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Economic implications of unintentional carbon monoxide poisoning in the United States and the cost and benefit of CO detectors☆,☆☆

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Abstract

Background: Unintentional non-fire-related (UNFR) carbon monoxide (CO) poisoning has been among the leading causes of poisoning in the United States. Current estimation of its economic burden is important for an optimal allocation of resources for UNFR CO poisoning prevention.

Objective: This study was to estimate the morbidity costs of UNFR CO poisoning. We also compared the costs and benefits of installing CO detectors in residences.

Methods: We used 2010–2014 charges and cost data from Healthcare Cost and Utilization Project (HCUP), and Truven© Health MarketScan Commercial Claims and Encounters and Medicare Supplemental data. We directly measured the morbidity cost as the summation of costs for different healthcare services. Benefit of installing CO detector was estimated by summing up the avoidable morbidity cost and mortality cost (value of life). Cost of CO detectors was calculated using the average market price of CO detectors. We also calculated the benefit-to-cost ratio by dividing the benefit by its cost. All expenditures were converted into 2013 U.S. dollars.

Results: For UNFR CO poisoning, total annual medical cost ranged from $33.6 to $37.7 million. Annual non-health-sector costs varied from $3.7 to almost $4.4 million. The benefit-to-cost ratio can be as high as 7.2 to 1.

Conclusion: UNFR CO poisoning causes substantial economic burden in the U.S. The benefit of using CO detectors in homes to prevent UNFR CO poisoning can considerably exceed the cost of installation. Public health programs could use these findings to promote broad installation of CO detectors in homes.

Keywords

Unintentional non-fire carbon monoxide poisoning; Economic cost; Carbon monoxide detectors

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1. Introduction

Carbon monoxide (CO) is produced by incomplete combustion of fossil fuels [1]. CO, a colorless, odorless, toxic gas, can cause symptoms including headache, lightheadedness, dizziness, nausea, fatigue, vomiting, disorientation, collapse, coma, and death [2,3]. Each year in the United States, CO poisoning is the cause of >20,000 emergency department (ED) visits, >3000 hospitalizations, and close to 1000 deaths [2,4]. Between 2010 and 2014, over half of all CO poisoning ED visits and more than one third of all CO poisoning hospitalizations were unintentional and not fire-related CO poisoning (Table 1). Furthermore, unintentional non-fire-related (UNFR) CO poisoning is the leading cause of after-natural-disaster unintentional poisoning deaths [5]. The loss of power during and after a disaster increases use of generators and other CO-emitting appliances, leading to an increase in injuries and mortality from CO poisoning.

Approximately 73% of UNFR CO exposures occurred at home [4]. Preventing CO poisoning in the home includes following activities: performing regular maintenance of fossil fuel-burning appliances such as furnaces, placing generators at least 20 ft away from the house, not letting cars idle in a garage, and using CO detectors. CO gas is colorless, tasteless and odorless, but a CO detector can alert occupants that the life-threatening gas is present. To measure the benefit of CO detector installation, we need to estimate the avoidable economic loss of UNFR CO poisoning.

Previous studies estimated the burden of mortality and hospitalizations for UNFR CO poisoning in the United States [2,3], with preliminary estimation (in 2008 dollars) of annual mortality ($500 million), and morbidity costs ($180 million) [6]. Hampson estimated annual acute medical hospitalization cost related to UNFR CO poisoning in the United States to be $12.4 million and loss in earnings to be $22.2 million (in 2015 dollars), based on a Consumer Product Safety Commission report [7]. In addition, a report in the United Kingdom mentioned the cost and benefits in 2008 values of installing CO detectors according to appliances [8]. For instance, the cost of the detectors for base case gas appliances and solid fuel appliances were £102 million and £4.6 million respectively; while the benefits were £7.5 million and £13 million respectively. However, none of these studies provided a comprehensive estimation of the cost of UNFR carbon monoxide poisoning. Moreover, average costs in those studies were estimated based on previous literature or expert opinion rather than on actual cost data.

This paper contributes to the literature because it is the first study that estimated the total cost of UNFR carbon monoxide poisoning in a comprehensive way, including medical costs (i.e., costs related to hospitalizations, ED visit, doctor’s office visit, ambulance use, outpatient hospital visit, urgent care facility visit, and visits to other places such as patient home and independent laboratory), non-health-sector cost (productivity loss resulting from hospitalization or other outpatient visits), and cost of mortality. Second, this study uses actual cost or charge information based on Healthcare Cost and Utilization Project (HCUP) and Truven Health MarketScan data. Third, this study estimates the cost and benefit of installing CO detectors in the homes, providing evidence for public health policy makers to support this important prevention program in the United States.

2. Methods

2.1. Data

We used data from years 2010–2014 [9,10] from the National Inpatient Sample (NIS) and Nationwide Emergency Department Sample (NEDS) of the HCUP, the databases sponsored by the Agency for Healthcare Research and Quality. We also used Truven© Health MarketScan Commercial Claims and Encounters and Medicare Supplemental data.

The sampling design of NIS and NEDS data enables the researchers to obtain nationwide estimates using individual weights. NIS is a national sample derived from hospital billing data from across the United States and represents hospitalizations for approximately 95% of the population. NIS provides information on > 7 million hospital inpatient stays. It includes individuals covered by various payers (such as Medicare, Medicaid, or private insurance) as well as uninsured individuals. NIS was redesigned in 2012 to reduce sampling error, which in improved estimates [11]. Similarly, the NEDS includes approximately 30 million ED visits made by individuals that accounted for 67.7% of the U.S. population [12]. It is the largest all-payers ED database publicly available in the United States. The NIS approximates a 20% stratified sample of discharges from U.S. community hospitals, and NEDS is built using 20% stratified sample of hospital-based EDs.

MarketScan commercial claims and encounters as well as Medicare supplemental datasets provide information on clinical and pharmacy utilization and expenditures of insured employees, early retirees, employees with temporary extension of health coverage under Consolidated Omnibus Budget Reconciliation Act (COBRA), and Medicare-eligible retirees with employer-provided Medicare Supplemental plans [13]. The databases include health data from roughly 350 private payers and Medicare [13]. While the NIS and NEDS from HCUP cover only hospitalizations and ED visits, MarketScan data additionally provide information on ambulance use and on other medical services such as doctors' offices, hospital outpatient clinics, and urgent care facility. We used both MarketScan and HCUP for more complete estimates of the total cost of UNFR CO poisoning in the United States.

2.2. Case definition

We defined UNFR CO poisoning using the International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) code, as well as external cause-of-injury codes (E-codes) [14]. If a case has a diagnosis code of986 (ICD-9-CM) or any of the following E-codes: E868.2, E868.3, E868.8, E868.9, E982.0, E982.1, then it is a confirmed case of CO poisoning [15]. We ruled out cases with E-codes of E950.0-E979.9 or E990.0–E999 to exclude intentional CO poisoning. In addition, we excluded fire-related (E890–E899) or undetermined causes. Finally, UNFR CO poisonings were cases with ICD-9-CM code of 986 and any of the following E-codes: E818, E825, E838, E844, E867, E868, E869.9; or cases with any of E868.2–E868.9, regardless of presence or absence of 986 [14]. In this paper, we reported the UNFR CO poisoning cases and estimated the costs for those cases.

2.3. Cost calculation

We took a societal perspective in estimating morbidity cost of UNFR CO poisoning considering both medical cost and non-health-sector cost. Medical cost included the costs of hospitalization, ED visit, hospital outpatient visit, doctors' office visit, ambulance use, and rare visits to places such as urgent care. Non-health-sector cost included productivity loss resulting from time spent during hospitalization or outpatient visits (including travel time to and from outpatient facilities).

2.3.1. Medical cost calculation—We calculated medical cost using both the HCUP and MarketScan data. Average cost of hospitalization was obtained from the NIS data. Since the NIS has only facility charges of the service, we applied charge-to-cost ratios (provided by HCUP) to obtain cost estimates. In addition, facility charges include charges for room and board but exclude charges for service rendered by physicians, healthcare professionals, or clinicians. Therefore, professional fee ratios (accounting for charges related to services of healthcare professionals) were applied in addition to the cost-to-charge ratios [16]. We used MarketScan commercial claims and Medicare datasets to estimate an average cost of ED visits, particularly because HCUP NEDS data do not provide a charge-to-cost ratios. We also used MarketScan payment data to calculate an average cost for hospital outpatient visit, doctor's office visit, and ambulance use. Some patients visited both hospital outpatient clinics and EDs, or hospital outpatient clinics and doctors' offices, likely incurring higher average cost than those who visited only EDs, hospital outpatient clinics, or doctors' offices. Therefore, outpatient visits were divided into ED only, hospital outpatient clinics + ED, ED + others (including doctor's office, inpatient hospital, urgent care, in additional to hospital outpatient clinics), hospital outpatient clinics only, doctor's office only, hospital outpatient clinics + doctor's office, and other non-ED visits (including patient home, inpatient hospital, independent laboratory). Medical cost for each category was then the product of the average cost per visit and the number of visits. The numbers of ED visits and hospitalization were obtained from HCUP data using proc. survey means in Statistical Analysis System (SAS) (version 9.4; SAS Institute Inc., Cary, NC). The numbers of other outpatient visits (including hospital outpatient clinics, doctor's office, inpatient hospital, urgent care, patient home, and independent laboratory) and ambulance use were estimated by multiplying the ratios of ED visits and other outpatient visits (in MarketScan data) by the number of ED visits in NEDS.

2.3.2. Non-health-sector cost calculation—We estimated loss of productivity as the product of hourly wage and the average time lost from work because of hospitalization, ED or outpatient visit related to CO poisoning. Average time lost from work because of hospitalization was estimated using the length of stay in the NIS data. Average time lost because of outpatients or ED visits was estimated using data from previous literature and reports [17–19].

In addition, economic loss associated with death from UNFR CO poisoning was calculated by multiplying the number of deaths by average value of statistical life. SAS was the main statistical software used for our analysis. All cost estimations were converted into 2013 U.S. dollars.

2.4. Cost and benefit of CO detector installation

Benefits of CO detector installation include the costs of averted mortality and morbidity composed of medical cost and non-health-care-sector cost from UNFR CO poisoning. Cost of the CO detector was obtained through simple search in the market. Net benefit is the difference between the benefit and cost of CO detector installation. Benefit-to-cost ratio is the ratio of benefit to cost of installing CO detectors.

3. Results

3.1. Numbers of hospitalization, visits, and mortality

In 2010–2014, annual total hospitalizations resulting from UNFR CO poisoning ranged from 1232 to 1388 stays, accounting for over one third of all CO poisoning hospitalizations. Annual total UNFR CO poisoning ED visits ranged from 10,835 to 13,718, accounting for over half of the ED visits that resulted from CO poisoning. Similarly, annual total UNFR CO poisoning non-ED visits ranged from 11,491 to 15,848, accounting for approximately one half of the non-ED visits resulting from CO poisoning. Annual total UNFR CO poisoning deaths ranged from 341 to 429, accounting for almost half of all CO poisoning deaths (Table 1).

A total of 6381 UNFR hospitalizations occurred during 2010–2014. Among those hospitalized patients, 55% were male, and approximately 40% were aged between 45 and 64 years. Similarly, approximately half of the 60,479 cases of UNFR CO poisoning ED visits were male, and 46% were from 15 to 44 years of age. We present the details of demographics in Table 2.

3.2. Cost

Per admission cost of UNFR CO poisoning hospitalization varied by year from $9554 to $11,678. Annual cost of an UNFR CO poisoning ED visit varied from $515 to $734, while annual cost per UNFR CO poisoning outpatient visit varied from $578 to $890. On average, cost of doctor’s office was lower, varying by year between $119 and $190. For patients who visited both outpatient hospital and ED, cost per visit varied by year from $1173 to $1387. For UNFR CO poisoning patients who visited other places (up to three) such as doctor’s office, inpatient hospital, urgent care, in additional to outpatient hospital, in addition to ED, the average cost was even higher, between $2005 and $3477, varied by year. Average ambulance service cost varied by year from $892 to $1402 (Table 3).

Total annual UNFR CO poisoning medical cost was between $33.6 million and $37.7 million. Among all categories of medical services, hospitalization as well as outpatient hospital visits plus ED visits accounted for approximately two thirds of the medical cost. High hospitalization cost per stay is the main contributor to high total cost. Additionally, patients were more likely to visit both outpatient hospital and ED, which on average costs more than visiting ED only. This category of medical service also contributed to high total cost in this category (Table 3).

Total annual productivity loss because of UNFR CO poisoning was between $3.7 million to $4.4 million. Approximately 80% of the productivity loss was due to hospitalizations and outpatient hospital visits plus ED visits, because of the longer duration of those services as well as higher average costs (Table 4).

Total morbidity cost (resulting from medical cost and non-health-sector cost) was between $37.3 and $43.1 million annually.

3.3. Cost-benefit analysis

We compared the cost and benefit of CO detector installation in homes. Market price for a stand-alone battery-run CO detector ranged from $25 to $60 (including $5–$10 battery cost, given that battery replacement took place at least every 6 months). Assuming a typical household installs one to three CO detectors with a lifespan generally lasting 7–10 years (the general practice is to install a CO alarm outside of the sleeping area, say, one on each floor, in places that one can hear it), the annual cost per household would be $3.6 (=$25 / 7) to $18 (= $60 × 3 / 10). Previous studies show that from 35% to 40% of the U.S. households already had working CO detectors installed [20,21]. Therefore, we assumed that only 65% of American households needed CO detector installation. Both the cost and benefit calculation was based on this assumption.

Averted deaths, medical cost, and non-health-sector cost were the three types of benefits. We used the Value of Statistical Life (VSL) approach to measure the value of averted death resulting from UNFR CO poisoning (Table 5). Over 50% of UNFR CO poisoning deaths [3,6,22] and roughly 73% of the non-fatal poisoning [4] took place at home; thus, we assumed that 50% of the mortality costs (measured by VSL) and 73% of the medical as well as non-health-sector cost would be avoided if CO detectors were installed in 65% of American homes [23]. The formula for cost calculation is: *Total cost* = *annual CO detector unit cost* × *number of households* × 65%. The formula for benefit calculation is: *Total Benefit* = ((*total medical cost averted* + *total nonhealthsector cost averted*) × 73% + *per person VSL* × *total death averted* × 50%). Since the averted deaths, medical cost, and non-health-sector cost were calculated from actual data, the benefit estimation was implicitly based on the fact that 35% to 40% of the U.S. households already had working CO detectors installed. Without considering this implicit assumption, the total potential benefit would have been higher.

In the least costly case, if every household installed a 7 year-lifetime CO detector at an annual cost of $2.5, the benefit-to-cost ratio would range from 5.6:1 to 7.2:1. Even in the most costly case of installing three most expensive detectors in a residence (with annual cost of $18 and lifetime of 10 years), the benefit-to-cost ratio would still be greater than one, specifically, 1.1 to1. Therefore, the benefit of CO detector installation in homes substantially outweighs the cost of the installation (Table 6).

4. Discussion

We found substantial economic loss resulting from UNFR CO poisoning for every year of the study. However, this burden can be substantially reduced by preventive programs including installing CO detectors in homes. In particular, a $1 investment in an inexpensive CO detector with a seven-year residential lifespan can generate on average benefit as high as $7.2. Even if one installs three more expensive CO detectors with longer lifespan, the benefit will still be greater than the cost.

The benefit of installing CO detectors could be even higher, given that we adopted a relatively conservative approach in estimating economic loss from UNFR CO poisoning. First, ED visits might have been underestimated, since the NEDS data cover only approximately two thirds of the visits resulting from poisoning (as illustrated in Table D.4. Introduction to the HCUP NEDS, 2013) [12]. Further, some of non-health-sector costs were not included in our estimation. According to Mason and Brown [6], this cost includes time spent by patient seeking medical care, childcare and caregiver time, and transportation to and from medical services. Also, intangible costs (pain and suffering, peace of mind) were not included. In addition, minor cases of CO poisoning could be misdiagnosed and treated as flu or other sickness, the costs of which were not included as well [2]. Some research also indicates that CO poisoning might result in chronic neurologic sequelae [2,7], which can cause on average 15% loss in lifetime earnings [7]. If all the above-mentioned items were included, our estimated economic loss would be much higher. On the other hand, installing CO detectors can cause additional cost to the society. For instance, false alarms incur unnecessary 911 calls, evacuation and even ED admission. If this extra cost were considered, the societal cost of installing CO detectors would be higher.

The average UNFR CO poisoning cost of hospitalization was estimated using charge data in HCUP, adjusted by the cost-to-charge ratio and professional fees ratio, potentially affecting the actual cost of hospitalization. Another limitation is that we used MarketScan data to estimate average UNFR CO poisoning cost of ED visits. This factor might cause the average ED cost to be slightly different from the actual average, since we used private payer and Medicare payment information, which might be higher than payment by Medicaid or other payers for some cases. We also used the ratios of ED visits and other visits from MarketScan data to estimate the visits to other places for HCUP data, which might be slightly different from actual visits to these places. In addition, not all the E-codes were recorded in MarketScan data. Therefore, average outpatient costs were calculated using MarketScan data under the assumption that cost of CO poisoning is the same regardless of the cause, potentially causing under- or over-estimation of the cost of outpatient visits resulting from UNFR CO poisoning. Lastly, <3% of UNFR CO poisoning patients visited the ED or hospital more than once per year; however, we treated those visited independently. This fact might potentially cause less precise cost estimation, since patients poisoned a second time might be more experienced and therefore take action to lessen the severity of the effects of the poisoning before seeking for medical services, thereby lowering medical costs.

To increase the awareness of the potential benefit of installing CO detectors at American homes, we conducted a simple cost-benefit analysis to compare the benefit of installing CO detectors with its cost. The potential benefit was measured in a relatively ideal situation, which might not hold in reality. For instance, we assumed that there were few barriers in installing CO detectors at homes. However, it was pointed out that there is lack of information regarding CO detectors installation and usage [24]. Furthermore, some CO detectors might fail to function properly [25]. Since the degree of information lack and the failure rate have not been properly quantified at the national level, we did not include these factors in our analysis. However, future research can add those factors when their impacts are precisely quantified.

Despite the limitations, our study combines the strength of HCUP and MarketScan databases to estimate the actual morbidity cost of UNFR CO poisoning including medical costs and non-health-sector cost. In the absence of a sustainable nationwide surveillance system for UNFR CO poisoning, our study provides a science-based estimation of the economic burden associated with UNFR CO poisoning. Most of the assumptions of this study are based on real data or reliable reference, such as the prevalence, the ratio of houses without detectors, and the annual cost of poisoning. Therefore our estimation, especially the economic cost related to UNFR CO poisoning, reflects the real burden in the United States and provides robust estimates. If, hypothetically, 90% of CO poisonings occur at home and none of the houses have CO detectors, the benefit-cost ratio would be higher, ranging from 1.3:1 to 8.4:1.

5. Conclusion

To our knowledge, this is the first comprehensive economic study on the cost of UNFR CO poisoning using cost and charges data. Our results indicate that the economic burden of UNFR CO poisoning can be substantial. On the other hand, the benefit of installing CO detectors in homes can substantially exceed the cost of the program. Public health professionals and clinicians can provide residents information on CO detectors to increase the awareness of this cost-beneficial intervention, especially as a part of emergency preparedness efforts. Manufacturing smoke detectors with CO detecting function could also have important public health implications by increasing the installation rate.

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Abbreviations:

UNFR	unintentional non-fire-related
CO	carbon monoxide
NIS	National Inpatient Sample
NEDS	Nationwide Emergency Department Sample
HCUP	Healthcare Cost and Utilization Project
ED	emergency department
COBRA	Consolidated Omnibus Budget Reconciliation Act

ICD-9-CM	the International Classification of Disease, Ninth Revision, Clinical Modification
E-codes	external cause-of-injury codes
SAS	Statistical Analysis System
VSL	value of statistical life

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Table 1

UNFR CO poisoning-related hospitalizations, ED visits, outpatient visits, and death in United States, 2010–2014.

	Year	Cases
Hospitalizations	2010	1232
	2011	1388
	2012	1305
	2013	1220
	2014	1245
ED visits	2010	13,718
	2011	12,173
	2012	11,717
	2013	12,036
	2014	10,835
Non-ED outpatient visits	2010	15,848
	2011	14,085
	2012	12,580
	2013	11,491
	2014	12,278
Deaths	2010	391
	2011	429
	2012	341
	2013	354
	2014	393

Table 2

Gender and age distribution of UNFR CO poisoning cases in the United States, 2010–2014.

Variable	Subgroup	Hospitalizations N (%)	ED visits N (%)
Gender	Male	3528 (55)	29,564 (49)
	Female	2853 (45)	30,915 (51)
Age	<5	105 (2)	5231 (9)
	5–14	216 (3)	7565 (13)
	15–24	312 (5)	8718 (14)
	25–34	507 (8)	10,314(17)
	35–44	762 (12)	8899 (15)
	45–54	1385 (22)	8523 (14)
	55–64	1178 (18)	5572 (9)
	65–74	825 (12)	3059 (5)
	75–84	648 (10)	1670 (3)
	≥ 85	441 (7)	927 (2)
	Total	6379(100)	60,479 (100)

Table 3

Medical costs of UNFR CO poisoning by category at mean level (in 2013$).

Category	Year	2010		2011		2012		2013		2014	
	Subcategory	Average cost	Total cost	Average cost	Total cost	Average cost	Total cost	Average cost	Total cost	Average cost	Total cost
Hospitalization	Hospitalization	$9579	$11,801,291	$9712	$13,479,965	$10,936	$14,271,075	$9554	$11,656,344	$11,678	$14,539,660
ED	ED only	$734	$2,837,036	$515	$1,640,011	$589	$1,804,493	$603	$2,347,025	$580	$2,455,848
	ED + OH[b]	$1237	$11,198,300	$1173	$10,021,064	$1256	$10,337,291	$1281	$9,753,523	$1387	$11,451,188
	ED + others[c]	$2005	$1,598,394	$2591	$1,153,049	$2605	$1,096,643	$2,521[a]	$1,968,992	$3477	$1,447,561
Non-ED	OH only	$578	$4,824,631	$739	$4,524,023	$724	$4,087,353	$890	$4,573,816	$512	$2,475,287
Outpatient	DO only	$119	$500,656	$190	$896,640	$138	$574,816	$133	$512,144	$133	$515,320
	DO + OH	$357	$171,778	$410	$153,894	$263[a]	$107,274	$291	$38,831	$222	$67,942
	Others (non-ED)[d]	$647a	$2,241,996	$556	$1,591,339	$651	$2,159,104	$307	$723,454	$596	$1,940,109
Ambulance	Ambulance	$1,193a	$2,502,349	$1119	$1,648,846	$892	$1,027,599	$1,095[a]	$2,047,564	$1402	$1,998,418
	Total		$37,676,430		$35,108,831		$35,465,649		$33,621,694		$36,891,333

[a]Adjusted for outlier(s).

[b]OH: hospital outpatient clinic; DO: doctor's office.

[c]Others include: doctor's office, inpatient hospital, urgent care, in additional to hospital outpatient clinic.

[d]Others (non-ED) include: patient home, inpatient hospital, independent laboratory.

Table 4

Non-health-sector costs of UNFR CO poisoning (in 2013$).

Year	2010 (hourly wage[a] $24.07)		2011 (hourly wage $23.83)		2012 (hourly wage $23.80)		2013 (hourly wage $23.98)		2014 (hourly wage $24.09)	
	Average hours lost	Wage loss	Average hours lost	Wage loss	Average hours lost	Wage loss	Average hours lost	Wage loss	Average hours lost	Wage loss
Hospital	74.9	$2,221,103	78.3	$2,589,854	80.8	$2,509,567	67.2	$1,965,976	84.9	$2,546,617
ED only[b]	4	$372,248	4	$303,512	4	$291,683	4	$373,652	4	$408,345
ED + OH[b]	4.8	$1,046,063	4.8	$977,297	4.8	$940,538	4.8	$876,632	4.8	$954,299
ED + others[b]	4.8	$92,082	4.8	$50,901	4.8	$48,095	4.8	$60,314	4.8	$48,143
OH only[c]	1.4	$281,184	1.4	$204,108	1.4	$192,682	1.4	$172,530	1.4	$163,196
Doctor's office only[c]	1.4	$141,696	1.4	$157,720	1.4	$139,108	1.4	$129,743	1.4	$130,744
OH + doctor's office[c]	2	$23,134	2	$17,893	2	$19,380	2	$6408	2	$14,710
Others (non-ED)[c]	2	$135,650	2	$136,514	2	$105,440	2	$112,884	2	$156,910
Sum		$4,313,161		$4,437,799		$4,246,493		$3,698,141		$4,422,964

[a] Average wage from: http://www.bls.gov/webapps/legacy/cesbtab3.htm.

[b] Average ED time obtained by calculating the weighted average of ED time (including waiting time and time spent in ED) from National Ambulatory Medical Care Survey (https://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2011_ed_web_tables.pdf) in addition to travel time of approximately 20 min one way. Others include either hospital outpatient clinic, doctor's office visit or other similar places such as inpatient hospital, urgent care. See footnote [c] for others' average duration.

[c] OH, hospital outpatient clinic; average time obtained by estimating the sum of average time spent with physician from National Ambulatory Medical Care Survey, average waiting time (http://www.vitals.com/about/press/wait-times-doctors-decrease-even-americans-enter-health-care-system), and average travel time (http://www.ofm.wa.gov/researchbriefs/2013/brief070.pdf).

Table 5

Value of averted death resulting from UNFR CO poisoning (in 2013$).

Year	Deaths	VSL[a] per person	Value of averted death
2010	396	$9,100,000	$3,558,100,000
2011	433	$9,100,000	$3,903,900,000
2012	341	$9,100,000	$3,103,100,000
2013	355	$9,100,000	$3,221,400,000
2014	393	$9,100,000	$3,576,300,000

[a]VSL, value of statistical life.

Table 6

Costs and benefits of carbon monoxide detectors (2013$).

Year	Households (million)	Total benefit[a]	Annual cost of CO detector $3.6			Annual cost of CO detector $18		
			Total cost	Benefit to cost ratio	Net benefit	Total cost	Benefit to cost ratio	Net benefit
2010	117.54	$1,830,697,197	$275,043,600	6.7:1	$1,555,653,597	$1,375,218,000	1.3:1	$455,479,197
2011	118.68	$2,000,592,354	$277,711,200	7.2:1	$1,722,881,154	$1388,556,000	1.4:1	$612,036,354
2012	121.08	$1,600,395,935	$283,327,200	5.6:1	$1,317,068,735	$1,416,636,000	1.1:1	$183,759,935
2013	122.46	$1,656,603,396	$286,556,400	5.8:1	$1,370,046,996	$1,432,782,000	1.2:1	$223,821,396
2014	123.23	$1,818,309,437	$288,358,200	6.3:1	$1,529,951,237	$1,441,791,000	1.3:1	$376,518,437

[a]Assuming 50% of the death and 73% of the morbidity cost would be avoided by installing CO detectors at 65% of the American homes.