Are Increasing Trends in Opioid-Related Hospitalizations Attributable to Increases in Diagnosis Recordability? Evidence from 2 Large States

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ABSTRACT: Based on calculations using all-listed diagnoses, the Agency for Healthcare Research and Quality (AHRQ) reports increasing national trends in opioid-related hospitalizations. It is unclear whether the reported increases are attributable to increases in available diagnosis fields. We leveraged increases in available diagnosis fields, ie, diagnosis recordability, in 2 states to examine their effects on opioid-related hospitalizations, graphically and with nonlinear least squares. Hospitalization data from Texas (1999-2011, N= 36 593 049) and New York (2005-2015Q3, N = 27 582 208) were aggregated to quarter-year in each state. Opioid-related hospitalizations were identified using the same International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) Diagnosis Codes as AHRQ. In Texas, the increase in diagnosis recordability resulted in a 29.9% discrete shift in the number of recorded opioid diagnoses and a 3-fold increase in the slope. In New York, a smaller discrete shift (3.1%) and a 3-fold increase in the slope were identified, although a more pronounced change in the trend occurred 5 years earlier (slope change from flat to increasing). Increases in recordability lead to a broader definition of opioid-related hospitalizations, if all-listed diagnoses are used; we found that more hospitalizations are identified using the postchange definition than with the prechange definition (9.7% more in Texas and 4.9% more in New York after 4 years). We conclude that reported increases in opioid-related hospitalizations are partially attributable to increases in diagnosis recordability. Cross-state and temporal comparisons of opioid-related hospitalization rates based on all-listed diagnoses can misrepresent the true relative extent of opioid-related hospital use and therefore of the opioid epidemic.

KEYWORDS: opioids, hospitalizations, hospital use, diagnosis field, diagnosis coding

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Introduction

The misuse of and addiction to opioids in the United States have amounted to a national crisis, which was declared a public health emergency in 2017.[1] In 2018, the National Science and Technology Council's Fast-Track Action Committee on Health Science and Technology Response to the Opioid Crisis[2] (Opioid FTAC) made a recommendation to assess opioid morbidity and mortality more accurately. Increases in opioid-related hospitalization rates, one of the main measurements of the opioid epidemic, are reported as part of the Healthcare Cost and Utilization Project (HCUP). However, their measurement, which uses all-listed diagnoses, may not be fully accurate because it may not only capture increases in the true prevalence of opioid-related conditions but also increases in the number of recordable diagnoses, which states adopted at different times. Our study on 2 large states, Texas and New York, addresses this potential measurement issue. We show that increases in diagnosis recordability, in part, account for HCUP-reported increasing trends in opioid-related hospitalizations, although the contribution of diagnosis recordability may vary by state.

Motivation for the study

The extent of the current opioid crisis is primarily reflected in opioid overdose mortality (or drug overdose mortality in general) as well as hospitalizations and emergency department (ED) visits for opioid-related conditions, such as opioid poisoning, opioid dependency, and adverse effects of opioid use, among others.[3–8] Overdose deaths involving opioids increased more than 5 times between 1999 and 2016, from a little more than 8000 to more than 42 000, according to the National Institute on Drug Abuse[8] (NIDA). The Agency for Healthcare Research and Quality (AHRQ), the main agency that reports national and state-specific statistics in hospital use for opioid-related conditions in the United States within its Healthcare Cost and Utilization Project (HCUP), has shown increasing trends in opioid-related hospitalizations and ED visits over time, in most of the states and nationally. The HCUP-reported rate of opioid-related hospitalizations among adults increased 153% between 1993 and 2012, from 116.7 to 295.6 hospitalizations per 100 000 adults.[4] In the total population, this reported rate increased by 79% between 2008 and 2016, from 165.7 to approximately 297 hospitalizations per 100 000 population in 2016.[5,9] HCUP-reported opioid-related ED visits increased even more dramatically between 2008 and 2016, by 158%, from 94.1 to approximately 243 visits per 100 000 population.[5,9]

In its hospitalization and ED visit rate calculations, HCUP uses all-listed opioid-related diagnoses (principal and all secondary codes, including external cause of injury codes, or E-codes). However, it is commonly known in health services research that there has been a growing tendency to record more diagnoses over the past couple of decades. The HCUP recognized this phenomenon by showing that the average number of secondary diagnosis codes on hospital discharge records increased from 2.86 in 1993 to 7.93 in 2012.[4] In its most recent statistical brief on opioid-related hospital use, HCUP made an attempt to ensure comparability over time by holding the number of secondary diagnosis fields constant across data years (25 diagnosis codes for hospitalization records).[6] This does not, however, necessarily account for the increases in recordability that occurred in the past 2 decades, especially as states transitioned to recording 25 diagnoses, from different lower previous numbers and at different times. As the Safe States Alliance's Injury Surveillance Workgroup on Poisonings (ISW7) emphasized, analyses using all-listed diagnoses when comparing states that collect different numbers of diagnosis codes and E-codes in hospitalization data can potentially be problematic.[10] This is because states and years in which more diagnoses can be recorded may have more identified cases that those with fewer diagnosis fields. The ISW7's corresponding consensus recommendation is to examine methods for counting poisoning-related hospitalizations and ED visits.[10]

Given HCUP's approach to identifying opioid-related hospitalizations and the ISW7's concern about using all-listed diagnoses, it is important to investigate whether some of the HCUP-reported increases in opioid-related hospitalizations might be attributable to the growing tendency to record more secondary diagnoses and to increases in secondary diagnosis and E-code fields on administrative forms. If the observed increasing opioid-related hospitalization trends were at least partially caused by these recordability changes and trends, the real growth in the prevalence of the epidemic as measured by opioid-related hospitalizations would be lower than the growth reported using all-listed diagnoses.

Issues of measurement of the opioid epidemic

The opioid epidemic has been primarily measured by opioid prescriptions, opioid drug overdose deaths, and opioid-related hospital use (ED visits and hospitalizations).[3–7,11] A few studies to date have attempted to address the questions of inadequate measurement of opioid-related mortality and hospital use. Research addressing inadequacy of measurement of opioid-related deaths deals with identification of opioid-related overdoses from recorded unidentified drug-related deaths, suggesting that national estimates of opioid-related mortality may be underreported[12–14] and that disparities along multiple dimensions (sex, racial/ethnic, age, socioeconomic, and geographic) underlie the issue with unidentified drug involvement in fatal overdoses.[15]

Issues of measuring opioid-related hospital use have been addressed in a few studies. Slavova et al.[16] compared 3 definitions to identify drug overdoses in 2000-2011 hospital discharge data from Kentucky: (1) based on the E-code matrix, (2) based on principal diagnosis or first E-code, and (3) based on any diagnosis (principal, secondary, or E-code). The study concluded that definition 3 identified almost 50% more drug overdose cases than definition 1 and approximately 5% more drug overdoses than definition 2, which is not surprising given the relative broadness of these definitions. Of particular interest to this article is that temporal trends based on the 3 definitions were similar. Given that Kentucky changed the number of recordable diagnosis fields from 9 (principal and 8 secondary) to 25 (principal and 24 secondary), and the number of E-codes from 2 to 3, in 2008, this might indicate that changes in recordability did not contribute to the observed increase in opioid-related hospitalizations over the study period. Although measurement questions were not the central focus of their nationwide study, Tedesco et al.[17] show in sensitivity analyses that temporal trends for opioid dependence and for nondependent opioid abuse diverge substantially based on whether all-listed diagnoses or only the principal diagnosis is used, suggesting that hospitalizations and ED visit trends for these conditions are sensitive to the case definition used (in contrast, hospital use for opioid poisoning, whether heroin, methadone, prescription opioids, or unspecified opioids, were not sensitive). In addition, it has been suggested that potential misclassification of opioid-related conditions using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) Diagnosis Codes may result in either an underestimation or an overestimation of the true effect of the opioid epidemic.[18]

Purpose of this study

Our study objective was to determine whether the reported increasing trends in opioid-related hospitalizations are attributable to increases in diagnosis recordability and increasing tendencies in diagnosis recording. Specifically, we answer the following research questions: (1) Did increases in recordability affect the number of recorded diagnoses for *all* conditions? (2) Did increases in recordability affect the number of recorded diagnoses for *opioid-related* conditions? (3) Did increases in recordability affect opioid-related hospitalization rates?

If an increase in the number of recordable diagnoses indeed accounted for some of the observed increases in opioid-related hospitalizations, we would expect (1) a discrete increase in the number of recorded opioid diagnoses at or shortly after the change in recordability and (2) a higher hospitalization rate based on the case definition after the change ("postchange definition"), relative to the rate based on the case definition before the recordability change ("prechange definition"), starting at or shortly after the change in recordability. Changes in recordability, coupled with the general growing tendency to record more information to improve clinical decisions and/or enhance hospital reimbursements, may bring about an increasing trend in recording. Such a trend would manifest in a steeper slope in the number of recorded opioid diagnoses following recordability changes. If trends in recording were increasing, we would also expect to see an increasing discrepancy between the opioid-related hospitalization rate based on the "postchange definition" and that based on the "prechange definition" over time.

Methods

Choice of states

We address our research question by analyzing hospitalization data from 2 states with large populations: New York and Texas. Together, New York and Texas comprise approximately 15% of the US population, equaling more than 48 million people in 2018, according to the US Census Bureau.[19] Demographically, the 2 states have similar age distributions and are both racially and ethnically diverse. By some metrics, the 2 states are similarly burdened by the opioid crisis. The states experience similar rates of opioid abuse or dependence, at around 7%.[20] In terms of the number of drug overdose deaths, the 2 states are also similar, with 3638 deaths in New York and 2831 deaths in Texas in 2016.[21] However, there are certain opioid-related metrics that set the 2 states apart. Age-adjusted drug overdose death rates are dissimilar, with Texas having a significantly lower drug overdose rate than New York (10.1 vs 18.0 deaths per 100 000 population).[21] The rates of opioid-related hospitalizations in the 2 states are far from similar. On one hand, New York experienced a small increase in the hospitalization rate between 2009 and 2014, at 2.9%, although the rate itself was substantially higher than the national average in 2014, at 360.5 hospitalizations per 100 000 population (national average was 224.6).[5] Texas, on the other hand, had a significantly lower hospitalization rate in 2014—98.6 hospitalizations per 100 000 population, but the change in the rate in 2009-2014 was much higher than that of New York, at 15.6%.[5]

These differences could potentially reflect differential access to health care between the 2 states: New York has historically had a lower uninsured rate and a higher Medicaid coverage rate than Texas; in addition, New York's Medicaid program provides coverage for all 9 care levels, as defined by the American Society of Addiction Medicine (ASAM), and all medication-assisted treatment therapies, buprenorphine, methadone, and naltrexone, whereas in Texas only 4 ASAM levels are included in Medicaid coverage and methadone coverage is not provided.[22] Other potential explanations could include differences in the potency of drugs used, intensity of care, and use of life-saving measures. The fact that Texas and New York have distinct differences in their health care systems, especially regarding substance use prevalence, trends, and treatment, would allow for broader generalizations of our findings, if findings are consistent in both states.

Data

We used hospital inpatient records from 1999 to 2011 Texas' Hospital Discharge Data Public Use Data File[23] (N = 36 593 049) and 2005-2015Q3 New York's Statewide Planning and Research Cooperative System (SPARCS) (N = 27 582 208). Hospital inpatient records contain hospitalization-level information, including patient's basic demographic characteristics, the principal and secondary diagnoses, expected payer, etc.

Both Texas and New York had changes in the number of recordable diagnoses on hospital administrative forms, as explained in the data documentation. In Texas, the number changed from 8 to 24 secondary diagnoses beginning in 2004 (although all 24 of these variables are available in 2004 data files, variables for secondary diagnoses 9 to 24 only had missing values in all 4 quarters, and only starting with the first quarter of 2005, these variables had filled in values); in addition, the number of E-code fields changed from 1 to 10. This change could increase the tendency to record more diagnoses after 2004. In New York, a corresponding change in recordable secondary diagnoses occurred more gradually, in 2 steps: in January 1994, the number changed from 8 to 14, and in August 2011, from 14 to 24; with just 1 recordable E-code field available starting in 1990 and throughout the study period (additional E-codes can be recorded as secondary diagnoses after December 1998). In our study period of 2005-2015 for New York, we only observe the second change in the number of secondary diagnoses, from 14 to 24, a less dramatic change than in Texas, especially when taken together with no change in E-code fields. We exclude the fourth quarter of 2015 in our New York analysis, due to the sharp increase in identified opioid-related hospitalizations after the transition in diagnosis coding from ICD-9-CM to International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM), which occurred in October 2015, suggesting that the new classification is able to capture more opioid-related hospitalizations.[24] Observations with missing values for month in the SPARCS data (approximately 2%) were assigned to the 4 quarters evenly.

In calculating opioid-related hospitalization rates, we used 1999-2011 annual population estimates from Texas Department of State Health Services[25] for Texas and 2005-2015 1 year population estimates from the American Community Survey[26] for New York.

Measures

To show trends in the reporting of principal and secondary diagnoses and E-codes for all conditions, we calculated the number of total recorded diagnoses and E-codes in each hospitalization record and then averaged the number across hospitalizations for each quarter-year for each state

$$\text{Number of Recorded Diagnoses} = \frac{\sum_{j=1}^{k}\sum_{i=1}^{n} dx_{ij}}{k}$$

where dx_{ij} is an indicator for a diagnosis field i in a hospitalization j being filled in. Diagnosis fields are comprised of the principal diagnosis field, secondary diagnosis fields, and E-code field(s) (total number of recordable diagnoses n). $\sum_{i=1}^{n} dx_{ij}$ sums the number of recorded diagnoses in a hospitalization j. $\sum_{j=1}^{k} \sum_{i=1}^{n} dx_{ij}$ sums all these numbers across all k hospitalizations in a quarter-year-state. Our measure, which for simplicity we refer to as Number of Recorded Diagnoses, is the average of these numbers across k hospitalizations. We calculate this measure for each quarter-year in each state.

To show trends in reporting for opioid-related conditions, we followed the same procedure, first calculating the number of recorded opioid diagnoses for each hospitalization record (not each opioid-related hospitalization record) and then averaging it across all hospitalizations in each state-year-quarter. Because most hospitalizations are not opioid-related, calculation of the average is based on many zeroes, making the average smaller than 1. Following the HCUP approach, we used the following ICD-9-CM codes to identify opioid-related diagnoses: (1) 304.00-304.02: *Opioid type dependence*; (2) 304.70-304.72: *Combinations of opioid type drug with any other drug dependence*; (3) 305.50-305.52: *Opioid abuse*; (4) 965.00-965.02; 965.09: *Poisoning by opium (alkaloids); heroin; methadone; other opiates and related narcotics*; (5) 970.1: *Poisoning by opiate antagonists*; (6) E850.0-E850.2: *Accidental poisoning by heroin; methadone; other opiates and related narcotics*; (7) E935.0-E935.2: *Heroin, methadone, other opiates and related narcotics causing adverse effects in therapeutic use*; and (8) E940.1: *Opiate antagonists causing adverse effects in therapeutic use*. The E-codes can appear in a secondary diagnosis or an E-code field, but not in the principal diagnosis field.

We calculated both measures described above by payer in each state. In Texas, we were able to capture Medicare, Medicaid, and Blue Cross/Blue Shield as expected payers; commercial insurance payer and self-pay category are not consistently coded throughout the years. In New York, we calculated the measures by 5 major types of payers: Medicare, Medicaid, commercial insurance, self-pay, and Blue Cross/Blue Shield.

Furthermore, we calculated annualized quarterly opioid-related hospitalization rates per 100 000 population for 3 case definitions of hospitalization counts based on: (1) only principal diagnosis, throughout the years; (2) using all-listed diagnoses before the change in recordability ("prechange definition"), ie, 9 total diagnoses and 1 E-code in Texas, and 15 total diagnoses and 1 E-code in New York; and (3) using all-listed diagnoses after the change in recordability ("postchange definition"), ie, 25 total diagnoses and 10 E-codes in Texas, and 25 total diagnoses and 1 E-code in New York. Following HCUP calculations, annualized quarterly rates were defined as the quarterly hospitalization counts divided by one-fourth the annual population, times 100 000. Annualized quarterly rates allow for easy interpolation of a quarterly rate to the annual rate.

Analytic strategy

All analyses were done separately for the 2 states. Each data set is structured at the quarter-year level, with 52 quarter-years in Texas and 43 quarter-years in New York. Given that our statistical population in each analysis is the universe of quarter-years in the corresponding period of time and state and therefore meaningful definitions of standard errors do not exist, no traditional measures of statistical significance are reported.

To illustrate trends in recording diagnoses, we graphed the average number of recorded diagnoses for all conditions and for opioid-related diagnoses over time in each state. To assess whether observed breaks in trends coincide with the times of increases in recordability, we used a nonlinear least squares approach to identify where the trends change. In cases when the identified break in trends did not coincide with the increase in recordability, we fit a model with an imposed break at the time of the shift; such a model allows to both find the observed break in the trend and identify the changes in slope and intercept when the increase in recordability occurred. Fitted trend lines were then graphed for each period.

We further examined trends in opioid-related hospitalization rates over time in each state depending on the case definition used to identify an opioid-related hospitalization. Because population estimates by insurance status are not available annually, we graphed payer-specific opioid-related hospitalization counts instead, an approach consistent with HCUP reporting.

Results

Descriptive statistics

To provide an understanding of the hospitalizations' demographics and expected payer composition in New York and Texas, we present summary statistics in Table 1. Because the study periods are different for the 2 states, we used 2 quarters, at the beginning and at the end of the overlapping time frame (we chose the first quarter of 2011, rather than the last, because the recordability changed occurred in August 2011 in New York, which would change how opioid-related hospitalizations with all-listed diagnoses are identified). Distribution of hospitalizations for all conditions by sex and age is similar across the time periods and the states, but Texas has a larger portion of Medicaid-paid hospitalizations, whereas New York has a larger portion of hospitalizations paid by Blue Cross/Blue Shield. As for opioid-related hospitalizations, the differences between the states are more pronounced. In Texas, most opioid-related hospitalizations are missing sex information. Compared with New York, opioid-related hospitalizations in Texas are skewed toward an older population. A considerably higher percentage of opioid-related hospitalizations is covered by Medicaid in New York, compared with Texas, whereas the percentage covered by Medicare is lower. Because our measure is calculated only using information on diagnoses, missing values in demographic characteristics do not present a problem. Our measure calculations are based on all hospitalizations, and Table 1 serves an informational purpose.

Table 1. Descriptive statistics of hospitalizations in Texas and New York in the first quarter of 2005 and 2011.

	TEXAS		NEW YORK	
	2005Q1	2011Q1	2005Q1	2011Q1
Overall hospitalizations				
Total	715 593	740 817	649 922	635 626
Sex				
Men	37.1%	37.1%	42.9%	43.6%
Women	58.4%	56.7%	57.1%	56.4%
Missing/Unknown	4.5%	6.2%	<0.01%	<0.01%
Age, y				
0-17	21.0%	20.2%	15.8%	14.9%
18-44	26.6%	26.0%	26.1%	24.7%
45-64	20.9%	22.9%	22.9%	25.3%
65+	31.5%	30.9%	35.2%	35.1%
Missing	—	<0.01%	<0.01%	<0.01%
Payer[a]				
Medicare	33.5%	31.3%	32.4%	34.5%
Medicaid	20.8%	21.8%	16.5%	14.3%
BCBS	7.4%	6.5%	12.7%	13.6%
Commercial	—	—	34.5%	31.7%
Self-pay	—	—	3.1%	4.2%
Opioid-related hospitalizations (all-listed diagnoses)				
Total	3995	6821	15 242	15 390
Sex				
Men	8.5%	9.9%	69.9%	65.9%
Women	16.7%	19.4%	30.1%	34.1%
Missing	74.8%	70.7%	—	—
Age[b], y				
0-17	3.3%	3.4%	0.7%	0.8%
18-44	47.3%	44.9%	63.1%	53.0%
45-64	34.2%	34.2%	32.3%	39.6%
65+	15.2%	17.4%	3.9%	6.5%
Payer[a]				
Medicare	25.6%	28.2%	9.9%	15.7%
Medicaid	17.7%	14.5%	57.3%	43.9%
BCBS	6.8%	6.2%	4.1%	5.8%
Commercial	—	—	18.6%	24.9%
Self-Pay	—	—	9.7%	8.1%

Abbreviation: BCBS, Blue Cross/Blue Shield.
[a]Payer category percentages do not sum to 100% because the categories are not exhaustive. Variables for commercial insurance and self-pay are not included in the TX analyses due to data limitations such as considerable changes in variable coding and potential errors in reporting.
[b]Age group percentages do not sum to 100% in TX and NY 2011Q1 in opioid-related hospitalizations because of rounding decimals.

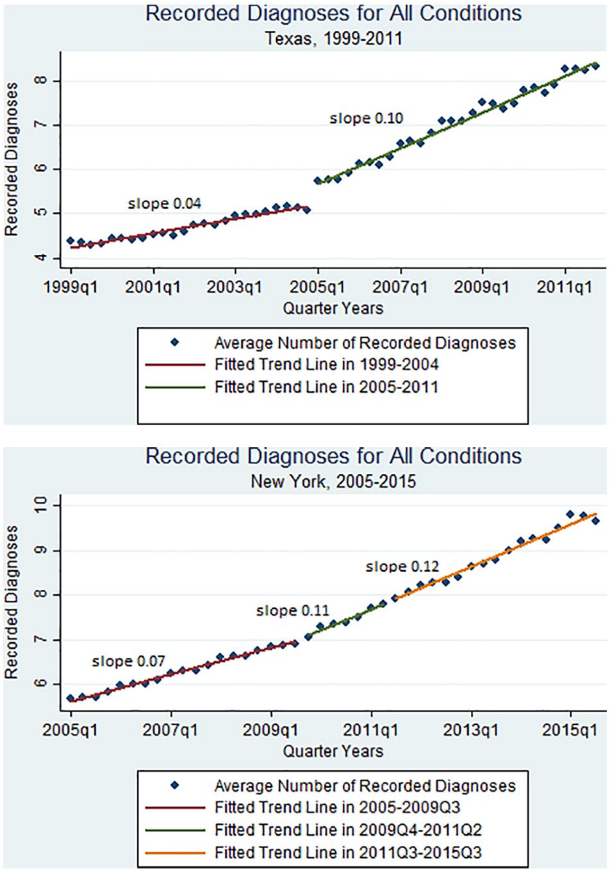

Figure 1. Trends in the number of recorded diagnoses for all conditions: Graph 1—Texas and Graph 2—New York.

Trends in the number of recorded diagnoses for all conditions

Figure 1 shows the trends in the average number of recorded diagnoses for all conditions, in Texas and New York. In Texas, there is a discrete increase in the trend a year after the change, in 2005Q1 (of approximately 0.8 diagnoses) and a change in the slope (Figure 1, Graph 1). In New York, however, the trend throughout the study period is remarkably linear and stable, indicating that although there is likely a general growing tendency to record more diagnoses over time, this can hardly be attributed to the recordability change in August of 2011 (Figure 1, Graph 2). These inferences are confirmed in nonlinear least squares analyses. In Texas, the break in the trend was identified at around 2005Q1, with slope coefficient 0.04 before 2005Q1 and 0.10 after. The 2 fitted trend lines are shown in Figure 1, Graph 1. In New York, the break in the trend was estimated around 2009Q4, with slope coefficient 0.07 before 2009Q4 and 0.12 in or after. When we impose an additional break in 2011Q3, when the increase in recordability in fact occurred, the 3 estimated slopes are 0.07, 0.11, and 0.12 in 2005-2009Q3, 2009Q4-2011Q2, and 2011Q3-2015Q3, respectively. Figure 1, Graph 2 shows the 3 fitted trend lines. Taken together, these findings indicate that the increase in recordability had a pronounced effect on diagnosis recording trends in Texas, but not as much in New York, where the trend changed more

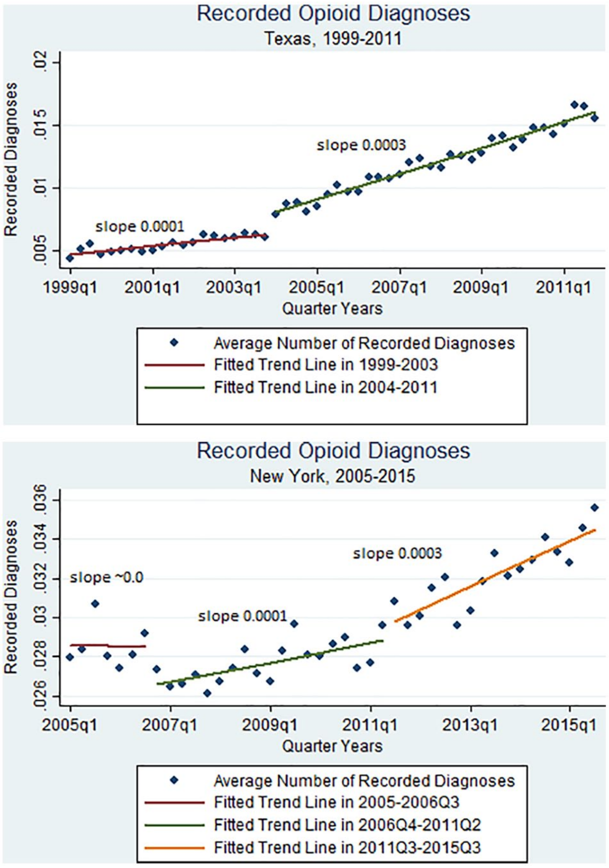

Figure 2. Trends in the number of recorded opioid diagnoses: Graph 1—Texas and Graph 2—New York.

considerably at an earlier point in time. Supplemental Figure A1 shows the trends by payer in both states. There are larger effects in Medicare than for other payers in both states.

Trends in the number of recorded opioid diagnoses

Figure 2 shows the trends in the average number of recorded diagnoses for opioid-related conditions in each state. The graphs suggest that Texas had both a discrete increase and a change in slope (Figure 2, Graph 1). New York presents an interesting case: it appears that the change in the trend occurred around 2006-2007, before which the slope is slightly decreasing, and after which the slope is increasing for the rest of the study period (Figure 2, Graph 2).

These inferences are confirmed in nonlinear least squares analyses. In Texas, the break in the trend was around 2004Q1, with slope coefficient 0.0001 before 2004Q1 and 0.0003 in or after. The 2 fitted trend lines are shown in Figure 2, Graph 1. Using values from the fitted linear trend, we calculated that the number of recorded opioid diagnoses changed from approximately 0.006 to 0.008 in 2004Q1, a 29.9% increase. In New York, the break in the trend is at around 2007Q4, with slope coefficient −0.0002 before 2007Q4 and 0.0003 in or after. When we impose an additional break in 2011Q3, the time of the increase in recordability, the break is in 2006Q4 and the 3 estimated slopes are −0.000003, 0.0001, and 0.0003 in 2005-2006Q3, 2006Q4-2011Q2, and 2011Q3-2015Q3, respectively. Figure 2, Graph 2 shows the 3 fitted trend lines. At the time of the recordability change, the number of recorded opioid diagnoses changed from approximately 0.029 to 0.030, a 3.1% increase. Again, the effect of the recordability change on opioid diagnosis recording trends appears to be pronounced in Texas, but not as much in New York, where the trend started to increase almost 5 years earlier. Supplemental Figure A2 shows the trends by payer in both states. In Texas, the effect is present among all 3 payers; in New York, changes in the trends predate the recordability change for hospitalizations paid by Medicare, commercial insurance, and Blue Cross/Blue Shield.

Opioid-related hospitalization trends by case definitions

Trends in opioid-related hospitalization rates by case definition are shown in Figure 3. Based on identifying opioid-related hospitalizations by principal diagnosis only, the trend is stable in Texas and is decreasing in New York. The rates based on the prechange definition and the postchange definition overlap in the prechange period and diverge in the postchange period. As shown in Figure 3, the divergence in the trends based on these 2 definitions appears similar in Texas and New York. We calculated the absolute and relative differences between annualized rates based on the old and new definitions after 4 years of change (in 2015Q3 in New York and in 2008Q1 in Texas). The annualized rates based on the prechange and postchange definitions in New York were 372.9 and 391.2, respectively, a 4.9% difference. The annualized rates based on the prechange and postchange definitions in Texas were 80.1 and 87.9, respectively, a 9.7% difference. At the end of the study period, 8 years after the change in recordability, the discrepancy in Texas reached 15.9%.

Supplemental Figure A3 shows hospitalization trends by payer in both states. Definition-based differences in hospitalization trends are pronounced in Medicare, less so in Medicaid, and are minimal in hospitalizations paid by Blue Cross/Blue Shield in Texas (Supplemental Figure A3 Panel A). In New York, divergence in trends is seen in Medicare and is minimal for commercial insurance and Blue Cross/Blue Shield. There is hardly any difference in the definitions in Medicaid-paid and self-pay hospitalizations (Supplemental Figure A3 Panel B).

Discussion

Our analyses have 3 main findings: (1) the 2004 increase in recordable diagnoses in Texas resulted in both a discrete increase and a steeper subsequent increase in the number of recorded diagnoses for *all* conditions. In New York, the trend was steadily increasing throughout the study period, with a more pronounced increase in the trend predating the increase in recordability. (2) The change in Texas resulted in both a pronounced discrete increase and a steeper subsequent increase in

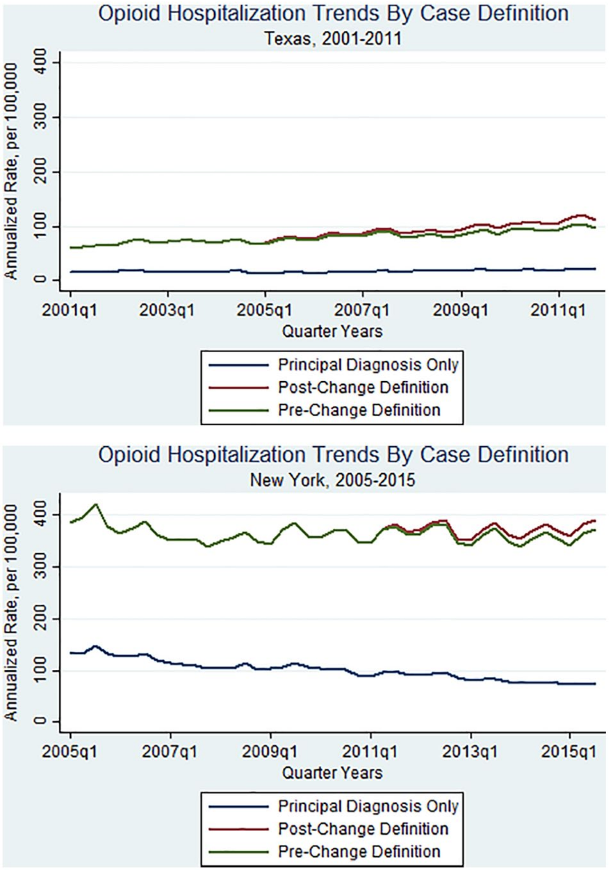

Figure 3. Opioid-related hospitalization trends by case definition: Graph 1—Texas and Graph 2—New York.
Study period in Texas is truncated to 11 years (2001-2011) to ensure graphical comparability with New York. The annualized quarterly rates were calculated by dividing quarterly hospitalization counts by one-fourth the annual population, times 100 000. Annualized quarterly rates allow for easy interpolation of a quarterly rate to the annual rate. The trend using definition based on just principal diagnosis is shown for a visual comparison to the other 2 definitions, not for evaluation of the effect of recordability changes.

the number of recorded diagnoses for *opioid-related* conditions. In New York, the trend changed dramatically (from flat to increasing) at the end of 2006, but less so at the time of the recordability change (2011). (3) The divergence between opioid-related hospitalization rate trends based on the prechange and postchange definitions is slightly larger in Texas than in New York. To the extent that Centers for Medicare and Medicaid Services may provide incentives for hospitals to record more diagnoses when possible to boost reimbursement and allow for some flexibility in re-billing in cases of denied claims, our findings by payer may provide additional evidence of the effects of increases in diagnosis recordability.

Potential explanations for weaker evidence in New York

Although our findings suggest that the increase in diagnosis recordability partially accounts for HCUP-reported increases in the hospitalization rates in Texas, evidence in New York is less compelling. The HCUP-reported trend in hospitalization rates in New York is not increasing much, and it is feasible that strongly increasing rates (using all-listed diagnoses) and clear responses to changes in recordability are correlated.

The more interesting question, however, is why increases in recordability generate responses of varying magnitude in different states. One potential explanation could be that New York changed the number of recordable secondary diagnoses from 8 to 24 in 2 steps, and the 2011 change, which falls in our study period, is the change from 14 to 24 available secondary diagnosis fields, a less dramatic change than in Texas. Perhaps, the steady increase that is observed prior to 2011 is the long-term consequence of the earlier change (from 8 to 14). It is also possible that the response was more likely to be present in earlier years (early or mid-2000s), when the increase in recordability happened in Texas. A more comprehensive analysis using longer time frames and better variation in timing of the changes from including more states could address this question.

Relevance to research and policy

Our findings suggest that increasing trends in HCUP-reported opioid-related hospitalizations are partially attributable to changes in diagnosis recordability, at least in some states. Because the timing and the extent of these changes vary across states, responses to recordability are unlikely to be the same. We therefore conclude that using all-listed diagnoses to identify opioid-related hospitalizations in cross-state and over-time comparisons may be misleading. Instead of measuring true between-state dissimilarities and temporal trends in opioid-related hospital use, such comparisons may in fact reflect differences and changes in recording. Our conclusion is in alignment with the ISW7's recommendation to use the lowest number of diagnosis fields and E-code fields among states and over time for comparative analyses between states as well as longitudinal studies.[10] However, we note that evidence of increases in the slope in both states suggests that this recommendation would result in underestimating the trend over time if the lower number, ie, before an increase in recordability, is used.

Questions surrounding the meaning of responses to recordability changes remain. It is possible that health care providers and hospital administration have improved recording accuracy and comprehensiveness and have become better at reflecting the true clinical picture. A growing emphasis on screening is another potential reason for recording more secondary diagnoses. It is possible that with increasing awareness of the opioid epidemic, clinicians are better able to recognize opioid-related conditions and record them in charts and hospital coding specialists are more likely to keep these diagnoses on administrative forms, which become the basis of discharge data. Although prevalence of opioid-related conditions has undoubtedly increased, it is unlikely to be the underlying reason for the immediate discrete increases in the number of recorded diagnoses, especially in Texas. The above questions could be addressed in future qualitative research.

Limitations

This study has some limitations worth noting. First, although the number of diagnosis fields increased from 9 to 25 at the beginning of 2004 in Texas, the new fields were not used throughout 2004 (ie, the new variables had no values in any hospitalizations). Correspondingly, a discrete increase in the trend of the number of recorded diagnosis for all conditions is observed between the last quarter of 2004 and the first quarter of 2005. However, the discrete increase in the trend of the number of recorded diagnoses for opioid-related conditions is observed at the start of 2004. It is unclear why this is the case, but it may indicate that there was a response to the increase in recordability in terms of recording more opioid diagnoses, even though the actually new diagnosis fields were not used. It could also reflect increased utilization of 9 additional E-codes, which are more pertinent to opioid involvement specifically, rather than to all medical conditions in aggregate. Furthermore, because we structured our New York data at the quarter-year level, which is dictated by Texas's data structure and is consistent with HCUP reporting, we were not able to align the recordability change in New York (August 2011) seamlessly with quarterly breakdown. In this article, we consider 2011Q3 as the change in recordability, but this quarter includes July 2011, a month before the change. Finally, we would have liked to capture the first shift in recordability in New York (from 8 to 14 secondary diagnoses) to assess whether its effect may have been more pronounced; however, these earlier data are not available.

Conclusions

HCUP-reported increasing trends in opioid-related hospitalizations are, in part, attributable to increases in diagnosis recordability, at least in some states. Using hospital discharge data from Texas in 1999-2011 and New York in 2005-2015Q3, we found strong evidence of diagnosis recordability influences in Texas and weaker evidence in New York, where changes in trends appear to precede the observed increase in recordability. Although more research is necessary to determine whether diagnosis recordability changes account for some of the reported increases in opioid-related hospitalizations across the United States, we conclude that cross-state and temporal comparisons of opioid-related hospitalization rates based on all-listed diagnoses can misrepresent the true relative extent of opioid-related hospital use and therefore of the opioid epidemic among states and over time.

Author Contributions

AD conceived of the study idea and performed the data analysis. AD and PV acquired the data. AD, TM and PV contributed to the study design and interpretation of the results. AD and TM wrote the paper with input from all authors. All authors provided critical feedback and commented on the manuscript. PV supervised the project.

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Supplemental Material

Supplemental material for this article is available online.

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