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Association between different modalities of opioid use disorder-related care delivery and opioid use disorder-related patient outcomes: A retrospective cohort study

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ABSTRACT

Objective: This study assessed the impact of different modalities of delivery of opioid use disorder (OUD)-related care on several patient outcomes.

Methods: This study was conducted among patients newly diagnosed with OUD and receiving OUD-related care between March 2020 and March 2022, using data from Epic Cosmos. We examined the association between the most common modality of OUD-related care delivery (audio-only vs. audiovisual vs. in-person) and the number of emergency department (ED) visits for any overdose and opioid-specific overdose and receipt of medication treatment for OUD (MOUD; primary). We also examined the association between the most common modality of OUD-related care delivery and all-cause ED visits, hospitalizations, and psychiatric-related hospitalizations (secondary outcomes). We estimated logistic regression for receipt of MOUD and negative binomial for all other outcomes.

Results: Most patients primarily received OUD-related care in person (87.6 %, n = 159,351), followed by audiovisual visits (11.3 %, n = 20,629) and audio-only visits (1.1 %, n = 1,869). The mean (SD) ages for these groups were 51.7 (15.9), 47.1 (15.0), and 51.1 (15.8) years, respectively. Compared to receiving OUD-related care primarily in-person, receiving care predominantly through audio-only or audiovisual visits was associated with a modest decrease in number of all-cause ED visits. Receiving OUD-related care primarily through audiovisual visits, compared to in-person care, was associated with a slight increase in the odds of receiving MOUD. No statistically significant differences were found between the care delivery modalities and the other outcomes we examined.

Conclusion: Telehealth, delivered via audio-only or audiovisual methods, appears to provide care of similar quality to in-person OUD care and may modestly reduce OUD-related ED visits while slightly increasing MOUD receipt. These findings support continued delivery of OUD-related care through telehealth and continuation of COVID-19-related policies.

1. Introduction

The opioid epidemic is a serious and complex public health issue in the United States (Hedegaard et al., 2021; M & AI, 2019). According to the U.S. Centers for Disease Control and Prevention (CDC), more than 100,000 Americans died from drug overdoses in 2023, with opioids accounting for approximately 70 % of those deaths (Centers for Disease Control and Prevention, 2024; National Institute on Drug Abuse, 2020). Beyond the risk of overdose, the CDC estimates 2.1 million Americans are affected by opioid use disorder (OUD), a disease state characterized by increasing risk for overdose, lowering quality of life, and fracturing relationships (Centers for Disease Control & Prevention, 2021).

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The COVID-19 pandemic ushered in many federal policy changes and significantly reshaped healthcare delivery. Healthcare systems swiftly transitioned to telehealth and other remote treatment modalities for delivery of care; telehealth encounters increased by 766 % in the first 3 months of the pandemic (Shaver, 2022). Specific to OUD, the U.S. Centers for Medicare and Medicaid (CMS) changed their federal regulations in March 2020 to allow telehealth delivery for buprenorphine (Lin et al., 2020), a life-saving medication treatment for OUD (MOUD) known to prevent overdose deaths (Volkow et al., 2019; Wakeman et al., 2020) by removing the requirement for an initial in-person visit (United States Code, 2020). Likewise, the Drug Enforcement Administration (DEA) and the Substance Abuse and Mental Health Services Administration (SAMHSA) updated their guidance to permit buprenorphine visits via telephone (U.S. Department of Justice Drug Enforcement Administration, 2020), allowing for the prescribing of controlled substances, including buprenorphine, via telemedicine without a prior in-person visit. These regulatory changes, along with modifications to reimbursement policies, facilitated rapid and ubiquitous incorporation of telehealth into routine practice. This shift may be especially beneficial for persons with OUD as they often face barriers to accessing traditional in-person care due to stigma, geographical limitations, and logistical challenges (Jones et al., 2022; Mann et al., 2020).

Previous studies have shown a wide range of benefits of telehealth for persons with OUD (Cantor et al., 2020; Ruetsch et al., 2010, 2012; Tofighi et al., 2016). One scoping review of 69 studies found that incorporating telehealth into care plans resulted in higher patient satisfaction, reduced healthcare costs, lowered no-show rates, and increased rates for buprenorphine treatment for OUD (Guillen et al., 2022). For example, outpatient substance use programs and mental health treatment programs in Rhode Island saw 88 % of patients kept their appointments after the implementation of telehealth as compared to 77 % of patients in the prior period when only in-person visits were available (Hughto et al., 2021). Several other studies have found audio and audiovisual modalities of telehealth are more cost-efficient than in-person care by reducing the need for expensive in-person visits (Guille et al., 2020; Luce & Strike, 2011) and minimizing the risk of fraudulent billing (Hughto et al., 2021).

2. Study aim

This study addresses critical gaps in understanding how different healthcare delivery modalities—audio-only, audiovisual, and in-person—impact key outcomes for individuals with opioid use disorder (OUD), including emergency department visits (overall and overdose-related), hospitalizations (overall and psychiatric-related), and receipt of medication for opioid use disorder (MOUD). Unlike prior studies that focused on proximal outcomes such as patient satisfaction or treatment retention (Molfenter et al., 2021), this research uniquely evaluates more distal and patient-centered OUD-related care outcomes, with a novel emphasis on psychiatric hospitalizations—a critical yet often overlooked area for individuals with high rates of co-occurring mental health conditions. Furthermore, it is the first study to directly compare the effectiveness of specific telehealth modalities (audio-only vs. audiovisual) and in-person care, providing granular insights that reflect the real-world delivery of OUD care. Conducted in the post-pandemic context of expanded telehealth use, this study answers whether primary use of the differing modalities of care (i.e., audio, audio-visual, and in-person) is associated with OUD-related care outcomes, specifically receipt of MOUD and healthcare utilization including emergency room visits, hospitalizations, and psychiatric hospitalizations. This study's findings have timely relevance for healthcare providers and policymakers, offering evidence to guide decisions about optimizing telehealth models and promoting equitable access to effective care.

3. Methods

3.1. Study design and data source

This retrospective cohort study used nationally representative electronic medical record data from Epic Cosmos, a collaborative network of health systems that aggragates data from diverse care settings including outpatient, emergency, and hospital settings, in both rural and urban settings, to gain insights and make healthcare discoveries (Epic Cosmos, 2024). It contains over 240 million patient records from over 1,395 hospitals and 32,300 clinics from all 50 states, and it accounts for 36 % of the U.S. hospital market share. The Epic Cosmos U.S.-based patient population reflects the diversity of the U.S. population, closely aligning with national proportions for age, race, ethnicity, and insurance coverage as reported by the U.S. Census Bureau. Epic Cosmos also integrates data from two other sources and merges this data with the patient records. These sources are (1) Rural-Urban Commuting Area (RUCA) codes and (2) county-level Social Vulnerability Index (SVI) from the CDC. RUCA codes classify U.S. census tracts into metropolitan, micropolitan, small town, and rural commuting areas based on several measures. The composite SVI is derived from four domains consisting of continuous variables ranging from 0 to 1 of four geographically defined vulnerability domains: (1) socioeconomic status, (2) household composition and disability, (3) minority status and language, and (4) housing and transportation (CDC/ATSDR, 2023; Lehnert et al., 2020; USDA ERS, 2023).

3.2. Study population and cohort identification

Eligible patients for this study were U.S. residents aged 18 to 89 at the time of the OUD diagnosis, who received a new diagnosis for OUD between March 23, 2020, and March 21, 2022. We limited our study population to those between 18 and 89 to focus on adult patients and minimize potential identification of patients 90 years of age and older. We limited our study to patients who received an OUD diagnosis between March 23, 2020, and March 21, 2022, to focus on the period following the declaration of public health emergency (PHE) for the COVID-19 pandemic (March 23, 2020) and to ensure a full year of data following a patient's OUD diagnosis (up to March 21, 2022) (Federal Register, 2020). OUD diagnosis was operationalized using International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes following a previous published algorithm (eTable 1) (Lagisetty et al., 2021; Owens et al., 2020).

3.3. Exclusion criteria

This study focused on adults that were newly diagnosed with OUD following the declaration of the COVID-19 PHE. It utilized data from a health system feeding into the Epic Cosmos database and focused on individuals who began treatment for OUD after receiving the diagnosis. Four exclusion criteria were implemented based on records from the Epic Cosmos database: (1) receipt of an OUD diagnosis in the 365-day period before their current OUD diagnosis to isolate new OUD diagnoses, (2) lack of at least one healthcare system visit in the 365 days preceding the OUD diagnosis date to ensure the new OUD diagnosis was not due to lack of visits to an Epic-based healthcare system, (3) lack of at least one outpatient visit for OUD-related care in the 180 days after the OUD diagnosis date to be able to classify individuals by their modality of care, and (4) death on or before 180 days after the OUD diagnosis date as this is the period for determining modality of care. Fig. 1 visualizes the study population and flow diagram.

3.4. Main independent variable

Patients were categorized by the modality of care delivery used most frequently for OUD-related care (i.e., where the billing diagnosis was

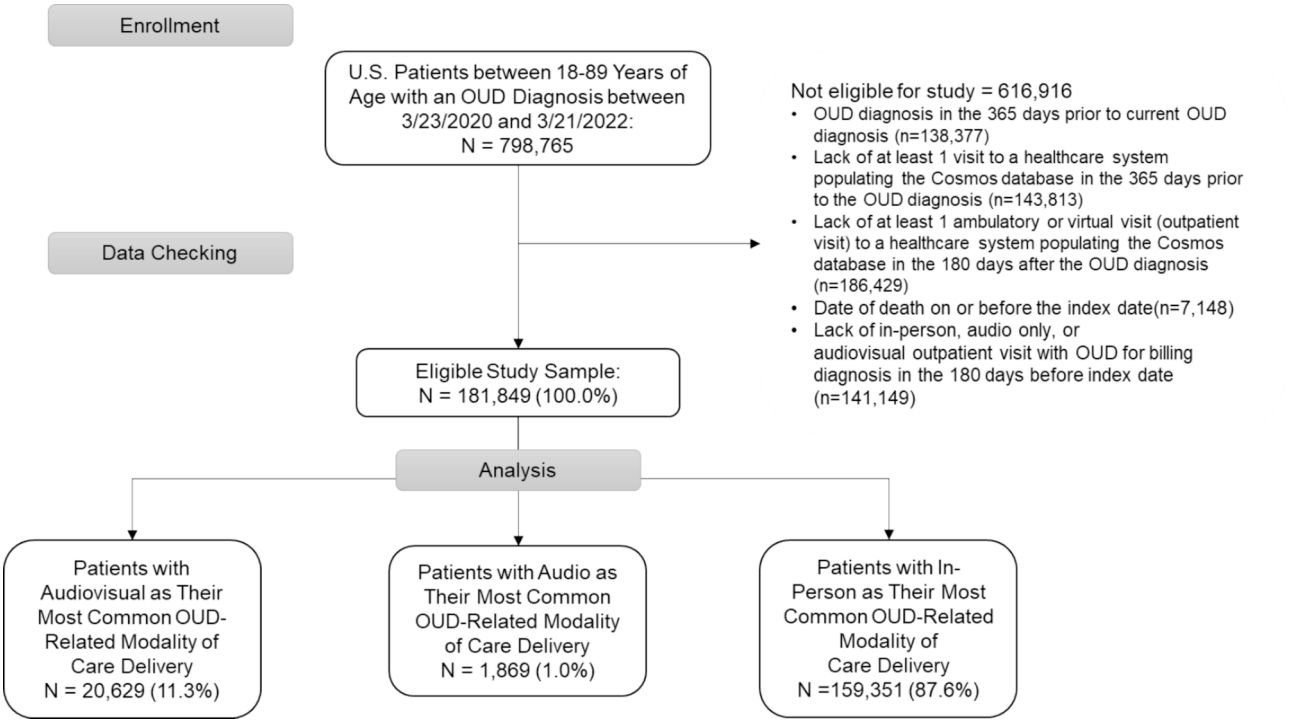
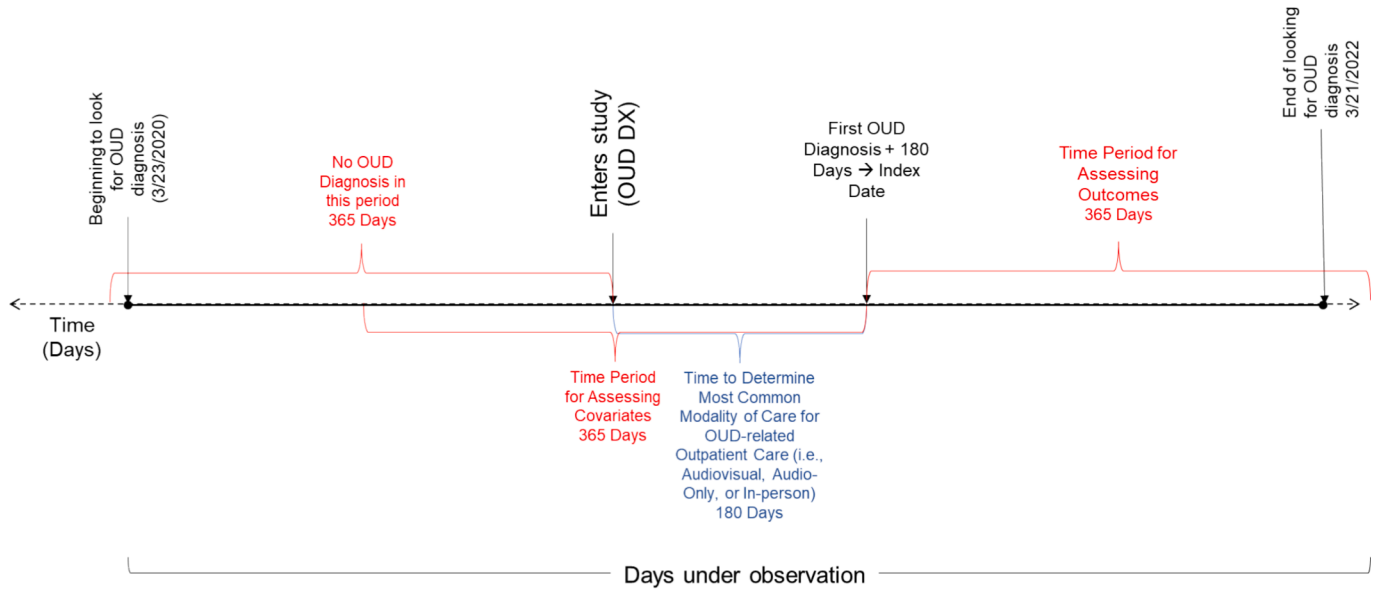


Fig. 1. Flow diagram of study cohort.

OUD) in the 180 days after initial OUD diagnosis. These categories for modality of care delivery included (1) audio only, (2) audiovisual, and (3) in-person. Since many patients used more than one modality of care, we defined the most frequent modality as that with the highest number of records for OUD-related care delivery. For example, a patient having audio-only visits as their most frequent modality of OUD-related care delivery may have had 3 audio-only visits, 2 audiovisual visits, and 1 in-person visit. Audio only visits were identified as telephone consultations or visits coded as office visits and e-visits with procedure codes 99441, 99442, and 99,443 (Bartelt, EB, et al., 2024; Bartelt, Piff, Allen, et al., 2024; Gerhart et al., 2024a, 2024c, 2024b). Audiovisual visits were identified where the visit type was mentioned as "telemedicine" in Cosmos (Alban et al., 2024; Bartelt, EB, et al., 2024; Gerhart et al., 2024c). In-person visits were identified as any office-based visit using any procedure code other than 99441, 99442, and 99,443 (Bartelt, EB, et al., 2024; Bartelt, Piff, Allen, et al., 2024; Bartelt, Piff, Gerhart, et al.,



- Jane Doe enters the study by getting an OUD diagnosis. Jane cannot have an OUD diagnosis in the 12 months prior to the current OUD diagnosis. The OUD diagnosis visit + 180 days becomes the "index date."
- The most common modality of care delivery (i.e., in-person, audio-only, audiovisual) for OUD-related outpatient visits is determined between the OUD diagnosis date + 180 days. The most common modality of care delivery becomes Jane's categorization for modeling.
- Covariates are assessed in the 365 days prior to the "index date." Covariates include count of visits in the period between OUD diagnosis + 180 days. Outcomes are assessed in the 365 days after the "index date."
- OUD=Opioid Use Disorder; Dx=Diagnosis

Fig. 2. Visual depiction of time frame definitions using a fictitious patient named jane doe.

2024; Gerhart et al., 2024a). These three types of visits were defined based on existing literature for Epic Cosmos. In cases where patients had an equal number of visits across different types of care (e.g.,4 audio visits and 4 in-person visits), we used a specific order to determine their primary mode of care: (1) audiovisual, (2) audio, and (3) in-person. This means that if a patient had the same number of audio and in-person visits, they would be placed in the audio group. However, these ties were uncommon, occurring in just 0.015 % of the patient population. A patient's index date was the 181st day after their OUD diagnosis. A diagram visualizing the index date, OUD diagnosis date, and time periods for baseline covariate and outcome measurement is shown in Fig. 2.

3.5. Outcomes

3.5.1. Primary outcomes

Three primary outcomes were identified because of their direct association with OUD over the 365-day period after the index date. These included the number of emergency department visits for (1) overdose (2) opioid-related overdose, and (3) receipt of medication treatment for opioid use disorder. Overdose-related emergency department visits were identified using ICD-10-CM codes of 'T36′, 'T37′, 'T38′, 'T39′, 'T41′, 'T42′, 'T43′, 'T44′, 'T45′, 'T46′, 'T47′, 'T48′, 'T49′, 'T50′, 'T40.0′, 'T40.1′, 'T40.2′, 'T40.3′, and 'T40.4′ (Williams et al., 2020). Opioid overdose-related emergency department visits were identified using ICD-10-CM codes of 'T40.0′, 'T40.1′, 'T40.2′, 'T40.3′, 'T40.4′ (Williams et al., 2020). Receipt of medication treatment for opioid use disorder was defined as receipt of any medication with a generic name "buprenorphine" and of the pharmaceutical class "opioid withdrawal" or with a generic name "methadone" or "naltrexone" (National Institute on Drug Abuse, 2021; Shulman et al., 2021).

3.5.2. Secondary outcomes

Three secondary outcomes were identified for this study using Epic Cosmos data over the 365-day period after the index date. These included the number of (1) emergency department visits, (2) hospitalizations, and (3) psychiatric-related hospitalizations. Emergency department visits were defined as any encounter marked as an ED visit. Likewise, hospitalizations were identified as any encounter where the hospital admission is marked. Psychiatric-related hospitalizations were defined as any hospital admission where the department was listed as either "Psychiatry" or "Psychology." These outcomes, along with their definitions using data from Epic Cosmos, are shown in eTable 2.

3.6. Covariates

To adjust for confounding of the association between modality of care delivery and OUD-related outcomes, we selected covariates based on existing literature (Cousins et al., 2016; Frost et al., 2022; Jones et al., 2022; Lyons et al., 2019; Nguyen et al., 2024; O'Donnell et al., 2020; Weiner et al., 2022). These covariates are categorized as sociodemographic characteristics of the patient, area characteristics for the patient, diagnosis and treatment characteristics of the patient, and time of observation in the outcome period.

3.6.1. Sociodemographic characteristics

We extracted age as of the index date, sex, race, and ethnicity. "Age" was treated as a continuous variable. Sex consisted of three categories: male, female, and unknown. Race is defined by two variables. The first variable categorizes race into the following seven groups: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Other Race, and Unspecified. The second variable for race is a binary indicator for whether the patient is "Multiracial." For our analysis, we combined these two columns; therefore, if the "Multiracial" variable was marked as "1," we considered the patient "Multiracial." We also collapsed null values and "Unspecified" values for the first race variable into one category called "Unknown." This left us with the following race categories for the analysis: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Other Race, Multiracial, and Unknown. Ethnicity is categorized into three groups: Hispanic or Latino, Not Hispanic or Latino, and Unspecified.

3.6.2. Area characteristics

Geographic location of residence can influence healthcare quality and access (Baicker et al., 2005). We tried to capture this variation by incorporating two area characteristics: (1) rural/urban status and (2) social vulnerability of the patient's county of residence. The rural/urban status was defined using the RUCA code for the ZIP code of the patient's residence before, but closest to, the index date. RUCA codes were categorized into two broad groups: urban (RUCA 1–3) and rural (RUCA 4–10). Social vulnerability was measured using the overall SVI score (average) and the SVI score for each of the four domains discussed above.

3.6.3. Diagnosis and treatment characteristics

Using inpatient and outpatient encounters in the 365 days before the index date, we assessed the presence of key comorbid diagnoses including tobacco use disorder, alcohol use disorder, other drug use disorders (e.g., cocaine, cannabis), major depression, psychotic disorder, post-traumatic stress disorder, anxiety disorders, bipolar disorder, hepatitis C, and chronic pain. Using the same encounters, we determined if the patients had a history of opioid overdose and constructed a count of Elixhauser comorbidities (Kidney International Reports, 2021; Quan et al., 2005; University of Manitoba, n.d.) and several measures of baseline health service use (i.e., emergency room visits, psychotherapy visits, inpatient admissions, psychiatric admission).

3.6.4. Time of observation in the outcome period

We also included a covariate for length of time the person was observed in the outcome period. Specifically, we counted the number of days the patient was alive in the outcome period, capping the number of days at 365, as that was the maximum of the outcome period. eTable 3 provides details on how the main independent variable and each of these covariates were defined using Epic Cosmos data.

3.7. Statistical analyses

We determined the mean and standard deviation (SD) for all continuous variables and proportions for categorical variables in our analysis. Descriptive statistics included bivariate tests for differences in our covariates by modality of care delivery. These tests included X^2 tests for categorical variables and analysis of variance (ANOVA) tests for continuous variables. We estimated unadjusted and adjusted (for all previously described covariates) negative binomials to quantify the relationship between our primary independent variable (i.e., modality of care delivery) and each of our count outcomes. In-person visits was the reference category. We chose negative binomial models, as opposed to Poisson, based on the dispersion parameter alpha (α). If α was different from 1, negative binomial models were preferred over Poisson (Andrew Wheeler, n.d.; Stoklosa et al., 2022). The α for overdose-related and opioid overdose-related emergency department visits were 1.18 and 1.41, respectively. The α for overall emergency department visits, hospitalizations, and psychiatric-related hospitalizations were 0.096, 0.37, and 0.25, respectively. We reported the incidence rate ratio (IRR) and 95 % confidence intervals for the negative binomial models. We conducted tests for zero inflation in our dataset using the Negative Binomial model to determine if the observed number of zeros exceeded the expected number (Bruin, 2011; Colin & Pravin, 2013). The results indicated that some outcomes, particularly opioid overdose-related emergency department visits and psychiatric-related hospitalizations, had more observed zeros than expected, suggesting potential zero inflation. Overdose-related emergency department visits and

hospitalizations had observed zeros close to the expected numbers, indicating no significant zero inflation, while overall emergency department visits had fewer observed zeros than expected, showing no zero inflation. For MOUD receipt, we estimated unadjusted and adjusted logistic regression models.

Prior to conducting the analyses, we assessed the normality and homogeneity of variance for all outcomes. Skewness and kurtosis values were calculated to evaluate the distributional properties of each outcome. The Shapiro-Wilk test was also performed to formally test for normality. Homogeneity of variance was assessed using Levene's Test and Bartlett's Test. Results of these tests indicated that none of the outcomes met the assumptions of normality, as evidenced by significant skewness, kurtosis, and Shapiro-Wilk test results. Homogeneity of variance was also violated for some outcomes, particularly emergency department visits (overall and overdose-related) and receipt of MOUD. The results of these tests are demonstrated in eTable 4.

Given these results, generalized linear models (GLMs) were employed to account for the non-normal distribution of the data. For count-based outcomes (e.g., emergency department visits and hospitalizations), negative binomial regression was used to model over dispersed count data. For the binary outcome (receipt of MOUD), logistic regression was performed. These models were robust to violations of normality and homogeneity of variance. All analyses were adjusted for covariates, including the covariates list shown in Table 1.

For all statistical analyses, p-values less than 0.05 from 2-sided significance tests were considered statistically significant. We used Microsoft SQL for data manipulation and Python 3.11 for analysis.

3.8. Sensitivity analyses

In our primary analyses, patients could use each of the three modalities of OUD-related care; however, they were assigned only one modality of care based on which modality they used most commonly for OUD-related care. As a sensitivity analysis, we restricted our cohort to only those patients who used one type of modality of care. Of our cohort, 76 % of patients assigned to the in-person modality of OUD-related care, 45.5 % of patients assigned to the audio-only modality, and 45.4 % of patients assigned to the audiovisual modality had no other types of visits for OUD-related care within 180 days of their OUD diagnosis. We reran our models among these patients to test the robustness of the findings from our primary analyses.

3.9. Ethical considerations

The study adhered to ethical standards in data analysis and handling, ensuring compliance with relevant guidelines for secondary data use and research ethics. (Tripathy, 2013) Data were de-identified prior to analysis to maintain participant confidentiality and minimize privacy risks. All the patient information and dates were de-identified by the Epic Cosmos team. They followed HIPAA guidelines to protect patient safety. University of Arkansas for Medical Sciences (UAMS) Institutional Review Board (IRB) approval was obtained (IRB #276340). UAMS IRB considered the research to be non-human subject research. Furthermore, all analyses were conducted with consideration of potential societal impacts, particularly regarding the interpretation and use of results in policymaking and healthcare settings.

4. Results

A total of 181,849 patients met the inclusion and exclusion criteria. In-person visits were the most common modality of OUD-related care delivery for 159,351 (87.6 %) patients while audiovisual and audio-only visits were the most common modality of OUD-related care delivery for 20,629 (11.3 %) and 1,869 (1.0 %) patients, respectively. Table 1 provides descriptive statistics for the cohort, categorized by the most common modality of OUD-related care delivery. Across all groups, 76 %

Table 1
Characteristics of patients in the sample by most common modality of opioid use disorder related care delivery.

N = 181,849	Most Common Modality of Opioid Use Disorder-Related Care Delivery					
	Audio		Audiovisual		In-Person	
	N = 1,869		N = 20,629		N = 159,351	
Sociodemographic Characteristics of the Patient						
Age on Index Date (years; Mean, SD[1]) [θ]	51.1	(15.8)	47.1	(15.0)	51.7	(15.9)
Age group						
18–35	358	(19.6)	4,996	(24.2)	27,942	(17.7)
36–50	476	(25.5)	6,862	(33.3)	41,970	(26.3)
51–64	559	(29.9)	5,704	(27.7)	49,989	(31.4)
65–80	380	(20.3)	2,706	(13.1)	32,926	(20.7)
80+	49	(2.6)	339	(1.6)	5,398	(3.4)
Sex (N, %) [α]						
Male	826	(44.2)	9,504	(46.1)	74,829	(47.0)
Female	1,043	(55.8)	11,122	(53.9)	84,510	(53.0)
Unknown	0	(0.0)	3	(0.0)	12	(0.0)
Race (N, %) [θ]						
American Indian or Alaska Native	14	(0.7)	84	(0.4)	1,032	(0.6)
Asian	9	(0.5)	108	(0.5)	478	(0.3)
Black or African American	190	(10.2)	2,300	(11.1)	19,693	(12.4)
Native Hawaiian or Other Pacific Islander	1	(0.1)	20	(0.1)	126	(0.1)
White	1,436	(76.8)	15,761	(76.4)	119,951	(75.3)
Multiracial	163	(8.7)	1,771	(8.6)	13,856	(8.7)
Other Race	40	(2.1)	405	(2.0)	3,147	(2.0)
Unknown	16	(0.9)	180	(0.9)	1,068	(0.7)
Ethnicity (N, %) [θ]						
Hispanic or Latino	118	(6.3)	1,441	(7.0)	8,835	(5.5)
Not Hispanic or Latino	1,657	(88.7)	18,145	(88.0)	144,969	(91.0)
Unknown	94	(5.0)	1,043	(5.1)	5,547	(3.5)
Area Characteristics for the Patient						
Residential Rurality (N, %) [θ]						
Urban	1,768	(94.6)	19,225	(93.2)	146,444	(91.9)
Rural	96	(5.1)	1,382	(6.7)	12,583	(7.9)
Unspecified	5	(0.3)	22	(0.1)	324	(0.2)
SVI Score (Mean, SD) [θ]						
Socioeconomic Status	0.5	(0.3)	0.5	(0.3)	0.5	(0.3)
Household Composition	0.5	(0.3)	0.4	(0.3)	0.5	(0.3)
Minority Status and Language	0.7	(0.2)	0.6	(0.3)	0.6	(0.2)
Housing Type and Transportation	0.7	(0.3)	0.6	(0.3)	0.6	(0.3)
Overall SVI Score	0.6	(0.2)	0.6	(0.2)	0.6	(0.2)
Diagnosis and Treatment Characteristics of the Patient						
Prior Year Health Service Use (Mean, SD) [θ]						
Emergency Department Visits	2.3	(3.8)	2.1	(4.2)	2.4	(4.5)
Psychiatric Admissions	0.02	(0.2)	0.03	(0.2)	0.02	(0.2)
Inpatient Admissions and Outpatient Visits in the 180 Days after OUD Diagnosis						
Number of Outpatient Visits	1.9	(5.3)	2.0	(5.0)	2.9	(6.1)

(continued on next page)

Table 1 (*continued*)

N = 181,849	Most Common Modality of Opioid Use Disorder-Related Care Delivery					
	Audio		Audiovisual		In-Person	
	N = 1,869		N = 20,629		N = 159,351	
Number of Inpatient Admissions	0.7	(1.2)	0.7	(1.2)	0.7	(1.2)
Prior Year Overdose History (Mean, SD)						
Opioid [Ω]	0.3	(1.1)	0.3	(1.5)	0.35	(2.0)
Non-opioid [θ]	0.5	(2.3)	0.6	(3.4)	0.76	(2.0)
Comorbidity Estimation (Mean, SD)						
Elixhauser Score [θ]	5.2	(3.4)	4.7	(3.2)	5.3	(3.3)
Prior Year Substance Use Disorder History (N, %) [θ]						
Alcohol use disorder	268	(14.6)	3,665	(18.1)	23,000	(14.6)
Tobacco use disorder	1,144	(62.3)	12,614	(62.2)	103,935	(66.1)
Cannabis use disorder	222	(12.1)	3,030	(14.9)	17,745	(11.3)
Cocaine use disorder	147	(8.0)	2,324	(11.5)	14,180	(9.0)
Prior Year Mental Health History (N, %) [θ]						
Anxiety disorder	1,030	(55.1)	12,209	(59.2)	83,540	(52.4)
Depression	707	(37.8)	8,319	(40.3)	61,536	(38.6)
PTSD[2]	235	(12.6)	3,035	(14.7)	15,684	(9.8)
Prior Year Physical Medical History (N, %)						
Chronic pain [θ]	1,532	(82.0)	16,522	(80.1)	140,770	(88.3)
HCV[3, ns]	240	(12.8)	2,678	(13.0)	21,202	(13.3)
Treatment with MOUD in 180 days of OUD diagnosis (N, %) [θ]						
Received Buprenorphine in 180 days of OUD Diagnosis	393	(21.0)	5,433	(26.3)	28,442	(17.8)
Received Methadone in 180 days of OUD Diagnosis	160	(8.6)	1,508	(7.3)	11,912	(7.5)
Received Naltrexone in 180 days of OUD Diagnosis	24	(1.3)	542	(2.6)	3,050	(1.9)
Prescription Opioid	1,246	(67.7)	12,551	(60.8)	107,767	(67.6)
Prior Year Treatment History with Prescription Opioids (Mean, SD) [θ]						
Average Morphine daily dose in Prior 365 days	13.4	(52.3)	10.7	(39.9)	11.7	(36.7)
Time of Observation in the Outcome Period [θ]						
Days Available for study	356.8	(45.0)	358.3	(38.7)	357.7	(42.1)

[1] SD = Standard deviation.
[2] PTSD = post-traumatic stress disorder.
[3] HCV = Hepatitis C virus.
[θ] $p < 0.001$.
[Ω] $p < 0.01$.
[α] $p < 0.05$.
[ns] $p > 0.05$.

were White, 54 % were female, and nearly 92 % resided in urban areas. Patients in the audiovisual group tended to be younger than those in the other two groups. Prior year emergency department visits were lower in the audiovisual group (58.8 %) compared to the audio (63 %) and in-person (64 %) groups. Conversely, prior year psychiatric-related admissions were higher in the audiovisual group (2.3 %) compared to the audio (1.4 %) and in-person (1.6 %) groups. Prescription opioid usage in the year prior to the index date was also lower in the audiovisual group at nearly 61 %, while the audio and in-person groups had usage rates of around 68 %. Other medication use was similar across all three groups, with antidepressant use around 15 % and benzodiazepine use at approximately 50 %.

eTable 5 provides the rates for primary and secondary outcomes by the most common modality of care delivery, assessed in the year following the index date. The highest percentages of ED visits for overdose and opioid-related overdose were observed in the in-person group (8.3 % and 3.4 %, respectively), as compared to the audio-only group (7.5 % and 2.6 %) and the audiovisual group (7.9 % and 3.3 %). Receipt of MOUD was highest in the audiovisual group (27.3 %), followed by the audio (20.5 %) and in-person (18.3 %) groups. Regarding secondary outcomes, all ED visits and all hospital admissions were highest in the in-person group (50.1 % and 25.7 %, respectively) compared to the audio (44.7 % and 23.3 %) and audiovisual (45.6 % and 23.6 %) groups. However, psychiatric-related hospitalizations were higher in the audiovisual group (1.8 %) compared to the audio (1.2 %) and in-person (1.6 %) groups.

Table 2 provides the regression results for the primary and secondary outcomes. In unadjusted analyses, having audio-only as the most common modality of OUD-related care delivery was associated with a decrease in the number of opioid overdose-related ED visits (IRR = 0.779, 95 %CI: 0.603, 1.006) and all-cause ED visits (IRR = 0.878, 95 % CI: 0.845, 0.913), as well as an increase in the likelihood of receiving MOUD (OR = 1.184, 95 %CI: 1.057, 1.326), compared to having in-person visits as the most common modality of OUD-related care delivery. Likewise, having audiovisual as the most common modality of OUD-related care delivery was associated with a decrease in the number of overdose-related ED visits (IRR = 0.923, 95 %CI: 0.881, 0.968), all-cause ED visits (IRR = 0.890, 95 %CI: 0.879, 0.900), and hospitalizations (IRR = 0.916, 95 %CI: 0.896, 0.936), as well as an increase in the likelihood of receiving MOUD (OR = 1.659, 95 %CI: 1.605, 1.714), compared to having in-person as the most common modality of OUD-related care delivery. In the adjusted analyses, most associations were null; only the association between the most common modality of OUD-related care delivery and all-cause ED visits and receipt of MOUD remained significant. Specifically, having audio-only or audiovisual as the most common modality of OUD-related care delivery was associated with a decrease in the number of all-cause ED visits, as compared to those having in-person as the most common modality of OUD-related care delivery (IRR = 0.942, 95 % CI: 0.930, 0.955; IRR = 0.945, 95 % CI: 0.907, 0.985, respectively). Patients with audiovisual visits as the most common modality of OUD-related care delivery was associated with an increase in the likelihood of receiving MOUD as compared to patients with in-person as the most common modality of OUD-related care delivery (OR = 1.346, 95 % CI: 1.294, 1.399).

The coefficients and confidence intervals of all other covariates included in the adjusted models are shown in eFigs. 1–6, one figure for each of the six models for each outcome.

The results of our sensitivity analyses mentioned in section 3.8 were similar to the results of our primary analyses (results available upon request).

5. Discussion

In this study, we assessed the relationship between the modalities of OUD-related care delivery (i.e., audio only, audiovisual, and in-person) and OUD-related patient outcomes among persons with OUD during the years following COVID-19 telehealth-related policy changes. We found patients who received most of their OUD-related outpatient care via audiovisual or audio-only, as compared to those primarily receiving outpatient care via in-person visits, had modestly lower rates of emergency department visits and were modestly more likely to receive MOUD. These findings suggest telehealth delivery of OUD-related care, either audiovisual or audio-only, may be slightly better than or equivalent to in-person delivery of OUD-related care at improving rates of emergency department visits and receipt of MOUD. We found no

Table 2
Unadjusted and adjusted analyses for most common modality opioid use disorder-related care delivery.

Outcomes	Most Common Modality of Opioid Use Disorder-Related Care Delivery Reference category: In-person Group											
	Audiovisual						Audio					
	Unadjusted			Adjusted			Unadjusted			Adjusted		
Primary Outcomes												
	IRR[1]	**P Value**	**95 % CI[2]**	**IRR[1]**	**P Value**	**95 % CI[2]**	**IRR[1]**	**P Value**	**95 % CI[2]**	**IRR[1]**	**P Value**	**95 % CI[2]**
Overdose-Related Emergency Department Visits	0.923	0.001	0.881 to 0.968	0.977	0.364	0.930 to 1.027	0.876	0.089	0.751 to 0.980	0.919	0.306	0.783 to 1.080
Opioid Overdose-Related Emergency Department Visits	0.950	0.171	0.883 to 1.022	0.949	0.180	0.880 to 1.024	0.779	0.056	0.603 to 1.006	0.819	0.136	0.630 to 1.065
	OR[3]	**P Value**	**95 % CI[2]**	**OR[3]**	**P Value**	**95 % CI[2]**	**OR[3]**	**P Value**	**95 % CI[2]**	**OR[3]**	**P Value**	**95 % CI[2]**
Receipt of Medication Treatment for Opioid Use Disorder	1.659	0.000	1.605 to 1.714	1.346	0.000	1.294 to 1.399	1.184	0.003	1.057 to 1.326	1.069	0.316	0.938 to 1.219
Secondary Outcomes												
	IRR[1]	**P Value**	**95 % CI[2]**	**IRR[1]**	**P Value**	**95 % CI[2]**	**IRR[1]**	**P Value**	**95 % CI[2]**	**IRR[1]**	**P Value**	**95 % CI[2]**
Emergency Department Visits	0.890	0.000	0.879 to 0.900	0.942	0.000	0.930 to 0.955	0.878	0.000	0.845 to 0.913	0.945	0.007	0.907 to 0.985
Hospitalizations	0.916	0.000	0.896 to 0.936	1.013	0.295	0.989 to 1.038	0.958	0.228	0.894 to 1.027	0.972	0.468	0.903 to 1.048
Psychiatric hospitalizations	1.028	0.456	0.955 to 1.106	0.947	0.170	0.878 to 1.023	1.042	0.731	0.826 to 1.314	1.099	0.437	0.867 to 1.392

[1] IRR = Incident Rate Ratio.
[2] CI=Confidence Interval.
[3] OR=Odds Ratio.

differences in rates for other OUD-related adverse patient outcomes (i.e., overdose-related emergency department visits, hospitalizations, and psychiatric-related hospitalizations) between those that most commonly use audio-only, audiovisual, or in-person visits for their OUD-related care. This suggests that telehealth delivery of OUD-related care, either audiovisual or audio-only, may be equivalent to in-person delivery in regard to rates of these other outcomes.

Our findings are consistent with recent studies evaluating more proximal outcomes. Specifically, several studies have shown improved retention on MOUD with telehealth, as compared to in-person delivery of care (Frost et al., 2022; Jones et al., 2022; Williams et al., 2023). To our knowledge, only one study has evaluated the association between telehealth delivery of MOUD and distal, patient outcomes. Using a cross-sectional study design with a cohort of commercially insured patients initiating buprenorphine for OUD, the study (Nguyen et al., 2024) found patients who initiated buprenorphine treatment with telehealth were more likely to stay engaged in MOUD and had a 36 % lower overdose rate as compared to those that initiated MOUD in person. While we did not find a similar statistically lower risk of overdose, we did see a similar trend. The difference could be explained by four key differences. First, we separated audio-only and audiovisual instead of grouping them into a combined telehealth group. Combining these two groups could provide more power and result in similar findings. Second, our study was among a cohort of patients, more like the U.S. Census, with OUD and different types of insurance plans. Third, this study assessed MOUD initiations with buprenorphine, either by telehealth or in-person care; our study was not limited to those persons with OUD initiating MOUD but any person engaging in OUD-related care after diagnosis. During the 180 days after the OUD diagnosis (also the 180 days before the index date), we found a higher percentage of patients whose primary modality of care delivery was audiovisual received buprenorphine (26.3 %) compared to those whose primary modality of care delivery was in-person (17.8 %). Outpatient visits were higher among those whose primary modality of care delivery was in-person care as compared to those whose primary modality of care delivery was audiovisual (Mean for in-person: 2.9 vs. Mean for audiovisual: 2.0). This may indicate that early variations in these patient groups, despite adjustments, might still include some residual confounding.

Like previous literature, our findings support the case for extending COVID-19-related telehealth policies to provide the flexibility to prescribe MOUD via telehealth (Eibl et al., 2017; Frost et al., 2022). Prescribers and patients have taken advantage of telehealth following policy changes due to the COVID-19 pandemic, including the audio-only option, resulting in substantial benefits with few downsides (Krawczyk et al., 2023). These policies may improve outcomes for persons with OUD by reducing unnecessary barriers to access and engagement in OUD-related care, such as travel time to appointments and transportation challenges. Our study is evidence that telehealth, from either modality (audiovisual or audio), can help improve access and receipt of MOUD and potentially modestly reduce rates of ED visits and hospitalizations.

6. Limitations

This study's findings should be considered in light of certain limitations. First, more than 90 % of patients in our study are from urban areas. Thus, these results may not generalize to a largely rural population. Second, modality of care delivery may have been misclassified in two ways. "E-consults" in Epic Cosmos have been considered telehealth in previous studies (Bartelt, Piff, Allen, et al., 2024; Bartelt, Piff, Gerhart, et al., 2024; Gerhart et al., 2024a). However, the "E-consults" classification does not provide details on whether the visit was audio only or audiovisual; therefore, we did not define any E-consult as any type of OUD-related care. Misclassification may also have occured if a patient received an OUD diagnosis from a healthcare system that does not participate in Epic Cosmos. In that case, we may have missed including patients with OUD in our sample. Third, our study period covers the time following the start of the COVID-19 pandemic; more than 50 % of our index dates fall in the year 2021 when most non-emergency outpatient care was remote. This may have required persons to have a telehealth visit, despite their preferred modality of OUD-related care delivery, which could overestimate or underestimate the association between the

preferred modality of OUD-related care delivery and the patient outcomes studied. Fourth, this study is based on electronic health record data from the Epic Cosmos system, which may be incomplete in capturing all healthcare received by the patient since care outside of an Epic-based system is not captured. Fifth, the data used for this study does not systematically capture the method of opioid administration or opioid of choice for the patient. As such, we were unable to include these variables as covariates.

7. Conclusions

Delivery of OUD-related care primarily through audio only or audiovisual visits was associated with modestly lower rates of ED visits as compared to OUD-related care primarily through in-person visits. Delivery of OUD-related care primarily through audiovisual visits was associated with slightly higher odds of receiving MOUD compared to care delivered primarily through in-person visits. No differences were found in other patient outcomes by delivery of OUD-related care. These findings suggest telehealth and in-person delivery of OUD-related care are likely comparable in quality. These findings support the permanent adoption of telehealth policies introduced during the COVID-19 pandemic, as they may improve access to MOUD and enhance OUD-related patient outcomes. Further research is needed to evaluate how to maximize the combination of telehealth and in-person care to optimize positive patient outcomes.

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CRediT authorship contribution statement

Nahiyan Bin Noor: Writing – original draft, Methodology, Formal analysis, Data curation. **George Pro:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Mahip Acharya:** Writing – review & editing, Validation, Supervision, Methodology. **Hari Eswaran:** Writing – review & editing, Funding acquisition. **Corey J. Hayes:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.abrep.2025.100588.

Data availability

The authors do not have permission to share data.

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