Morbidity and Mortality of Unintentional Carbon Monoxide Poisoning: United States 2005 to 2018

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Study objective: Centers for Disease Control and Prevention conducts case surveillance through the National Notifiable Diseases Surveillance System (NNDSS). This study aimed to provide surveillance report of unintentional carbon monoxide poisoning across multiple data sources to provide baseline data for the new NNDSS carbon monoxide poisoning surveillance.

Methods: For the period 2005 to 2018, we used 4 data sources to describe unintentional carbon monoxide poisoning: exposures reported by poison centers, emergency department (ED) visits, hospitalizations, and deaths. We conducted descriptive analyses by the cause of exposure (fire, nonfire, or unknown), age, sex, season, and US census region. Additional analyses were conducted using poison center exposure case data focusing on the reported signs and symptoms, management site, and medical outcome.

Results: Annually, we observed 39.5 poison center exposure calls (per 1 million, nationally), 56.5 ED visits (per 1 million, across 17 states), 7.3 hospitalizations (per 1 million, in 26 states), and 3.3 deaths (per 1 million, nationally) due to unintentional carbon monoxide poisoning. For 2005 to 2018, there was a decrease in the crude rate for non–fire-related carbon monoxide poisonings from hospital, and death data. Non–fire-related cases comprised 74.0% of ED visits data, 60.1% of hospitalizations, and 40.9% of deaths compared with other unintentional causes. Across all data sources, unintentional carbon monoxide poisonings were most often reported during the winter season, notably in January and December. Children aged 0 to 9 years had the highest reported rates in poison center exposure case data and ED visits (54.1 and 70.5 per 1 million, respectively); adults older than 80 years had the highest rates of hospitalization and deaths (20.2 and 9.9 per 1 million, respectively); and deaths occurred more often among men and in the Midwest region. Poison center exposure call data revealed that 45.9% of persons were treated at a health care facility. Headaches, nausea, and dizziness/vertigo were the most reported symptoms.

Conclusion: The crude rates in non–fire-related carbon monoxide poisonings from hospitalizations, and mortality significantly decreased over the study period (ie, 2005 to 2018). This surveillance report provides trends and characteristics of unintentional carbon monoxide poisoning and the baseline morbidities and mortality data for the Centers for Disease Control and Prevention national surveillance system of carbon monoxide poisoning. [Ann Emerg Med. 2022;■:1-9.]

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INTRODUCTION

Background

Carbon monoxide is a colorless, odorless, nonirritating gas produced through the incomplete combustion of carbon-containing substances. Unintentional carbon monoxide poisoning is preventable yet remains a leading cause of poisoning-related deaths in the United States. Annually, unintentional non–fire-related carbon monoxide poisoning is responsible for approximately 101,847 emergency department (ED) visits (48.3 visits per 1 million), 14,365 hospitalizations (4.1 cases per 1 million), and at least 430 deaths.[1-5]

Importance

There is no active carbon monoxide surveillance system in the United States, and national estimates and surveillance activities are largely based on secondary data sources that were not primarily designed for carbon monoxide surveillance.[2,6-10] Current surveillance data on carbon monoxide exposure are piecemealed from multiple data sets. The National Poison Data System (NPDS) collects data from all 55 US poison centers representing 50 states, the District of Columbia, and the American territories. However, NPDS data underestimate all carbon monoxide exposures because calls to poison centers voluntarily come from health care professionals or persons reporting a poison exposure.[11] Although more than 20,000 carbon monoxide exposure-related ED visits are reported annually in the United States, NPDS only captured 36,691 of those over a 10-year period.[2,12] Unintentional carbon monoxide poisoning is one of the nationally consistent data

Editor's Capsule Summary

What is already known on this topic

Carbon monoxide poisoning is a leading cause of unintentional poisoning-related death in the United States.

What question this study addressed

What are the trends over time in unintended carbon monoxide poisoning?

What this study adds to our knowledge

Evaluating 4 US data sets that compiled data from 2005 to 2018, the reported consequences of carbon monoxide poisoning, including hospitalization and death, trended downward.

How this is relevant to clinical practice

Although not directly applicable to clinical practice, these data inform disease surveillance efforts.

and measures on the Centers for Disease Control and Prevention (CDC) national tracking portal.[13] The Environmental Public Health Tracking program (tracking program) collects data regarding hospital discharge and death due to carbon monoxide poisoning, providing annual state-specific morbidity and mortality. The Healthcare Cost and Utilization Project, a nationally representative sample of inpatient and emergency visits across the United States, is often used to estimate the hospital admission burden associated with carbon monoxide poisoning.[9] In addition, the US American housing survey provides the national percentage of households with working carbon monoxide alarms.[14] Hyperbaric oxygen treatment centers report patient information, including carbon monoxide alarm usage at the exposure location.[15] Despite the wide breadth of carbon monoxide poisoning data available, no comprehensive data source provides the full context of unintentional carbon monoxide poisoning across the United States.

Since 1998, there have been efforts to try to standardize carbon monoxide poisoning case definitions and data collections and report methods and interest to create an improved data surveillance system. In 1998, the Council of State and Territorial Epidemiologists (CSTE) carbon monoxide surveillance workgroup developed a surveillance case definition for acute carbon monoxide poisoning to provide a nationally consistent measure for carbon monoxide exposures.[16] In 2019, CSTE's position statement was updated to include intentional and unintentional carbon monoxide poisoning cases from multiple data sources. First-tier data include clinical, laboratory, epidemiologic, and exposure data from public health surveillance based on case identification and follow-up investigations. Recommendations for second-tier surveillance data include poison center case records, workers compensation records, health care records, and death certificates. Based on the CSTE position statement, CDC developed the carbon monoxide poisoning message mapping guide as part of the National Notifiable Diseases Surveillance System (NNDSS). Once operational, NNDSS carbon monoxide poisoning surveillance will simultaneously collect standardized carbon monoxide poisoning cases across the available multiple data sources (first and second tiers).[17]

Goals of This Investigation

This study aimed to provide an up-to-date surveillance report of unintentional carbon monoxide poisoning across 4 different data sources. We summarize morbidity and mortality from 2005 to 2018 to better understand unintentional carbon monoxide exposures. This project will inform stakeholders of the historical and current trends of unintentional carbon monoxide exposures and provide baseline data for the new NNDSS carbon monoxide poisoning surveillance.

MATERIALS AND METHODS

Study Design

This is a secondary data analysis of the existing individual-level data sets. We used 4 different data sources to track unintentional carbon monoxide poisoning: poison center exposure calls, ED visits, hospital discharge data, and mortality data for 2005 to 2018.

Data Sources

Poison center exposure case data. NPDS is a near real-time, surveillance system that collects case data. Calls to poison centers are received from both the public and health care professionals. Case data reported through NPDS include basic demographic information (eg, age, gender, state, and management location), exposure substance, clinical effects, and medical outcomes (ie, death, major effect, moderate effect, minor effect, no effect, not followed, and unrelated effect). Additional case criteria included the following: location (50 states and District of Columbia), case type (closed, human, exposures excluding confirmed nonexposure), and reason for exposure (all unintentional exposures). After data analysis, cases with the product codes (manufactured products and diesel engine

exhaust) were excluded. Cases with carbon monoxide generic code and a product code of toxic products of combustion, fire hazards—toxic products of combustion, smoke, carbon monoxide, or null product codes were retained. We removed 3 unintentional reason classifications from the final data set: unintentional—therapeutic, unintentional—bite/sting, and unintentional—food poisoning, leaving a final set of 172,489. The 2019 CSTE position statement classified moderate, major medical outcome, or death as probable cases; whereas minor medical outcome cases were classified as suspected cases per the 2019 CSTE position statement.[16]

ED visits and hospital discharge records. The tracking program receives data annually from tracking recipients (currently 25 states and 1 city). The quality of data entered into the tracking network tool is critical, as these data can affect environmental health surveillance efforts and subsequent public health action and decisionmaking. After state programs submit the data, the tracking program performs multiple layers of data validation to improve data quality. These data validation processes include a simple check for duplicates, descriptive statistics, and trend analysis that compare current data with archived data.[18,19] Because of the different lag time of the data collection per state, we were able to update the discharge data only up to 2018, which is the most up-to-date individual-level data available at the time of this publication and covers the maximum number of the tracking states (26 states). Hospital discharge data from the 26 tracking former and current states (Arizona, California, Colorado, Connecticut, Florida, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Utah, Vermont, Washington, and Wisconsin) and ED visits data from 16 states (Arizona, California, Connecticut, Florida, Iowa, Maine, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, New York State, Rhode Island, Utah, Vermont, and Wisconsin) were included in this analysis.

We defined hospitalization and ED visits on the basis of the admission date when a condition was treated or patient was admitted after treatment for carbon monoxide poisoning diagnoses. Inpatient hospitalizations required a stay longer than 23 hours. Multiple ED visits are considered separate events if they occurred more than 48 hours apart.

The tracking program developed a uniform case definition, based on CSTE's position statement, for recipient-reported unintentional carbon monoxide poisoning cases.[13,16] Carbon monoxide poisoning cases were identified using *International Classification of Diseases*, *Ninth Revision*; *International Statistical Classification of Diseases*, *Tenth Revision* (ICD-10); *International Classification of Diseases*, *Ninth Revision*, *Clinical Modification* (ICD-9-CM) (January 1, 2005, to September 31, 2015), or *International Classification of Diseases*, *Tenth Revision*, *Clinical Modification* (ICD-10-CM) (October 1, 2015, to December 31, 2018) codes. Any records of carbon monoxide poisoning with one or more of the following ICD-9-CM codes (986) in any of the discharge diagnosis fields (primary/principal or other diagnosis fields) or E-code fields (E868.2, E868.3, E868.8, E868.9, E982.0, and E982.1) were included. Any records with a T58 (toxic effect of carbon monoxide) ICD-10-CM code were included. Any intentional or purposeful carbon monoxide poisoning ICD-9-CM or ICD-10-CM codes were excluded from this analysis. All unintentional carbon monoxide poisonings recorded are subcategorized as fire-related, non–fire-related, and unknown mechanisms or intent on the basis of the ICD-10-CM codes.

Death certificates. Carbon monoxide poisoning mortality data were sourced from the National Center for Health Statistic's national vital statistics system (NVSS). We used the NVSS multiple causes of death files for years 2005 to 2018 in 50 states and District of Columbia.[13] Each death certificate contains a single underlying cause of death and up to 20 additional causes. Any death records with the ICD-10 code T58 for any of the cause of death codes were selected; ICD-10 codes X60-Y09, Y35, or Y36 were excluded from the analysis. Unintentional carbon monoxide poisoning–related deaths were assigned to 1 of 3 categories: fire-related (X00-X09), non–fire-related (X47), or unknown mechanism/intent. Foreign nonresidents were excluded from the analysis. All carbon monoxide poisoning–related deaths are confirmed cases per the CSTE position statement.

Analysis

We conducted descriptive analyses (frequency, percent, and prevalence) by demographic characteristics including the following: age groups (0 to 9, 10 to 19, 20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, 70 to 79, ≥80, unknown), sex (female, male), cause (fire-related, non–fire-related, unknown mechanism or intent), and season (spring [March to May], summer [June to August], fall [September to November], winter [December to February]). US census region (Midwest, northeast, west, south) data were available for both poison center exposure case data and death data. Medical outcome (death, major effect, moderate effect, minor effect, no effect, not followed, and unrelated effect), exposure site (residence,

workplace, school, public area, health care facility, restaurants or food service, other, unknown), treatment level, and clinical effects were available only from the poison center exposure data.

To calculate the crude rates per 1 million, we used the intercensal or postcensal annual estimates of the resident population for the United States: April 1, 2005, to July 1, 2018.[18] For ED visits and hospitalizations, rates were calculated using cases and corresponding state population data from 2005 to 2018. To determine whether there was a statistical difference in the crude rate over 14 years, we calculated an average annual percentage change and 95% confidence intervals (CIs) using Poisson regression (PROC GEMMOD) ($P<.05$).

RESULTS

Over the 14-year study period, we observed 172,489 poison center exposure cases in 50 states, 105,833 ED visits in 16 states (representing 42.9% of the US population), 19,230 hospitalizations in 26 states (representing 60.1% of the US population), and 14,448 deaths in 50 states due to unintentional carbon monoxide poisoning. Per 1 million, these represent 39.5 exposure cases, 56.5 ED visits, 7.3 hospitalizations, and 3.3 deaths due to unintentional carbon monoxide poisoning during 2005 to 2018 (Table 1). Non–fire-related carbon monoxide poisoning annual estimates are 5,593 ED visits, 825 hospital visits, and 422 deaths in the United States annually.

Carbon monoxide exposures were most frequently reported among children aged 0 to 9 years in poison center exposure data (17.6%). ED visits were high for young adults aged 20 to 29 years (17.1%) and 30 to 39 years (15.8%). Adults aged 50 to 59 years represented the highest proportions for hospitalizations (19.9%) and deaths (17.3%) (Table 1). Children aged 0 to 9 years had the highest reported rates in poison center exposure and ED visit data (54.1 and 70.5 cases per 1 million, respectively). Conversely, adults older than 80 years had the highest hospitalization rates and deaths (20.2 and 9.9 per 1 million, respectively) (Table 1). Although women comprised more than half of poison center exposure calls (51.8%) and ED visits (51.3%), men were more prevalent among reported hospitalizations (56.6%) and deaths (66.3%) due to unintentional carbon monoxide poisoning. The northeast US census region represented the highest rate of poison center exposure calls (57.2 per 1 million), and the Midwest had the highest mortality rate (5.0 per 1 million). Non–fire-related cases comprised approximately 74.0% ED visit data, 60.1% of hospitalization, and 40.9% of deaths compared with other unintentional causes. Across all data sources, unintentional carbon monoxide poisonings peaked in the winter season (December to February).

In the poison center exposure case data, residential (N=138,493; 80.3%) and workplace exposure sites (N=16,369; 9.5%) were most frequently reported regardless of the management site (on-site versus health care facility) (Table 2). Of the cases with available information, almost half of the poison center exposure calls were treated at a health care facility (45.9%). The minor effect was the most often reported medical outcome treated at a health care facility. Major and moderate effects were reported by 19.6% of poison center exposure calls treated at a health care facility versus 1.5% of the poison center exposure calls were managed on-site ($P<.001$). During the 14-year study period, NPDS reported 551 deaths. Clinical symptoms were reported for 42.6% (N=73,558) of the total carbon monoxide exposure cases, and headache (24.8%), nausea (14.3%), dizziness/vertigo (12.4%), drowsiness/lethargy (5.9%), and vomiting (5.8%) were the most frequently reported symptoms related to carbon monoxide exposure. Other, less commonly reported symptoms included cough/choke (2.6%), confusion (2.1%), dyspnea (2.0%), syncope (1.9%), throat irritation (1.6%), chest pain (1.4%), tachycardia (1.0%), muscle weakness (0.9%), coma (0.8%), and ocular irritation/pain (0.8%) (Table 2).

The crude rate for unintentional carbon monoxide poisoning decreased over the study period for 3 data sources (ED visits, hospitalizations, deaths). Overall, the non–fire-related carbon monoxide poisoning crude rates of ED visits (average annual percentage change, −1.6%; 95% CI −1.43 to −1.77; $P<.0001$), hospitalizations (average annual percentage change, −0.23%; 95% CI 0.22 to −0.68; $P=0.3118$), and deaths (average annual percentage change, −1.4%, 95% CI −0.76 to −2.01; $P<.0001$) decreased from 2005 to 2018. However, the hospitalization and ED visit rates showed temporal increases from 2016 to 2018 (Figure).

LIMITATIONS

The findings in this report are subject to limitations per each data source. First, calls to the poison center centers come from health care professionals or persons voluntarily reporting a poison exposure (a passive reporting system). There are no qualifications necessary to report, which can raise concerns about incorrect identification of exposure and toxicity syndromes. Second, cause classifications (fire-related, non–fire-related, unknown mechanism or intent) were only available from the hospitalization, ED visit, and death data. We classified poison center exposure cases as

Table 1. Morbidity and mortality due to unintentional carbon monoxide poisoning, United States, 2005 to 2018.

	PC Exposure Calls (N=172,489)			ED Visits (16 States, N=105,833)			Hospitalizations (26 States, N=19,230)			Deaths (N=14,448)		
Variable	**N**	**%**	**Rate***	**N**	**%**	**Rate***	**N**	**%**	**Rate***	**N**	**%**	**Rate***
Total	172,489	100	39.5	105,833	100	56.5	19,230	100	7.3	14,448	100	3.3
Age (y)												
0-9	30,415	17.6	54.1	16,566	15.7	70.5	973	5.1	3.0	1,108	7.7	2.0
10-19	16,470	9.5	27.8	13,237	12.5	52.8	824	4.3	2.3	717	5.0	1.2
20-29	22,982	13.3	37.8	18,056	17.1	69.1	1,521	7.9	4.2	1,347	9.3	2.2
30-39	22,666	13.1	39.4	16,728	15.8	67.7	1,930	10.0	5.6	1,499	10.4	2.6
40-49	15,241	8.8	25.5	15,238	14.4	58.9	3,049	15.9	8.5	2,249	15.6	3.8
50-59	11,843	6.9	20.2	12,210	11.5	48.5	3,817	19.9	10.7	2,495	17.3	4.2
60-69	6,325	3.7	14.6	65,48	6.2	35.5	2,885	15.0	11.0	1,967	13.6	4.6
70-79	3,297	1.9	13.0	3,957	3.7	35.6	2,145	11.2	13.8	1,468	10.2	5.8
80+	2,068	1.2	12.8	3,198	3.0	43.3	2,084	10.9	20.2	1,592	11.0	9.9
Unknown	41,182	23.9	NA	95	0.1	NA	2	0.0	NA	6	0.0	NA
Sex												
Female	89,294	51.8	40.2	54,242	51.3	56.9	8,300	43.2	6.2	4,863	33.7	2.2
Male	76,461	44.3	35.6	51,554	48.7	56.0	10,885	56.6	8.4	9,585	66.3	4.5
Unknown	6,734	3.9	NA	37	0.0	NA	45	0.2	NA	—	—	—
Region[†]												
Midwest	45,691	26.5	48.6	NA	NA	NA	NA	NA	NA	4,714	32.6	5.0
Northeast	44,453	25.8	57.2	NA	NA	NA	NA	NA	NA	2,157	14.9	2.8
West	40,474	23.5	24.8	NA	NA	NA	NA	NA	NA	2,746	19.0	1.7
South	41,871	24.3	40.9	NA	NA	NA	NA	NA	NA	4,831	33.4	4.7
Cause[†,‡]												
Fire	26,636	15.4	6.1	4,412	4.2	2.4	2,967	15.4	1.1	6,771	46.9	1.5
Nonfire	NA	NA	NA	78,295	74.0	41.1	11,554	60.1	4.4	5,906	40.9	1.4
Unknown	145,853	84.6	33.4	23,126	21.9	12.3	4,709	24.3	1.8	1,771	12.3	0.4
Season[†,§]												
Winter	69,075	40.0	15.8	41,182	38.9	22.0	7,028	36.5	2.7	5,279	36.5	1.2
Spring	34,945	20.3	8.0	21,575	20.4	11.5	4,226	22.0	1.6	3,472	24.0	0.8
Summer	27,195	15.8	6.2	16,144	15.3	8.6	3,150	16.4	1.2	2,388	16.5	0.6
Fall	41,274	23.9	9.4	26,932	25.4	14.4	4,826	25.1	1.8	3,309	22.9	0.8

PC, Poison center; *NA*, not applicable.

*Total population from 50 states and District of Columbia based on the US Census Bureau data. For hospitalization data, the total population from 26 states was included. For ED visit data, the total population from 16 states was included; rates are provided per 1,000,000.

[†]Variable-specific rates could not be calculated. Total population was used to calculate the rate.

[‡]ED visits, hospitalization, and deaths were categorized as fire-related, non–fire-related, and unknown using *International Classification of Diseases* codes. PC exposures with product codes of toxic products of combustion (3177725), fire hazards (toxic products of combustion) (3177733), and smoke (3403310) are classified as fire-related. PC exposures with product code of carbon monoxide (3428006) or the carbon monoxide generic code (0106000) and a null product code are classified as unknown.

[§]Season: spring (March to May), summer (June to August), fall (September to November), and winter (December to February).

fire-related or unknown if fire-related on the basis of the case's substance. Cases coded as carbon monoxide only (either generic code or not otherwise specified carbon monoxide product code) were classified as unknown if fire-related. Cases using the substance code smoke, toxic products of combustion, or fire hazards (toxic products of combustion) were grouped as fire-related. Substance codes are chosen by the poison specialist on the basis of the caller's history and clinical presentation. Third, the death and poison center exposure data provided national estimates on carbon monoxide mortality and exposure. However, the analysis using ED visit and hospitalization data did not cover all 50 states. Therefore, the annual rates or cases could not represent the national data. Fourth,

Table 2. Exposure site, medical outcomes, and signs and symptoms of persons exposed to unintentional carbon monoxide poisoning by management site—National Poison Data System, United States, 2005 to 2018.

	Total* (N=172,489)		Managed On-Site (N=88,545)		Treated at Health Care Facility (N=79,148)	
Variable(s) of Interest	**N**	**(%)**	**N**	**(%)**	**N**	**(%)**
Exposure site						
Residence	138,493	80.3	74,229	83.8	60,680	76.7
Workplace	16,369	9.5	5,482	6.2	10,439	13.2
School	5,376	3.1	3,474	3.9	1,519	1.9
Public area	5,304	3.1	2,722	3.1	2,497	3.2
Other	5,480	3.2	2,128	2.4	3,119	3.9
Unknown	790	0.5	116	0.1	634	0.8
Health care facility	412	0.2	299	0.3	113	0.1
Restaurant/food service	265	0.2	95	0.1	147	0.2
Medical outcome†						
Death	551	0.3	187	0.2	320	0.4
Major effect	1,917	1.1	28	0.03	1,882	2.4
Moderate effect	15,121	8.8	1,348	1.5	13,592	17.2
Minor effect	43,435	25.2	13,203	14.9	29,500	37.3
No effect	39,674	23.0	28,203	31.9	10,811	13.7
Not followed	59,788	34.6	38,595	43.6	18,320	23.1
Unrelated	12,003	7.0	6,981	7.9	4,723	6.0
Clinical effects (related)	Total‡		Managed on-site		Treated at health care facility	
Headache	42,800	24.8	11,908	13.4	30,062	38.0
Nausea	24,580	14.3	6,338	7.2	17,805	22.5
Dizziness/vertigo	21,360	12.4	5,592	6.3	15,337	19.4
Drowsiness/lethargy	10,253	5.9	2,514	2.8	7,526	9.5
Vomiting	9,984	5.8	1,565	1.8	8,231	10.4
Cough/choke	4,455	2.6	2,113	2.4	2,179	2.8
Confusion	3,541	2.1	401	0.5	3,078	3.9
Dyspnea	3,414	2.0	547	0.6	2,807	3.5
Syncope	3,344	1.9	68	0.1	3,259	4.1
Throat irritation	2,728	1.6	1,725	1.9	933	1.2
Chest pain (including noncardiac)	2,340	1.4	300	0.3	2,008	2.5
Tachycardia	1,811	1.0	69	0.1	1,735	2.2
Muscle weakness	1,469	0.9	225	0.3	1,217	1.5
Coma	1,460	0.8	14	0.02	1,439	1.8
Ocular—irritation/pain	1,324	0.8	860	1.0	402	0.5
Other miscellaneous related clinical effects	22,908	—	4,149	—	18,262	—

*Total includes management sites: patient already in (enroute to) health care facility when PCs were called, and patient was referred by the PCs to health care facility.
†NPDS defines 11 medical outcomes: no effects, minor effect, moderate effect, major effect, not followed (judged as nontoxic exposure), not followed (minimal clinical effects possible), unable to follow (judged as potentially toxic exposure), unrelated effect (the exposure was probably not responsible for the effects), death, death (indirect report), and confirmed nonexposure.
‡A total of 73,558 cases (42.6%) has 157,771 clinical effects (signs and symptoms) reported from unintentional carbon monoxide poisoning during 2005 to 2018. The percentage represents carbon monoxide exposures with that clinical effect.

ICD-10-CM replaced ICD-9-CM to code medical terminology and disease classification in October 2015. This coding change affects information classifications for hospital discharge and ED records in all health care settings. Differences in the counts and rates in years before 2015 (ICD-9-CM) compared with 2015 (ICD-9-CM and ICD-10-CM) and subsequent years (ICD-10-CM) could be a result of this coding change in October 2015 and not

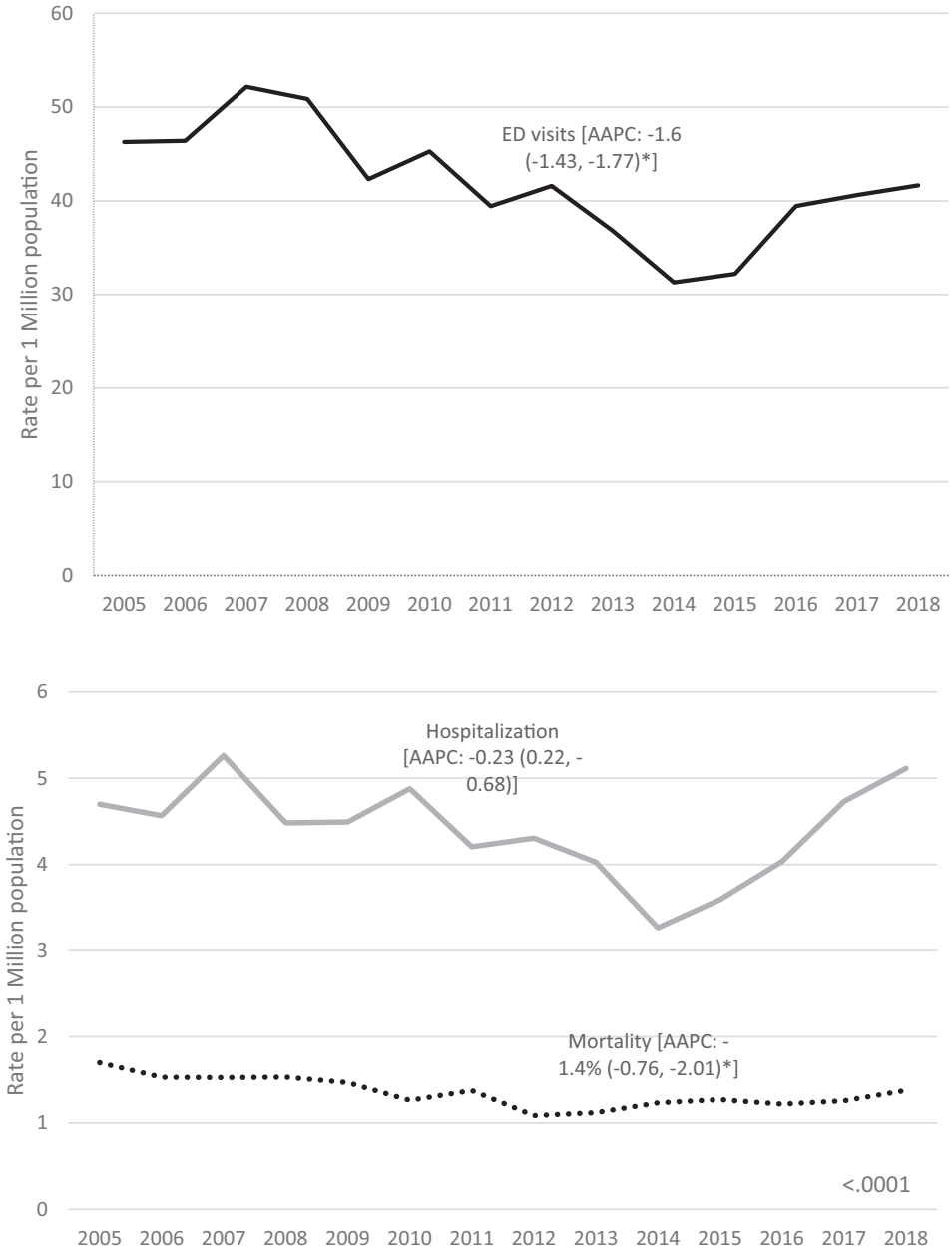

Figure. Rates due to unintentional non-fire carbon monoxide poisoning, United States, 2005-2018. *$P<.0001$. *AAPC*, average annual percentage change.

an actual difference in the number of events. Fifth, although duplicate records for the same ED visit are excluded, the ED visits and hospitalizations are based on occurrences, not individuals, because a unique identifier is not always available. When multiple admissions for the same person during the year are not identified, the rate is calculated as the number of events per 1 million, which is an overestimate of the proportion. Finally, death investigation laws vary by location, potentially leading to variations in how medical examiners/coroners/physicians assign intentionality.

DISCUSSION

This report provides a summary of unintentional carbon monoxide exposure/poisonings from poison center exposure case data, ED visits, hospital discharges, and death data for 2005 to 2018. Our study focused only on

unintentional carbon monoxide poisoning cases, including fire-related and non–fire-related causes.

Our demographic trends for unintentional carbon monoxide poisoning were consistent with those of some previous studies.[3,6,9,20] Children and younger adults represented the most frequently reported exposures in poison center exposure case and ED visit data; however, carbon monoxide exposure-related deaths occurred more often among men and older adults (aged ≥80 years) and in the Midwestern region.[1,6,9,20,21] Exposures most often occurred during the winter season across all study years.

Children and the elderly may be more vulnerable to carbon monoxide poisoning because of their increased metabolic demand, inability to vocalize symptoms, and/or mobility restriction.[11] Mobility may be especially important considering seeking medical care and procurement of rapid diagnosis and treatment increase the likelihood of desirable outcomes.[22,23] Older adults may have higher rates of underlying comorbidities or conditions at the time of carbon monoxide exposure, potentially leading to further complications.[22,23] Awareness, recognition and management of the signs and symptoms of carbon monoxide poisoning requires educational programs be provided for emergency physicians, clinical toxicologists, and neuroradiologists to speed up diagnosis and treatment to reduce unintentional carbon monoxide exposure-related morbidity and mortality rates among vulnerable populations.[7,24,25]

We observed significantly decreased crude rates in non–fire-related carbon monoxide poisonings from ED visits and mortality over the study period (ie, 2005 to 2018). Using the population-based discharge data from the tracking program, our study shows a slight decrease in the ED visits (56.5 per 1 million) and hospitalization (7.3 per 1 million) rates compared with the previous study.[9] The previous study reported 71 ED visits and 8 hospitalizations per 1 million during 2000 to 2009; however, their estimates were based on the nationwide ED and inpatient sample data in the Healthcare Cost and Utilization Project.[9] We also observed a slightly increasing trend in ED visits and hospitalization rates from 2016 to 2018. This temporal trend shift may be related to the transition in reporting ICD-9-CM to ICD-10-CM codes in October 2015 and may make temporal comparison challenging in trends of hospital discharge data moving forward.[6,16] A previous study reported that non–fire-related carbon monoxide poisoning mortality did not substantially decrease from 2000 to 2014.[1] Using the same data source, non–fire-related carbon monoxide poisoning mortality showed a significant decrease during our study period. The death certificate data provide a more comprehensive estimate across the states where ICD-10 codes were assigned consistently during the full study period.

The CSTE position statement defines and classifies cases as confirmed, probable, and suspect by data source and medical outcome.[16] After exclusions, all probable poison center cases with moderate, major, and death medical outcomes and suspect calls (minor medical outcome) were included in this analysis. Only confirmed or probable hospital discharge cases and confirmed death cases were included in this analysis. Among 172,489 poison center exposure calls, we observed 17,589 probable (10.2%) and 43,435 suspect (25.2%) carbon monoxide exposures.

Our surveillance report provides a summary of the morbidities and mortality of unintentional carbon monoxide poisonings. In 2019, as a part of the NNDSS Modernization Initiative, CDC developed the carbon monoxide poisoning message mapping guide to collect standardized data elements across multiple data sources.[17] This single platform containing pertinent data sources will save valuable time and resources, improve data transmission, and reduce the burden of case reporting and duplicates. The standalone surveillance system is important to summarize and update the surveillance report for carbon monoxide exposures and poisoning timely and will incorporate different data sources and make it possible to link cases using personal identifiers or exposure information for the event. The new NNDSS system will timely collect case-based carbon monoxide poisoning data across data sources; therefore, it will drive accurate public health policy and actions ultimately aimed at reducing mortality and morbidity caused by carbon monoxide poisoning.[26,27]

In conclusion, this surveillance report provides the baseline data for the new CDC case surveillance, a national NNDSS system for carbon monoxide poisoning. The more standardized and continued public health surveillance of carbon monoxide poisoning is necessary to monitor the public health burden and assess the effectiveness of targeted prevention strategies. A comprehensive approach and public health responses from federal, state, and local public health agencies will play a role in enhancing public health surveillance and highlight the importance of the case-based carbon monoxide poisonings surveillance.

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