RESEARCH ARTICLE

Racial and ethnic trends in unintentional carbon monoxide poisoning deaths

Neil B. Hampson, MD

Virginia Mason Medical Center, Seattle, Washington, and
University of Washington School of Medicine, Seattle, Washington U.S.

CORRESPONDING AUTHOR: Neil Hampson – *neil.hampson@gmail.com*

ABSTRACT

Objective: Government programs have attempted to impact a recognized elevated risk for carbon monoxide (CO) poisoning among minority racial and ethnic groups. This study sought to describe U.S. mortality due to unintentional, non-fire-related CO poisoning, examining the distribution and trends by race and ethnicity.

Methods: CDC Wonder was used to extract and analyze data on all U.S. resident deaths from unintentional CO poisoning from 2000-2017, categorizing them by year, race, ethnic origin and gender.

Results: The absolute number of unintentional CO deaths decreased from about 450 to 380 per year during the period studied, a number near totally accounted for by the decrease in deaths occurring among non-Hispanic/Latino whites. The number of deaths among the remainder of the population did not significantly change. However, greater growth in minority populations resulted in a similar decline in the mortality rate between non-Hispanic/Latino whites and the combined minority population. The decline in combined minority death rate resulted from a decrease in the Hispanic/Latino white rate. Death rate did not decline in the black or African American population.

Conclusions: All minority groups continue to display a disproportionate number of unintentional non-fire-related CO poisoning deaths compared to non-Hispanic/Latino whites. The decrease in U.S. deaths from unintentional non-fire-related carbon monoxide poisoning from 2000-2017 is accounted for by a decrease in non-Hispanic/Latino white deaths. While numbers of such deaths among minority groups have not changed since 2000, increases in the size of minority populations have resulted in a declining crude death rate for Hispanic/Latino whites.

KEYWORDS: carbon monoxide poisoning; minority race; ethnic groups; risk

INTRODUCTION

As in all industrialized societies, carbon monoxide (CO) poisoning is a significant public health problem in the United States, with unintentional non-fire-related (UNFR) CO poisoning responsible for more than 20,000 emergency department visits annually [1,2]. UNFR CO poisoning is also the cause of approximately 400 deaths in the country each year [3,4].

The roles of minority race/ethnicity and often associated English language barriers have been previously described as risk factors for UNFR CO poisoning. A number of studies over the past three decades have reported that members of minority racial and ethnic groups are disproportionately represented among those evaluated, treated, or dying from CO poisoning [5-12].

A decline in overall deaths due to UNFR CO poisoning was seen from 1968-1998 [13] and from 1999-2014 [3], attributed at least in part to progressively stringent regulations on automobile emissions, as well as public education programs targeting at-risk groups, and possibly home carbon monoxide alarms. CO production by automobiles has been correlated with a decrease in both unintentional and intentional CO death rates [13,14]. Public education programs have included development of CO-related educational materials in multiple languages [15], warning labels with non-verbal pictograms, and promotion of targeted neighborhood awareness programs [10,16]. A majority of states have mandated installation of CO alarms in at least some type of domicile, which has resulted in increased use where assessed and has been calculated to be cost-effective [17,18].

This study sought to examine the decrease in UNFR CO mortality by race and ethnicity to determine whether there is evidence the targeted prevention efforts have been effective. Specifically, the study sought to evaluate whether decreases in UNFR CO deaths from 2000-2017 have been distributed equally across racial and ethnic groups or whether some groups have benefited more than others.

Table 1: Number of total and unintentional CO deaths in the US from 2000-2017 by race/ethnicity

	ALL DEATHS		CO DEATHS	
	number (M:F)	percent (M:F)	number	percent
White, not Hispanic or Latino	36,236,035 (17,836,338:18,399,697)	80.0	5,287 (3,920:1,367)	70.6
Black or African American	5,366,974 (2,740,768:2,626,206)	11.8	1,060 (746:314)	14.3
White, Hispanic or Latino	2,543,601 (1,405,546:1,138,055)	5.6	797 (642:155)	10.8
Asian or Pacific Islander	914,275 (475,518:438,757)	2.0	175 (113:62)	2.4
American Indian or Alaskan Native	276,285 (151,040:125,245)	0.6	89 (66:23)	1.2
	45,337,170		**7,408**	

METHODS

Annual U.S. data on number of deaths and crude death rate from CO poisoning, exposure intent, and decedent race/ethnicity were obtained using CDC Wonder [19]. This is an open-access online search system offered by the U.S. Centers for Disease Control and Prevention (CDC) for disseminating public health data. The file "Multiple Cause of Death 1999-2017" was utilized [20]. It contains mortality data drawn from all death certificates filed in the country for U.S. residents. States provide coded data from death certificates to the National Center for Health Statistics (NCHS) or coding is done by NCHS from copies of state death certificates. Coding is performed by a standardized method [21]. Underlying and multiple causes of death are indexed by ICD-10 codes, 113 selected causes of death, injury causes, and drug/alcohol induced causes of death. Each death certificate record contains a single underlying cause of death (UCD), up to 20 additional multiple causes, and demographic data [21]. Race is coded as American Indian or Alaska Native (AIAN), Asian or Pacific Islander (API), Black or African American (BAA), or White. Ethnicity is identified as Hispanic/Latino or not Hispanic/Latino. Hispanic/Latino is defined as a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin.

Unintentional CO poisoning deaths were identified in CDC Wonder by requesting results grouped by year, race, Hispanic origin, gender and underlying cause of death. The UCD terms "All Causes of Death," "Unintentional," and "Poisoning," then ICD-10 code T58 (Toxic effects of carbon monoxide) plus code X47 (Unintentional poisoning by and exposure to other gases and vapours) were used for the Multiple Cause of Death field. Codes related to fires were not included in this analysis.

Population figures reported for 2000 and 2010 are April 1 Census counts. For 2001-2009, they are intercensal bridged race estimates of the July 1 population by NCHS and for 2011-2017 are postcensal bridged-race estimates of the July 1 resident population [19]. All reported population counts are those published and utilized for calculation of death rates by NCHS. When the numerator (number of deaths) is less than 20 in a year, mortality rate in felt by NCHS to be unreliable and is not calculated. Crude death rates per million reported are those obtained from CDC Wonder.

Two-tailed logistic regression was utilized to evaluate trends [22] and covariance analysis to compare slopes of linear regression lines [23].

RESULTS

From 2000 to 2017, a total of 45,337,170 individuals died in the United States, with the racial/ethnic distribution shown in Table 1. Race and ethnicity were identified in 100% and 99.7% of all records, respectively. Numbers of individuals identified as being of Hispanic/Latino

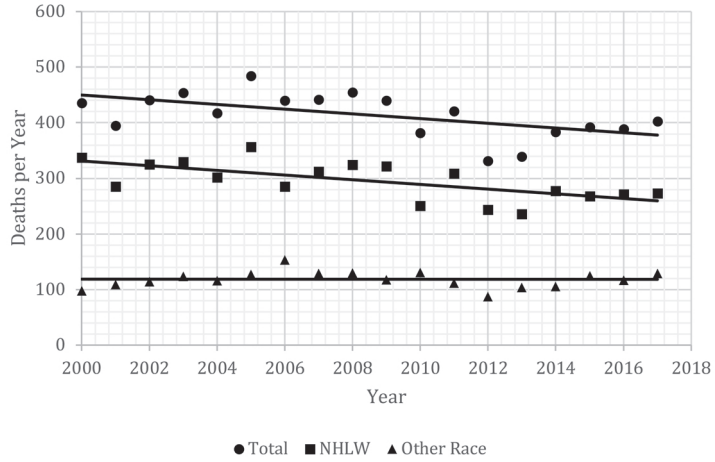

FIGURE 1. Annual number of unintentional CO deaths in the U.S. from UNFR CO poisoning by racial group.
Total = total population, NHLW = non-Hispanic or Latino whites, Other = all minority racial/ethnic groups combined.

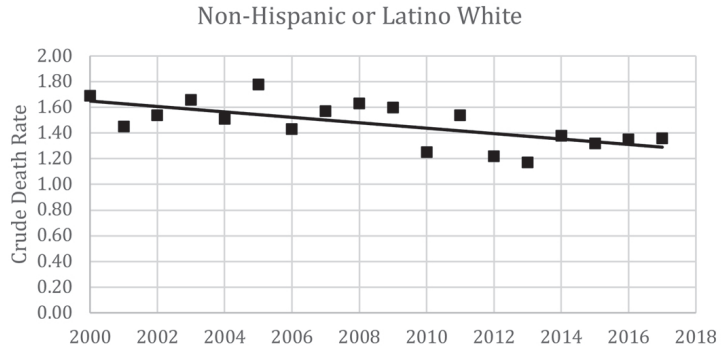

FIGURE 2A. UNFR CO poisoning crude death rates per million from 2000-2017 in non-Hispanic/Latino white population (p = 0.0014).
P-value denotes significance of change over time.

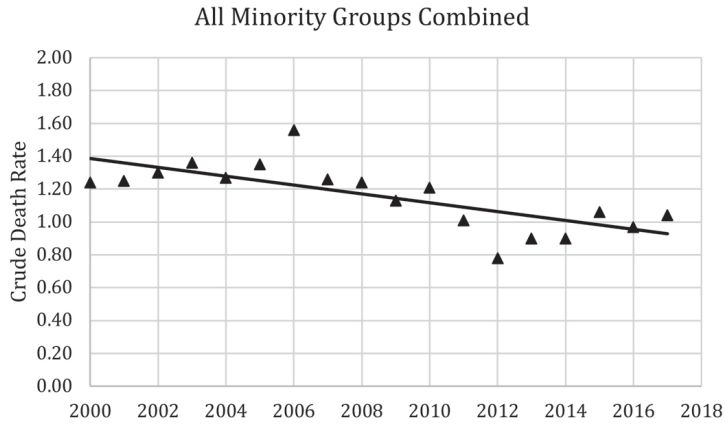

FIGURE 2B. UNFR CO poisoning crude death rates per million from 2000-2017 in all minority groups combined (p=0.0001).

ethnicity and a race other than White were so small (<1%) that they were combined with their designated racial group and not separately analyzed. The white population, however, was divided into NHLW (93%) and Hispanic/Latino white (HLW) (7%). Over the same time period, 7,408 individuals died from UNFR CO poisoning. Racial distribution and gender are again shown in Table 1. Hispanic origin was recorded for 99.7%. Overall, males accounted for 74% of CO deaths, with individual racial/ethnic groups ranging from 65% among API to 81% among HLW.

Total unintentional CO deaths decreased in the United States during the period examined (Figure 1, p=0.0124). Figure 1 also demonstrates a decline in NHLW deaths (p=0.0029), but no significant decrease in number of deaths among the combined minority populations (p=0.9233). No individual minority group experienced a significant change in number of deaths. The decline in total deaths was not different than the decline in NHLW deaths (p=0.9999). The same was true for gender, with the number of minority female and male deaths not significantly changing (p=0.2220 and p=0.6405, respectively), while the number of NHLW deaths decreased for both females (p=0.039) and males (0.003).

Over the 18 years examined, the racial/ethnic composition of the U.S. population changed [20]. From 2000 to 2017, the NHLW population increased 2%, BAA 24%, HLW 61%, API 75%, and AIAN 57% (Table 2). As a result, mortality trends described for each group differ when death rates are considered instead of absolute number of deaths. From 2000 to 2017, the crude death rate for both the NHLW and the combined minority populations decreased (Figure 2a, p=0.0014 and Figure 2b, p=0.0010, respectively). The rate of decline was not significantly different (p=0.9834).

When examining individual minority groups, crude death rate in the HLW population significantly declined (Figure 3a, p=0.0060), as a result of population growth

Table 2: U.S. population by race/ethnicity in 2000 and 2017, with interval change

	POPULATION		
	2000	**2017**	**Change**
White, not Hispanic or Latino	197,324,684	201,240,793	+2%
Black or African American	36,594,309	45,883,808	+24%
White, Hispanic or Latino	32,761,078	52,694,857	+61%
Asian or Pacific Islander	11,757,685	21,210,673	+75%
American Indian or Alaskan Native	2,984,150	4,689,047	+57%
Totals	**281,421,906**	**325,719,178**	**+16%**

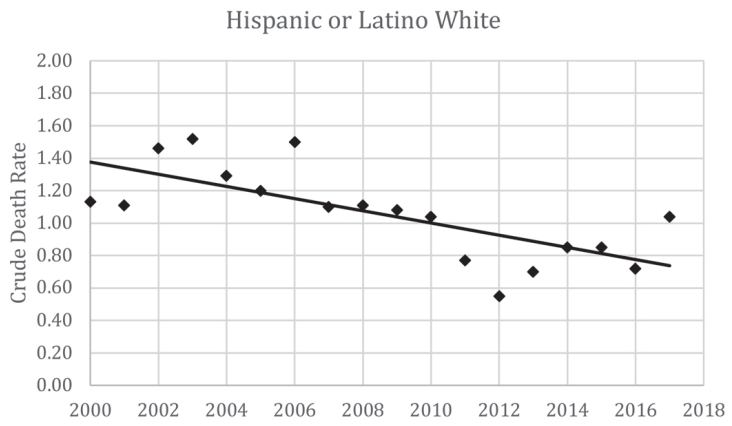

FIGURE 3A. UNFR CO poisoning crude death rates per million from 2000-2017 in Hispanic/Latino white population (p=0.006).

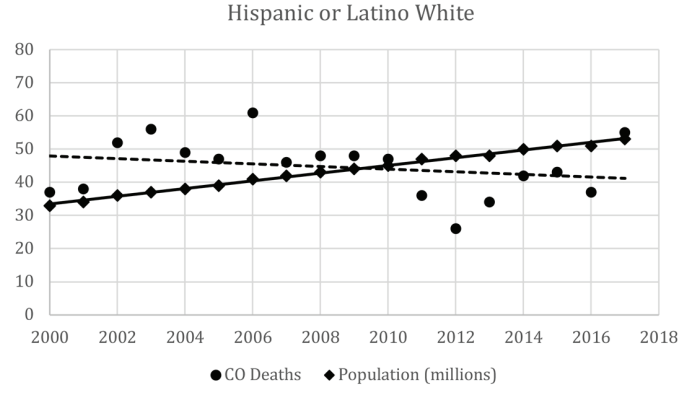

FIGURE 3B. Hispanic/Latino population (diamond markers, solid line) and number of UNFR deaths (circle markers, dashed line).

in the face of stable total numbers of CO deaths (Figure 3b). Conversely, the crude death rate for BAA did not significantly change (Figure 4a, p=0.5947), the result of similar proportionate growth in the numbers of CO deaths and population (Figure 4b). Annual death rates in the API and AIAN populations are not available because they were characterized as unreliable by NCHS.

Crude death rate decreased significantly in the female NHLW population (p=0.0161). Death rate decreased significantly in the male HLW and NHLW populations (p=0.012 and p=0.0016, respectively) while death rate in the male BAA population did not significantly change (p=0.8982). Death rates in female minority groups and male AIAN and API were characterized as unreliable by NCHS.

DISCUSSION

This study has at least three important findings. First, the decrease in number of UNFR CO deaths from 2000-2017 was explained almost entirely by a decrease in deaths in the NHLW population. This was true among both males and females. Of the 72 fewer annual deaths occurring over that time span, 71 were in the NHLW population and one occurred in the combined minority population. Second, when changes in population

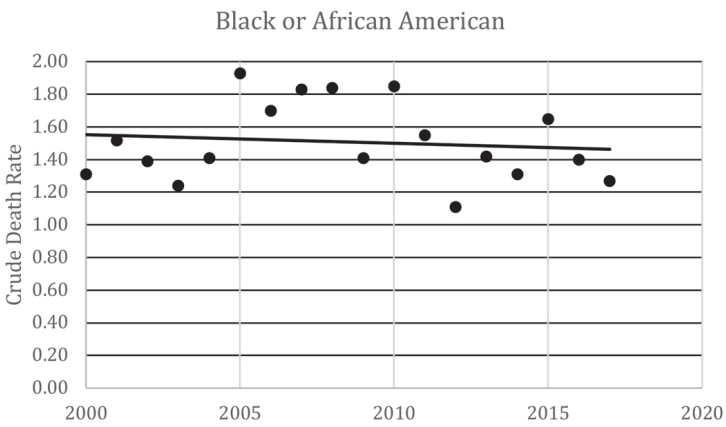

FIGURE 4A. UNFR CO poisoning crude death rates per million from 2000-2017 in the black or African American population (p=0.5947).

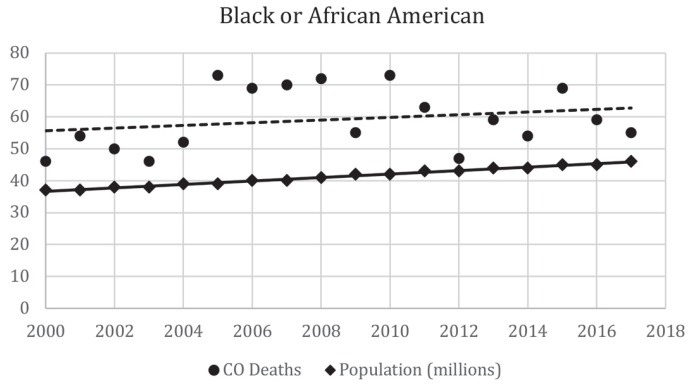

FIGURE 4B. Black or African American population (diamond markers, solid line) and number of UNFR deaths (circle markers, dashed line).

demographics are taken into account, the crude death rate from UNFR CO poisoning is seen to have decreased similarly in the NHLW and combined minority populations. Third, almost all of the reduction in crude death rate seen in the combined minority group is due to a decrease in the HLW rate. The crude death rate for UNFR CO poisoning for BAA did not significantly change during this time period.

Earlier studies have described an increased risk for fatal CO poisoning among minority racial and ethnic groups. In 1991, workers at the Centers for Disease Control and Prevention (CDC) reported a 20% higher death rate from unintentional CO poisoning among blacks compared to whites from 1979-1988 [5]. Similarly, a retrospective study of deaths from CO poisoning due to house fires in a metropolitan Ohio county from 1988-1998 showed higher race-specific death rates for blacks than whites [8]. Another CDC report on unintentional U.S. CO deaths covering 1999-2004 reported the highest death rates were among blacks [12]. The present data support this, showing that members of minority racial/ethnic groups are disproportionately represented among UHFR CO deaths relative to their representation in the population (Table 1).

Non-fatal CO poisoning has been reported to affect minority racial/ethnic groups disproportionately. In studies describing the treatment experience at a regional referral center in Seattle, blacks and Hispanic/Latino whites were over-represented in comparison to the regional population [7, 11]. One reason proposed for increased minority risk is non-English speaking by first-generation immigrants to the United States, with inability to comprehend English language verbal warning labels on CO sources. Two studies from Seattle reported an increased risk of poisoning from charcoal briquettes for non-English speaking minority immigrants [6,10]. In the 1992 report, the most frequent primary language in this group was Spanish or Vietnamese. By 2006, that had changed to Somali.

Lack of awareness that continuation of specific cultural practices carries increased risk for CO exposure after immigration to the United States is possible. For example, poisoning could result from indoor use of charcoal in a dwelling that is more airtight and less ventilated than those in their country of origin.

The possibility has been proposed that reduced knowledge and/or lack of use of CO alarms is placing minorities at risk. In a CDC household survey, awareness of a local CO alarm ordinance in a North Carolina county was not associated with any particular racial group [24]. However, in a Connecticut emergency department survey, the reported use of CO alarms was 58% among non-Hispanic/Latino whites, 42% for blacks or African Americans, and 25% among Hispanic/Latino whites [25].

Initiatives such as production of warning labels and educational material in numerous languages [15], as well as development of targeted educational programs at local levels [10,16] have attempted to address the issue.

The present study suggests that these programs may be having an effect, at least among the Hispanic/Latino whites. While the number of deaths in the HLW population has been stable, a 61% increase in the size of this group since 2000 has resulted in a significant reduction in the mortality rate (Figures 3a and 3b). In contrast, a 24% increase in the BAA population was accompanied by a similar increase in number of deaths, resulting in an unchanged death rate (Figures 4a and 4b). Annual UNFR CO poisoning death rates for the API and AIAN populations are not available from CDC Wonder due to small sample size.

The reasons for the lack of improvement in the UNFR CO death rate in the BAA population are unclear. Knowledge of the sources of CO could potentially help explain this. Unfortunately, changes in death certificate coding that occurred with the 1999 switch from ICD-9 to ICD-10 discontinued recording of CO source. It will be necessary to obtain contemporary data from the treatment experience of large referral centers or multicenter collection systems to examine current CO source by race at a national level.

LIMITATIONS

Limitations of this study include the fact that sample sizes for API and AIAN populations were inadequate to meet the NCHS minimum requirement for death rate calculations. This precluded assessment of death rate trends in those two groups. In addition, lack of information about CO sources limits evaluation of targeted efforts at exposure prevention, while also precluding explanation of the apparent failure of prevention efforts in the BAA population. Finally, CDC Wonder data exclude deaths of non-residents (e.g., non-resident aliens, residents residing abroad and those living in U.S. territories).If non-resident aliens are overrepresented by members of minority racial/ethnic groups, the current numbers would underestimate the problem.

CONCLUSIONS

This study demonstrates the decrease in deaths from unintentional non-fire-related carbon monoxide poisoning in the United States from 2000-2017 is accounted for by a decrease in the number of deaths in the non-Hispanic/Latino white population. While numbers of such deaths among minority groups have not changed since 2000, increases in the size of minority populations have resulted in a declining crude death rate for Hispanic/Latino whites, but not black or African Americans. Targeted CO poisoning prevention efforts may be reaching only some minority populations.

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Conflict of interest statement
The author reports that no conflict of interest exists with this submission.

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