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Interrupted time series analysis to evaluate the performance of drug overdose morbidity indicators shows discontinuities across the ICD-9-CM to ICD-10-CM transition

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ABSTRACT

Introduction On 1 October 2015, the USA transitioned from the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) to the International Classification of Diseases, 10th Revision (ICD-10-CM). Considering the major changes to drug overdose coding, we examined how using different approaches to define all-drug overdose and opioid overdose morbidity indicators in ICD-9-CM impacts longitudinal analyses that span the transition, using emergency department (ED) and hospitalisation data from six states' hospital discharge data systems.

Methods We calculated monthly all-drug and opioid overdose ED visit rates and hospitalisation rates (per 100 000 population) by state, starting in January 2010. We applied three ICD-9-CM indicator definitions that included identical all-drug or opioid-related codes but restricted the number of fields searched to varying degrees. Under ICD-10-CM, all fields were searched for relevant codes. Adjusting for seasonality and autocorrelation, we used interrupted time series models with level and slope change parameters in October 2015 to compare trend continuity when employing different ICD-9-CM definitions.

Results Most states observed consistent or increased capture of all-drug and opioid overdose cases in ICD-10-CM coded hospital discharge data compared with ICD-9-CM. More inclusive ICD-9-CM indicator definitions reduced the magnitude of significant level changes, but the effect of the transition was not eliminated.

Discussion The coding change appears to have introduced systematic differences in measurement of drug overdoses before and after 1 October 2015. When using hospital discharge data for drug overdose surveillance, researchers and decision makers should be aware that trends spanning the transition may not reflect actual changes in drug overdose rates.

INTRODUCTION
Background

Epidemiologists and researchers have historically relied on International Classification of Diseases (ICD) coded emergency department (ED) and hospitalisation administrative claims data reported through state-level hospital discharge data (HDD) systems to track drug overdose trends.[1–9] The transition from the ICD 9th Revision, Clinical Modification (ICD-9-CM) to the 10th Revision (ICD-10-CM) on 1 October 2015 marked a major change in medical claims coding for all USA health-care entities covered by the Health Insurance Portability and Accountability Act.[10–12]

The number of injury and poisoning diagnosis codes increased from 2600 in ICD-9-CM to 43 000 in ICD-10-CM, greatly improving code specificity. ICD-10-CM also streamlined the coding process by incorporating both drug and intent (unintentional, intentional self-harm, assault and undetermined) information into a single code. In ICD-9-CM, overdose visits were coded with a diagnosis code indicating the drug involved and/or a separate non-billable external cause of injury code indicating intentionality.[13 14] Though these are positive changes for drug overdose surveillance, the extensive revisions preclude a simple one-to-one cross-walk between the ICD-9-CM and ICD-10-CM coding systems and raise questions about how best to track overdose trends over time using claims data.[10–13]

Two recent studies examined opioid overdose trends across the ICD transition using inpatient data from the Healthcare Cost and Utilization Project, finding that hospitalisations mentioning an opioid overdose code in any field decreased by 10.2% and 12.4% from 2015 Q3 (last quarter of ICD-9-CM) to 2015 Q4 (first quarter of ICD-10-CM).[15 16] The reported decreases, however, could be because both studies excluded assault and intentional self-harm codes from their ICD-10-CM indicator but not their ICD-9-CM indicator.[15 16] Other studies employing ICD-9-CM-based drug overdose indicators,[1–8] as well as guidance from the Council of State and Territorial Epidemiologists (CSTE) and CDC,[9 17–19] vary in terms of which ICD-9-CM codes are included and which fields are searched for relevant codes. In ICD-10-CM, CSTE and CDC recommendations agree that all available fields should be searched for overdose indicator codes.[17 18 20 21]

To the best of our knowledge, this study is the first to use interrupted time series (ITS) methodology to analyse the performance of all-drug and opioid overdose indicators across the ICD transition in both ED and inpatient datasets. ITS methodology accounts for pre-existing trends, seasonality and autocorrelation,[22 23] which were not addressed by previous trend analysis studies.[15 16] It is important

for stakeholders relying on longitudinal data to understand that while ICD-10-CM presents opportunities for improved drug overdose surveillance, the new coding scheme essentially constitutes an instrument change and could affect epidemiological analysis of temporal trends that span October 2015.

Objectives

The purpose of this study is to examine trends in nonfatal all-drug and opioid overdose indicators across the ICD-9-CM to ICD-10-CM transition using ED and hospitalisation data from six states (Kentucky, Missouri, Montana, Nevada, New Mexico and Tennessee). Three different ways of defining all-drug and opioid overdose indicators in ICD-9-CM were tested to compare trend continuity with ICD-10-CM-based definitions. It was hypothesised that using the most inclusively structured indicator definitions in both coding schemas would minimise discontinuity in all-drug and opioid overdose trends that span the transition.

METHODS

Data source and study population

States participating in the CSTE Drug Poisoning Indicators Workgroup (DPI-WG) were eligible to participate in the study if their state HDD system captured both ED visit and hospital inpatient administrative claims data from 2010 to at least 2016. State HDD systems are based on the nationally standardised Uniform Billing 2004 (UB-04) form, which is completed by licenced medical coders for reimbursement purposes. Thus, HDD is high-quality, population-based and comparable across states, making it an important public health surveillance data source. State HDD typically includes demographic information, several fields for ICD diagnosis, external cause and procedure codes, and payment source for every patient discharged from an acute care facility in the state, although federal and specialty hospitals are often exempt from reporting.[24] UB-04 coding rules state that for inpatient admissions, the first-listed code should capture the 'principal diagnosis', or main diagnosis necessitating inpatient care as determined by the attending medical provider. For ED visits, the term 'first-listed' is used in lieu of 'principal'

since oftentimes providers do not reach a confirmed diagnosis in the ED setting.[25 26]

In this study, each state's ED visit and hospitalisation datasets were analysed separately. ED visits resulting in admission were included in the hospitalisation dataset only. Interfacility transfers and repeat visits for the same overdose event were not excluded because no personal identifiers were available. Records from federal, specialty or other non-acute care facilities were excluded, along with in-hospital deaths and out-of-state residents. All records containing at least one drug overdose ICD-9-CM (discharge date before 1 October 2015) or ICD-10-CM code (discharge date on or after 1 October 2015) (listed in [17 18 20 21]) in any field were included in the analytic datasets.

Case definitions

For ICD-9-CM coded data, we explored three different ways of defining each indicator. The first ICD-9-CM definition required one of the included ICD-9-CM diagnosis codes to be present in the principal/first-listed diagnosis field or one of the included ICD-9-CM external cause codes to be the first-listed valid external cause code (included codes are listed in table 1) (definition 1). This definition structure was recognised by Injury Surveillance Workgroup (ISW) 7 as a conservative option for identifying poisoning cases and was used by CDC for state injury indicator reporting prior to 2015.[9 19] The second ICD-9-CM definition required an included diagnosis code to be present in the principal/first-listed diagnosis field or an included external cause code to be listed anywhere in the record (definition 2). Both CDC and CSTE used this definition structure for reporting opioid overdoses in ICD-9-CM coded data.[17 18] The third ICD-9-CM definition required at least one included ICD-9-CM code to be listed anywhere in the record (definition 3). This definition structure, also known as 'any mention', was recognised by ISW 7 as the most inclusive option for identifying poisoning cases in ICD-9-CM coded data.[19] For ICD-10-CM coded data, 'any mention' of at least one of the included ICD-10-CM diagnosis codes was required (table 1).[17 18 20 21]

Table 1 ICD-9-CM and ICD-10-CM codes included in all-drug overdose and opioid overdose indicators

Indicator	ICD-9-CM codes		ICD-10-CM codes	
All-drug overdose	Diagnosis codes	960–979: poisoning by drugs, medicinal and biological substances.	Diagnosis codes	T36-T50: poisoning by drugs, medicaments and biological substances (code must have an intent character of 1 (accidental/unintentional), 2 (intentional self-harm), 3 (assault) or 4 (undetermined) and a seventh character of A (initial encounter) or missing).
	External cause codes	E850-E858: accidental poisoning by drugs, medicinal and biological substances. E950.0-E950.5: suicide and self-inflicted poisoning by solid or liquid substances. E962.0: assault by drugs and medicinal substances E980.0-E980.5: poisoning by solid or liquid substances undetermined whether accidentally or purposely inflected.		
Opioid overdose	Diagnosis codes	965.00: poisoning by opium. 965.01: poisoning by heroin. 965.02: poisoning by methadone. 965.09: poisoning by other opiates and related narcotics.	Diagnosis codes	T40.0X: poisoning by opium. T40.1X: poisoning by heroin. T40.2X: poisoning by other opioids. T40.3X: poisoning by methadone. T40.4X: poisoning by synthetic narcotics. T40.60: poisoning by unspecified narcotics. T40.69: poisoning by other narcotics. (code must have an intent character of 1 (accidental/unintentional), 2 (intentional self-harm), 3 (assault) or 4 (undetermined) and a seventh character of A (initial encounter) or missing).
	External cause codes	E850.0: accidental poisoning by heroin. E850.1: accidental poisoning by methadone. E850.2: accidental poisoning by other opiates and related narcotics.		

ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical Modification; ICD-10-CM, International Classification of Diseases, 10th Revision, Clinical Modification.

Table 2 Characteristics of participating states' datasets

				Hospitalisation dataset		ED visit dataset	
State	Date range analysed	Preintervention time points (months)	Postintervention time points (months)	Diagnosis code fields	External cause code fields	Diagnosis code fields	External cause code fields
Kentucky	January 2010–June 2018	69	33	25	3	25	3
Missouri	January 2010–December 2017	69	27	23	1	23	1
Montana	January 2010–December 2017	69	27	9	3	9	3
New Mexico	January 2010–December 2017	69	27	18	3	48	6
Nevada	January 2010–December 2016	69	15	33	4	33	4
Tennessee	January 2010–December 2017	69	27	18	3	18	3

ED, emergency department.

Study design and analytic plan

Each state generated monthly counts of all-drug and opioid overdose ED visits and hospitalisations using the three ICD-9-CM indicator definitions for records with a discharge date before 1 October 2015 and the ICD-10-CM definition for records with a discharge date on or after 1 October 2015. To account for population changes over time, monthly crude rates per 100 000 population were generated and used as model outcome variables.[27] ITS methods were used to examine how all-drug and opioid overdose indicators performed over time, with an interruption point at October 2015.[22 28–30] The study period spanned from January 2010 to the most recent year of data available, which varied by state (table 2). We modelled each state's pretransition overdose trends so that the trends observed after the transition could be compared with the 'counterfactual', or the expected ongoing trend if ICD-10-CM had never been introduced. Inclusion of at least 12 time points before and after the transition allowed for evaluation of monthly seasonality.[22 28 29] We calculated segmented regression models that included both a level and a slope change parameter using the following autoregressive error linear regression model[22 23 31]:

$$Y_t = \beta_0 + \beta_1 \times Time_t + \beta_2 \times Transition_t + \beta_3 \times TimeAfterTransition_t + v_t$$

$$v_t = -\varphi_1 v_{t-1} - \varphi_1 v_{t-1} - ... - \varphi_k v_{t-k} + \varepsilon_t$$

$$\varepsilon_t \sim IN\left(0, \sigma^2\right)$$

Where:
Y_t=overdose morbidity rate at time (t).
β_0=intercept.
β_1=pretransition slope.
β_2=immediate effect of transition.
β_3=post-transition slope change.
v_t=autoregressive error term of order k at time (t).
ε_t=error at time (t), independently normally distributed with mean=0 and variance=σ^2.

The *Intercept* parameter (β_0) represents the estimated all-drug or opioid overdose ED visit or hospitalisation rate per 100 000 population at time (t)=0 (January 2010). The β_1 parameter models the slope (average monthly change) in overdose rate during ICD-9-CM (January 2010–September 2015). *Time* is coded as 1 for the first time point (January 2010) increasing sequentially through the last time point in the study (ie, 96 for December 2017). The β_2 parameter represents a change in level between the time points immediately before and after the transition, controlling for the pretransition trend. *Transition* is a dummy variable coded 0 for all time points before the transition and 1 for October 2015 onward. A positive β_2 coefficient,

or 'positive level change', is interpreted as an abrupt increase in overdose rate in October 2015 that is inconsistent with the existing ICD-9-CM trend. A negative β_2 coefficient, or 'negative level change', is interpreted as an abrupt decrease in October 2015 that is inconsistent with the existing ICD-9-CM trend. The β_3 parameter models the difference between the pretransition and post-transition slopes. *TimeAfterTransition* is an interaction term between *Time* and *Transition*. Adding coefficients $\beta_1 + \beta_3$ yields the post-transition slope, or average monthly change in overdose rate after October 2015.[22 28–31]

Overdose morbidity rates were tested for seasonality using SAS PROC X12, after accounting for length-of-month variation.[32] If seasonality was identified, multiplicative decomposition was used to seasonally adjust the data.[33] SAS PROC AUTOREG with the BACKSTEP option was used to select the correct model by sequentially eliminating autoregressive terms not statistically significant at the 0.05 level from an initial full model with order (k)=13.[32] If the final model contained autoregressive terms, we reported the maximum likelihood estimates with autoregressive parameters assumed given. Model fit was assessed by examining residual plots, white noise probabilities, autocorrelation functions and partial autocorrelation functions.[23 32] P values less than 0.05 were considered statistically significant. We performed sensitivity analyses by testing models that only included a level change parameter, and using different approaches to adjust for seasonality.[22 23 33] The findings were consistent with those from the primary analysis. All analyses were performed using SAS software V.9.4.[32] It was not appropriate or possible to involve patients or the public in the design, conduct, reporting or dissemination plans of our research.

RESULTS
All-drug overdose results
Intercept
For all-drug overdose ED visits, ICD-9-CM definition 3 resulted in the highest intercept estimate compared with definitions 1 and 2 in all states except Nevada. The largest difference was seen in Kentucky, where the estimated all-drug overdose ED visit rate in January 2010 was 4.1% higher using definition three compared with definition 1. Similarly, for all-drug overdose hospitalisations, definition 3 resulted in the highest intercept estimates compared with definitions 1 and 2 in all states except Montana. For hospitalisations, the largest difference was seen in Nevada, where the estimated rate in January 2010 was 5.9% higher using definition three compared with definition 1 (table 3).

Time
Trends in all-drug overdose ED visit rates and hospitalisation rates prior to the transition (January 2010–September 2015)

Table 3 Interrupted time series model regression parameters: all-drug overdose emergency department (ED) visit and hospitalisation rates per 100 000 population using three different ICD-9-CM indicator definitions

State	ICD-9-CM all-drug overdose indicator definition†	ED visit regression parameters				Hospitalisation regression parameters			
		Intercept‡	Time§	Transition¶	TimeAfterTransition**	Intercept	Time	Transition	TimeAfterTransition
Kentucky	Definition 1	10.88*	0.10*	0.97	0.09	11.17*	−0.01	2.00*	−0.05
	Definition 2	10.91*	0.11*	0.55	0.10	11.23*	−0.01	1.69*	−0.05
	Definition 3	11.33*	0.10*	0.68	0.09	11.64*	−0.01	1.90*	−0.05*
Missouri	Definition 1	13.21*	−0.02*	2.19*	0.06	11.26*	−0.02*	0.65*	−0.02
	Definition 2	13.23*	−0.02*	1.79*	0.07*	11.49*	−0.02*	0.69*	−0.02
	Definition 3	13.46*	−0.02*	1.81*	0.07*	11.61*	−0.02*	0.61*	−0.02
Montana	Definition 1	11.78*	0.00	1.74	0.08	9.95*	−0.01*	0.38	0.04
	Definition 2	11.86*	0.00	1.65	0.08	10.09*	−0.02*	0.48	0.03
	Definition 3	12.19*	0.00	1.39	0.08	9.88*	0.00	−0.54	0.03
New Mexico	Definition 1	21.11*	−0.01	−1.54	−0.11	12.60*	−0.05*	1.07*	0.03
	Definition 2	21.50*	−0.01	−1.16	−0.13	12.82*	−0.06*	0.94*	0.04
	Definition 3	21.58*	0.01	−2.77*	−0.13	13.07*	−0.06*	0.75	0.04
Nevada	Definition 1	16.64*	−0.03*	−0.49	0.14	8.92*	−0.01	−0.14	0.03
	Definition 2	16.80*	−0.03*	−0.58	0.14	9.00*	0.00	−0.31	0.03
	Definition 3	16.75*	−0.02	−1.24	0.09	9.45*	−0.01	−0.43	0.04
Tennessee	Definition 1	16.62*	−0.01	0.94	0.11*	9.46*	0.00	1.57*	−0.06*
	Definition 2	16.80*	−0.01	0.86	0.11*	9.59*	0.00	1.45*	−0.06*
	Definition 3	16.96*	−0.01	0.62	0.11*	9.71*	0.00	1.31*	−0.06*

Statistically significant results are marked with * (α=0.05).

†ICD-9-CM all-drug overdose indicator definitions (used prior to 1 October 2015): definition 1 searched the principal/first-listed diagnosis and first-listed valid external cause fields, definition 2 searched the principal/first-listed diagnosis and all external cause fields and definition 3 searched all available fields for the presence of an included code.

‡Intercept – estimated rate in January 2010.

§Time: average monthly change in rate (slope) from January 2010 to September 2015.

¶Transition: immediate level change observed in October 2015.

**TimeAfterTransition: change in slope after October 2015 compared with the pretransition slope.

ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical Modification.

varied by state, regardless of the ICD-9-CM indicator definition applied. For example, Kentucky saw increasing ED visit rates and stable hospitalisation rates during ICD-9-CM, while Missouri observed declining overdose rates for both ED visits and hospitalisations (table 3).

Transition

For all-drug overdose ED visits, four states (Kentucky, Montana, Nevada and Tennessee) did not observe a level change at the time of the ICD transition. Missouri saw a positive level change that was largest with definition 1. In New Mexico, there was no level change using definitions 1 and 2 and a negative level change using definition 3. For all-drug overdose hospitalisations, two states (Montana and Nevada) did not observe a level change at the transition, while the remaining four states (Kentucky, Missouri, New Mexico and Tennessee) had positive level changes that were smallest using definition 3 (table 3).

TimeAfterTransition

For all-drug overdose ED visits, Missouri had a positive slope change after the ICD transition when using definitions 2 and 3, and Tennessee observed a positive slope change regardless of the ICD-9-CM definition used. For all-drug overdose hospitalisations, Kentucky observed a negative slope change following the ICD transition when using definition 3, and Tennessee observed a negative slope change with all the ICD-9-CM definitions (table 3).

See online supplementary appendices 1 and 2 for graphs of the predicted versus observed all-drug overdose ED visit and hospitalisation rates in each state.

Opioid overdose results

Intercept

For opioid overdose ED visits, ICD-9-CM definition 3 resulted in the highest intercept estimate compared with definitions 1 and 2 in five states (Missouri, Montana, New Mexico, Nevada and Tennessee). The largest difference was seen in Tennessee where the estimated opioid overdose ED visit rate in January 2010 was 55.1% higher using definition 3 compared with definition 1. For opioid overdose hospitalisations, definition 3 resulted in the highest intercept estimates compared with definitions 1 and 2 in all states. The largest difference was seen in Kentucky where the estimated rate in January 2010 was 61.3% higher using definition 3 compared with definition 1 (table 4).

Time

Four states (Kentucky, Missouri, New Mexico and Tennessee) observed positive slopes in their opioid overdose ED visit rates during ICD-9-CM regardless of which ICD-9-CM definition was applied. For opioid overdose hospitalisations, Tennessee observed no slope, meaning that rate was stable from January 2010 to September 2015. New Mexico observed a negative slope with all three ICD-9-CM definitions, while Nevada had a negative slope with definition 3 (table 4).

Transition

All participating states observed positive level changes immediately following the ICD transition for opioid overdose ED visits as well as hospitalisations. Using definition 1 to capture cases in ICD-9-CM resulted in the largest positive level change, while definition 3 resulted in the smallest level change. In New Mexico and Nevada, the positive level change in opioid overdose ED

Table 4 Interrupted time series model regression parameters: opioid overdose emergency department (ED) visit and hospitalisation rates per 100 000 population using three different ICD-9-CM indicator definitions

State	ICD-9-CM opioid overdose indicator definition†	ED visit regression parameters				Hospitalisation regression parameters			
		Intercept‡	Time§	Transition¶	TimeAfter-Transition**	Intercept	Time	Transition	TimeAfter-Transition
Kentucky	Definition 1	0.54	0.07*	5.08*	−0.02	1.73*	0.00	1.56*	−0.03*
	Definition 2	0.61	0.07*	4.99*	−0.02	1.99*	0.00	1.37*	−0.03*
	Definition 3	1.04	0.07*	4.71*	−0.01	2.79*	0.00	0.63*	−0.02
Missouri	Definition 1	1.59*	0.02*	1.38*	0.05*	1.59*	0.00	1.36*	−0.02*
	Definition 2	1.66*	0.02*	1.33*	0.05*	1.76*	0.00	1.20*	−0.02*
	Definition 3	1.89*	0.02*	1.10*	0.05*	2.26*	0.00	0.67*	−0.02*
Montana	Definition 1	0.98*	0.00	0.68*	0.01	1.25*	0.00	0.74*	0.00
	Definition 2	1.03*	0.00	0.63*	0.01	1.29*	0.00	0.64*	0.00
	Definition 3	1.33*	0.00	0.45*	0.01	1.81*	0.00	0.29	0.00
New Mexico	Definition 1	3.40*	0.01*	1.20*	0.00	2.10*	−0.01*	1.44*	−0.02*
	Definition 2	3.49*	0.01*	0.84	0.02	2.30*	−0.01*	1.30*	−0.02*
	Definition 3	3.91*	0.02*	−0.06	0.01	2.95*	−0.01*	0.76*	−0.02
Nevada	Definition 1	2.27*	0.00	0.86*	0.01	1.87*	0.00	1.17*	−0.01
	Definition 2	2.57*	0.00	0.75*	0.01	2.09*	0.00	0.92*	0.00
	Definition 3	3.06*	0.00	0.27	0.01	2.69*	−0.01*	0.55*	0.01
Tennessee	Definition 1	1.27*	0.01*	1.48*	0.10*	1.60*	0.00*	1.34*	−0.02*
	Definition 2	1.46*	0.01*	1.35*	0.10*	1.91*	0.00*	1.10*	−0.02*
	Definition 3	1.97*	0.01*	0.97*	0.10*	2.48*	0.00	0.64*	−0.02*

Statistically significant results are marked with * (α=0.05).

†ICD-9-CM all-drug overdose indicator definitions (used prior to 1 October 2015): definition 1 searched the principal/first-listed diagnosis and first-listed valid external cause fields, definition 2 searched the principal/first-listed diagnosis and all external cause fields and definition 3 searched all available fields for the presence of an included code.

‡Intercept: estimated rate in January 2010.

§Time: average monthly change in rate (slope) from January 2010 to September 2015.

¶Transition: immediate level change observed in October 2015.

**TimeAfterTransition: change in slope after October 2015 compared with the pretransition slope.

ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical Modification.

visits completely disappeared using definition 3 and similarly in Montana for opioid overdose hospitalisations (table 4).

TimeAfterTransition

The change in slope of opioid overdose ED visits and hospitalisations after the transition varied by state without a clear pattern. Missouri and Tennessee observed increases in ED visit slope during ICD-10-CM compared with ICD-9 CM, while for hospitalisations, Kentucky, Missouri, New Mexico and Tennessee observed negative post-transition slope changes (table 4).

See online supplementary appendices 3 and 4 for graphs of the predicted versus observed opioid overdose ED visit and hospitalisation rates in each state.

DISCUSSION
Key results

In this study, we used ITS analysis to examine how the transition from ICD-9-CM to ICD-10-CM impacts surveillance of all-drug and opioid overdose morbidity trends. We tested several ways of structuring indicators in ICD-9-CM, yet discontinuities were present even when using 'any mention' definitions in both coding systems and controlling for pre-existing overdose morbidity trends in each state. Our findings suggest that the coding change on 1 October 2015 introduced systematic differences in measurement of all-drug and opioid overdose ED visits and hospitalisations.

The most common type of trend discontinuity observed was a sudden uptick in overdose case capture on ICD-10-CM implementation (positive level change). This could be related to the major expansion of available codes in ICD-10-CM. In addition, the shift to coding overdoses with a single diagnosis code in ICD-10-CM, rather than a combination of diagnosis and external cause codes, could systematically increase in case capture under ICD-10-CM in jurisdictions with low external cause coding rates.[14 31 34] The observed trend discontinuities could also reflect actual shifts in the underlying incidence of overdoses.

Adjusting the number of diagnostic fields searched without changing any of the codes included in ICD-9-CM indicator definitions influenced the magnitude and direction of trend discontinuities seen in October 2015, when using the standardised ICD-10-CM 'any mention' definitions issued by CDC and CSTE.[18 20 21] ICD-9-CM 'any mention' definitions consistently increased capture of drug overdose cases compared with ICD-9-CM definitions that searched only specific fields. For states that observed positive level changes, using the ICD-9-CM 'any mention' definition either narrowed or closed the gap between lower rates during the final month of ICD-9-CM (September 2015) and higher rates first month of ICD-10-CM (October 2015), which was consistent with our original hypothesis. This phenomenon was consistently more pronounced for the opioid overdose indicator than the all-drug overdose indicator. We are unsure why the ICD-9-CM 'any mention' definition captured more all-drug overdose cases than the ICD-10-CM 'any mention' definition in New Mexico's ED dataset, resulting in a negative level change. The extent to which level changes were affected by using various ICD-9-CM indicator definitions may be related to the total number of diagnostic fields available in the discharge dataset, which differs by state (table 2). States with more available fields are excluding a greater number of potential cases by using ICD-9-CM indicator definitions that search only the principal/first-listed diagnosis field or first-listed valid external cause field.[24 34]

Limitations

We do not recommend generalising these results to other states or nationally because our convenience sample of six states from the CSTE DPI-WG was not representative. We also caution generalisation of these results to other drug overdose indicators not specifically investigated in this study. Limitations of HDD include the lack of personal identifiers, and the exemption of federal facilities (Indian Health Services and Veterans Affairs) from reporting. In addition, we did not explicitly control for external factors that could affect the true incidence of drug overdose, for example, increased federal and local funding for prevention activities, introduction of the CDC guideline for prescribing opioids for chronic pain,[35] emergence of fentanyl and other illicit drugs on the market, increases in take-home naloxone prescribing, and other policy changes or state-specific factors.

CONCLUSION

The transition from ICD-9-CM to ICD-10-CM appears to have introduced major systematic differences in measurement of drug overdoses such that data from the two coding systems should not be interpreted as continuous. However, understanding that trend data are paramount amid the current drug overdose epidemic, the results of this study can be used to guide methodology for overdose surveillance and research employing ICD-coded ED visit or hospitalisation data. Graphs presenting longitudinal data across October 2015 should clearly indicate the ICD-10-CM transition with a vertical line and label. Statistical models of overdose trends that incorporate data from both coding schemes should include terms to control for the ICD-10-CM transition. Summary statistics for the year 2015 should not combine data from both ICD-9-CM and ICD-10-CM. Instead, consider reporting statistics for fiscal year 2015 (October 2014–September 2015) or the first three quarters of calendar year 2015 only (January 2015–September 2015). Lastly, it is important to consider the structural comparability of indicator definitions used to capture cases under each coding system, both in terms of which codes are included and which fields are searched.

What is already known on the subject

► Epidemiologists rely on International Classification of Diseases (ICD)-coded administrative claims data to monitor drug overdose morbidity, a major public health problem.
► Drug overdose coding went through substantial revision in the transition from International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) to International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM).
► Studies have begun to evaluate the impact of the transition on surveillance of health outcomes.

What this study adds

► This study uses interrupted time series methodology to analyse the performance of all-drug and opioid overdose indicators across the ICD transition in both ED and inpatient datasets.
► No other study has evaluated how adjusting the number of diagnostic fields searched in ICD-9-CM indicator definitions impacts trend comparability across the transition.

Disclaimer The findings and conclusions in this paper of those of the authors and do not necessarily represent the official position of the Centres for Disease Control and Prevention or the Council of State and Territorial Epidemiologists.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Provenance and peer review Commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. This study used aggregate hospital discharge data from six states. To request these data, contact the hospital discharge data system administrators from each state. To obtain the statistical code used in this study, please contact the corresponding author.

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