US Trends of Opioid-use Disorders and Associated Factors Among Hospitalized Patients With Spinal Conditions and Treatment From 2005 to 2014

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Study Design. Serial cross-sectional study utilizing the National Inpatient Sample (NIS) 2005 to 2014.
Objective. The aim of this study was to examine the trends of opioid-use disorders among hospitalized patients with spinal conditions and treatment and to identify its contributing factors.
Summary of Background Data. The opioid is widely used in chronic spinal conditions, and misuse of prescriptions is the main culprit of the opioid crisis. Cannabis, the most commonly utilized illicit drug, has recently been substituted for opioid despite increasing cannabis-use emergency room visits. There is limited information on opioid-use disorders, the association with cannabis, and other contributing factors.
Methods. We analyzed the 2005 to 2014 NIS data that identified opioid-use disorders among hospitalized patients with

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Chronic low back pain (CLBP) is the most common reason for opioid prescription in outpatient clinics in the United States.1 The United States has the highest surgical rate for spinal disorders in the world, and the rate is increasing, despite the similar incidence and prevalence of spinal disorders worldwide.2–4 Considering that CLBP is the most common reason for prescribed opioids, it is common for CLBP patients to be on opioids before spinal surgery. Chronic opioid use is more common among patients who undergo orthopedic surgeries than
among those who undergo other types of surgeries.\textsuperscript{5} Retrospective studies have revealed that preoperative opioid use in patients with spinal diseases is associated with increased risks of postoperative opioid use and worse surgical outcomes including a higher rate of repeated surgeries.\textsuperscript{6,7}

In 2016, >11.5 million people reported misuse of prescription pain medicine\textsuperscript{8} and 115 Americans to die every day from an opioid overdose.\textsuperscript{9} On October 27, 2017, the president declared the opioid crisis a national public health emergency under section 319 of the Public Health Service Act. This declaration was renewed on October 18, 2018, because of the continued consequences of the opioid epidemic. In effect, the opioid-use disorder has been increasing among the general population with some variance in the rate of opioid-related hospitalization depending on age, ethnicity, geographic location,\textsuperscript{10} and household income.\textsuperscript{11} However, the study on opioid-use disorders among more vulnerable population such as patients with painful spinal conditions and treatment was limited.

Substances abuse and mental health conditions were previously reported to be a contributor to the development of chronic opioid use that begins during the postoperative period.\textsuperscript{5,12,13} Cannabis remains the most commonly used illicit drug in the United States with an estimated 22.2 million people using it currently, and an additional 2.4 million people reporting first-time use annually.\textsuperscript{14} There were increasing emergency department visits related to cannabis use from 2006 to 2014\textsuperscript{15} with marijuana legalization in 33 states and the District of Columbia during the last two decades. Although there is an ongoing debate on whether cannabis is a gateway drug\textsuperscript{16} or a substitute for opioid use,\textsuperscript{17} little attention about the effects of marijuana legalization on opioid-use disorders among patients with spinal conditions and treatment is rising. Therefore, it is necessary to examine the association of cannabis, mental health conditions, and other substances abuse among patients with painful spinal conditions and treatment.

The purpose of our study is two-fold: to examine the temporal trends of opioid-use disorders among hospitalized patients with spinal conditions and treatment in the United States from 2005 to 2014, and to identify contributing factors to the increasing opioid-use diseases within the same period (Summary slide-2, http://links.lww.com/BRS/B450, Suppl Tables, http://links.lww.com/BRS/B451).

METHODS

Data Source and Study Population

This study was based on the National Inpatient Sample (NIS). NIS is the largest publicly available, all-payer US hospital inpatient dataset. It contains a 20% stratified sample of hospital inpatient stays from across the United States. The dataset captures discharge information from hospital inpatient stays and belongs to the family of the Healthcare Cost and Utilization Project sponsored by the Agency for Healthcare Research and Quality (AHRQ).\textsuperscript{18} The NIS can be weighted to generate national estimates. We used a 10-year data from 2005 to 2014. The use of the NIS dataset is entirely anonymous with no risk of a confidentiality breach. An institutional review board approval was waived. We completed a data user agreement with the AHRQ before using the NIS database.

Measures

We identified opioid-use disorders in hospitalized patients with cervical and lumbar spinal conditions and treatment using the International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) diagnostic and procedure codes to identify opioid abuse, dependence or poisoning. (Search terms included “continuous”, “episodic”, “unspecified”; See Table 1 for details.). The term “in remission” was excluded.

Events of interest measured included the annual rate of opioid, cannabis, other substance-use disorders and spinal conditions, and treatment-related hospital discharges. We also measured the annual number of hospitalizations and length of stay. We examined patient characteristics including age, sex, race, primary payer, number of comorbidities, the severity of illness, cannabis use, other substance use, and hospital region (Table 2), as there has been a variation of opioid-related hospitalization based on these factors.\textsuperscript{10,11} All-patient refined diagnosis-related group was used to classify the severity of illness (0 [lowest]–4 highest]).\textsuperscript{19} A dummy variable was created for the year subset of 2010–2014 for two reasons. First, the CDC designated 2010 as the start of the second wave epidemic era when heroin overdose deaths began to increase sharply.\textsuperscript{20} Furthermore, on October 19, 2009, the Department of Justice issued a memo stating that it would not prosecute marijuana users and sellers who complied with state laws for marijuana use.\textsuperscript{21}

Statistical Analysis

First, the compound annual growth rate (CAGR) was used to quantify temporal trends of the annual number of opioids, cannabis, and other substance use-use hospitalizations in patients with spinal diseases. Its statistical significance was tested by Rao-Scott correction for \( \chi^2 \) tests for categorical variables. The CAGR supposes that year A is x and year B is y, and CAGR = \( \left( \frac{y}{x} \right)^{\frac{1}{(B-A)-1}} \) has been widely used for health care valuation.\textsuperscript{22,23} Multilevel and multivariable regression analysis was performed to determine the relationship between opioid-use disorders and patient demographics, hospital factors, and socioeconomic status. To evaluate the effect of missing data on spine-related hospitalizations, we compared baseline characteristics between the missing and analyzed samples’ characteristics. There were no statistical differences between the baseline characteristics of the selected and missing data. The model was determined to be stable, and the assumption of randomly missing data was found to be reasonable using the observed data. All analyses were performed using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC). All reported \( P \) values were 2-tailed and \( P \) value <0.05 was considered statistically significant.
### TABLE 1. ICD-9-CM Codes Used for Spinal Conditions and Treatment, Opioid, Cannabis, and Substance-use Disorders and Mental Health Conditions

| Diagnostic Categories                      | ICD-9-CM Codes                                      |
|--------------------------------------------|-----------------------------------------------------|
| Lumbar spine                               |                                                     |
| Disc and spine diseases                    | 7213, 72142, 72210, 72251, 72273, 72293, 72402, 72403, 7242, 7243, 7244, 7245, 7246, 72470, 72471, 72479, 7248, 7249, 7265 |
| Status post-surgery                        | 72280, 72283, V454                                  |
| Procedure codes                            | 301, 302, 309, 31, 8050, 8051, 8052, 8053, 8054, 8059, 8104, 8105, 8106, 8107, 8108, 8130, 8134, 8135, 8136, 8137, 8138, 8139, 8162, 8163, 8164, 8165, 8166, 8451, 8459, 8460, 8464, 8465, 8468, 8469, 8480, 8481, 8482, 8483, 8484, 8485 |
| Cervical spine                              |                                                     |
| Disc and spine diseases                    | 7210, 7211, 7220, 7224, 72271                      |
| Status post-surgery                        | 72281, 72291, 7230, 7231, 7232, 7233, 7236, 7237, 7238, 7239 |
| Procedure codes                            | 8101, 8102, 8103, 8131, 8132, 8133, 8461, 8462, 8466 |
| Drugs                                      |                                                     |
| Opioid                                     | 30400, 30401, 30402, 30403, 30470, 30471, 30472, 30473, 30550, 30551, 30552, 30553, 98000, 96500, 96502, 96509, 8500, E8501, E8502, E9350, E9351 E9352 |
| Marijuana                                  | 3043, 30430, 30431, 30432, 30433, 30520, 30521, 30522, 30523 |
| Alcohol                                    | 30300, 30301, 30302, 30303, 30390, 30391, 30392, 30393, 30500, 30501, 30502, 30503, 9800, 9801, 9802, 9803, 9808, 9809 |
| Sedative                                   | 30410, 30411, 30413, 30540, 30541, 30542, 30543, 30480, 9691, 9692, 9693, 9694, 9695, 8581, 8582, E8521, E8522, E8523, E8524, E8525, E8528, E8529, E8530, E8531, E8532, E8538, E8539, E9370, E9371, E9372, E9379, E9380, E9801, E9802, E9803 |
| Cocaine                                    | 30420, 30422, 30423, 30560, 30561, 30562, 30563, 97081, 97089 |
| Stimulant                                  | 30440, 30441, 30442, 30443, 30570, 30571, 30572, 30573, 9696, 96970, 96971, 96972, 96973, 96979, 9700, 9701, 9709, E8541, E8542, E8543, E8548, E9040, E9409, E9412 |
| Hallucinogen                               | 30450, 30451, 30452, 30530, 30531, 30532, 30533, E8541, E8555, E8556, E8558, E8559 |
| Other                                      | 30460, 30461, 30462, 30463, 30470, 30471, 30472, 30480, 30481, 30482, 30490, 30491, 30492, 30508, 30580, 30581, 30582, 30583, 30590, 30591, 30592, 9690, 96901, 96902, 96903, 96904, 96905, 96909, E8541, E9390, E9391, E9392, E9393, E9394, E9395, E9396, E9397, E9398, E9399 |
| Mental health condition                    |                                                     |
| Mood disorders                             | 29600, 29601, 29602, 29603, 29604, 29605, 29606, 29607, 29608, 29610, 29611, 29612, 29613, 29614, 29615, 29616, 29620, 29621, 29622, 29623, 29624, 29625, 29626, 29627, 29630, 29631, 29632, 29633, 29634, 29635, 29640, 29641, 29642, 29643, 29644, 29645, 29646, 29650, 29651, 29652, 29653, 29654, 29656, 29657, 29658, 29659, 29660, 29661, 29662, 29663, 29664, 29665, 29666, 29670, 29680, 29681, 29682, 29689, 29690, 29699 |
| Psychosis                                  | 2970, 2971, 2972, 2973, 2978, 2979, 2980, 2981, 2982, 2983, 2984, 2988 |
| Anxiety disorders                          | 30000, 30001, 30002, 30009, 30010, 30011, 30012, 30013, 30014, 30015, 30016, 30019, 30020, 30021, 30022, 30023, 30029, 30030, 30031, 30032, 3006, 3007, 30081, 30082, 30089 |
| Personality and other disorders            | 3009, 3010, 30110, 30111, 30112, 30113, 30120, 30121, 30122, 3013, 3014, 30150, 30151, 30159, 3016, 3017, 30181, 30183, 30184, 30189, 30199 |

ICD-9-CM indicates International Classification of Diseases, 9th Revision, Clinical Modification.
**TABLE 2. Temporal Trends of Hospitalized Patients With Spinal Conditions and Treatment**

| Variables                          | 2005     | 2008     | 2011     | 2014     |
|------------------------------------|----------|----------|----------|----------|
| N/Total weighted N                 | 1,370,599| 1,875,053| 2,339,687| 1,997,471|
| Age group, y                       |          |          |          |          |
| <30                                | 92,266   | 6.7%     | 110,617  | 5.9%     |
| 30–39                              | 121,507  | 8.9%     | 147,748  | 7.9%     |
| 40–49                              | 231,918  | 16.9%    | 287,322  | 15.3%    |
| 50–59                              | 253,208  | 18.5%    | 371,294  | 19.8%    |
| 60–69                              | 225,864  | 16.5%    | 352,183  | 18.8%    |
| 70–79                              | 239,558  | 17.5%    | 317,560  | 16.9%    |
| ≥80                                | 206,279  | 15.1%    | 288,330  | 14.5%    |
| Sex                                |          |          |          |          |
| Male                               | 598,783  | 43.7%    | 822,914  | 43.9%    |
| Female                             | 771,816  | 56.3%    | 1,052,140| 56.1%    |
| Race                               |          |          |          |          |
| Black                              | 119,303  | 8.7%     | 177,837  | 9.5%     |
| Hispanic                           | 84,594   | 6.2%     | 113,351  | 6.0%     |
| Asian or Pacific Islander          | 16,460   | 1.2%     | 28,379   | 1.5%     |
| Native American/other              | 37,053   | 2.7%     | 56,449   | 3.0%     |
| White                              | 1,113,188| 81.2%    | 1,499,038| 79.9%    |
| Median household income            |          |          |          |          |
| 0–25th percentile                  | 339,412  | 24.8%    | 497,422  | 26.5%    |
| 26th–50th percentile               | 336,443  | 24.5%    | 516,330  | 27.5%    |
| 51st–75th percentile               | 360,701  | 26.3%    | 439,744  | 23.5%    |
| 76th–100th percentile              | 334,043  | 24.4%    | 421,557  | 22.5%    |
| Primary payer                      |          |          |          |          |
| Medicare                           | 651,392  | 47.5%    | 895,040  | 47.7%    |
| Medicaid                           | 127,519  | 9.3%     | 178,378  | 9.5%     |
| Uninsured                          | 48,341   | 3.5%     | 72,103   | 3.8%     |
| Other                              | 75,705   | 5.5%     | 98,995   | 5.3%     |
| Private insurance                  | 467,642  | 34.1%    | 630,537  | 33.6%    |
| Number of comorbidities*           | 1.80     | 1.53     | 2.0      | 1.72     |
| Severity of illness subclass       |          |          |          |          |
| APR-DRG 0, lowest                  | 508,773  | 37.1%    | 587,229  | 31.3%    |
| APR-DRG 2                          | 543,601  | 39.7%    | 756,688  | 40.4%    |
| APR-DRG 3                          | 232,031  | 16.9%    | 396,032  | 21.1%    |
| APR-DRG 4, highest                 | 86,194   | 6.3%     | 135,105  | 7.2%     |
| Opioid-use disorders               |          |          |          |          |
| Yes                                | 5632     | 0.4%     | 46,738   | 2.5%     |
| No                                 | 27,351   | 2.0%     | 1,828,316| 97.5%    |
| Cannabis-use disorders             |          |          |          |          |
| Yes                                | 9956     | 0.7%     | 17,159   | 0.9%     |
| No                                 | 1,360,643| 99.3%    | 1,857,894| 99.1%    |
| Substance-use disorders            |          |          |          |          |
| Yes                                | 80,855   | 5.9%     | 124,059  | 6.6%     |
| No                                 | 1,289,744| 94.1%    | 1,750,994| 93.4%    |
| Mental health conditions           |          |          |          |          |
| Yes                                | 275,212  | 20.1%    | 469,148  | 25.0%    |
| No                                 | 1,095,387| 79.9%    | 1,405,906| 75.0%    |
| Hospital region                    |          |          |          |          |
| Northeast                          | 320,150  | 23.4%    | 407,343  | 21.7%    |
| Midwest                            | 248,622  | 18.1%    | 301,844  | 16.1%    |
| South                              | 507,396  | 37.0%    | 742,567  | 39.6%    |
| West                               | 294,432  | 21.5%    | 423,299  | 22.6%    |

*Mean/SD.
RESULTS

Descriptive Characteristics of Hospitalized Patients With Spinal Conditions and Treatment and Opioid-use Disorders

The 2005 to 2014 NIS database contained 382,516,561 hospital inpatient stays. Among the 23,663,307 hospitalizations with cervical and lumbar spinal conditions and treatment, 4,657,522 cases were removed because of missing value in an observation (Figure 1). Among 19,005,785 hospitalizations with spinal conditions and treatment, opioid-use disorders were 2.93% (557,423). Table 2 presents a descriptive analysis of patient and hospital characteristics.

Trends of Hospitalizations With Spinal Conditions and Treatment and Length of Hospital Stay

Figure 2 presents the temporal trends of hospitalizations with spinal conditions and treatment and the annual average length of hospital stay. The CAGR of these hospitalizations was 4.27% \( (P < .001; 1,370,599 \text{ hospitalizations in 2005 and } 1,997,471 \text{ hospitalizations in 2014}) \). There were two trends in the annual number of hospitalizations with spinal conditions and treatment: monotonic increase during the period between 2005 and 2011 and decrease during the period between 2011 and 2014. Most patient sociodemographics and hospitalization characteristics were relatively stable during the period observed, as shown in Table 2. We observed overall decreasing trends in the length of hospital stay, with the sharpest decrease from 2010 to 2011. The CAGR of hospital length of stay was \(-1.60\%\) \( (P < 0.001)\).

Trends of Opioid, Cannabis, and Other Substance-use Disorders Among Hospitalized Patients With Spinal Conditions and Treatment

Figure 3 presents the trends of annual rates of opioid, cannabis, and other substance-use disorders among hospitalized patients. We observed an increasing trend in annual rates of all opioid, cannabis, and other substance-use disorders except the rate of other substance-use disorder in 2008. The CAGRs of them were 6.47%, 10.34%, and 3.88%, respectively \( (\text{all } P < 0.001)\).

Multivariable Analyses of Opioid-use Disorders and Its Associated Factors Among Hospitalized Patients With Spinal Conditions and Treatment

Table 3 shows the relationship between opioid-use disorder and its associated factors based on multivariable analyses. On average, the likelihood of opioid-use disorders increased about 5.2% annually from 2005 to 2014 \( (\text{odds ratio [OR] } 1.052, 95\% \text{ confidence interval [CI]} \ 1.049–1.054)\). Opioid-use disorders happened over 25% more often among hospitalized patients with spinal conditions and treatment during the period from 2010 to 2014 compared from 2005 to 2009 \( (\text{OR } 1.268, 95\% \text{ CI } 1.252–1.284)\).

Regarding age, opioid-use disorder among hospitalized patients was more common in the younger age group, and monotonically declined as the age increased. Compared to privately insured patients, all other patients were \( >1.5 \) times more likely to be diagnosed as opioid abuse, dependence, or poisoning \( (\text{OR } 1.668, 95\% \text{ CI } 1.637–1.699 \text{ for Medicare patients}; \text{OR } 1.780, 95\% \text{ CI } 1.746–1.814 \text{ for Medicaid patients})\).
Regarding cannabis and substance, patients with cannabis and substance-use disorders were more vulnerable to opioid (OR 1.714, 95% CI 1.666–1.765 for cannabis; OR 5.382, 95% CI 5.299–5.466 for other substances).

It is not surprising that patients with mental health conditions were more vulnerable to opioid than patients without mental health conditions (OR 2.203, 95% CI 2.172–2.234).

Opioids abuse, dependence, or poisoning was more common in the Western and Northeastern region than the Midwestern and Southern region among hospitalized patients with spinal conditions and treatment.

**DISCUSSION**

The present study examined the nationwide temporal trends of opioid-use disorders among hospitalized patients with spinal conditions and treatment. The critical finding is the monotonically increasing pattern of opioid-use disorders (annually 6.47%) as observed in national reports from the CDC and self-report studies of increasing opioid abuse, dependence, or poisoning and treatment utilization patterns in the United States. A growing trend of opioid-use disorder...
| TABLE 3. Relationship Between Opioid-use Disorders and Contributing Factors Among Hospitalized Patients With Spinal Conditions and Treatment (Multivariate regression analysis) |
|---------------------------------------------------------------|
| **Odds ratios** | **95% CIs** | **Odds ratios** | **95% CIs** |
| Year increment (continuous variable) | | 1.052 | 1.049 | 1.054 |
| Year dummy (categorial variable) | | 1.268 | 1.252 | 1.284 |
| 2010–2014 | Reference |
| 2005–2009 | Reference |
| Age group. y | | | |
| <30 | Reference |
| 30–39 | 0.996 | 0.972 | 1.021 | 0.997 | 0.973 | 1.022 |
| 40–49 | 0.702 | 0.686 | 0.719 | 0.704 | 0.687 | 0.721 |
| 50–59 | 0.567 | 0.554 | 0.580 | 0.565 | 0.552 | 0.579 |
| 60–69 | 0.291 | 0.283 | 0.300 | 0.290 | 0.282 | 0.298 |
| 70–79 | 0.130 | 0.125 | 0.135 | 0.130 | 0.125 | 0.135 |
| ≥80 | 0.063 | 0.060 | 0.066 | 0.063 | 0.060 | 0.066 |
| Male sex | | 1.083 | 1.069 | 1.098 | 1.083 | 1.068 | 1.097 |
| Race | | | |
| White | Reference |
| Black | 0.601 | 0.587 | 0.615 | 0.600 | 0.587 | 0.614 |
| Hispanic | 0.696 | 0.677 | 0.714 | 0.695 | 0.677 | 0.714 |
| Asian or Pacific Islander | 0.407 | 0.373 | 0.445 | 0.405 | 0.371 | 0.443 |
| Native American/other | 0.765 | 0.735 | 0.796 | 0.765 | 0.735 | 0.796 |
| Median household income | | | |
| 0–25th percentile | Reference |
| 25th–50th percentile | 1.004 | 0.987 | 1.021 | 1.001 | 0.984 | 1.019 |
| 51st–75th percentile | 1.046 | 1.028 | 1.065 | 1.046 | 1.028 | 1.065 |
| 76th–100th percentile | 1.090 | 1.069 | 1.111 | 1.089 | 1.068 | 1.111 |
| Primary payer | | | |
| Private insurance | Reference |
| Medicare | 1.668 | 1.637 | 1.699 | 1.667 | 1.636 | 1.698 |
| Medicaid | 1.780 | 1.746 | 1.814 | 1.771 | 1.737 | 1.805 |
| Uninsured | 1.965 | 1.918 | 2.014 | 1.963 | 1.916 | 2.011 |
| Other | 1.114 | 1.081 | 1.148 | 1.114 | 1.081 | 1.148 |
| Number of comorbidities | 1.059 | 1.055 | 1.063 | 1.060 | 1.055 | 1.064 |
| Severity of illness subclass | | | |
| APR-DRG 0,1, lowest | Reference |
| APR-DRG 2 | 1.446 | 1.422 | 1.470 | 1.446 | 1.423 | 1.470 |
| APR-DRG 3 | 1.473 | 1.443 | 1.504 | 1.463 | 1.433 | 1.494 |
| APR-DRG 4, highest | 1.313 | 1.273 | 1.354 | 1.308 | 1.268 | 1.349 |
| Cannabis-use disorders | | | |
| Yes | 1.714 | 1.666 | 1.765 | 1.707 | 1.659 | 1.757 |
| No | Reference |
| Substance-use disorders | | | |
| Yes | 5.382 | 5.299 | 5.466 | 5.389 | 5.306 | 5.473 |
| No | Reference |
| Mental health conditions | | | |
| Yes | 2.203 | 2.172 | 2.234 | 2.194 | 2.163 | 2.225 |
| No | Reference |
| Hospital region | | | |
| West | Reference |
| Northeast | 0.983 | 0.965 | 1.002 | 0.987 | 0.968 | 1.006 |
| Midwest | 0.644 | 0.631 | 0.658 | 0.643 | 0.629 | 0.656 |
| South | 0.756 | 0.742 | 0.769 | 0.755 | 0.742 | 0.768 |

APR-DRG indicates all-patient refined diagnosis-related group. CI, confidence interval.
in this study is consistent with the same epidemiologic database of increasing opioid-use hospitalizations among patients with lumbar spinal fusion procedures.\textsuperscript{12}

**Trends of Hospitalizations With Spinal Conditions and Treatment and Length of Hospital Stay**

Regarding trends of hospitalizations with spinal conditions and treatment, our findings are consistent with those from other studies on decreasing trends of elective lumbar spinal surgeries since 2011.\textsuperscript{24} Spinal surgeries are among the most costly procedures in the US health care system.\textsuperscript{25} Length of hospital stay decreased during the study period. The Center for Medicare and Medicaid Services implemented a series of Medicare reform policies linking quality of performance to payment under the umbrella of Affordable Care Act including Hospital Acquired Conditions in 2008, Hospital Readmission Reduction Program in 2012, and spine bundle program in 2013. These policies led to cost containment by reducing hospital length of stay as well as readmission after spinal procedures and surgeries. Besides, the rapid proliferation of ambulatory surgery centers in the 2000s may have contributed to the reduction in the hospital-based elective spinal surgery.\textsuperscript{26,27} The effect of this shift of this practice pattern on the increasing trend of increasing opioid-related hospitalizations despite the decreasing hospital stay warrants further investigation beyond the health policy effects.\textsuperscript{28}

**Age, Demographic and Socioeconomic Characteristics and Assumption of Purpose of Opioid Abuse, Dependence, or Poisoning**

We observed a distinct pattern in the relationship between age and opioid-use disorders. Compared to middle-aged and older adults, young adults (\(<30\) years old) are the most vulnerable to opioid, and the risk of opioid-use disorders declines monotonically with progressing age. This finding supports the previous results that young adults are more likely than older adults to use opioids because young adults tend to perceive opioids as low risk, both for prescription and recreational uses.\textsuperscript{29} Our findings may suggest illicit use as a potential contributing factor for opioid-use disorders among young adults, although the reason for opioid use was not available in our analysis. It is interesting to see the discordance of the median household income and primary payer in opioid-use disorders. Population with private insurance has the lowest rate, whereas the group with the highest median household income has the highest percentage. It may be secondary to the shift of the insurance carrier regardless of the household income after chronic disabling painful spinal conditions with opioid abuse, dependence, or poisoning. This fact warrants further investigation as this report lacked the longitudinal socioeconomic information of the individuals.

**Cannabis, Other Substances, and Mental Health Conditions as Associated Factors of Opioid-use Disorders**

Cannabis legalization during the last 18 years has led to a broader spectrum of medicinal as well as recreational use. Sound production is more efficient than black market production, and falling cannabis prices have increased the accessibility of use among young adults.\textsuperscript{30} Although there is an ongoing debate about whether cannabis is a gateway drug, our findings imply that cannabis use and opioid use can mutually increase each other, based on the reports from survey\textsuperscript{31} and claim data.\textsuperscript{15} Continuous use of cannabis, either medicinally or recreationally, may lead to increased dependence and higher tolerance levels. Therefore, it is possible that medical and recreational use of marijuana might lead to more detrimental health outcomes such as cannabis abuse or dependence. Because of the nature of our cross-sectional study design using the NIS dataset, we were unable to examine whether cannabis use begins before the opioid use. Also, socioeconomic status, depression, and anxiety were reported to be associated with an increased risk of persistent opioid use at 1 year following the intervention in this group.\textsuperscript{13,32} A recent study revealed about 50\% of patients undergoing spinal surgery might be consuming opioids at the time of the surgical procedures, and 20\% of this population may be opioid-dependent.\textsuperscript{28}

**Limitations and Strengths**

As this study was a retrospective review of hospital discharge-based data, there are several significant limitations. First, this study only included discharge data and no actual medical assessments. Besides, the hospital discharge-based database does not provide information on actual consumption, dosage, or use patterns of the opioids, cannabis, or other substances. Second, we relied on ICD-9-CM codes that, to a certain extent, may have limited accuracy in capturing the actual person who used opioid, cannabis, and other substances with or without mental health conditions because of incorrect coding or missing data from coding practices and awareness of clinician’s differences.\textsuperscript{13} Furthermore, the identification of persons who used illicit drugs with mental health conditions was significantly underestimated, considering low sensitivity and high specificity in weighted estimates from discharge dataset.\textsuperscript{33} This study cannot address the potential for unrecognized coding errors or unreported events that could influence the results. Third, our analysis could not fully specify the severity and onset of spinal diseases as well as time since spinal surgeries or procedures. Also, the temporal relationship, that is, the opioid-use disorders occurred before admission and was the cause of hospitalization, or occurred during the hospitalization, as an unintended overdose from the hospital-prescribed medication, was not investigated. Future studies need to consider this information using other datasets. Lastly, we did not fully interpret factors associated with opioid-use disorders among hospitalized patients with spinal conditions and treatment and variables (sex, income) because of insufficient precedent studies explaining clinical and policy implications of these findings. Given the extensive and recent data from the nationally representative dataset, we believe that temporal trends and associated factors of opioid-use disorders among hospitalized patients
with spinal conditions and treatment are likely generalizable to most patients with spinal diseases.

In summary, this study shows that opioid-use disorders among hospitalized patients with spinal conditions and treatment steadily increased from 2005 to 2014 in US hospitals. This trend was associated with cannabis and other substance-use disorders, mental health conditions, younger age, white race, higher household income, and public insurance or uninsured.

Key Points

- Previous studies reported that chronic opioid use or preoperative opioid prescription for patients with spinal conditions and treatment increased the risk of opioid-related hospitalization or postoperative readmission.
- This study shows that opioid-use disorders increased by 6.4% annually among patients with spinal diseases from 2005 to 2014 in US hospitals.
- This increasing rate of opioid-use disorder was associated with the cannabis-use disorder, younger age, white race, male sex, higher income, and public insurance, and uninsured.

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