Preventive Medicine Reports 24 (2021) 101531

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Analyzing the national fire incident reporting system to identify carbon monoxide incidents in the U.S. lodging industry

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ARTICLE INFO

Keywords:
Carbon monoxide
Hotels
Exposure
Carbon monoxide alarms
NFIRS

ABSTRACT

Carbon Monoxide (CO) poisonings in the U.S. lodging industry have become a regular occurrence, however there is no current mandatory national reporting, tracking, or surveillance mechanism for CO incidents in the U.S. lodging industry. As such, the problem is largely invisible. The objective of this study was to utilize the National Fire Incident Reporting System (NFIRS) data to better understand the public health risk from Carbon Monoxide (CO) incidents in the U.S. lodging industry. The NFIRS datasets for years 1999 through 2018 were assessed to identify CO incidents occurring at U.S. hotels and motels. The results of the analysis identified 3405 incidents. Incidents were strongly correlated with increased fire department participation in NFIRS (R = 0.82). The number and frequency of CO incidents in the U.S. lodging industry are underreported. Previous efforts relying on news media identified only 10% of the incidents reported in the NFIRS data. This indicates a greater public health risk associated with CO exposure in the U.S. lodging industry than previously realized.

1. Introduction

Accidental carbon monoxide (CO) poisonings account for 50,000 emergency department visits and 430 deaths annually in the U.S. (CDC, 2020) The danger of CO is well known (Lehr, 1970; Lewis, 2016; Mayers, 1927; Wheeler-Martin et al., 2015) and poisonings in the U.S. lodging industry have become a regular occurrence, however there is no current mandatory national reporting, tracking, or surveillance mechanism for CO incidents in the U.S. lodging industry. As such, the problem is largely invisible.

The objective of this study was to utilize the National Fire Incident Reporting System (NFIRS) data to better understand the public health risk from CO incidents in the U.S. lodging industry. Previous efforts to identify incidents have relied heavily upon exhaustive searches of news media and publicly available sources such as legal databases. This study examines the NFIRS data to identify lodging related CO incidents to develop a more comprehensive understanding of the public health threats posed by these incidents.

2. Methods

A previously underutilized data source for identifying lodging CO incidents is NFIRS, which serves as a uniform reporting standard and repository of data from fire department responses to a variety of incidents across the U.S. (Administration USF, 2020)

The NFIRS database contains approximately 75 percent of all reported fires (and fire department responses) that occur annually in the United States. After responding to an incident, a fire department representative completes the appropriate NFIRS data entry modules based on the nature of the emergency. Each module collects a common set of information that describes the nature of the emergency, the actions taken in response to the emergency, and resulting outcomes. (Administration USF, 2020).

Since 1999, the NFIRS Version 5.0 reporting system has included a property type specifically for commercial hotels or motels (Prop_Use = 449) and an incident type specific to CO incidents (Inc_Type = 424). Incidents in which no hazardous conditions were identified upon fire department arrival (i.e. a false alarms) are classified as Inc_type = 736 and 746; these types of incidents were excluded from this study. The NFIRS datasets for 1999 through 2018 were analyzed in this study. The Basic Incident datasets were joined with the Address datasets using the common unique incident number. This combined data set was then filtered based on incidents matching property use '449' and incident type '424' to determine the number of reported CO incidents occurring

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https://doi.org/10.1016/j.pmedr.2021.101531
Received 19 May 2021; Received in revised form 17 August 2021; Accepted 22 August 2021
Available online 26 August 2021

Table 1
Fire department responses to CO related incidents in U.S. lodging industry 1999–2018 as recorded by NFIRS and previous studies.

Year	Annual U.S. Lodging Industry CO Incidents Identified by Source				Fire Departments Reporting to NFIRS
	NFIRS (1999–2018)	Hampson et al.[b] (2005–2018)	Weaver et al. (1989–2004)	The Jenkins Foundation	
1967–98	–	–	38	143	–
1999	3	–	3	3	11,173
2000	7	–	4	8	11,351
2001	30	–	6	6	13,020
2002	30	–	4	3	14,372
2003	52	–	7	5	17,257
2004	56	–	6	11	18,776
2005	85	Data not categorized by year.	–	4	19,590
2006	84	n = 14 years	–	10	20,411
2007	120		–	5	21,162
2008	176		–	7	21,263
2009	172		–	9	21,457
2010	187		–	9	21,502
2011	228		–	13	21,915
2012	214		–	7	21,960
2013	276		–	25	21,585
2014	308		–	17	21,980
2015	330		–	11	22,610
2016	303		–	17	22,712
2017	343		–	15	22,823
2018	404		–	15	22,735
2019	–	–	–	21	–
2020[c]	–	–	–	3	–
Total	3405[d]	115	68	367	
Frequency (incidents/year)	170.25	8.21	4.25	6.80	

[b] Hampson et al does not provide incidents identified by year; Total incidents are identified by state for the time frame 2005–2018.
[c] Current as of September 2020; Incomplete data available for entire year.
[d] This study identified 3408 CO incidents in the lodging industry, however 3 of these were fire department responses canceled en route to the call and are not included in the total number of actual incidents.

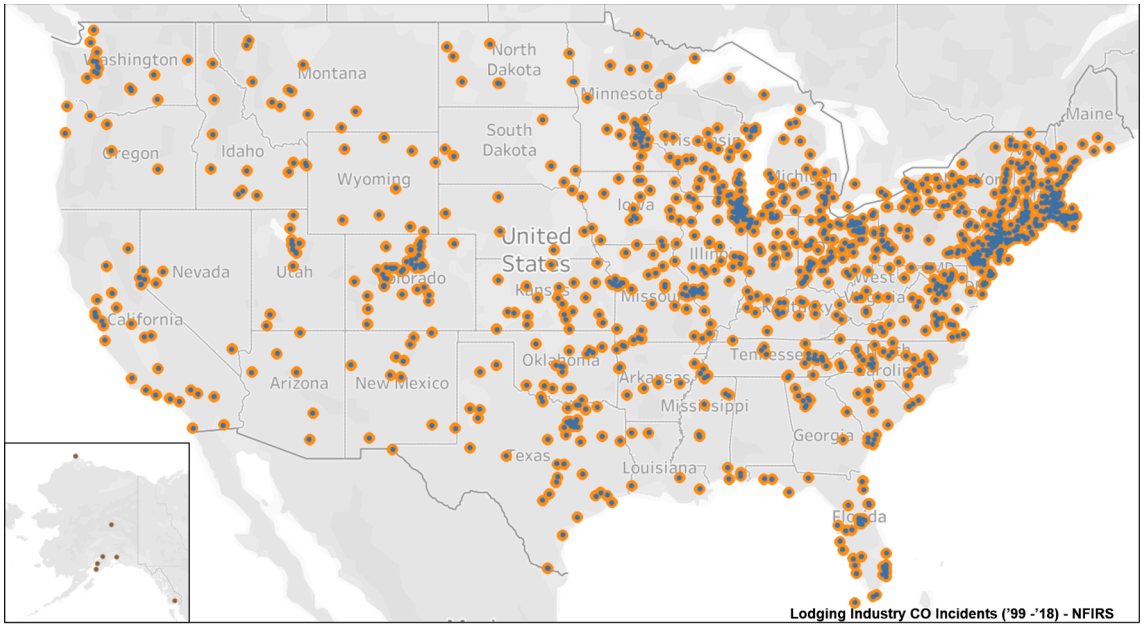

Fig. 1. Heat map of CO incidents in U.S. lodging industry identified using NFIRS.[e] [e]Note: Further details on each incident identified can be viewed using the interactive map found at https://remrisk.com/resources/carbon-monoxide-hotels/.

at a commercial hotel or motel.

3. Results

The analysis of the NFIRS data identified 3405 CO incidents in the U. S. lodging industry (commercial hotels and motels) between 1999 and

2018. When compared to other property types, the total number of CO incidents at lodging properties second only to restaurants and cafeterias.[a] The lodging industry CO incidents identified by NFIRS are compared to the previous efforts in Table 1. A map showing the relative location of the incidents identified in Table 1 is presented in Fig. 1; Supplemental Fig. 1 shows the scatter plot of the data presented in Table 1.

For each incident recorded in the NFIRS system, departments can select up to three predefined sequential actions when arriving on scene, a primary action and two additional actions. All incidents reported at least a primary action, 1523 of the incidents reported a single additional action, and 675 reported a second additional action, for a total of 5603 fire department actions taken during the 3405 incidents as summarized in Supplemental Table 1.

NFIRS maintains an optional EMS module that departments can complete if the fire department provides emergency medical service. The module is not used by non-fire department EMS services, which make up a 60 percent of the country's EMS capabilities (Mears et al., 2012). Fire department EMS apparatus responded during 458 of the 3405 CO incidents identified, but only three of these incidents were recorded in the optional NFIRS EMS database. While EMS data was not available for a majority of the incidents, the data regarding actions taken on scene indicate that basic life support was administered 29 times (action code 32) and advanced life support was administered 25 times (action code 33). Emergency medical services or first aid was administered at least 17 times (action codes 30–31), and persons were transported from the scene in an ambulance or other apparatus at least twelve times (action code 34). Based on the recorded actions taken, some sort of injury to the public was reported during 83 of the 3405 CO incidents. Fourteen firefighters were reportedly injured during the incident responses across 7 incidents. While this is not a complete record of the true impact to public health, previous studies on fire department responses to residential CO alarms identified that between 5 and 13% of calls result in symptoms of CO poisoning (Bizovi et al., 1998), indicating that there are likely additional incidents with injuries that are not reflected in the NFIRS data.

4. Discussion

The three previous efforts to identify CO incidents in the U.S. lodging industry have all identified far fewer incidents than those reflected in NFIRS. Each study has identified differing frequencies for lodging industry CO incidents per year and injuries and deaths caused by each incident:

- Weaver et al (2007) identified 68 incidents resulting in 27 deaths and 772 injuries between 1989 and 2004 (Weaver and Deru, 2007). This equates to 115 incidents over 16 years (8.21 incidents/year; 0.19 deaths and 7.87 injuries per incident)
- Hampson et al. (Hampson et al., 2019) identified 115 incidents resulting 22 deaths and 905 injuries between 2005 and 2018 (Hampson et al., 2019). This equates to 68 incidents over 14 years (4.25 incidents/year; 0.44 deaths and 6.56 injuries per incident)
- The Jenkins Foundation continuously tracks and studies the frequencies of occurrence and common causes of CO incidents in the lodging industry (The Jenkins Foundation, 2020). The foundation has identified a total of 367 incidents to date, resulting in 161 deaths and 2407 injuries between 1967 and 2020. This equates to 367 incidents over 54 years (6.80 incidents/year; 0.44 deaths and 6.56 injuries per incident)

Differences in frequencies are likely due to varying approaches in identifying incidents and the time periods assessed. Based on the NFIRS data, the lodging industry experienced 3405 CO incidents from 1999 to 2018, or 170.3 incidents per year. This suggests that the frequency of CO incidents in the U.S. lodging industry was previously underreported in publicly available sources by a factor ranging from 20.73 to 40.05. This is likely due to only a small percentage of incidents being deemed 'newsworthy'.

The NFIRS data indicated fire departments provided CO related response information to the public or the media (action code 83) in only 20 of the 3405 incidents identified (0.59%). The number of lodging industry CO incidents and the number of fire departments participating in NFIRS (as seen in Table 1) were found to have a strong correlation ($R = 0.82$). As fire department participation in NFIRS is voluntary (only 24,112 out of 29,705 active U.S. fire departments reported to NFIRS in 2018) (Administration USF, 2020; Administration USF, 2019), the frequency of CO incidents in the lodging industry is likely further underreported.

5. Conclusions

The NFIRS data assessment indicates that the public is being exposed to dangerous levels of CO during stays at lodging properties more frequently than previously realized. While the NFIRS EMS data is only available for approximately 1% of lodging industry CO incidents, the data available shows injuries are occurring to the public and to first responders. The harm caused to the public by these incidents is likely much greater than the NFIRS data indicates. Applying the frequencies of injury and deaths observed by the previous efforts to the NFIRS data indicates a potential for 651 to 1498 deaths and 22,336 to 38,657 injuries to have been caused by CO incidents in the U.S. lodging industry over the last 20 years.

To better protect the public from CO exposure, the U.S. lodging industry needs to implement a risk-based approach for building design, equipment selection, and life safety system design. Adopting a methodology such as the hierarchy of controls to assist in making these decisions would help reduce the likelihood of CO exposure and systematically reduce risk of an incident. This approach should be applied to both existing buildings as well as new construction.

Suggestions for future research include the development of a CO risk reduction strategy for the lodging industry, a study of the true cost of fire department responses to CO incidents in the lodging industry, and a detailed study of the injuries resulting from the incidents identified in this study.

CRediT authorship contribution statement

Patrick K. Smith: Conceptualization, Investigation, Visualization, Writing – original draft. **Benjamin N. Craig:** Writing - review & editing. **Kristina L. Hauschildt:** Conceptualization, Writing - review & editing. **Michael D. Larrañaga:** Conceptualization, Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The research presented in this paper is that of the authors and does not reflect the official policy of NFIRS or the U.S. Fire Administration. Funding for this paper was provided by R.E.M. Risk Consultants.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

[a] See Supplemental Table 2

org/10.1016/j.pmedr.2021.101531.

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