Title

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Journal

Substance Abuse, 39(1)

ISSN

0889-7077

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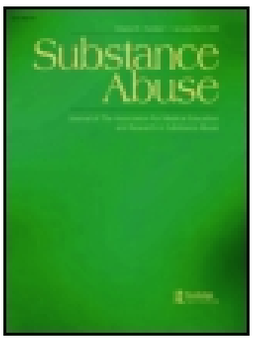
Publication Date

2018

DOI

10.1080/08897077.2017.1356789

Peer reviewed



Substance Abuse

ISSN: 0889-7077 (Print) 1547-0164 (Online) Journal homepage: http://www.tandfonline.com/loi/wsub20

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To cite this article: Amber L. Bahorik, Derek D. Satre, Andrea H. Kline-Simon, Constance M. Weisner, Kelly C. Young-Wolff & Cynthia I. Campbell (2017): Alcohol, marijuana, and opioid use disorders: 5-Year patterns and characteristics of emergency department encounters, Substance Abuse, DOI: 10.1080/08897077.2017.1356789

To link to this article: https://doi.org/10.1080/08897077.2017.1356789

Accepted author version posted online: 19 Jul 2017.
Published online: 06 Sep 2017.

SUBSTANCE ABUSE
https://doi.org/10.1080/08897077.2017.1356789

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Alcohol, marijuana, and opioid use disorders: 5-Year patterns and characteristics of emergency department encounters

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ABSTRACT

Background: Changes in substance use patterns stemming from opioid misuse, ongoing drinking problems, and marijuana legalization may result in new populations of patients with substance use disorders (SUDs) using emergency department (ED) resources. This study examined ED admission trends in a large sample of patients with alcohol, marijuana, and opioid use disorders in an integrated health system. *Methods*: In a retrospective design, electronic health record (EHR) data identified patients with ≥1 of 3 common SUDs in 2010 (n = 17,574; alcohol, marijuana, or opioid use disorder) and patients without SUD (n = 17,574). Logistic regressions determined odds of ED use between patients with SUD versus controls (2010–2014); mixed-effect models examined 5-year differences in utilization; moderator models identified subsamples for which patients with SUD may have a greater impact on ED resources. *Results*: Odds of ED use were higher at each time point (2010–2014) for patients with alcohol (odds ratio [OR] range: 5.31–2.13, Ps < .001), marijuana (OR range: 5.45–1.97, Ps < .001), and opioid (OR range: 7.63–4.19, Ps < .001) use disorders compared with controls; odds decreased over time (Ps < .001). Patients with opioid use disorder were at risk of high ED utilization; patients were 7.63 times more likely to have an ED visit in 2010 compared with controls and remained 5.00 (average) times more likely to use ED services. ED use increased at greater rates for patients with alcohol and opioid use disorders with medical comorbidities relative to controls (Ps < .045). *Conclusions*: ED use is frequent in patients with SUDs who have access to private insurance coverage and integrated medical services. ED settings provide important opportunities in health systems to identify patients with SUDs, particularly patients with opioid use disorder, to initiate treatment and facilitate ongoing care, which may be effective for reducing excess medical emergencies and ED encounters.

KEYWORDS

Access/demand/utilization of services; administrative data uses; managed care organizations; mental health; substance abuse

Introduction

The United States faces a dynamic landscape regarding marijuana, opioids, and alcohol. Concerns about these substances center around opioid misuse,[1,2] an ongoing high prevalence of alcohol-related harms,[3] and the liberalization of marijuana use policies.[4,5] Not surprisingly, excessive use of alcohol, marijuana, and prescription opioids increases risk of addiction and developing associated substance use disorders (SUDs).[6] In 2014, 17.0 million people 12 years of age or older were diagnosed with alcohol use disorder, 4.2 million had a marijuana use disorder, and 1.9 million had a disorder related to the nonmedical use of prescription pain relievers.[6] In recent years, heroin and other potent opioids such as fentanyl have made increasing contributions to rising opioid overdoses.[7] In addition, persons with alcohol, marijuana, or opioid use disorder are more likely to have comorbid conditions, which worsen prognosis, contribute to poor health,[8] and can lead to inappropriate health service use.[9,10]

Utilization of emergency department (ED) resources are 50% to 100% higher for patients with SUD compared with patients without SUD.[9–12] In addition to acute medical emergencies, ED use may be indicative of poor health, unmet service need, or inappropriate use of health care.[9–14] To date, studies have found most SUD-related ED visits are associated with alcohol,[9,10,13] and frequently document ED-based treatments have focused on alcohol to the exclusion of other drugs.[4,10] Yet, ED visits associated with the misuse of opioids and marijuana are common,[4,10,11] and considerable SUD-related ED visits involve concurrent or other drug use.[4] In addition, alcohol and opioid use disorders are among the most severe SUD diagnoses in terms of their negative impact on health, and evidence continues to emerge about the adverse health effects associated with marijuana use disorder.[4,15,16] Thus, the study of ED trends among patients with alcohol, marijuana, and opioid use disorders is important.

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High rates of SUD-related clinical emergencies and associated ED visits are a persistent barrier to improving health outcomes in this population.[9,10] Thus, a study that seeks to identify how patients with alcohol, marijuana, and opioid use disorders use ED resources is important, to potentially inform more specific ED-based treatment efforts (e.g., identification of SUD, ED-initiated brief intervention for substance use, and referral to follow-up care). This study examined ED trends across patients with alcohol, marijuana, and opioid use disorders, and controls, over time in a large integrated health care system in which all patients have insurance coverage to access health care. Using electronic health record (EHR) data, we aimed to (1) determine the odds of having an ED visit each year from 2010 to 2014 for patients with alcohol, marijuana, and opioid use disorders relative to controls without these conditions; (2) evaluate differences in ED use between controls and those with alcohol, marijuana, and opioid use disorders over 5 years; and (3) explore subsamples for which patients with SUD (vs. controls) may have a greater impact on ED resources.

Methods

Setting

Kaiser Permanente of Northern California (KPNC) is a nonprofit, integrated health care delivery system with 4 million members, who account for 44% of the commercially insured population in the region. KPNC operates over 54 outpatient clinics and employs more than 7000 physicians. About 88% of members are commercially insured, 28% have Medicare, and 10% have Medicaid coverage. All patients were selected from the KPNC membership.

Data source and study participants

We used secondary EHR data for this database-only study. These data were used to identify all health plan members who (1) were aged 18 or older, (2) who had a visit to a KPNC facility in 2010, and (3) had a recorded ICD-9 (International Classification of Diseases Ninth Revision) diagnosis of alcohol, marijuana, or opioid abuse or dependence in 2010. The first mention for each ICD-9 diagnosis of alcohol, marijuana, or opioid use disorder recorded from January 1, 2010, to December 31, 2010, were included; patients in the sample could have multiple diagnoses (e.g., SUD groups were not mutually exclusive). We also included all current or existing SUD diagnosis that were additionally documented for patients with alcohol, marijuana, or opioid use disorder during health plan visits in 2010 (see Appendix 1 for included ICD-9 codes). Within KPNC, SUD and other behavioral health diagnoses (e.g., major depressive disorder, schizophrenia, etc.) can be assigned to patients in any clinic setting, e.g., primary care or any specialty care clinic. Diagnoses can be assigned by physicians or any other qualified health care provider who is directly evaluating a patient. All diagnoses are captured through ICD-9 codes.

EHR data were used to identify control patients who did not have current or existing SUDs or other behavioral health diagnoses. Control patients were selected for all unique patients with alcohol, marijuana, and opioid use disorders and matched one-to-one on gender, age, and medical home facility. This accounted for differences in services, types of behavioral health conditions, or unobservable differences by geographic location. To control for varying lengths of membership, participants were required to be KPNC members for at least 80% of the study (at least 4 out of the 5 years studied[17]).

The final analytical sample consisted of 35,148 patients: 12,411 with alcohol use disorder, 2752 with marijuana use disorder, 2411 with opioid use disorder, and 17,574 controls. Institutional review board approval was obtained from the Kaiser Foundation Research Institute.

Measures

Patient characteristics

Age, gender, race/ethnicity, and clinical diagnoses were extracted from the EHR. Race/ethnicity consisted of 5 categories: white, black, Hispanic, Asian, and other. Psychiatric and SUD diagnoses were determined from ICD-9 codes documented during health system visits in 2010 and included current and existing diagnoses. Co-occurring medical conditions were measured using the Charlson Comorbidity Index[18]; higher scores indicate greater medical burden.

ED utilization

ED data from 2010 through 2014 was extracted from the EHR. For each year, dichotomous ED utilization measures were defined (1 = present, 0 = else). ED encounters both within and outside of KPNC for the study duration were included to account for members who may have used ED resources outside the KPNC health care system.

Data analysis

Frequencies and means were used to characterize the sample. We then employed χ^2 tests (categorical variables) and independent t tests (continuous variables) to identify differences between the controls and those with alcohol, marijuana, or opioid use disorder. A series of logistic regression analyses were computed for each year (2010, 2011, 2013, and 2014) to compare the odds of having ED visits for each SUD group relative to controls. All models adjusted for gender (1 = men, 0 = else), race/ethnicity (white = reference, Hispanic, Asian, black, "other"), age (18–29 = reference, 30–39, 40–49, 50+), and medical comorbidities (Charlson Comorbidity Index score).

Longitudinal analyses were conducted within a generalized mixed-effects growth model framework, using penalized-quasi-likelihood estimation for computing parameter estimates of binary outcomes. This approach is a form of hierarchical linear modeling for repeated measures data, where multiple measurement occasions are nested within persons.[19] These analyses began with unconditional growth models predicting ED utilization from time (coded: 0 = 2010; 1 = 2011; 2 = 2012; 3 = 2013; 4 = 2014) to examine the 5-year patterns of ED utilization for each SUD group. We then constructed conditional growth models predicting ED use from time and a time × SUD group interaction (reference = control), to examine differences between alcohol, marijuana, and opioid use disorder patients and controls on ED use over 5 years. For these conditional

growth models, the time × SUD group interaction indicates differences in the rates of ED utilization between patients with versus without SUD over 5 years, controlling for person-level differences (e.g., age, gender, race/ethnicity, and medical comorbidity). Finally, we computed a series of moderator analyses employing mixed-effects moderator models to explore subsamples for which patients with SUD (vs. controls) may have a greater impact on ED resources over time. Moderator model analyses proceeded by examining potential differences in the association among patients with SUD (reference = controls) and ED use by age, gender, race/ethnicity, and medical comorbidity by time. Analyses were run in R version 3.3.1[20] and statistical significance was defined at $P < .05$.

Results

Sample characteristics

Overall, the sample was 35.5% women, 60.0% white, 16.1% Hispanic, 11.0% Asian, 8.6% black, and 4.0% other race/ethnicity. Patients were 37 years old on average. Differences in the characteristics among patients with alcohol, marijuana, and opioid use disorders and the controls are reported in Table 1. Compared with controls, more patients with alcohol, marijuana, or opioid use disorder were white or black; more controls were Asian, Hispanic, or had a race/ethnicity categorized as "other" compared with those with alcohol, marijuana, and opioid use disorder with few exceptions. In addition, compared with controls, patients with alcohol, marijuana, and opioid use disorders had greater medical comorbidities (Table 1), and co-occurring mental health and substance use conditions were common (Table 2).

Patterns of emergency department utilization

ED utilization patterns among patients with alcohol, marijuana, and opioid use disorders and controls were examined during each year (2010–2014). At each time point, more patients with alcohol, marijuana, and opioid use disorders used ED services relative to controls (Table 1; Figure 1); ED use decreased over the follow-up. Similarly, compared with controls, patients with alcohol, marijuana, and opioid use disorders were more likely to have an ED visit at each time point, and these odds decreased from 2010 to 2014 (Figure 2). Patients with opioid use disorder were at risk of high ED utilization, with these patients being 7.63 times more likely of having an ED visit in 2010 versus controls, and remaining 5.00 (average) times more likely to have ED visits over time.

As shown in Table 3, ED ($B = -0.01$ [95% confidence interval, CI = 0.978, 0.987], $P < .001$) use significantly declined in the sample over 5 years. Patients with alcohol use disorder ($B = 0.24$ [95% CI = 1.247, 1.311], $P < .001$) were more likely than controls to have an ED visit in 2010 and then subsequently demonstrated a faster decline in ED use ($B = -0.03$ [95% CI = 0.951, 0.971], $P < .001$) relative to controls over 5 years. Patients with marijuana ($B = 1.41$ [95% CI = 3.569, 4.702], $P < .001$) and opioid ($B = 1.82$ [95% CI = 5.387, 7.134], $P < .001$) use disorders were also more likely than controls to have an ED visit in 2010, and then those with marijuana ($B = -0.23$ [95% CI = 0.747, 0.837], $P < .001$) and opioid ($B = -0.12$ [95% CI = 0.830, 0.930], $P < .001$) use disorders exhibited a faster decline in ED service use compared with controls over time (Table 3).

Subsamples for which having a SUD may have a greater impact on ED visits were investigated. A greater increase in ED use was observed for patients with medical comorbidities who had alcohol ($B = 0.01$ [95% CI = 0.998, 1.017], $P < .001$) or opioid ($B = 0.02$ [95% CI = 0.977, 1.179], $P = .045$) use disorder compared with controls with medical comorbidities. Although not significant, a trend increase in ED use was found for patients with medical comorbidities who had marijuana use disorder ($B = 0.03$ [95% CI = 0.998, 1.066], $P = .069$) compared with controls with medical comorbidities. Compared with black controls, a greater decline in ED use was observed among black patients with alcohol use disorder ($B = -0.01$ [95% CI = 0.971, 0.999], $P < .001$). A greater increase in ED

Table 1. Patient characteristics.

Variable	Alcohol use disorder ($n = 12,411$) %	Control ($n = 12,411$) %	P	Marijuana use disorder ($n = 2752$ %	Control ($n = 2752$) %	P	Opioid use disorder ($n = 2411$) %	Control ($n = 2411$) %	P
Race/ethnicity									
White	65.9	53.1	<.001	60.7	46.1	<.001	75.1	54.8	<.001
Hispanic	16.4	16.1	.429	15.7	18.8	.002	13.3	17.5	<.001
Asian	6.3	18.2	<.001	5.1	20.2	<.001	2.6	15.1	<.001
Black	8.3	7.6	.061	15.6	8.7	<.001	7.4	7.3	.999
Unknown	2.8	4.8	<.001	2.6	5.9	<.001	1.3	4.9	<.001
Women	31.3	31.3	ns	35.8	35.7	ns	54.8	54.8	ns
Age (years), *M* (SD)	49.6 (15.2)	49.8 (15.3)	ns	36.4 (15.7)	36.8 (15.2)	ns	44.7 (14.6)	45.1 (14.6)	ns
Medical (CCI[a] score), *M* (SD)	0.44 (0.97)	0.36 (0.87)	<.001	0.33 (0.89)	0.20(0.63)	<.001	0.55 (1.11)	0.26 (0.72)	<.001
ED utilization									
2010	49.1	15.5	<.001	53.4	16.6	<.001	59.0	13.8	<.001
2011	29.9	14.5	<.001	33.3	16.1	<.001	47.4	14.5	<.001
2012	28.7	15.3	<.001	31.8	16.2	<.001	46.3	15.5	<.001
2013	28.6	14.9	<.001	31.1	14.3	<.001	45.3	15.1	<.001
2014	28.8	15.3	<.001	29.7	16.0	<.001	42.9	13.6	<.001

Note. Medical = medical comorbidity; ED = emergency department. Patients with alcohol, marijuana, and opioid use disorders were matched to controls by gender, age, and medical home facility; ns = nonsignificant *P* values were equal to 1 for gender and age as patients were matched based on these variables.
[a]CCI = Charlson Comorbidity Index; higher mean scores indicate greater medical disease burden.

Table 2. Substance use and psychiatric comorbidity among patients with alcohol, marijuana, and opioid use disorders.

	Alcohol use disorder ($n = 12,411$)		Marijuana use disorder ($n = 2752$)		Opioid use disorder ($n = 2411$)	
Variable	*n*	%	*n*	%	*n*	%
Any psychiatric condition[a]	5201	41.9	1578	57.3	1713	71.0
Depression	3834	30.8	1106	40.1	1357	56.2
Anxiety	2689	21.6	859	31.2	996	41.3
Bipolar	572	4.6	287	10.4	226	9.3
Schizophrenia	111	0.8	90	3.2	37	1.5
Other psychoses	221	1.7	157	5.7	70	2.9
Personality disorders	276	2.2	142	5.1	156	6.4
Attention-deficit/ hyperactivity disorder	209	1.6	152	5.5	104	4.3
Dementia	124	0.9	14	0.5	29	1.2
Autism	16	0.1	8	0.2	5	0.2
>1 Psychiatric condition	3103	25.0	766	27.8	812	33.6
>2 Psychiatric conditions	1648	13.2	535	19.4	652	27.0
Any substance use disorder[b]	1681	13.5	1216	44.1	833	34.5
Alcohol use disorder	—	—	907	32.9	499	20.6
Marijuana use disorder	907	7.3	—	—	—	—
Opioid use disorder	499	4.0	272	9.8	272	11.2
Cocaine use disorder	293	2.3	157	5.7	76	3.1
Barbiturate use disorder	182	1.4	78	2.8	246	10.2
Amphetamine use disorder	302	2.4	210	7.6	115	4.7
Hallucinogen use disorder	14	0.1	26	0.9	10	0.4
>1 Substance use disorder	10,730	86.4	1536	55.8	1578	65.4
>2 Substance use disorders	1278	10.2	888	32.2	544	22.5

[a]1 = any psychiatric comorbidity; 0 = else.
[b]1 = any nonalcohol, nonmarijuana, or nonopioid substance use disorder; 0 = else.

use was observed among patients in the "other" race/ethnicity who had alcohol use disorder ($B = 0.05$ [95% CI = 1.014, 1.043], $P < .001$) compared with controls who had a race/ethnicity characterized as other. No other significant interactions were observed (Table 3).

Discussion

Alcohol, marijuana, and opioids frequently take center stage in public policy and debate as concerns remain focused around opioid misuse and overdose,[1,2] ongoing drinking problems,[3] and liberalization of marijuana use policies.[4,5] Persons who excessively use these substances face the risk of developing an associated SUD,[6] which can have considerable implications for patient health and health systems,[15] in part by contributing to high use of ED services.[9–12] Thus, we examined how patients with alcohol, marijuana, and opioid use disorders, and controls, used ED resources over time in a large health care system.

Similar to studies conducted in the general population and other health systems,[6,21–23] alcohol use disorder was diagnosed the most frequently, followed by marijuana use disorder, and opioid use disorder, and the rates of co-occurring medical, psychiatric, and SUD were substantial in each. Because these conditions worsen prognosis, lead to high morbidity,[21,22,24] and can contribute to inappropriate service use,[9,10] it is not surprising we found that patients with these disorders consistently had greater likelihood of ED use relative to controls. ED visits were the highest among patients with opioid use disorder, followed

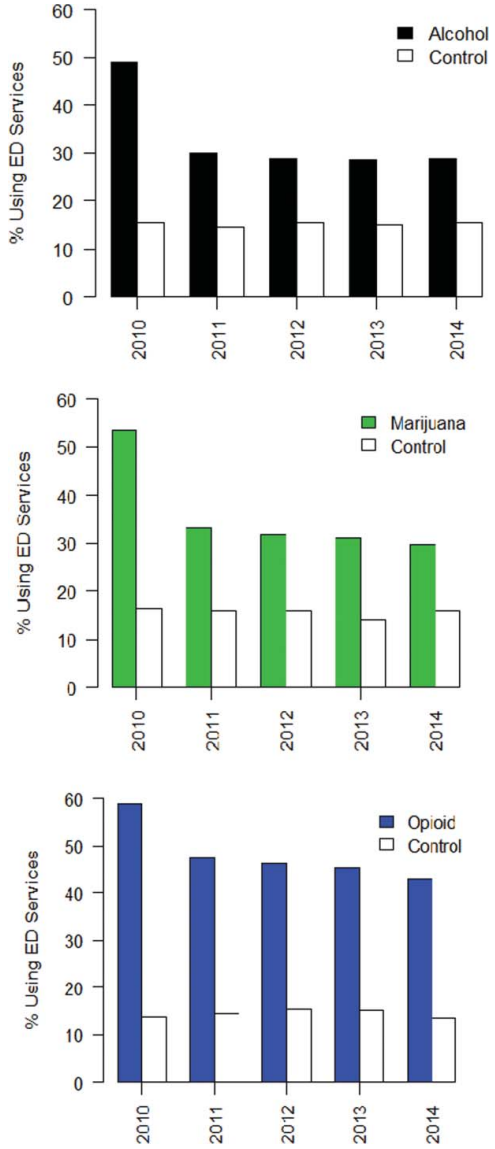

Figure 1. Emergency department visits among patients with alcohol, marijuana, and opioid use disorders compared with controls for all years 2010 to 2014.

by those with marijuana and alcohol use disorders, which is contrary to prior work that has documented most SUD-related ED visits are associated with alcohol use disorder.[9,10,13] This difference could reflect the effects of

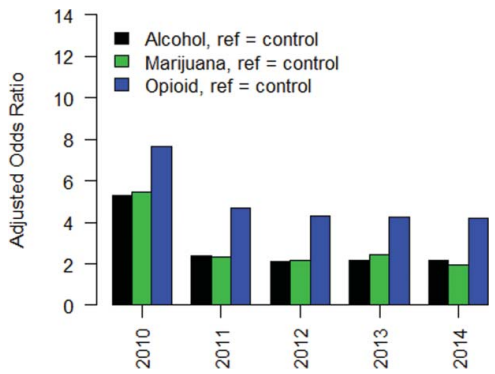

Figure 2. Adjusted odds ratios of emergency department visits among patients with alcohol, marijuana, and opioid use disorders compared with controls for all years 2010 to 2014.

Table 3. Longitudinal predictors of emergency department utilization.

Variable	Emergency department utilization			
	B	95% CI	SE	*P*
Unconditional Growth Model				
Time	−0.01	(0.978, 0.987)	0.01	<.001
Conditional Growth Model—Alcohol				
Race/ethnicity[a]				
Hispanic	−0.01	(0.981, 1.006)	0.01	.325
Asian	0.01	(1.004, 1.019)	0.01	.002
Black	−0.02	(0.962, 0.984)	0.01	<.001
Other	0.02	(1.019, 1.038)	0.01	<.001
Age[b]				
30–39	−0.01	(0.985, 1.011)	0.01	.752
40–49	−0.01	(0.981, 1.005)	0.01	.269
50+	−0.01	(0.982, 1.006)	0.01	.340
Female	0.02	(1.013, 1.045)	0.01	<.001
Medical comorbidity[c]	0.05	(1.053, 1.068)	0.01	<.001
Alcohol[d]	0.24	(1.247, 1.311)	0.01	<.001
Time × Alcohol[d]	−0.03	(0.951, 0.971)	0.01	<.001
Moderated Growth Model[e]—Alcohol				
Race/ethnicity[a]				
Time × Hispanic × Alcohol	−0.01	(0.977, 1.010)	0.01	.641
Time × Asian × Alcohol	−0.01	(0.980, 0.999)	0.01	.967
Time × Black × Alcohol	−0.01	(0.971, 0.999)	0.01	<.001
Time × Other × Alcohol	0.05	(1.014, 1.043)	0.01	<.001
Age[b]				
Time × 30–39 × Alcohol	0.01	(1.005, 1.034)	0.01	.319
Time × 40–49 × Alcohol	0.01	(0.993, 1.021)	0.01	.412
Time × 50+ × Alcohol	0.01	(1.004, 1.035)	0.01	.406
Female				
Time × Female × Alcohol	0.06	(1.050, 1.093)	0.01	.380
Medical comorbidity[c]				
Time × Medical × Alcohol	0.01	(0.998, 1.017)	0.01	<.001
Conditional Growth Model—Marijuana				
Race/ethnicity[a]				
Hispanic	−0.08	(0.863, 0.987)	0.03	.019
Asian	0.07	(1.034, 1.119)	0.01	<.001
Black	−0.14	(0.817, 0.909)	0.02	<.001
Other	0.18	(1.133, 1.274)	0.02	<.001
Age[b]				
30–39	0.01	(0.958, 1.068)	0.02	.676
40–49	−0.07	(0.883, 0.977)	0.02	.004
50+	−0.08	(0.882, 0.965)	0.02	<.001
Female	0.07	(0.992, 1.167)	0.04	.078
Medical comorbidity[c]	0.29	(1.290, 1.405)	0.02	<.001
Marijuana[d]	1.41	(3.569, 4.702)	0.07	<.001
Time × Marijuana[d]	−0.23	(0.747, 0.837)	0.02	<.001
Moderated Growth Model[e]—Marijuana				
Race/ethnicity[a]				
Time × Hispanic × Marijuana	0.01	(0.980, 1.027)	0.01	.792
Time × Asian × Marijuana	−0.01	(1.044, 1.114)	0.01	.378
Time × Black × Marijuana	−0.01	(0.970, 1.012)	0.01	.671
Time × Other × Marijuana	−0.01	(0.961, 1.081)	0.01	.375
Age[b]				
Time × 30–39 × Marijuana	−0.01	(0.967, 1.022)	0.02	.655
Time × 40–49 × Marijuana	0.01	(0.990, 1.041)	0.01	.251
Time × 50+ × Marijuana	−0.01	(0.975, 1.020)	0.01	.819
Female				
Time × Female × Marijuana	0.03	(0.993, 1.156)	0.01	.082
Medical comorbidity[c]				
Time × Medical × Marijuana	0.03	(0.998, 1.066)	0.01	.069
Conditional Growth Model—Opioid				
Race/ethnicity[a]				
Hispanic	−0.08	(0.851, 0.986)	0.03	.019
Asian	0.14	(1.107, 1.211)	0.02	<.001
Black	−0.21	(0.760, 0.858)	0.03	<.001
Other	0.20	(1.147, 1.306)	0.30	<.001
Age[b]				
30–39	0.05	(0.996, 1.116)	0.02	<.001
40–49	−0.10	(0.852, 0.949)	0.02	.069
50+	−0.08	(0.875, 0.971)	0.02	<.001

(*Continued on next page*)

Table 3. (Continued)

Variable	Emergency department utilization			
	B	95% CI	SE	*P*
Female	1.82	(1.221, 1.426)	0.07	<.001
Medical comorbidity[c]	0.30	(1.309, 1.415)	0.01	<.001
Opioid[d]	1.82	(5.387, 7.134)	0.07	<.001
Time × Opioid[d]	−0.12	(0.830, 0.930)	0.02	<.001
	Moderated Growth Model[e]—Opioid			
Race/ethnicity[a]				
Time × Hispanic × Opioid	−0.01	(0.861, 1.018)	0.01	.281
Time × Asian × Opioid	0.01	(1.055, 1.160)	0.01	.591
Time × Black × Opioid	−0.01	(0.709, 0.819)	0.01	.551
Time × Other × Opioid	0.01	(1.055, 1.160)	0.01	.371
Age[b]				
Time × 30–39 × Opioid	−0.01	(0.890, 1.118)	0.01	.670
Time × 40–49 × Opioid	−0.01	(0.891, 1.100)	0.01	.891
Time × 50+ × Opioid	−0.01	(1.045, 1.273)	0.01	.092
Female				
Time × Female × Opioid	−0.01	(0.900, 1.177)	0.01	.670
Medical comorbidity[c]				
Time × Medical × Opioid	0.02	(0.977, 1.179)	0.01	.045

Note. Alcohol = patients with alcohol use disorder; Marijuana = patients with marijuana use disorder; Opioid = patients with opioid use disorder.
[a]Reference = white.
[b]Reference = ages 18–29.
[c]Charlson Comorbidity Index; higher scores indicate greater medical disease burden.
[d]Reference = controls.
[e]Only a priori moderated effects of interested are presented to reduce visual clutter.

changing marijuana use disorder patterns and an overall high morbidity among patients with opioid disorder, which may have large effects on health system resources.[1,2,4,6,8–10] Most ED-based treatments focus on alcohol to the exclusion of other drugs,[4,10] and since our data suggest that ED visits are also frequent among patients with marijuana and opioid use disorders, these patients may be at risk for having unmet or unidentified treatment needs. Consequently, building on ED-based treatments for patients with alcohol use disorder,[4,10] it will be important for future studies to extend these treatments to patients with opioid and marijuana use disorders, to reduce medical emergencies and improve patient health in this population.

Patients with opioid use disorder constituted a modest proportion of the sample, and these patients consistently had high odds of ED use. Similar to this, previous studies report that patients with opioid use disorder are overrepresented in ED settings.[1,12,25,26] This could be due to the individual or combined effects of complex medical conditions, injury, or overdose,[26] which have large impact on the burden of disease and are some of the more persistent barriers to improving overall health outcomes among patients with opioid use disorder.[15] Consequently, ED settings offer important opportunities to identify patients with opioid use disorder and initiate treatment. Recent evidence suggests that ED-initiated buprenorphine increases subsequent engagement in addiction treatment and reduces illicit opioid use.[27] Devoting more health resources to initiating evidence-based ED-based treatments for patients with opioid use disorder in health systems, including ED-initiated buprenorphine and referral to SUD treatment,[27] may be a step toward improving health outcomes and reducing high SUD-related ED visits among patients with opioid use disorder.

Over time, all patients had fewer ED visits, and a greater decrease in ED use was observed for patients with SUDs compared with controls, although those with SUDs continued to have more ED visits. These ED utilization patters are consistent with general population studies, which show decreasing ED visits involving alcohol and opioid use disorders.[4–6,8–11] At the same time, our ED utilization patterns regarding marijuana use disorder are inconsistent with national data, which suggest increasing ED visits involving marijuana-related problems.[4,28] This national increase could be due to the combined effects of increasing marijuana potency, liberalizing views of the drug, and increasing trends toward its legalization.[4,16] Notably, however, we found a decrease in ED use over time across patients with marijuana use disorder as well as those with alcohol and opioid use disorders, which may suggest that some patients' health status improves (with the likely exception of more complex patients with co-occurring conditions) more quickly. Another possibility is that the observed decrease in ED use may be specific to those who receive care within integrate health systems in which specialty services are provided internally. For example, prior studies conducted within KPNC found that patients with SUD who had ongoing primary care and addiction treatment were less likely to have subsequent ED visits.[29,30] It will be important for future studies in other systems to investigate the potential impact of specialty and primary care on reducing subsequent acute services across those with alcohol, marijuana, and opioid use disorders.

Our results confirm the work of prior studies showing that patients with alcohol and opioid use disorders, and to a lesser degree patients with marijuana use disorder, have frequent and increasing ED visits over time associated with poor health or complex medical conditions.[9,13,14,24] Since our medical comorbidity measure combined acute and chronic conditions, it will be important for future work to

identify which individual medical conditions (e.g., overdose, injury, respiratory infections, etc.) contribute most strongly to ED admission. Other characteristics that were not measured (e.g., income, education, etc.) may also influence ED use rates in patients with SUD, and understanding these factors may further help improve service planning efforts and ED-based treatments for this population. In addition, comorbid conditions were common among patients with SUD, and these individuals may have ED visits that require a range of medical treatments, psychiatric symptom stabilization, or detoxification from alcohol or drugs.

Limitations should be noted. Our use of provider-assigned diagnoses restricted the sample to patients with at least 1 of the 3 most common SUD diagnoses in 2010 (i.e., alcohol, marijuana, or opioid use disorder). As with other studies that have used claims-based data,[8,30–35] our study captures patients with SUD through ICD-9 codes noted in health plan visits during the study period. This methodology is vulnerable to diagnostic underestimation.[34] Therefore, the SUD prevalence data in our study may underestimate the general ED patient population prevalence. Although not available for this study, future database studies could examine if the inclusion of pharmacy-based prescription data to ICD-9 diagnosis improves prevalence estimates. Another potential limitation with the methods we used to select our SUD sample is that we required a single mention of an ICD-9 code for SUD during the study period to link the patient with that diagnosis. Although the single mention methodology is well established,[31–35] it could result in an overestimation of the true diagnostic rates if diagnoses only mentioned one time in the EHR are more likely to be inaccurate. Patients were insured members of an integrated health system, and thus our results may not be generalizable to uninsured populations or other types of health systems. Our findings of SUD-related ED trends are somewhat inconsistent with prior work,[9,10–13] which suggests a need for replication. All patients were required to have a health system visit in 2010 to enter the study, but they were not required to have a health system visit to remain in the study. These criteria may explain the steep decline in ED visits between 2010 and 2011 and subsequent leveling of ED use. We cannot identify the reason for why patients had an ED visit (i.e., opioid-related overdose, chronic disease type, etc.), which will be an important focus of future work. ED utilization that KPNC did not pay for is not captured, although we capture external, paid-for ED utilization through claims. Consequently, ED use may be higher than we report. Low base rates of SUDs other than alcohol, marijuana, and opioid use disorders (e.g., cocaine use disorder, amphetamine use disorder, etc.) precluded our ability to examine the effect of these conditions on ED visits.

Conclusion

This study revealed consistent and remarkably high ED use in a sample of patients with alcohol, marijuana, and opioid use disorders, who had insurance coverage and access to integrated health services. ED use increased at greater rates for patients with medical comorbidities who also had an alcohol or opioid use disorder, and patients with opioid use disorder were at particular risk of high ED use. Results suggest that it will be important for future efforts to deliver enhanced ED-based screening and intervention efforts for persons with SUD. Such efforts should include a strong focus on reducing medical emergencies associated with opioid disorder, which may help improve health outcomes and reduce ED visits in this population.

Funding

This work was supported by the Sidney R. Garfield Memorial Fund and National Institute on Drug Abuse (NIDA) grant T32DA007250. Funders were not involved in the study design; extraction, analysis, or interpretation of the data; the writing of the report; or the decision to submit the manuscript for publication. The content is the responsibility of the authors and does not necessarily represent the views of the funders.

The authors declare that they have no conflicts of interest.

Author contributions

Drs. Bahorik, Campbell, and Satre developed the research questions and study design. Ms. Kline-Simon extracted the data from the KPNC EHR, and Dr. Bahorik carried out the statistical analyses. Dr. Bahorik wrote the first draft of the manuscript, and all authors provided critical revisions. All authors contributed to and approved the final manuscript.

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Appendix 1. Substance use disorder and psychiatric diagnoses and International Classification of Diseases Ninth Revision codes

ICD-9 code	Substance use disorder
291	Alcohol-induced mental disorders
291.0	Alcohol withdrawal delirium
291.2	Alcohol-induced persisting amnestic disorder
291.3	Alcohol-induced psychotic disorder with hallucinations
291.4	Idiosyncratic alcohol intoxication
291.5	Alcohol-induced psychotic disorder with delusions
291.8	Other specified alcohol-induced mental disorders
291.81	Alcohol withdrawal
291.82	Alcohol-induced sleep disorders
291.89	Other alcohol-induced mental disorders
291.9	Unspecified alcohol-induced mental disorders
292	Drug-induced mental disorders
292.0	Drug withdrawal
292.1	Drug-induced psychotic disorders
292.11	Drug-induced psychotic disorder with delusions
292.12	Drug-induced psychotic disorder with hallucinations
292.2	Pathological drug intoxication
292.8	Other specified drug-induced mental disorders
292.81	Drug-induced delirium
292.82	Drug-induced persisting dementia
292.83	Drug-induced persisting amnestic disorder
292.84	Drug-induced mood disorder
292.85	Drug-induced sleep disorders
292.89	Other specified drug-induced mental disorders
292.9	Unspecified drug-induced mental disorder
303	Alcohol dependence syndrome
303.0	Acute alcoholic intoxication
303.00	Acute intoxication in alcoholism, unspecified
303.01	Acute intoxication in alcoholism, continuous
303.02	Acute intoxication in alcoholism, episodic
303.03	Acute alcoholic intoxication in alcoholism, in remission
303.9	Other and unspecified alcohol dependence
303.90	Other and unspecified alcohol dependence, unspecified
303.91	Other and unspecified alcohol dependence, continuous
303.92	Other and unspecified alcohol dependence, episodic
303.93	Other and unspecified alcohol dependence, in remission
304	Drug dependence
304.0	Opioid-type dependence
304.00	Opioid-type dependence, unspecified
304.01	Opioid-type dependence, continuous
304.02	Opioid-type dependence, episodic
304.03	Opioid-type dependence, in remission
304.1	Sedative, hypnotic or anxiolytic dependence
304.10	Sedative, hypnotic or anxiolytic dependence, unspecified
304.11	Sedative, hypnotic or anxiolytic dependence, continuous
304.12	Sedative, hypnotic or anxiolytic dependence, episodic
304.13	Sedative, hypnotic or anxiolytic dependence, in remission
304.2	Cocaine dependence
304.20	Cocaine dependence, unspecified
304.21	Cocaine dependence, continuous
304.22	Cocaine dependence, episodic
304.23	Cocaine dependence, in remission
304.3	Cannabis dependence
304.30	Cannabis dependence, unspecified
304.31	Cannabis dependence, continuous
304.32	Cannabis dependence, episodic
304.33	Cannabis dependence, in remission
304.4	Amphetamine and other psychostimulant dependence
304.40	Amphetamine and other psychostimulant dependence, unspecified
304.41	Amphetamine and other psychostimulant dependence, continuous
304.42	Amphetamine and other psychostimulant dependence, episodic
304.43	Amphetamine and other psychostimulant dependence, in remission

(*Continued on next column*)

Appendix 1. (Continued)

ICD-9 code	Substance use disorder
304.5	Hallucinogen dependence
304.50	Hallucinogen dependence, unspecified
304.51	Hallucinogen dependence, continuous
304.52	Hallucinogen dependence, episodic
304.53	Hallucinogen dependence, in remission
304.6	Other specified drug dependence
304.60	Other specified drug dependence, unspecified
304.61	Other specified drug dependence, continuous
304.62	Other specified drug dependence, episodic
304.63	Other specified drug dependence, in remission
304.7	Combinations of opioid-type drug with any other drug dependence
304.70	Combinations of opioid-type drug with any other drug dependence, unspecified
304.71	Combinations of opioid-type drug with any other drug dependence, continuous
304.72	Combinations of opioid-type drug with any other drug dependence, episodic
304.73	Combinations of opioid-type drug with any other drug dependence, in remission
304.8	Combinations of drug dependence excluding opioid-type drug
304.80	Combinations of drug dependence excluding opioid-type drug, unspecified
304.81	Combinations of drug dependence excluding opioid-type drug, continuous
304.82	Combinations of drug dependence excluding opioid-type drug, episodic
304.83	Combinations of drug dependence excluding opioid-type drug, in remission
304.9	Unspecified drug dependence
304.90	Unspecified drug dependence, unspecified
304.91	Unspecified drug dependence, continuous
304.92	Unspecified drug dependence, episodic
304.93	Unspecified drug dependence, in remission
305	Nondependent abuse of drugs
305.0	Nondependent alcohol abuse
305.00	Alcohol abuse, unspecified
305.01	Alcohol abuse, continuous
305.02	Alcohol abuse, episodic
305.03	Alcohol abuse, in remission
305.2	Nondependent cannabis abuse
305.20	Cannabis abuse, unspecified
305.21	Cannabis abuse, continuous
305.22	Cannabis abuse, episodic
305.23	Cannabis abuse, in remission
305.3	Nondependent hallucinogen abuse
305.30	Hallucinogen abuse, unspecified
305.31	Hallucinogen abuse, continuous
305.32	Hallucinogen abuse, episodic
305.33	Hallucinogen abuse, in remission
305.4	Nondependent sedative, hypnotic or anxiolytic abuse
305.40	Sedative, hypnotic or anxiolytic abuse, unspecified
305.41	Sedative, hypnotic or anxiolytic abuse, continuous
305.42	Sedative, hypnotic or anxiolytic abuse, episodic
305.43	Sedative, hypnotic or anxiolytic abuse, in remission
305.5	Nondependent opioid abuse
305.50	Opioid abuse, unspecified
305.51	Opioid abuse, continuous
305.52	Opioid abuse, episodic
305.53	Opioid abuse, in remission
305.6	Nondependent cocaine abuse
305.60	Cocaine abuse, unspecified
305.61	Cocaine abuse, continuous
305.62	Cocaine abuse, episodic
305.63	Cocaine abuse, in remission
305.7	Nondependent amphetamine or related acting sympathomimetic abuse
305.71	Amphetamine or related acting sympathomimetic abuse, unspecified
305.72	Amphetamine or related acting sympathomimetic abuse, continuous
305.73	Amphetamine or related acting sympathomimetic abuse, episodic
305.8	Nondependent antidepressant-type abuse

(*Continued on next column*)

Appendix 1. (Continued)

ICD-9 code	Substance use disorder
305.80	Antidepressant-type abuse, unspecified
305.82	Antidepressant-type abuse, continuous
305.83	Antidepressant-type abuse, episodic
305.9	Nondependent other mixed or unspecified drug abuse
305.90	Other, mixed, or unspecified drug abuse, unspecified
305.91	Other, mixed, or unspecified drug abuse, continuous
305.92	Other, mixed, or unspecified drug abuse, episodic
305.93	Other, mixed, or unspecified drug abuse, in remission
	Psychiatric condition
300.00	Anxiety disorder NOS
300.01	Panic disorder without agoraphobia
300.02	Generalized anxiety disorder
300.2	Phobia, unspecified
300.21	Panic disorder with agoraphobia
300.22	Agoraphobia without history of panic disorder
300.23	Social phobia (social anxiety)
300.29	Specific phobia
300.3	Obsessive compulsive disorder
309.20	Adjustment disorders with anxiety
309.21	Separation anxiety disorder
309.24	Adjustment disorder with anxiety
309.81	Posttraumatic stress disorder
308.3	Acute stress disorder
314.00	Attention deficit disorder, inattentive type
314.01	Attention deficit disorder, hyperactive/impulsive or combined type
314.1	Hyperkinesis with developmental delay
314.2	Hyperkinetic conduct disorder of childhood
314.8	Other specific manifests hyperkinetic syndrome, child
314.9	Attention deficit disorder NOS
299.01	Autistic disorder, residual state
299.10	Childhood disintegrative disorder
299.11	Childhood disintegrative disorder, residual state
299.80	Asperger's disorder/pervasive developmental disorder
299.00	Autistic disorder, current or active state
296.00	Bipolar I disorder, single manic episode, unspecified
296.01	Bipolar I disorder, single manic episode, mild
296.02	Bipolar I disorder, single manic episode, moderate
296.03	Bipolar I disorder, single manic episode, severe without psychosis
296.04	Bipolar I disorder, single manic episode, severe with psychosis
206.05	Bipolar I disorder, single manic episode, in partial remission
296.06	Bipolar I disorder, single manic episode, in full remission
296.1	Manic recurrent episode
296.10	Manic disorder recurrent episode unspecified
296.11	Recurrent manic disorder, mild
296.12	Recurrent manic disorder, moderate
296.13	Recurrent manic disorder, severe
296.14	Manic affective disorder, recurrent episode, severe, specified as with psychotic behavior
296.15	Manic affective disorder, recurrent episode, in partial or unspecified remission
296.16	Recurrent manic disorder, full remission
296.40	Bipolar I disorder, most recent episode manic, unspecified
296.41	Bipolar I disorder, most recent episode manic, mild
296.42	Bipolar I disorder, most recent episode manic, moderate
296.43	Bipolar I disorder, most recent episode manic, severe without psychosis
296.44	Bipolar I disorder, most recent episode manic, severe with psychosis
296.45	Bipolar I disorder, most recent episode manic, in partial remission
296.46	Bipolar I disorder, most recent episode manic, in full remission
296.50	Bipolar I disorder, most recent episode depressed, unspecified
296.51	Bipolar I disorder, most recent episode depressed, mild
296.52	Bipolar I disorder, most recent episode depressed, moderate
296.53	Bipolar I disorder, most recent episode depressed, severe without psychosis
296.54	Bipolar I disorder, most recent episode depressed, severe with psychosis
296.55	Bipolar I disorder, most recent episode depressed in partial remission
296.56	Bipolar I disorder, most recent episode depressed, in full remission
296.60	Bipolar I disorder, most recent episode mixed, unspecified
296.61	Bipolar I disorder, most recent episode mixed, mild
296.62	Bipolar I disorder, most recent episode mixed, moderate

(*Continued on next column*)

Appendix 1. (Continued)

ICD-9 code	Substance use disorder
296.63	Bipolar I disorder, most recent episode mixed, severe without psychosis
296.64	Bipolar I disorder, most recent episode mixed, severe in partial remission
296.65	Bipolar I disorder, most recent episode mixed, in partial remission
296.66	Bipolar I disorder, most recent episode mixed, in full remission
296.7	Bipolar I disorder, most recent episode unspecified
296.80	Bipolar disorder NOS
296.81	Atypical manic disorder
296.89	Bipolar II disorder
301.11	Chronic hypomanic disorder
301.13	Cyclothymic disorder
296.2	Major depression, single episode, unspecified
296.20	Major depression, single episode, unspecified
296.21	Major depression, single episode, mild
296.22	Major depression, single episode, moderate
296.23	Major depression, single episode, severe without psychosis
296.24	Major depression, single episode, severe with psychosis
296.25	Major depression, single episode, in partial remission
296.26	Major depression, single episode, in partial remission
296.3	Major depression, recurrent, unspecified
296.30	Major depression, recurrent, unspecified
296.31	Major depression, recurrent, mild
296.32	Major depression, recurrent, moderate
296.33	Major depression, recurrent, severe without psychosis
296.34	Major depression, recurrent, severe with psychosis
296.35	Major depression, recurrent, in partial remission
296.36	Major depression, recurrent, in full remission
296.82	Atypical depressive disorder
298.0	Depressive-type psychosis
300.4	Dysthymia
301.12	Chronic depressive personality disorder
311	Depressive disorder NOS
309.0	Adjustment disorder with depressed mood
309.1	Prolonged depressive reaction
309.28	Adjustment disorder with mixed anxiety and depressed mood
297.1	Delusional disorder
297.3	Shared psychotic disorder
298.8	Brief psychotic disorder
298.9	Psychotic disorder NOS
310.0	Paranoid personality disorder
301.1	Affective personality disorder, unspecified
301.11	Chronic hypomanic personality disorder
301.12	Chronic depressive personality disorder
301.13	Cyclothymic disorder
301.2	Schizoid personality disorder
301.20	Schizoid personality disorder
301.3	Explosive
301.4	Obsessive compulsive personality disorder
301.5	Histrionic personality disorder
301.50	Histrionic personality disorder, unspecified
301.51	Chronic factitious illness with physical symptoms
301.52	Other histrionic personality disorder
301.6	Dependent personality disorder
301.7	Antisocial personality disorder
301.8	Other personality disorder
301.81	Narcissistic personality disorder
301.82	Avoidant personality disorder
301.83	Borderline personality disorder
301.84	Passive-aggressive personality
301.89	Other personality disorders
301.9	Unspecified personality disorder
295.0	Simple-type schizophrenia
295.00	Simple-type schizophrenia, unspecified
295.01	Simple-type schizophrenia, subchronic
295.02	Simple-type schizophrenia, chronic
295.03	Simple-type schizophrenia, subchronic with acute exacerbation
295.04	Simple-type schizophrenia, chronic with acute exacerbation

(*Continued on next column*)

Appendix 1. (Continued)

ICD-9 code	Substance use disorder
295.05	Simple-type schizophrenia, in remission
295.1	Disorganized-type schizophrenia, unspecified
295.11	Disorganized-type schizophrenia, subchronic
295.12	Disorganized-type schizophrenia, chronic
295.13	Disorganized-type schizophrenia, subchronic with acute exacerbation
295.14	Disorganized-type schizophrenia, chronic with acute exacerbation
295.15	Disorganized-type schizophrenia, in remission
295.2*	Catatonic-type schizophrenia
295.20	Catatonic type schizophrenia, unspecified
295.21	Catatonic type schizophrenia, subchronic
295.22	Catatonic type schizophrenia, chronic
295.23	Catatonic-type schizophrenia, subchronic with acute exacerbation
295.24	Catatonic-type schizophrenia, chronic with acute exacerbation
295.25	Catatonic-type schizophrenia, in remission
295.3	Schizophrenia, paranoid type
295.30	Paranoid-type schizophrenia, unspecified
295.32	Paranoid-type schizophrenia, subchronic
295.33	Paranoid-type schizophrenia, chronic
295.34	Paranoid-type schizophrenia, subchronic with acute exacerbation
295.35	Paranoid-type schizophrenia, in remission
295.4	Schizophreniform disorder
295.40	Schizophreniform disorder, unspecified
295.41	Schizophreniform disorder, subchronic
295.42	Schizophreniform disorder, chronic
295.43	Schizophreniform disorder, subchronic with acute exacerbation
295.44	Schizophreniform disorder, chronic with acute exacerbation
295.45	Schizophreniform disorder, in remission
295.5	Latent schizophrenia
295.50	Latent schizophrenia, unspecified
295.51	Latent schizophrenia, subchronic
295.52	Latent schizophrenia, chronic
295.53	Latent schizophrenia, subchronic with acute exacerbation
295.54	Latent schizophrenia, in remission
295.55	Latent schizophrenia, in remission
295.6*	Schizophrenia, residual type
295.60	Schizophrenic disorders, residual type, unspecified
295.61	Schizophrenic disorders, residual type, subchronic
295.62	Schizophrenic disorders, residual type, chronic
295.63	Schizophrenic disorders, residual type, subchronic with acute exacerbation
295.64	Schizophrenic disorders, residual type, chronic with acute exacerbation
295.65	Schizophrenic disorders, residual type, in remission
295.7	Schizoaffective disorder
295.70	Schizoaffective disorder, unspecified
295.71	Schizoaffective disorder, subchronic
295.72	Schizoaffective disorder, chronic
295.73	Schizoaffective disorder, subchronic with acute exacerbation
295.74	Schizoaffective disorder, chronic with acute exacerbation
295.75	Schizoaffective disorder, in remission
295.8	Other specified types of schizophrenia
295.80	Other specified types of schizophrenia, unspecified
295.81	Other specified types of schizophrenia, subchronic
295.82	Other specified types of schizophrenia, chronic
295.83	Other specified types of schizophrenia, subchronic with acute exacerbation
295.84	Other specified types of schizophrenia, chronic with acute exacerbation
295.85	Other unspecified types of schizophrenia, in remission
295.9	Unspecified schizophrenia
295.90	Unspecified schizophrenia, unspecified
295.91	Unspecified schizophrenia, subchronic
295.92	Unspecified schizophrenia, chronic
295.93	Unspecified schizophrenia, subchronic with acute exacerbation
295.94	Unspecified schizophrenia, chronic with acute exacerbation
295.95	Unspecified schizophrenia in remission