Administration (FDA) in 1972 for the treatment of OUD. Unlike methadone that is used as a treatment for chronic pain that can be prescribed by any medical provider, methadone used for treating OUD can only be dispensed by the Drug Enforcement Administration (DEA) registered opioid treatment programs (OTPs) to the patients who are enrolled in the OTPs. Patients need to get in-person medical evaluation before they enroll in an OTP, and then they have to go to the methadone clinic to get the daily dose for at least 6 days a week for at least the first 90 days of treatment. It is hard for patients to stay in the treatment. After the first 90 days, patients can receive take-home doses according to their performances. In addition, there are limited DEA approved OTPs in which patients can enroll, especially in rural areas. Not everyone in need of it can access to methadone treatment. [6,7]

The second medication is buprenorphine. Usually, it is used with naloxone to discourage buprenorphine misuse.[7] They were approved by the FDA for OUD treatment since October 2002.[8] In contrast to methadone, buprenorphine can be used in outpatient settings. Any physicians or practitioners with specialized training can prescribe buprenorphine, which increases the accessibility.[9]

The third medication is naltrexone, which the FDA approved for the oral treatment of OUD in 1984 and the oral treatment of alcohol use disorder (AUD) in 1995.[10] It can be used in outpatient settings. It has two formulations, oral pills taken daily, and the extended-release (ER) injectable naltrexone given every 3-4 weeks or once a month.[7,11] Unlike methadone or buprenorphine, before taking naltrexone, patients are required to complete detoxification from

opioids, and they should not use any other opioid, drink alcohol or use other drugs. It is very hard for patients to start with naltrexone. In addition, naltrexone cannot relieve the drug cravings, and if patients give up or relapse, taking lower doses of opioids may cause opioid overdose death due to a reduced tolerance to opioid. [7,8]

Besides the medications for opioid use disorder (MOUD), the American Society of Addiction Medicine (ASAM) describes criteria of other levels of care (LOCs) for OUD patients, such as inpatient detoxification, partial hospitalization, domiciliary partial residential services, intensive outpatient care, behavioral therapy, and outpatient treatment for different levels of OUD patients with different needs.[12,13] After the first 1-3 days inpatient detoxification, OUD patients will be sent to domiciliary/residential settings. They will continue with medication, along with some psychoeducation and family support for 7-14 days. When they get better, they will be transferred to intensive outpatient program (IOP) and continue with drug tests, medication and psychiatric assistance, and family session for the next 4 to 8 weeks. After that, they will be sent to outpatient care for individual/group therapy, drug test, medication, and family assistance.[12,14]

Although the number of patients with OUD increased dramatically, the accessibility of OUD treatment is restricted due to the geographic difference, lack of licensed providers, OTPs, or travel time for patients.[7] During the COVID-19 pandemic, opioid misuse deteriorated and the treatment of OUD was affected by the stay-at-home order, isolation, or reduced in-person visits, which will result in a high risk for relapse and overdose death.[15] As telehealth services was increasingly used in the U.S. during the pandemic, it seems to be a promising solution for this problem.

"Telehealth, sometimes referred to as telemedicine, is the use of electronic information and telecommunications technologies to extend care when you (the provider) and the patient aren't in the same place at the same time. Technologies for telehealth include videoconferencing, store-and-forward imaging, streaming media, and terrestrial and wireless communications."[16] This definition of "telehealth" is from the Centers for Medicare & Medicaid Services (CMS). It includes three main virtual services, telehealth visits, virtual check-ins, and e-visits.[17]

Before the pandemic, telehealth services were restricted by the regulatory and reimbursement policies, including only to be used in rural areas, for accepted patients, or by certain providers.[18] However, during the COVID-19 public health emergency, state and federal governments temporarily changed some telehealth policies to expand its accessibility to support the health care service. For example, both new and established patients can access telehealth services. Patients are allowed to have telehealth services outside of rural areas. It also changed the list of telehealth services and the reimbursement policies.[18,19] For the OUD treatments, providers are allowed to prescribe buprenorphine using telehealth without a prior in-person visit by waiving the Ryan Haigh Act requirement.[19–22] Patients can get 14 or 28-day take-home doses of methadone from OTPs and telehealth services at OTPs.[21,22] A new Medicare payment policy ,that bundled OTPs payment with OUD treatment services, was created for MOUD before and during the pandemic since January 1, 2020. [22,23]

As the regulatory and policies restrictions for telehealth, including telehealth for MOUD, were relaxed during the pandemic, the utilization of telehealth services has experienced an unprecedented increase, but the research for the utilization of the telehealth services compared with in-person visits among the OUD patients in limited. We ask: Do OUD patients take advantage

of telehealth services to replace in-person health services? In other words, are there any changes in in-person health services utilization of OUD treatment, such as intensive outpatient care, partial hospitalization, domiciliary partial residential services, outpatient services, behavioral therapy, and MOUD, between telehealth users and non- users? We hypothesized that the telehealth services would change the utilization of health care for OUD treatment during the COVID-19 pandemic.

CHAPTER 2: STUDY DATA AND METHODS

2.1 Study period and study population

This study used de-identified data for commercially insured enrollees in Blue Cross and Blue Shield (BCBS) and Blue Care Network (BCN) from October 1, 2019 to March 31, 2021 to examine the differences in OUD treatments between telehealth users and non-users. We used the 6 months pre-pandemic period October 1, 2019 to March 31, 2020 to construct background and historical data. The study period for OUD treatments is from April 1, 2020, to March 31, 2021. Patients with OUD diagnosis between 18 and 64 years old who had continuous insurance coverage and submitted at least one claim 6 months before the study period were selected. Patients' insurance membership files, medical claims, and pharmacy data were used to select the study population.

2.2 Telehealth services users and non-telehealth services users

There is no uniform gold standard that we know of to identify telehealth services in medical claims. The BCBSM and BCN had contracted special online providers who had their own national provider identifier (NPI). The place of service code "02" is described as "telehealth provided other than in patient's home."[24] Table A1.1 shows the Current Procedural Terminology (CPT) codes, the Healthcare Common Procedural Coding System (HCPCS) codes, and procedure modifier (PM) codes we identified from multiple sources. Using different combinations of these codes we can identify different numbers of patients who used telehealth services. Table A1.2 shows the potential algorithms one can use and we can see there is a wide range of numbers of patients identified. After consulting the billing department of the insurer, we used the Boolean logic combinations of procedure codes in the list "CPT1" or ("CPT2" and PM=='95') or PM to identify

telehealth services in our analyses. For the complete list of "CPT1" and "CPT2", see Table A1.1 in Appendix 1. If the patients had one or more telehealth service claims for any health conditions in the study period, they were considered a "telehealth user", otherwise, a "non-telehealth user". The telehealth services were not limited to OUD treatments.

Telehealth is an umbrella term that includes three main virtual services, telehealth visits, virtual check-ins, and e-visits. Telehealth visits entail a synchronized audio and video telecommunication system between the provider and patients instead of in-person office or hospital visits. Virtual check-ins are used to decide what kind of visits or services are needed via telephone or other telecommunication devices. E-visits are used to communicate with the provider asynchronously via patients' portals. Patients can send image or text questions to their provider, but they cannot get real-time video communication through e-visits.[17] Table A2 shows the CPT/HCPCS codes that differentiate the three types of telehealth services (see Appendix 2).

2.3 Different levels of OUD treatments

OUD patients were identified by the International Classification of Diseases, 10th Revision[25], Clinical Modification (ICD-10-CM) codes starting with "F11". Following the ASAM guideline for OUD levels of care (LOC), we identified inpatient detoxification, partial hospitalization, domiciliary partial residential services, intensive outpatient program, behavioral therapy, outpatient services, and MOUD in medical and pharmacy claims during the study period and created an indicator variable for each LOC treatment.

The inpatient detoxification treatment (ASAM LOC 3.3 or higher) is medically monitored inpatient withdrawal management. "Because of the "genetic memory" that the body has with opioids, patients are at a high risk for rapidly becoming dependent and or having a fatal overdose

should they relapse"[14]. The domiciliary/residential LOC (which goes by many different names but all in ASAM LOC 3.0-3.1) provides a safe and sober living environment with lesser temptation for relapse to reduce this risk after detoxification.[14] Domiciliary partial residential services will provide patients not only with the medication treatment, but also behavior therapy, family counseling and support, and psychoeducation.[26] "Critical items that will need to be addressed beyond biomedical and withdrawal conditions are education about the disease, assessing motivation to change and tools to reduce relapse potential. Evidence-based pharmacotherapy options such as Buprenorphine and Naltrexone may be considered."[14] "Following the domiciliary LOC, the partial hospitalization program/intensive outpatient program (PHP/IOP, ASAM LOC 2.0-2.5) would continue the work started in the domiciliary LOC. The patient could be living at home or in a half-way or 3/4 housing situation, ideally be back to work or school and simultaneously attending 12 step programming."[14] The PHP service would continue for 12-24 sessions or 20-24 hours per week on average depending on the needs of the member.[14,27] Patients in the IOP programs in general have 9-20 hours/week for treatment.[27] Once the ASAM LOC 2.0 is completed, the patient will be sent to outpatient care (ASAM 1.0). For outpatient treatment, patients travel to the hospital or facilities for treatment less than 9 hours a week.[27] Ideally, they will still be involved in routine drug testing, MOUD, 12 step programming.[14] Behavioral therapy or MOUD may be used in each LOC above.

The relevant revenue codes, Current Procedural Terminology (CPT) Codes or Healthcare Common Procedure Coding System (HCPCS) Codes, and the National Drug Codes (NDC)[14] are listed in Table A3 in Appendix 3. In addition, if the medical claims had procedure modifier codes

"95", "GT", "GQ", or "G0", they were considered as "telehealth OUD treatment", otherwise they were "in-person OUD treatment".

2.4 Demographic characteristics

Patients' characteristics, such as age and gender, and their address zip codes were obtained from their insurance membership documents and medical claims files. Age was a continuous variable, we split it into 5 groups ([18,25), [25,35), [35,45), [45,55), [55,65)) as a categorical variable. We linked the 5-digit zip code to Census Tracts using HUD-USPS zip crosswalk files from the U.S. Department of Housing and Urban Development (HUD).[28,29] If multiple census tracts were allocated in one zip code, the one with highest residential ratio was kept. The Area Deprivation Index (ADI) in 2019[30], the 2015 Childhood Opportunity Index (COI) [31], and the 2018 Social Vulnerability Index (SVI)[32] were also used to represent the patients' socioeconomic status at the census tract level. Higher ranking or scores of the ADI or SVI indicate more disadvantaged neighborhood, while lower scores of the COI indicate fewer opportunities for children to access to parks, highly-ranked schools, playground, healthy food, and other neighborhood conditions that are good for their growth.[33] We scaled all rankings or scores to (0, 100) for analysis.[14]

2.5 Comorbidity

Patients' comorbidities were collected based on the diagnosis codes in the medical claims within 6 months before the study period (from 10/1/2019 to 3/31/2020). Psychiatric comorbidities, such as mood disorders, anxiety/fear/trauma/stress-related disorders, suicide/attempt/intentional self-harm, alcohol-related disorders, and substance-related disorders are known risk factors for high utilization of health care.[14] Among non-psychiatric comorbidities, we used diagnoses of neoplasms, endocrine, nutritional, and metabolic diseases,

the nervous, circulatory, respirator, digestive and genitourinary system diseases, and musculoskeletal system and connective tissue diseases as indicators of chronic conditions, and injury, poisoning and certain other consequences of external causes which might be related to overdose.[14] Comorbid conditions were identified using the Clinical Classifications Software Refined (CCSR v2022.1) based on the ICD-10-CM codes[34] from the Agency for Healthcare Research and Quality (AHRQ), or the revenue codes in the medical claim files.[14] Emergency room visits, diagnosed OUD, opioid abuse, opioid dependent, opioid overdose in the 6 months before the study period were also considered and identified using the revenue code and diagnosis code in the medical claims. COVID-19 was identified by the diagnosis code "U07.1" during the study period.

2.6 Statistical methods

This retrospective observational study was analyzed using Stata/MP, version 17 (Stata Corp). First, we described the demographic characteristics and socioeconomic status, such as age, gender, comorbid conditions, ADI, COI and SVI, among the OUD patients. We used Pearson's chi-squared test (Fisher's exact test for small cell sizes) for categorical variables and t-test for continuous variables to compare the difference between the two groups at the 0.05 significance level.

Secondly, we described the proportions of patients using any OUD treatments (by LOCs) between the two groups, and used logistic regression to examine the association of each level of OUD treatments with telehealth users/non-user status adjusting for covariates described above because the characteristics of the patients were different between telehealth user and non-user groups. Each OUD treatment utilization was considered an outcome in separate regressions.

To build a parsimonious predictive model for each OUD treatment indicator, we used "backward elimination" strategy for variable selection. It started with a full model with all covariates in the model, and then dropped the least significant variable, which had the smallest test statistic, or the highest p-value compared to other covariates. After that, the model was re-estimated and the step was repeated until every variable in the model was significant at a pre-determined threshold of p-value less than 0.1.[35] In this step, we always kept the "exposure" variable for telehealth users in the model. As multiple patients may reside in the same zip code we used cluster-robust standard errors in all regressions.

Thirdly, we calculated the number of telehealth services the target OUD patients used for any health conditions, excluding virtual check-in and e-visits, during the study period. If the patients had two claim records for using the telehealth service on the same day, they were counted once. And then we used a hurdle model to analyze the association between the number of telehealth visits and patients' characteristics. A hurdle model is a two-part model, which consists of two independent stages of modeling. The first stage is to determine whether the patient used any telehealth service (yes or no), and the second stage is for the positive outcome, i.e., the number of telehealth services, not including the zero count, using models such as zero truncated Poisson regression or zero truncated negative binomial regression. Hurdle models are often used for outcomes with excess zero or other values, which will allow variables that determine the zero count to be different from the variables that determine the positive counts.[36] In our study, the first step was to use logistic regression to examine which variables were predictive of whether the patients used any telehealth service, and the second step was to use zero-truncated negative binomial regression to check which variables were correlated with how

many times patients used telehealth visits when they chose to use it. We also used the variable selection strategy, as we mentioned above, to choose appropriate variables for the model by removing redundant variables and reducing model complexity.[35] For the zero truncated negative binomial model the variables were selected based on a negative binomial regression due to the restriction of the software.

2.7 Sensitivity analysis

As the treatment options may differ for a patient newly diagnosed with OUD from the options for a patient who had repeated episodes, we excluded patients with OUD diagnosis within 6 months before April 1, 2020 (the beginning of the study population) for sensitivity analysis. Since OUD patients have different levels of treatments during the recovery process, only including the newly diagnosed patients may help understand the telehealth utilization patterns in this vulnerable subpopulation.

CHAPTER 3: STUDY RESULTS

3.1 Patient Characteristics

Figure 2 shows the flow chart of the inclusion and exclusion criteria to identify the study population. The study included 5,636 OUD patients, among whom 4,281 (76%) used telehealth services at least once for any health conditions and 1,355 (24%) did not use any telehealth services during the study period.

Table 1. shows the numbers and proportion of patients' socio-demographic and comorbidity characteristics and the p-values comparing differences between telehealth user and non-users. From this table, we can see that age, gender, comorbidities, and socioeconomic status are significantly different among the two groups. The telehealth users tend to be older, more likely to be female, have more emergency visits and higher prevalence of comorbid conditions 6 month before the study period, and more likely to live in less deprived and less vulnerable neighborhood compared with non-users. However, the characteristics of whether they had OUD diagnosis before the study period, whether they were opioid dependent or opioid overdose patients before the study period, or whether they lived in the largest metropolitan areas had no statistically significant difference.

In sensitivity analysis, the socio-demographic and comorbidity characteristics for the newly diagnosed OUD patients were similar to those in Table 1. Compared to Table 1, a few more variables became statistically non-significant between telehealth user and non-telehealth user groups, such as in age, prior emergency room visits, substance-related disorder, suicidal ideation/attempt/intentional self-harm, and neoplasms. (Details in Appendix 4 Table A4.1)

	Telehealth Service User	Non-Telehealth Service
Member patient 34,008	Members with claims 29,507	
	Drop members with no claim 4,501	
Members with claims 29,507	19,953	9,554
Insurance Coverage only started before 10/01/2019 (6 months before study period) and ended after 3/31/2021 13,115	9,505	3,610
Age in [18,65) 9,858	7,025	2,833
OUD patients 8,665	6,295	2,370
OUD patients with at least one medical claim 6 months prior 5,636	4,281	1,355

Figure 2. Flow chart of the study population and the inclusion and exclusion criteria.

Table 1. Socio-demographic characteristics of OUD patients between telehealth users and non-users from April 1. 2020 to March 31, 2021.

	Non-users N=1355	Users N=4281	p-value
Age category			
18-<25	82 (6.1%)	188 (4.4%)	
25-<35	171 (12.6%)	479 (11.2%)	
35-<45	350 (25.8%)	1043 (24.4%)	
45-<55	330 (24.4%)	1088 (25.4%)	
55-<65	422 (31.1%)	1483 (34.6%)	0.013*
Gender			
F	534 (39.4%)	2061 (48.1%)	
M	821 (60.6%)	2220 (51.9%)	<0.001
COVID-19 Diagnosis in the study period	57 (4.2%)	353 (8.2%)	<0.001*
Comorbidity 6 months prior to April 1, 2020 (the beginning of the study period)			
Emergency room visits	162 (12.0%)	687 (16.0%)	<0.001
Opioid use disorder diagnosis	959 (70.8%)	2964 (69.2%)	0.283
Opioid abuse	103 (7.6%)	174 (4.1%)	<0.001
Opioid dependent	771 (56.9%)	2361 (55.2%)	0.259
Opioid overdose	12 (0.9%)	45 (1.1%)	0.755*
Substance-related disorders	79 (5.8%)	344 (8.0%)	0.007
Mood disorders	233 (17.2%)	1267 (29.6%)	<0.001
Alcohol-related disorders	32 (2.4%)	235 (5.5%)	<0.001*
Anxiety/fear/trauma/stressor-related disorders	288 (21.3%)	1541 (36.0%)	<0.001
Suicidal ideation/attempt/intentional self-harm	4 (0.3%)	38 (0.9%)	0.028*
Neoplasms	59 (4.4%)	328 (7.7%)	<0.001*
Endocrine, nutritional and metabolic diseases	457 (33.7%)	1958 (45.7%)	<0.001
Diseases of the nervous system	497 (36.7%)	2133 (49.8%)	<0.001
Diseases of the circulatory system	393 (29.0%)	1578 (36.9%)	<0.001
Diseases of the respiratory system	275 (20.3%)	1098 (25.6%)	<0.001
Diseases of the digestive system	225 (16.6%)	1075 (25.1%)	<0.001
Diseases of the musculoskeletal system and connective tissue	660 (48.7%)	2578 (60.2%)	<0.001
Diseases of the genitourinary system	168 (12.4%)	868 (20.3%)	<0.001
Injury, poisoning and certain other consequences of external causes	176 (13.0%)	849 (19.8%)	<0.001
Live in one of the 100 largest metropolitan areas	920 (67.9%)	2973 (69.4%)	0.282
Neighborhood characteristics	**Mean (SD)**	**Mean (SD)**	

Table 1 (cont'd)

Mean state rank (ADI)	53.2 (21.0)	49.5 (21.7)	<0.001
Mean national rank (ADI)	63.9 (17.8)	60.4 (19.2)	<0.001
Mean childhood opportunity index	50.7 (19.1)	53.3 (20.5)	<0.001
Mean socioeconomic score (SVI)	49.2 (19.0)	45.3 (20.0)	<0.001
Mean household/disability score (SVI)	56.6 (16.8)	51.9 (18.3)	<0.001
Mean minority/language score (SVI)	29.8 (16.9)	32.0 (17.8)	<0.001
Mean housing/transportation score (SVI)	42.0 (14.4)	39.8 (14.4)	<0.001

ADI = Area deprivation index (higher values indicating more deprived census tracts)

SVI = Social vulnerability index (higher values indicating more vulnerable census tracts)

SD = Standard deviation

p-values are from Pearson's chi-squared test for categorical variables and t-test for continuous variables.

*p-value are based on the Fisher's exact test.

3.2 Utilization of different levels of OUD treatment

Next, we examined the number and proportion of patients receiving each OUD treatment (yes/no) and whether the treatment receipt was associated with telehealth user/non-user status. Each treatment outcome was run in a separate logistic regression. The stepwise backward elimination method was used to select variables from Table 1. The selected variables for each outcome differed and were shown in Table A5.1 in Appendix 5.

Results in Table 2 showed that the highest treatment modality was outpatient treatment in both telehealth and non-telehealth groups, followed by medication for OUD and behavioral therapy. After adjusting for other patient characteristics, the odds for taking outpatient treatment (adjusted OR=2.62, 95% CI=(2.24, 3.05), all CI's were based on cluster-robust standard errors [1]), domiciliary partial residential (OR=6.65, 95% CI=(1.61,27.5)), behavioral therapy (OR=1.97, 95% CI=(1.60,2.43)), medication for OUD (OR=1.26, 95% CI=(1.07,1.49)), and

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[1] The 5,636 patients resided in 1,935 zip-code areas. The number of patients in each zip-code ranged from 1 to 48. The results using regular standard errors were similar.

buprenorphine (OR= 1.23, 95% CI=(1.00,1.50)) in telehealth users were higher than the odds among non-users, which indicated that telehealth users were more likely to choose these services.

In the sensitivity analysis results among newly OUD diagnosed patients, most OUD treatments/cares were not significantly different between the two groups, except outpatient (OR=1.72, 95%CI=(1.33, 2.23)) and behavioral therapy (OR=2.03, 95%CI=(1.29, 3.20)), after adjusting for other covariates. (Details in Appendix 4 Table A4.2)

Table 2. OUD Treatment/care utilization.

Levels of OUD treatment/care [a]	Non-users N=1355	Users N=4281	Adjusted OR (95% CI)	Unadjusted OR (95% CI)
Outpatient	947 (69.9%)	3596 (84.0%)	2.62 (2.24,3.05)	2.26 (1.95,2.62)
Behavioral therapy	193 (14.2%)	841 (19.6%)	1.97 (1.60,2.43)	1.47 (1.22,1.77)
Medication for OUD	246 (18.2%)	831 (19.4%)	1.26 (1.07,1.49)	1.09 (0.92,1.28)
Buprenorphine	174 (12.8%)	569 (13.3%)	1.23 (1.00,1.50)	1.04 (0.86,1.26)
Methadone	26 (1.9%)	71 (1.7%)	1.31 (0.81,2.11)	0.86 (0.53,1.40)
Naltrexone	17 (1.3%)	104 (2.4%)	1.55 (0.90,2.67)	1.96 (1.17,3.27)
Injectable naltrexone	13 (1.0%)	83 (1.9%)	1.71 (0.92,3.18)	2.04 (1.15,3.62)
Oral naltrexone	8 (0.6%)	66 (1.5%)	1.94 (0.92,4.08)	2.64 (1.28,5.41)
Detoxification	30 (2.2%)	100 (2.3%)	1.01 (0.66,1.55)	1.05 (0.70,1.59)
Intensive outpatient	20 (1.5%)	48 (1.1%)	0.79 (0.45,1.36)	0.76 (0.44,1.29)
Partial hospitalization	17 (1.3%)	29 (0.7%)	0.59 (0.31,1.11)	0.54 (0.29,0.99)
Domiciliary/residential	2 (0.1%)	35 (0.8%)	6.65 (1.61,27.5)	5.58 (1.34,23.2)

CI = Confidence Interval based on cluster-robust standard errors.
OR = Odds Ratio
a. Each treatment outcome was run in a separate logistic regression. The stepwise backward elimination method was used to select variables from Table 1. The selected variables for each outcome were shown in Table A5.1 in Appendix 5.

To further understand the patterns, we examined the utilization of in-person OUD treatments among telehealth users and non-users (Table 3). There was no statistically significant

association between in-person domiciliary partial residential, partial hospitalization, behavioral therapy or MOUD and telehealth usage. However, telehealth users were less likely to have in-person outpatient treatments than non-users with adjusted OR 0.81 (95% CI: 0.71, 0.93), which was opposite to the results of adjusted OR 2.62 (95% CI: 2.24, 3.05) in Table 2. Telehealth users were also less likely to use in-person intensive outpatient program than non-users with the adjusted OR 0.55 (95% CI: 0.31,0.99).

In the sensitivity analysis results among newly OUD diagnosed patients, the OR for outpatient treatment similarly reversed direction (OR=0.76, 95%CI=(0.59, 0.98)) between the two groups, and no other significant differences were found, after adjusting for other covariates (see Appendix 4 Table A4.3).

Table 3. Utilization of in-person OUD treatments.

In-person OUD treatments	Non-users N=1355	Users N=4281	Adjusted OR (95% CI)	Unadjusted OR (95% CI)
Outpatient	947 (69.9%)	2760 (64.5%)	0.81 (0.71,0.93)	0.78 (0.68,0.90)
Behavioral therapy	193 (14.2%)	595 (13.9%)	1.22 (0.99,1.50)	0.97 (0.80,1.18)
Medication for OUD	50 (3.7%)	148 (3.5%)	1.08 (0.77,1.52)	0.93 (0.67,1.30)
Intensive outpatient	20 (1.5%)	35 (0.8%)	0.55 (0.31,0.99)	0.55 (0.31,0.97)
Partial hospitalization	17 (1.3%)	28 (0.7%)	0.56 (0.30,1.06)	0.52 (0.28,0.96)
Domiciliary/residential	2 (0.1%)	22 (0.5%)	3.14 (0.73,13.57)	3.49 (0.82,14.84)

CI = Confidence Interval
OR = Odds Ratio

3.3 Hurdle model for analyzing the number of times patients used telehealth services

First, we calculated the number of times patients used telehealth services, excluding virtual check-in and e-visits, as an outcome variable. Figure 3 shows the histogram of this outcome variable. This count outcome has a high peak at zero (the proportion of zero outcome is 24.6%)

with mean of 5.9, standard deviation of 9.9, ranging from 0 to 232. The high variance-to-mean ratio of the outcome indicated over-dispersion, so we used zero truncated negative binomial model for the second part of the hurdle model.
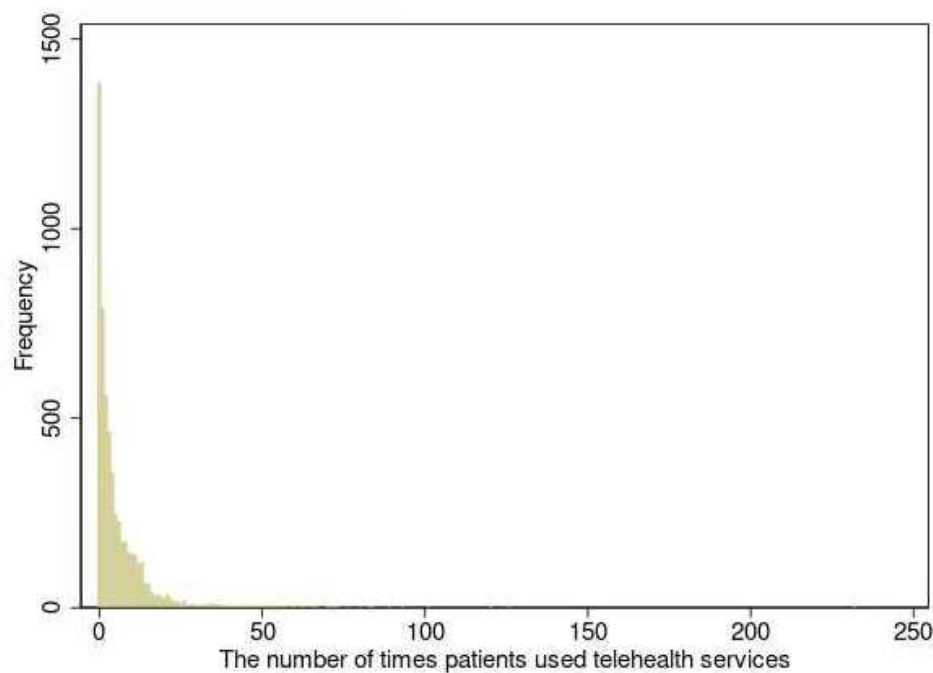
Figure 3. Histogram of the number of times patients used telehealth services.

Table 4 shows the results of the first and second parts of the hurdle model. In the first part, being a telehealth user was associated with age, gender, some of the comorbid conditions and most of the socioeconomic factors. The [25,45) year-olds were more likely to use telehealth services compared with ages [18,25) or [45,65). Male patients were less likely to use telehealth services than female. Patients with some prior comorbid conditions, such as mood disorder, alcohol-related, anxiety-related disorder, diseases of the endocrine, nutritional and metabolic, nervous, digestive, genitourinary, injury, poisoning and certain other external causes, and COVID-

19 were more likely to choose telehealth services, while patients with opioid abuse or living the

neighborhoods with the low COI index or high SVI sore were less likely to use telehealth services.

In the second part, the frequency they used the telehealth services was modeled by zero

truncated negative binomial regression. The statistically significant covariates were age of [55,65),

gender, patients with opioid dependence, some comorbid conditions, such as mood disorders,

alcohol-related disorders, anxiety, disease of circulatory system, diseases of the musculoskeletal

system and connective tissue, injury, poisoning and certain other consequences of external

causes and mean household /disability score.

In the sensitivity analysis for the newly diagnosed OUD patients, age of [55, 65) was not

significant in the first part, but significant in the second part in the hurdle model. There were

fewer significant comorbidities, compared to Table 4. Men, or patients living in the disadvantaged

neighborhoods were less likely to use telehealth services, similar to the results in Table 4 (see

Appendix 4 Table A4.4)

Table 4. Results of the first and second parts in the Hurdle model.

	Use any telehealth service		Number of non-zero telehealth services	
	OR (95% CI)	p-value	IRR (95% CI)	p-value
Age category				
25-<35	1.59 (1.13,2.23)	0.007	0.95 (0.71,1.28)	0.750
35-<45	1.56 (1.15,2.14)	0.005	0.90 (0.68,1.20)	0.483
45-<55	1.43 (1.03,1.98)	0.032	0.86 (0.65,1.13)	0.284
55-<65	1.46 (1.07,1.99)	0.017	0.65 (0.49,0.85)	0.002
Gender				
Male	0.81 (0.71,0.92)	0.002	0.86 (0.79, 0.93)	<0.001
COVID-19 diagnosis	1.93 (1.45,2.57)	<0.001	1.10 (0.96,1.28)	0.177
Comorbidity 6 months prior to April 1, 2020 (the beginning of the study period)				
Opioid abuse	0.51 (0.38,0.67)	<0.001		
Opioid dependent			1.24 (1.12,1.37)	<0.001
Mood disorders	1.50 (1.26,1.78)	<0.001	1.57 (1.41,1.75)	<0.001
Alcohol-related disorders	2.22 (1.51,3.26)	<0.001	1.39 (1.16,1.65)	<0.001
Anxiety/fear/trauma/stressor-related disorders	1.53 (1.31,1.79)	<0.001	1.29 (1.17,1.42)	<0.001
Endocrine, nutritional and metabolic diseases	1.24 (1.06,1.44)	0.006		
Diseases of the nervous system	1.25 (1.08,1.44)	0.003		
Diseases of the circulatory system			0.89 (0.81,0.99)	0.028
Diseases of the digestive system	1.19 (1.00,1.42)	0.048	1.10 (0.99,1.23)	0.089
Diseases of the musculoskeletal system and connective tissue	1.15 (0.99,1.33)	0.062	0.79 (0.71,0.88)	<0.001
Diseases of the genitourinary system	1.24 (1.03,1.49)	0.022		
Injury, poisoning and certain other consequences of external causes	1.21 (1.00,1.46)	0.049	1.25 (1.11,1.41)	<0.001
Live in one of the 100 largest metropolitan areas	0.82 (0.69,0.97)	0.018		

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Table 4 (cont'd)

Neighborhood characteristics				
Mean childhood opportunity index	0.97 (0.96,0.98)	<0.001	1.00 (0.99, 1.01)	0.666
Mean socioeconomic score (SVI)	0.98 (0.96,0.99)	<0.001	1.00 (0.99, 1.01)	0.607
Mean household/disability score (SVI)	0.98 (0.98,0.99)	<0.001	0.99 (0.99, 1.00)	<0.001
Mean minority/language score (SVI)	1.01 (1.00,1.01)	0.004	1.00 (1.00, 1.01)	0.053

OR = Odds Ratio

CI = Confidence Interval

NB = Negative Binomial

IRR = Incidence Rate Ratio

ADI = Area Deprivation Index (higher values indicating more deprived census tracts)

SVI = Social Vulnerability Index (higher values indicating more vulnerable census tracts)

CHAPTER 4: DISCUSSIONS

4.1 Findings

During the COVID-19 pandemic telehealth services in general increased dramatically. Many research papers investigated the effectiveness of telehealth delivery for OUD treatment in the aspects of retention, patient satisfaction, overdose.[22,37–40] In our study, we focused on whether telehealth service was associated with the utilization of different OUD treatment modalities. We found that after adjusting for patients' characteristics, there were significant differences in outpatient, behavioral therapy, MOUD, driven by buprenorphine, and domiciliary partial hospitalization, but not in methadone, naltrexone (oral or injectable), detoxification, intensive outpatient care, and partial hospitalization between the two groups. However, when considering only the in-person treatment modalities, telehealth users were less likely to have outpatient and intensive outpatient treatments than non-users. These facts indicated that having access to telehealth treatment for OUD reduced the in-person outpatient treatment and intensive outpatient program but did not do so for the other treatment modalities. These findings could be explained in two ways: 1) telehealth users chose the outpatient modalities (intensive or regular) over the inpatient modalities, or 2) telehealth users had different OUD severity that required different treatment strategies. We believe the second explanation to be more likely.
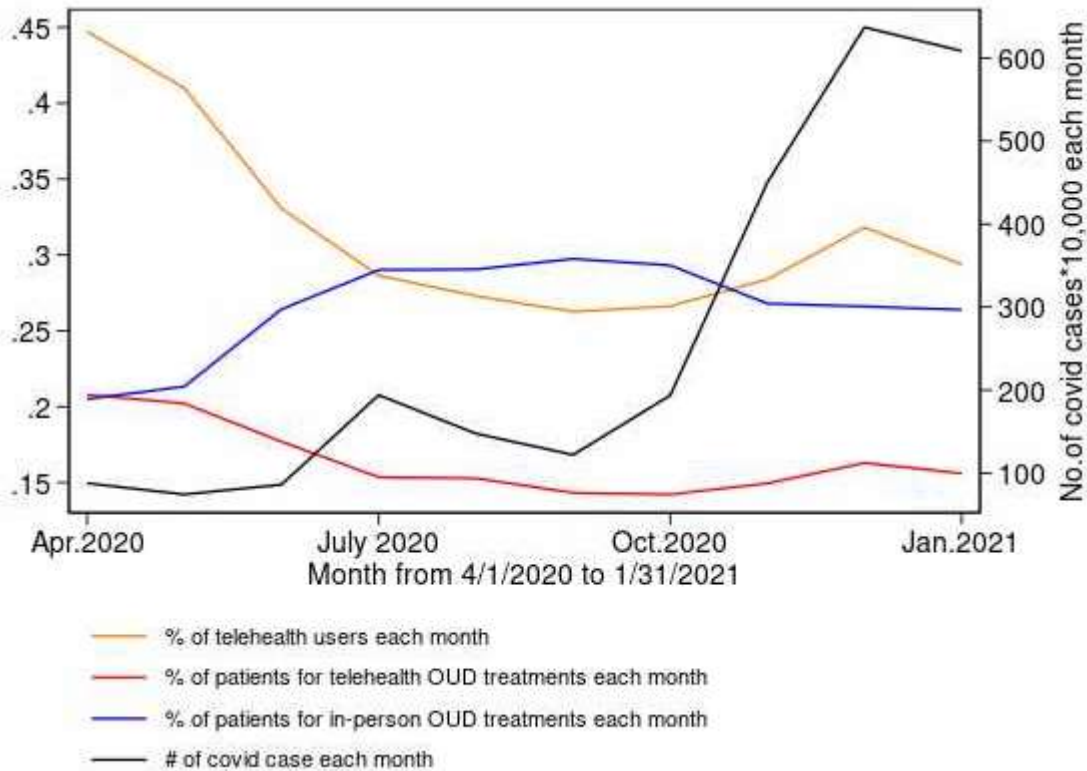
Figure 4. The percentage of patients using telehealth services for any conditions (yellow line) or for OUD (red), the percentage of patient using in-person OUD treatments (blue), and the number of COVID cases in the U.S. (black) each month from April 1, 2020 to January 31, 2021.

In addition, we compared the trends of patients who used telehealth services for any conditions, patients who used telehealth for OUD treatments, patients who used in-person OUD treatment each month from April 1, 2020 to January 31, 2021, shown in Figure 4. This plot also shows the number of COVID cases in the U.S. each month.[41] There were about 45% of patients using telehealth services for any conditions at the beginning of the pandemic, and the percentage of patients using telehealth service for OUD treatment was very close to the percentage of patients using in-person OUD treatments at the very beginning of the pandemic. However, the trend of using telehealth for OUD treatment went down over time, while the trend of in-person treatments went up. From October 2020 to December 2020, perhaps due to the increasing

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number of COVID cases, the use of telehealth for OUD treatment went up a little, and the use of in-person OUD treatments decreased a little. But the percentage of patients using in-person OUD treatments was always higher than that of patients using telehealth OUD treatments since May 2020. Had telehealth services been able to completely replace in-person OUD treatment, the trend for patients using in-person OUD treatments would have decreased, but it did not. However, this overall trend did not capture different treatment modalities nor the groups of telehealth users/non-users, and as such it cannot be directly compared with the results in regression analyses.

In the hurdle model we can see that factors associated with the use/no use of telehealth services and the frequency of using telehealth services were different. The [25, 65) year-old patients were more likely to use telehealth services compared to the [18,25) age group, but the [55,65) year-old patients had statistically significantly lower frequency of using telehealth services with Incidence rate ratio (IRR) 0.65 (95% CI:0.49,0.85). This result is similar to the result of prior research on telemedicine for buprenorphine, which found that older patients were less likely to use telemedicine services. [42]

In addition, some factors were only statistically significantly associated with one part of the hurdle model, e.g., living in one of the 100 largest metro areas was associated with lower probability for using telehealth but was not associated with the number of telehealth visits, which might be explained if these patients had easier access to in-person treatments. Patients living in the disadvantaged areas were less likely to use the telehealth services, which may be due to lower or slower internet access.

4.2 Limitations

Our study has several limitations. First, we used data for commercial beneficiaries from Blue Cross and Blue Shield (BCBS) and Blue Care Network (BCN). Our findings might not generalize to other populations, such as people with Medicaid, Medicare, other public insurances, or no insurance. In addition, the study population was OUD patients aged 18 to 64 years, excluding groups of adolescents and seniors, which also limits generalizability.

Secondly, we do not include all potential confounders in the statistical analysis, such as HIV, Hepatitis C or pain related chronic conditions. Other unmeasurable variables may also influence the findings.

Thirdly, the codes we used to identify the telehealth are mainly from the documents in the Centers for Medicare & Medicaid Services (CMS) website or provided by the insurer. As the telehealth codes and reimbursement policies were updated quickly during the pandemic, we may have missed some telehealth service codes. Similarly, we used diagnosis codes, CPT/HCPCS codes, NDC codes or the revenue codes in the medical or pharmacy files to identify the OUD patients, different levels of OUD treatments, or comorbidities. The patients who were mis-coded in the claim files could not be identified. We may underestimate or overestimate the study population and their characteristics.

CHAPTER 5: CONCLUSIONS

In this thesis, we found that OUD patients who used telehealth services were more likely to use outpatient OUD treatment, domiciliary partial residential care, behavioral therapy, medication for OUD treatment including buprenorphine when these treatments were delivered either in-person or by telehealth services. Using telehealth services in these treatments can increase access to OUD treatments even after the COVID-19 pandemic. Telehealth users were less likely to use in-person outpatient or intensive outpatient for OUD treatments, which suggested some in-person OUD treatment modalities may be delivered by telehealth. The overall percentage of patients using in-person OUD treatments are always higher than that of using telehealth service for OUD treatments, except at the very beginning of the pandemic. In-person treatment did not decrease much during the pandemic, contrary to what we expected.

We found patients not living in the largest metropolis were statistically significant more likely to use telehealth services, which means that telehealth can help people improve access to health care system in the rural area. However, patients living in the disadvantaged neighborhood were less likely to use the telehealth services. Improving the infrastructure and education, such as internet access and how to use electric devices for telehealth services, may increase the use of telehealth utilization and reduce transportation time and costs for some medical services. Updating the reimbursement policies to make telehealth worth the providers well may significantly affect the OUD treatments in the future.

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APPENDIX 1: IDENTIFICATION STRATEGIES FOR TELEHEALTH SERVICES BASED ON MEDICAL CLAIMS

There is no uniform gold standard that we know of to identify telehealth services in medical claims. The BCBSM and BCN had contracted special online providers who had their own national provider identifier (NPI). The place of service code "02" is described as "telehealth provided other than in patient's home."[24] Table A1.1 shows the Current Procedural Terminology (CPT) codes, the Healthcare Common Procedural Coding System (HCPCS) codes, and procedure modifier (PM) codes we identified from multiple sources. Using different combinations of these codes we can identify different numbers of patients who used telehealth services.

Table A1.1. Codes used to identify telehealth services.

Procedure modifier (PM) [a]	
Code	**Description**
GT	Via interactive audio and video telecommunication systems
95	A synchronous telemedicine service rendered via a real-time interactive audio and video telecommunications system
GQ	Via asynchronous telecommunications system
G0	Telehealth services for diagnosis, evaluation, or treatment, of symptoms of an acute stroke
Procedure code (HPCPS/CPT) provided by BCBS and BCN	
Code	**Description**
98966	Telephone assessment and management service, 5-10 minutes of medical discussion
98967	Telephone assessment and management service, 11-20 minutes of medical discussion
98968	Telephone assessment and management service, 21-30 minutes of medical discussion
98970	Qualified nonphysician health care professional online digital evaluation and management service, for an established patient, for up to 7 days, cumulative time during the 7 days; 5-10 minutes. Replace HCPCS code G2061 in January 2021.

98971	Qualified nonphysician health care professional online digital evaluation and management service, for an established patient, for up to 7 days, cumulative time during the 7 days; 11-20 minutes. Replace HCPCS code G2062 in January 2021.
98972	Qualified nonphysician health care professional online digital evaluation and management service, for an established patient, for up to 7 days, cumulative time during the 7 days; 21 or more minutes. Replace HCPCS code G2063 in January 2021.
99421	Online digital evaluation and management service, for an established patient, for up to 7 days, cumulative time during the 7 days; 5-10 minutes.
99422	Online digital evaluation and management service, for an established patient, for up to 7 days, cumulative time during the 7 days; 11-20 minutes.
99423	Online digital evaluation and management service, for an established patient, for up to 7 days, cumulative time during the 7 days; 21 or more minutes.
99441	Physician telephone patient service, audio only, 5-10 minutes of medical discussion
99442	Physician telephone patient service, audio only, 11-20 minutes of medical discussion
99443	Physician telephone patient service, audio only, 21-30 minutes of medical discussion
99444	Online E/M service provided by a physician or other qualified healthcare professional who may report E/M services provided to an established patient or guardian, not originating from a related E/M service provided within the previous seven days, using the Internet or similar electronic communications network. Replaced by 99441, 99442, 99443 in January 2020.
CPT/HCPCS codes from CMS quarterly update [a]	
Code	**Description**
G0071	Payment for communication technology-based services for 5 minutes or more of a virtual (non-face-to-face) communication between a rural health clinic (rhc) or federally qualified health center (fqhc) practitioner and rhc or fqhc patient, or 5 minutes or more of remote evaluation of recorded video and/or images by an rhc or fqhc practitioner, occurring in lieu of an office visit; rhc or fqhc only
G0406	Follow-up inpatient consultation, limited, physicians typically spend 15 minutes communicating with the patient via telehealth
G0407	Follow-up inpatient consultation, intermediate, physicians typically spend 25 minutes communicating with the patient via telehealth
G0406	Follow-up inpatient consultation, limited, physicians typically spend 15 minutes communicating with the patient via telehealth
G0407	Follow-up inpatient consultation, intermediate, physicians typically spend 25 minutes communicating with the patient via telehealth
G0408	Follow-up inpatient consultation, complex, physicians typically spend 35 minutes communicating with the patient via telehealth

Table A1.1 (cont'd)

G0425	Telehealth consultation, emergency department or initial inpatient, typically 30 minutes communicating with the patient via telehealth
G0426	Telehealth consultation, emergency department or initial inpatient, typically 50 minutes communicating with the patient via telehealth
G0427	Telehealth consultation, emergency department or initial inpatient, typically 70 minutes or more communicating with the patient via telehealth
G0459	Inpatient telehealth pharmacologic management, including prescription, use, and review of medication with no more than minimal medical psychotherapy
G0508	Telehealth consultation, critical care, initial , physicians typically spend 60 minutes communicating with the patient and providers via telehealth
G0509	Telehealth consultation, critical care, subsequent, physicians typically spend 50 minutes communicating with the patient and providers via telehealth
G2010	Remote evaluation of recorded video and/or images submitted by an established patient (e.g., store and forward), including interpretation with follow-up with the patient within 24 business hours, not originating from a related e/m service provided within the previous 7 days nor leading to an e/m service or procedure within the next 24 hours or soonest available appointment
G2012	Brief communication technology-based service, e.g. virtual check-in, by a physician or other qualified health care professional who can report evaluation and management services, provided to an established patient, not originating from a related e/m service provided within the previous 7 days nor leading to an e/m service or procedure within the next 24 hours or soonest available appointment; 5-10 minutes of medical discussion
G2025	Payment for a telehealth distant site service furnished by a rural health clinic (rhc) or federally qualified health center (fqhc) only
G2061	Qualified nonphysician healthcare professional online assessment and management service, for an established patient, for up to seven days, cumulative time during the 7 days; 5-10 minutes
G2062	Qualified nonphysician healthcare professional online assessment and management service, for an established patient, for up to seven days, cumulative time during the 7 days; 11-20 minutes
G2063	Qualified nonphysician healthcare professional online assessment and management service, for an established patient, for up to seven days, cumulative time during the 7 days; 21 or more minutes
G2077	Periodic assessment; assessing periodically by qualified personnel to determine the most appropriate combination of services and treatment (provision of the services by a Medicare-enrolled opioid treatment program); list separately in addition to code for primary procedure
G9868	Receipt and analysis of remote, asynchronous images for dermatologic and/or ophthalmologic evaluation, for use only in a Medicare-approved cmmi model, less than 10 minutes

Table A1.1 (cont'd)

G9869	Receipt and analysis of remote, asynchronous images for dermatologic and/or ophthalmologic evaluation, for use only in a Medicare-approved cmmi model, 10-20 minutes
G9870	Receipt and analysis of remote, asynchronous images for dermatologic and/or ophthalmologic evaluation, for use only in a Medicare-approved cmmi model, more than 20 minutes
Q3014	Telehealth originating site facility fee
S9110	Telemonitoring of patient in their home, including all necessary equipment; computer system, connections, and software; maintenance; patient education and support; per month
CPT codes from Optimize Health [b]	
99453	one-time reimbursement code related to setup. It's meant to take into account the effort spent educating a patient about the device they're going to be using for monitoring their particular condition.
99454	related to the supply of the device (or devices) to be used for monitoring. The device must be ordered by the patient's physician or other qualified healthcare provider.
99457	monthly reimbursement for time spent performing duties related to interpreting remotely monitored physiologic data. This would include medical decision making to assess the patient's clinical stability, communication with the patient via a synchronous two-way audio interaction, and oversight of the management and coordination of services as needed.
99458	an add-on code to 99457, for each additional 20 minutes of remote physiologic monitoring treatment management services provided in a 30-day calendar month
99091	for the collection and interpretation of physiologic data digitally stored and/or transmitted by the patient and/or caregiver to the physician or other QHCP.
CPT codes from CMS Frequently Asked Questions on billing [c]	
94002	Ventilator management services codes (94002-94005) were added to the list of
94003	telehealth services. Additional information regarding these codes is available here:
94004	https://www.cms.gov/Medicare/Medicare-General-
94005	Information/Telehealth/TelehealthCodes.

Table A1.1 (cont'd)

99281-99285 99291-99292 99217-99220 99224-99226 99235-99236	ED physicians can perform telehealth services from any location. CMS has temporarily added the ED E/M codes (CPT codes 99281–99285), the critical care codes (CPT codes 99291 and 99292), and the observation codes (CPT codes 99217–99220, 99224–99226, and 99234–99236) to the list of Medicare telehealth services for the duration of the COVID-19 PHE. When delivering emergency telehealth services, ED physicians should use the code that most accurately reflects that service and use the same place of service code that they would have used if that service was delivered in-person. The CPT telehealth modifier, modifier 95, should be applied to claim lines that describe services furnished via telehealth. For example, regardless of location, ED physicians who are delivering emergency services can use the ED E/M codes with place of service 23 (ED) and apply modifier 95
CPT codes from Revenue Cycle Advisor [d]	
99446	interprofessional telephone/internet/electronic health record assessment and management service provided by a consultative physician, including a verbal and written report to the patient's treating/requesting physician or other qualified healthcare professional; 5-10 minutes of medical consultative discussion and review
99447	…11-20 minutes
99448	…21-30 minutes
99449	…31 minutes or more
99451	interprofessional telephone/internet/electronic health record assessment and management service provided by a consultative physician, including a written report to the patient's treating/requesting physician or other qualified healthcare professional, 5 minutes or more of medical consultative time
99452	interprofessional telephone/internet/electronic health record referral service(s) provided by a treating/requesting physician or other qualified healthcare professional, 30 minutes

a. Data source: https://www.cms.gov/Medicare/Coding/HCPCSReleaseCodeSets/HCPCS-Quarterly-Update. Accessed 12 Nov. 2022

b. Data source: https://blog.optimize.health/cpt-code-series-99453-99454. Accessed 12 Nov. 2022.

c. Data source: https://www.cms.gov/files/document/03092020-covid-19-faqs-508.pdf. Accessed 12 Nov. 2022.

d. Data source: https://revenuecycleadvisor.com/news-analysis/qa-2019-cpt-codes-interprofessional-consultations#:~:text=99452%2C%20interprofessional%20telephone%2Finternet%2F,qualified%20healthcare%20professional%2C%2030%20minutes. Accessed 12 Nov. 2022.

CPT/HCPCS codes 99281-99236 have descriptions stating that "the CPT telehealth modifier, modifier 95, should be applied to claim lines that describe services furnished via telehealth." Therefore, these codes are called the CPT2 set and always combined with PM=='95'. Other CPT/HCPCS codes are called the CPT1 set. The four PM codes 'GT','95', 'GQ', or 'G0' are called the PM set. The place of service code '02' is called the POS set.

Table A1.2 shows the number of individuals who had at least one telehealth visit out of a total of 5,636 individuals using different combinations of these codes. After consulting the billing department of the insurer, we used the Boolean logic CPT1 or (CPT2 and PM=='95') or PM to identify telehealth services in our analyses.

Table A1.2. Potential algorithms for identifying telehealth service users in medical claims.

Method	Combination*	Telehealth user (N)	Non-telehealth user (N)
1	POS | NPI | CPT | PM	5023	613
2	NPI | CPT | PM	4590	1046
3	PM only	4025	1611
4	POS | NPI | (CPT & PM)	3496	2140
5	POS only	3332	2304
6	POS & (NPI | CPT | PM)	1611	4025
7	(POS | NPI | CPT) & PM	705	4931
8	(NPI | CPT | PM) & POS	1611	4025
9	POS | NPI | CPT & PM	3973	1663
10	POS & (CPT | PM)	1611	4025
11	CPT only	2608	3028
12	CPT & (POS | PM)	1798	3838
13	CPT1 | (CPT2 & PM=='95')	1508	4128
14	CPT1 | (CPT2 & PM=='95') |PM	4281	1355

* The notation "|" means "OR", and "&" means "AND".

APPENDIX 2: LIST OF CPT/HCPCS CODES USED FOR CLASSIFYING TELEHEALTH VISITS, VIRTUAL CHECK-INS, AND E-VISITS

Telehealth is an umbrella term that includes three main virtual services, telehealth visits, virtual check-ins, and e-visits. Telehealth visits entail a synchronized audio and video telecommunication system between the provider and patients instead of in-person office or hospital visits. Virtual check-ins are used to decide what kind of visits or services are needed via telephone or other telecommunication devices. E-visits are used to communicate with the provider asynchronously via patients' portals. Patients can send images or text questions to their provider, but they cannot get real-time video communication through e-visits.[17] Table A2 shows the CPT/HCPCS codes that differentiate the three types of telehealth services.

Table A2. Classification of three types of telehealth services.

Type	Codes
Virtual Check-ins	G2012, G2010, G2250, G2251, G2252
E-visits	99421, 99422, 99423,
	G2061, G2062, G2063, 98970, 98971, 98972
Telehealth visits	All other codes in Appendix 1 Table A1.1 for telehealth services excluding codes for E-visit and virtual check-ins

Data sources include:
1. COVID-19 Frequently Asked Questions (FAQs) on Medicare Fee-for-Service (FFS) Billing. :181. https://www.cms.gov/files/document/03092020-covid-19-faqs-508.pdf;
2. MEDICARE TELEMEDICINE HEALTH CARE PROVIDER FACT SHEET | CMS. https://www.cms.gov/newsroom/fact-sheets/medicare-telemedicine-health-care-provider-fact-sheet. Accessed 12 Nov. 2022;
3. mm12126.pdf. Accessed November 12, 2022. https://www.cms.gov/files/document/mm12126.pdf;
4. Nicoletti, Betsy. "Virtual Communication: HCPCS Codes G2010, G2012, G2250, G2251, G2252." CodingIntel, 27 Nov. 2018, https://codingintel.com/virtual-communication-codes/.

APPENDIX 3: LIST OF CODES USED FOR THE IDENTIFICATION OF STUDY PATIENTS AND TYPES OF OUD TREATMENTS

Patients with OUD, opioid dependence, opioid overdose, and opioid abuse were identified by the ICD-10-CM codes. Various levels of OUD treatments (inpatient detoxification, intensive outpatient, partial hospitalization, domiciliary behavioral services, outpatient, behavioral therapy, and methadone treatment) were identified by various revenue codes, CPT/HCPCS codes. Medication for OUD was identified by the National Drug Codes. Table A3 shows the details.

Table A3. Codes for the identification of OUD patients and OUD treatments.

Terms	Code	Code sources
Opioid use disorder (OUD)	F11.xxx	ICD-10-CM
Opioid dependence	F1120, F11220, F11221, F11222, F11229, F1123, F1124, F11250, F11251, F11259, F11281, F11282, F11288, F1129	ICD-10-CM
Opioid overdose	T400, T401, T402, T403, T404	ICD-10-CM
Opioid abuse	F1110, F1114, F1119, F11151, F11120, F11121, F11159, F11122, F11129, F11181, F11182, F11188, F11150	ICD-10-CM
Inpatient detoxification	0116, 0126, 0136, 0146, 0156	Revenue Code
Intensive outpatient	0906, 0908	Revenue Code
Partial hospitalization	0912, 0913	Revenue Code
Domiciliary behavioral services	0919	Revenue Code
Outpatient	90791, 90792, 90832, 90833, 90834, 90836, 90837, 90838, 90839, 90840, 90846, 90847, 90853, 90887, 99201, 99202, 99203, 99204, 99205, 99211, 99212, 99213, 99214, 99215	CPT/HCPCS

Table A3 (cont'd)

Behavioral therapy	90785, 90804, 90806, 90808, 90810, 90832, 90833, 90834, 90837, 90839, 90840, 90846, 90847, 90849, 90853, 90875, G0396, G0397, H0001, H0004, H0005, H0006, H0007, H0008, H0010, H0011, H0012, H0013, H0014, H0015, H0022, H0028, H0036, H0038, H0047, H0049, H0050, H2011, H2019, H2027, H2034, H2035, H2036, S0281, T1006, T1007, T1012, 90812, 90814, S0201	CPT/HCPCS
Medications for OUD	J0570, J0571, J0572, J0573, J0574, J0575, J0592, Q9991, Q9992, J2315, H0020, S0109, J1230, G2067-G2080, G2215, G2216, G1028	CPT/HCPCS
Medications for OUD	00054017613 00054017713 00054018813 00054018913 00054039168 00054039268 00054121811 00054121842 00054355344 00054355367 00054355467 00054355563 00054355663 00054421625 00054421725 00054421825 00054421925 00054453825 00054454725 00054457025 00054457125 00054854725 00054855311 00054855324 00054855411 00054855424 00056001122 00056001130 00056001170 00056007950 00074201201 00074201232 00093537856 00093537956 00093572056 00093572156 00185003901 00185003930 00228315303 00228315403 00228315473 00228315503 00228315567 00228315573 00228315603 00378092393 00378092493 00378326001 00378327201 00406009201 00406009203 00406052705 00406052710 00406054034 00406117001 00406117003 00406192303 00406192403 00406254001 00406345434 00406575501 00406575523 00406575562 00406577101 00406577123 00406577162 00406697434 00406872510 00409201203 00409201232 00555090201 00555090202 00904653060 00904653061 10544037702 10544037728 10544037808 10544037828 10544037830 10544037860 12496010001 12496010005 12496030001 12496030005 12496075701 12496075705 12496120201 12496120203 12496120401 12496120403 12496120801 12496120803 12496121201	NDC code

Table A3 (cont'd)

| Medications for OUD | 12496121203 12496127802 12496128302
12496130601 12496130602 12496131002
13107008801 13107008901 16590066630
16590067007 16590067045 16590067060
16590067071 16590067072 16590067082
16590067083 16590067090 16590068945
16590068960 16590068972 16590068990
16729008101 16729008110 17478038020
21695051510 23490587703 23490587706
23490587707 23490587709 23490587801
23490587802 23490587803 23490587809
23490779801 23490779803 35356000407
35356000430 35356055530 35356055630
35356083401 35356083430 35356083460
35356083490 35356083530 35356083560
35356083590 40042001001 42023017901
42023017905 42291017430 42291017530
42291063230 42549057702 42549057728
42549057802 42549057808 42549057828
42549057830 42549057856 42549057860
42858050103 42858050203 43063018407
43063018430 43063022260 43063022290
43063022293 43063022298 43063059115
47335032683 47335032688 49999039507
49999039515 49999039530 49999063830
49999063930 49999083901 49999083930
49999083960 49999083990 49999084030
49999084060 49999084130 49999084160
49999096330 49999096360 49999096390
50268014411 50268014415 50268014511
50268014515 50383028793 50383029493
50383092493 50383093093 50436010501
51079069439 51079089840 51224020630
51224020650 51285027501 51285027502
52152010502 52152010504 52152010530
52959030430 52959038602 52959038630
52959038660 52959038690 52959043530
52959074930 54123011430 54123090730
54123091430 54123092930 54123095730
54123098630 54569141600 54569141601
54569549600 54569573900 54569573901 | NDC code |

Table A3 (cont'd)

| Medication for OUD | 54569573902 54569639900 54569640800
54868285400 54868285401 54868285402
54868285403 54868440800 54868440801
54868494800 54868494801 54868494802
54868494803 54868494805 54868494806
54868494807 54868557400 54868570100
54868570101 54868570102 54868570103
54868570700 54868570701 54868570702
54868570703 54868570704 54868575000
55045378403 55289081430 55289081460
55289081490 55289081493 55289081498
55289081499 55390010010 55700014730
55700018430 55700030230 55700030330
55887009082 55887009090 55887013460
55887013490 55887020060 55887020082
55887020090 57866318701 57866318702
57866318801 57866318802 57866395001
57866395002 57866395003 57866707001
57866707002 57866707003 57866707006
57866708101 57866708102 58284010014
59385001201 59385001230 59385001401
59385001430 59385001601 59385001630
60429058630 60429058633 60429058730
60429058733 60687020932 60687020933
60687021401 60687021411 61553014978
62756045983 62756046083 63459030042
63629377101 63629377102 63629377103
63629377104 63629377105 63629377106
63629378801 63629402801 63629403401
63629403402 63629403403 63739000610
63874108403 63874108503 63874117303
64019053825 64019055367 64019055467
65162041503 65162041603 65694010003
65694010010 65757030001 66336001630
66336017030 66336017060 66336017062
66336017090 66336017094 66336017130
66336017142 66336017156 66336017160
66336017162 66336017190 66336017194
66336017198 66479053002 66591081551
66689069430 66689069439 66689069479 | NDC code |

Table A3 (cont'd)

Medication for OUD	66689069579 66689071116 66689071216 66689081010 66689089840 67457021720 67877011601 68071138003 68071151003 68084029111 68084029121 68084073801 68084073811 68084097732 68084097733 68094085362 68115057100 68115057200 68115068030 68258299903 68308020230 68308020830	NDC code
Injectable naltrexone	65757030001, 00406117003, 00555090202, 16729008101, 47335032688, 51224020650	NDC code
Injectable naltrexone	J2315	CPT/HCPCS
Buprenorphine	J0571, J0572, J0573, J0574, J0575	CPT/HCPCS

Table A3 (cont'd)

Buprenorphine	54569640800 63629403403 54868570704	NDC code
	00228315403 63629403402 54868570701	
	00228315503 63629403401 54868570702	
	00228315473 55887031204 54868570703	
	00228315573 55887031215 54868570700	
	53217013830 55045378403 54868575000	
	65162041603 68258299903 35356000407	
	65162041503 66336001530 55700014730	
	42291017530 66336001630 35356000430	
	42291017430 12496120203 49999039530	
	60429058730 12496120803 49999039515	
	60429058630 12496120801 49999039507	
	50383028793 12496120201 12496128302	
	50383029493 12496120403 12496130602	
	00406192403 12496121201 00490005160	
	00406192303 12496121203 00490005130	
	55700018430 12496120401 00490005190	
	00093572156 68071151003 00490005100	
	00093572056 68071138003 16590066630	
	00054018813 23490927009 16590066790	
	00054018913 23490927006 16590066705	
	54569639900 23490927003 16590066730	
	54569549600 43063018407 16590066605	
	54569573901 43063018430 54123098630	
	54569573900 52959074930 54123092930	
	54569573902 52959030430 54123011430	
	63874108403 54123091430 54123095730	
	63874108503 00054017613 00378092393	
	55700030330 00054017713 00378092493	
	35356055630 63874117303 68258299103	
	35356055530 63874117403 54569657800	
	55700030230 63629409201 53217024630	
	43063066706 49999063930 50383092493	
	68308020230 49999063830 50383093093	
	68308020830 12496131002 00093537956	
	00228315603 12496127802 00093537856	
	00228315303 54569632500 59011075704	
	35356060504 54569632600 59011075004	
	35356060704 59011075204 59011075104	
	35356060604 59011075804	

Table A3 (cont'd)

Oral naltrexone	52372075101 62991124301 00185003901	NDC code
	52372075103 62991124304 49452483501	
	52372075102 62991124302 49452483505	
	54868557400 63370015825 49452483503	
	16729008101 63370015810 49452483502	
	16729008110 63370015835 47335032688	
	52152010502 63370015815 47335032683	
	52152010530 00406117001 51224020630	
	68084029111 00406117003 51224020650	
	68084029121 38779088704 00555090202	
	52152010504 38779088708 00555090201	
	42291063230 38779088705 50436010501	
	63275990101 38779088706 00056001130	
	63275990103 38779088703 00056001170	
	63275990102 43063059115 00056001122	
	63275990105 68094085362 00056007950	
	63275990104 51927360200 51285027501	
	68115068030 51927275300 51285027502	
	65694010010 51927437700 00056008050	
	65694010003 00185003930 62991124303	
Methadone	H0020	CPT/HCPCS

Data sources include:

1.Alsabbagh MhdW, Chang F, Cooke M, Elliott SJ, Chen M. National trends in population rates of opioid‐related mortality, hospitalization and emergency department visits in Canada between 2000 and 2017. A population‐based study. Addiction. 2021;116(12):3482-3493. doi:10.1111/add.15571

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3.Heslin KC, Owens PL, Karaca Z, Barrett ML, Moore BJ, Elixhauser A. Trends in Opioid-related Inpatient Stays Shifted After the US Transitioned to ICD-10-CM Diagnosis Coding in 2015. Med Care. 2017;55(11):918-923. doi:10.1097/MLR.0000000000000805

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5.Peterson C, Xu L, Florence C, Mack KA. Opioid-related US hospital discharges by type, 1993–2016. J Subst Abuse Treat. 2019;103:9-13. doi:10.1016/j.jsat.2019.05.003

6.Saloner B, Chang HY, Krawczyk N, et al. Predictive Modeling of Opioid Overdose Using Linked Statewide Medical and Criminal Justice Data. JAMA Psychiatry. 2020;77(11):1155. doi:10.1001/jamapsychiatry.2020.1689

7.The Medicaid Outcomes Distributed Research Network (MODRN), Brown E, Schutze M, et al. Use of Medications for Treatment of Opioid Use Disorder Among US Medicaid Enrollees in 11 States, 2014-2018. JAMA. 2021;326(2):154. doi:10.1001/jama.2021.7374

8.Zhang P, Tossone K, Ashmead R, et al. Examining differences in retention on medication for opioid use disorder: An analysis of Ohio Medicaid data. J Subst Abuse Treat. 2022;136:108686. doi:10.1016/j.jsat.2021.108686

9. COVID-19 Frequently Asked Questions (FAQs) on Medicare Fee-for-Service (FFS) Billing. :181. https://www.cms.gov/files/document/03092020-covid-19-faqs-508.pdf

10. otp-billing-and-payment-fact-sheet.pdf. Accessed November 14, 2022. https://www.cms.gov/files/document/otp-billing-and-payment-fact-sheet.pdf

11. ICD-10-CM. Accessed November 14, 2022. https://icd10cmtool.cdc.gov/?fy=FY2023

12. Luo Z, Roychoudhury C, Pompos W, DiMaria J, Robinette C, Gore P. and Beecroft W. Prevention of 90-day inpatient detoxification readmission for opioid use disorder by a community-based life-changing individualized medically assisted evidence-based treatment (C.L.I.M.B.) program: a quasi-experimental design. PLOS ONE. Published online forthcoming.

APPENDIX 4: SENSITIVITY ANALYSIS FOR USING 1703 NEW DIAGNOSED OUD PATIENTS DURING THE STUDY PERIOD

Since the newly diagnosed OUD patients may require different levels of care from those with chronic OUD symptoms, we carried out a sensitivity analysis using patients who did not have any OUD diagnoses in the 6 months prior to the study period. A total of 1703 patients were identified, among whom 1310 were telehealth service users and 393 were non-users. Table A4.1 shows the socio-demographic characteristics and comorbid conditions in the 6 months prior to the study period. Table A4.2 shows the adjusted and unadjusted odds ratio (OR) for each level of treatment separately.

Table A4.1. Sensitivity analysis for socio-demographic characteristics of new diagnosed OUD patients between telehealth users and non-telehealth users from April 1. 2020 to March 31, 2021.

	Non-users N=393	Users N=1310	p-value
Age category			
18-<25	27 (6.9%)	60 (4.6%)	
25-<35	31 (7.9%)	88 (6.7%)	
35-<45	80 (20.4%)	220 (16.8%)	
45-<55	103 (26.2%)	366 (27.9%)	
55-<65	152 (38.7%)	576 (44.0%)	0.083*
Gender			
F	178 (45.3%)	731 (55.8%)	
M	215 (54.7%)	579 (44.2%)	<0.001
COVID-19 diagnosis	20 (5.1%)	112 (8.5%)	0.024
Comorbidity 6 months prior to April 1, 2020 (the beginning of the study period)			
Emergency room visits	57 (14.5%)	238 (18.2%)	0.092
Substance-related disorders	8 (2.0%)	36 (2.7%)	0.586*
Mood disorders	53 (13.5%)	362 (27.6%)	<0.001
Alcohol-related disorders	6 (1.5%)	49 (3.7%)	0.033*
Anxiety/fear/trauma/stressor-related disorders	64 (16.3%)	424 (32.4%)	<0.001
Suicidal ideation/attempt/intentional self-harm	1 (0.3%)	9 (0.7%)	0.47*
Neoplasms	22 (5.6%)	104 (7.9%)	0.12

Table A4.1 (cont'd)

Endocrine, nutritional and metabolic diseases	153 (38.9%)	675 (51.5%)	<0.001
Diseases of the nervous system	164 (41.7%)	727 (55.5%)	<0.001
Diseases of the circulatory system	134 (34.1%)	560 (42.7%)	0.002
Diseases of the respiratory system	90 (22.9%)	395 (30.2%)	0.005
Diseases of the digestive system	79 (20.1%)	385 (29.4%)	<0.001
Diseases of the musculoskeletal system and connective tissue	252 (64.1%)	934 (71.3%)	0.007
Diseases of the genitourinary system	56 (14.2%)	313 (23.9%)	<0.001
Injury, poisoning and certain other consequences of external causes	64 (16.3%)	323 (24.7%)	0.001
Live in one of the 100 largest metropolitan areas	259 (65.9%)	914 (69.8%)	0.146
Neighborhood characteristics	Mean (SD)	Mean (SD)	
Mean state rank (ADI)	53.9 (21.5)	49.3 (21.5)	<0.001
Mean national rank (ADI)	64.3 (18.1)	60.5 (19.2)	<0.001
Mean childhood opportunity index	50.4 (19.5)	53.3 (20.2)	0.011
Mean socioeconomic score (SVI)	49.9 (19.5)	45.3 (19.6)	<0.001
Mean household/disability score (SVI)	57.3 (17.1)	52.1 (18.3)	<0.001
Mean minority/language score (SVI)	30.0 (17.4)	32.4 (17.9)	0.023
Mean housing/transportation score (SVI)	42.7 (14.1)	39.7 (13.9)	<0.001

ADI = Area deprivation index (higher values indicating more deprived census tracts)

SVI = Social vulnerability index (higher values indicating more vulnerable census tracts)

SD = Standard deviation

p-values are from Pearson's chi-squared test for categorical variables and t-test for continuous variables

*p-value are based on Fisher's exact test

Table A4.2. Sensitivity analysis for OUD treatment/care utilization among new diagnosed OUD patients during the study period.

Levels of OUD treatment/care	Non-users N=393	Users N=1310	Adjusted OR (95% CI)	Unadjusted OR (95% CI)
Outpatient	237 (60.3%)	925 (70.6%)	1.72 (1.33,2.23)	1.58 (1.23,2.03)
Behavioral therapy	28 (7.1%)	126 (9.6%)	2.03 (1.29,3.20)	1.39 (0.90,2.14)
Medication for OUD	45 (11.5%)	149 (11.4%)	1.15 (0.80,1.63)	0.99 (0.69,1.42)
Buprenorphine	26 (6.6%)	83 (6.3%)	1.20 (0.76,1.90)	0.95 (0.61,1.50)
Methadone	0 (0.0%)	9 (0.7%)	1	1
Naltrexone oral or injectable	7 (1.8%)	35 (2.7%)	1.39 (0.59,3.27)	1.51 (0.67,3.44)
Injectable naltrexone	5 (1.3%)	25 (1.9%)	1.62 (0.53,4.99)	1.51 (0.57,3.98)
Oral naltrexone	5 (1.3%)	26 (2.0%)	1.23 (0.46,3.30)	1.57 (0.60,4.14)
Detoxification	14 (3.6%)	37 (2.8%)	0.84 (0.46,1.54)	0.79 (0.42,1.46)
Intensive outpatient	9 (2.3%)	18 (1.4%)	0.65 (0.28,1.51)	0.59 (0.27,1.33)
Partial hospitalization	8 (2.0%)	11 (0.8%)	0.51 (0.19,1.31)	0.41 (0.16,1.02)
Domiciliary/ residential*	1 (0.3%)	9 (0.7%)	3.56 (0.49,26.10)	2.71 (0.34,21.39)

CI = Confidence Interval based on cluster-robust standard error.
OR = Odds Ratio

Table A4.3. Sensitivity analysis for in-person OUD treatment/care utilization among new diagnosed OUD patients during the study period.

In-person OUD treatments/cares	Non-users N=393	Users N=1310	Adjusted OR (95% CI)	Unadjusted OR (95% CI)
Outpatient	237 (60.3%)	680 (51.9%)	0.76 (0.59,0.98)	0.71 (0.56,0.90)
Behavioral therapy	28 (7.1%)	86 (6.6%)	1.45 (0.90,2.33)	0.92 (0.59,1.43)
Medication for OUD	5 (1.3%)	21 (1.6%)	1.69 (0.59,4.82)	1.26 (0.47,3.36)
Intensive outpatient	9 (2.3%)	13 (1.0%)	0.48 (0.20,1.15)	0.43 (0.18,1.00)
Partial hospitalization	8 (2.0%)	11 (0.8%)	0.51 (0.19,1.31)	0.41 (0.16,1.02)
Domiciliary/residential	1 (0.3%)	7 (0.5%)	4.74 (0.76,29.65)	2.11 (0.26,17.11)

CI = Confidence Interval based on cluster-robust standard error.
OR = Odds Ratio

Table A4.4. Sensitivity analysis for the results of the first step and the second step in the hurdle model among newly diagnosed OUD patients during the study period.

	Logistic (part 1) OR (95% CI)	p-value	Zero truncated NB (part 2) IRR (95% CI)	p-value
Age category				
55-<65	1.24 (0.96,1.59)	0.096	0.45 (0.26,0.80)	0.006
Gender				
M	0.74 (0.58,0.95)	0.016	0.85 (0.72,1.00)	0.048
COVID-19 Diagnosis	1.89 (1.14,3.13)	0.013		
Comorbidity 6 months prior to April 1, 2020 (the beginning of the study period)				
Mood disorders	1.68 (1.18,2.40)	0.004	1.92 (1.60,2.29)	<0.001
Alcohol-related disorders			1.88 (1.33,2.68)	<0.001
Anxiety/fear/trauma/stressor-related disorders	1.76 (1.28,2.40)	<0.001	1.29 (1.08,1.54)	0.006
Endocrine, nutritional and metabolic diseases	1.30 (1.01,1.68)	0.040		
Diseases of the nervous system	1.37 (1.08,1.75)	0.010		
Diseases of the respiratory system			1.21 (1.01,1.46)	0.037
Diseases of the genitourinary system	1.44 (1.06,1.95)	0.020		
Injury, poisoning and certain other consequences of external causes			1.26 (1.04,1.52)	0.016
Live in one of the 100 largest metropolitan areas				
Neighborhood characteristics				
Mean childhood opportunity index	0.97 (0.95,0.99)	0.001		
Mean socioeconomic score (SVI)	0.97 (0.96,0.99)	0.005		
Mean household/disability score (SVI)	0.98 (0.97,0.99)	0.001	0.99 (0.99,1.00)	<0.001
Mean housing/transportation score (SVI)			0.99 (0.99,1.00)	0.025

OR = Odds Ratio

CI = Confidence Interval based on cluster-robust standard error.

NB = Negative Binomial

IRR = Incidence Rate Ratio

ADI = Area Deprivation Index (higher values indicating more deprived census tracts)

SVI = Social Vulnerability Index (higher values indicating more vulnerable census tracts)

APPENDIX 5: LISTS OF COVARIATES SELECTED FOR THE MODELS

Table A5.1. Covariates selected for logistic regressions in Table 2.

Levels of OUD treatment/care	Covariates selected
Outpatient	Age, COVID-19, Live in one of the 100 largest metropolitan areas, Diseases of the nervous system, Gender, Emergency room visits, Opioid abuse, Opioid dependent, Diseases of the genitourinary system, Suicidal ideation/attempt/intentional self-harm, Mean socioeconomic score (SVI), Mean housing/transportation score (SVI), Anxiety/fear/trauma/stressor-related disorders
Behavioral therapy	Age, Gender, Diseases of the genitourinary system, Opioid abuse, Emergency room visits, Opioid dependent, Mean childhood opportunity index, Substance-related disorders, Mood disorders, COVID-19, Anxiety/fear/trauma/stressor-related disorders, Mean housing/transportation score (SVI), Mean national rank (ADI), Endocrine, nutritional and metabolic diseases, Diseases of the nervous system, Diseases of the circulatory system, Mean minority/language score (SVI), Diseases of the musculoskeletal system and connective tissue, Diseases of the digestive system
Medication for OUD	Age, Gender, Mean national rank (ADI), Diseases of the musculoskeletal system and connective tissue, Alcohol-related disorders, Opioid dependent, Endocrine, nutritional and metabolic diseases, Anxiety/fear/trauma/stressor-related disorders
Buprenorphine	Age, Gender, Neoplasms, Endocrine, nutritional and metabolic diseases, Opioid abuse, Opioid dependent, Injury, poisoning and certain other consequences of external causes, Mean national rank (ADI), Diseases of the musculoskeletal system and connective tissue, Mean state rank (ADI), Anxiety/fear/trauma/stressor-related disorders
Methadone	Age, Emergency room visits, Opioid dependent, Mood disorders, Anxiety/fear/trauma/stressor-related disorders, Diseases of the nervous system, Diseases of the musculoskeletal system and connective tissue, Injury, poisoning and certain other consequences of external causes, Live in one of the 100 largest metropolitan areas, Mean national rank (ADI)

Table A5.1 (cont'd)

Naltrexone	Age, Gender, Diseases of the circulatory system, Diseases of the genitourinary system, Opioid dependent, Mean childhood opportunity index, COVID-19, Mood disorders, Mean socioeconomic score (SVI), Alcohol-related disorders
Injectable naltrexone	Age, Gender, Diseases of the genitourinary system, Alcohol-related disorders, Mean socioeconomic score (SVI), Opioid dependent, COVID-19, Mean childhood opportunity index, Mood disorders
Oral naltrexone	Age, COVID-19, Mean socioeconomic score (SVI), Diseases of the musculoskeletal system and connective tissue, Live in one of the 100 largest metropolitan areas, Opioid dependent, Mean childhood opportunity index, Alcohol-related disorders, Mood disorders
Detoxification	Age, Gender, COVID-19, Emergency room visits, Opioid dependent, Opioid overdose, Mood disorders, Alcohol-related disorders, Suicidal ideation/attempt/intentional self-harm, Diseases of the musculoskeletal system and connective tissue, Diseases of the nervous system, Injury, poisoning and certain other consequences of external causes, Mean state rank (ADI), Mean minority/language score (SVI)
Intensive outpatient	Age, Gender, COVID-19, Substance-related disorders, Diseases of the nervous system, Injury, poisoning and certain other consequences of external causes, Mean minority/language score (SVI), Mean housing/transportation score (SVI)
Partial hospitalization	Age, Gender, Emergency room visits, Alcohol-related disorders, Diseases of the respiratory system, Diseases of the musculoskeletal system and connective tissue, Mean childhood opportunity index, Mean household/disability score (SVI), Mean minority/language score (SVI)
Domiciliary/residential	Age, Emergency room visits, Alcohol-related disorders, Diseases of the respiratory system, Diseases of the circulatory system

Table A5.2. Covariates selected for logistic regressions in Table 3.

In-person OUD treatments	Covariates selected
Outpatient	Age, Gender, Endocrine, nutritional and metabolic diseases, Mean socioeconomic score (SVI), Mean household/disability score (SVI), Mean minority/language score (SVI), Mean housing/transportation score (SVI), Emergency room visits, Opioid abuse, Opioid dependent, Substance-related disorders, COVID-19, Anxiety/fear/trauma/stressor-related disorders, Suicidal ideation/attempt/intentional self-harm
Behavioral therapy	Age, Gender, Diseases of the musculoskeletal system and connective tissue, Emergency room visits, Opioid abuse, Opioid dependent, Mean minority/language score (SVI), Mean childhood opportunity index, Mood disorders, Mean household/disability score (SVI), COVID-19, Anxiety/fear/trauma/stressor-related disorders, Mean housing/transportation score (SVI), Diseases of the genitourinary system, Diseases of the nervous system, Diseases of the circulatory system
Medication for OUD	Age, Live in one of the 100 largest metropolitan areas, Endocrine, nutritional and metabolic diseases, Alcohol-related disorders, Diseases of the musculoskeletal system and connective tissue, Opioid dependent, Mean state rank (ADI)
Intensive outpatient	Age, Gender, Mean national rank (ADI), Mean minority/language score (SVI), Opioid dependent, Diseases of the nervous system, Substance-related disorders, Alcohol-related disorders, Injury, poisoning and certain other consequences of external causes, COVID-19
Partial hospitalization	Age, Gender, Emergency room visits, Mean household/disability score (SVI), Opioid dependent, Mean national rank (ADI), Substance-related disorders, Diseases of the musculoskeletal system and connective tissue, Alcohol-related disorders, Diseases of the respiratory system
Domiciliary/residential	Emergency room visits, Alcohol-related disorders, Diseases of the respiratory system, Opioid overdose

Table A5.3. Covariates selected for logistic regressions in Table A4.2 (sensitivity analysis).

Levels of OUD treatment/care	Covariates selected
Outpatient	Gender, COVID-19, Mean minority/language score (SVI), Mean childhood opportunity index, Mean housing/transportation score (SVI)
Behavioral therapy	Age, Gender, Emergency room visits, Diseases of the nervous system, Diseases of the musculoskeletal system and connective tissue, Diseases of the circulatory system, Mean household/disability score (SVI), Mean childhood opportunity index, Anxiety/fear/trauma/stressor-related disorders, Mean socioeconomic score (SVI)
Medication for OUD	Age, Gender, Alcohol-related disorders, Injury, poisoning and certain other consequences of external causes, Endocrine, nutritional and metabolic diseases, Diseases of the genitourinary system, Diseases of the digestive system, Diseases of the musculoskeletal system and connective tissue
Buprenorphine	Age, Diseases of the digestive system, Diseases of the musculoskeletal system and connective tissue, Mood disorders, Diseases of the genitourinary system
Methadone	
Naltrexone	Age, Live in one of the 100 largest metropolitan areas, Diseases of the genitourinary system, Injury, poisoning and certain other consequences of external causes, Mood disorders, Alcohol-related disorders, COVID-19, Diseases of the digestive system
Injectable naltrexone	Live in one of the 100 largest metropolitan areas, Age, Diseases of the digestive system, COVID-19, Injury, poisoning and certain other consequences of external causes, Alcohol-related disorders
Oral naltrexone	Age, COVID-19, Mean housing/transportation score (SVI), Diseases of the respiratory system, Mood disorders, Alcohol-related disorders, Mean childhood opportunity index, Live in one of the 100 largest metropolitan areas, Mean socioeconomic score (SVI)
Detoxification	Age, Gender, Mean minority/language score (SVI), COVID-19
Intensive outpatient	Age, Gender, COVID-19, Mean household/disability score (SVI), Mean minority/language score (SVI), Mean national rank (ADI)
Partial hospitalization	Age, Gender, Anxiety/fear/trauma/stressor-related disorders, Suicidal ideation/attempt/intentional self-harm, Emergency room visits, Diseases of the musculoskeletal system and connective tissue

Table A5.3 (cont'd)

Domiciliary/residential	

Table A5.4. Covariates selected for logistic regressions in Table A4.3 (sensitivity analysis).

In-person OUD treatments	Covariates selected
Outpatient	Age, Gender, COVID-19, Mean national rank (ADI), Mean housing/transportation score (SVI), Mean childhood opportunity index
Behavioral therapy	Mean national rank (ADI), Age, Gender, Emergency room visits, Mean childhood opportunity index, Diseases of the circulatory system, Diseases of the musculoskeletal system and connective tissue, Anxiety/fear/trauma/stressor-related disorders, Mean socioeconomic score (SVI), Mean household/disability score (SVI), Diseases of the nervous system
Medication for OUD	Age, Anxiety/fear/trauma/stressor-related disorders Diseases of the genitourinary system, Alcohol-related disorders
Intensive outpatient	Age, Gender, COVID-19, Mean household/disability score (SVI), Mean minority/language score (SVI), Mean national rank (ADI)
Partial hospitalization	Age, Gender, Anxiety/fear/trauma/stressor-related disorders, Suicidal ideation/attempt/intentional self-harm, Emergency room visits, Diseases of the musculoskeletal system and connective tissue
Domiciliary/residential	Age, Mean housing/transportation score (SVI)