Carbon Monoxide Poisoning

Hospitalizations and Deaths in Canada

Irwin Cohen, Len Garis, Fahra Rajabali, Ian Pike

October 2017

UNIVERSITY OF THE FRASER VALLEY
SCHOOL OF CRIMINOLOGY & CRIMINAL JUSTICE

UNIVERSITY OF THE FRASER VALLEY
CENTRE FOR PUBLIC SAFETY & CRIMINAL JUSTICE RESEARCH

The British Columbia Injury Research and Prevention Unit (BCIRPU) was established by the Ministry of Health and the Minister's Injury Prevention Advisory Committee in August 1997. BCIRPU is housed within the Evidence to Innovation research theme at BC Children's Hospital (BCCH) and supported by the Provincial Health Services Authority (PHSA) and the University of British Columbia (UBC). BCIRPU's vision is, *to be a leader in the production and transfer of injury prevention knowledge and the integration of evidence-based injury prevention practices into the daily lives of those at risk, those who care for them, and those with a mandate for public health and safety in British Columbia*.

Authors: Irwin Cohen, Len Garis, Fahra Rajabali, Ian Pike.

For any questions regarding this report, contact:

BC Injury Research and Prevention Unit
F508-4480 Oak Street
Vancouver, BC V6H 3V4
Email: bcinjury1@cw.bc.ca
Phone: (604) 875-3776
Fax: (604) 875-3569
Web page: www.injuryresearch.bc.ca

University of the Fraser Valley
33844 King Road
Abbotsford, BC V2S 7M8
Email: info@ufv.ca
Phone: (604) 875 3776

Web page: www.ufv.ca

Suggested Citation: Cohen, I, Garis, L, Rajabali F, Pike I. Carbon Monoxide Poisoning, Hospitalizations and Deaths in Canada. A report by the BC Injury Research and Prevention Unit, for the University of the Fraser Valley: Vancouver, BC. October, 2017.

Executive Summary

- Carbon monoxide (CO) disorients its victims and is most dangerous when people are sleeping and fail to wake up or realize they are at risk, as this gas has no colour, odour, or taste. The only way to detect the presence of the deadly gas is to install a carbon monoxide alarm.

- This research note provides an analysis of carbon monoxide poisoning hospitalizations and deaths in Canada to demonstrate the need for specific legislation in each province and territory to mandate the installation and maintenance of functioning CO alarms in every existing residence.

- According to Statistics Canada, between 2000 and 2013, in Canada, there were 4,990 deaths associated to CO poisoning. This included 1,125 deaths where there were no other underlying causes of death and 3,865 where there were other underlying causes of death.

- In terms of the total number of deaths, 34.8% were for people between the ages of 25 and 44 years old, and an additional 40% were for those between 45 and 64 years old.

- Quebec had the highest total number of carbon monoxide-related deaths (n = 1,445) followed by Ontario (27.5 per cent), the Prairies (24.6 per cent), British Columbia and the Territories (13.3 per cent), and the Maritimes (5.6 per cent).

- In total, there were 3,027 hospitalizations related to CO poisoning in Canada between 2002 and 2016, and 14.3% of CO-related hospitalizations in Canada were for people 65 years old or older.

- When missing data or unspecified data was removed from the analysis, 75% of CO-related hospitalizations occurred as a result of CO poisoning originating in the home.

- Ontario, Alberta, and British Columbia had the highest number of CO-related hospitalizations, while the largest increases in per capita hospitalization between 2002 and 2016 were in Saskatchewan (34.7 per cent), Manitoba (19.2 per cent), and British Columbia (7.6 per cent).

- There are more than 300 CO-related deaths per year in Canada, and more than 200 hospitalizations per year in Canada.

- Similar to the research on smoke alarms, CO alarms save lives and can reduce CO-related deaths.

- This research note recommends that all provincial governments either assist with regulating the requirement for the retrospective mandatory installation of CO detectors in all residential homes or legislate this requirement through building code amendments.

Introduction

Given the success in increasing fire safety across Canada as a result of legislative and community-based initiatives and policies related to smoke detectors, there are clear benefits to expanding the scope of the Smoke Alarm Movement to incorporate carbon monoxide (CO) alarms. Previous research has demonstrated that accidental CO poisoning can be reduced through a combination of public education, emission controls, warning labels on products, and combination residential CO and smoke alarms (Hampson & Holm, 2017).

Recent amendments to the Ontario Fire Protection and Prevention Act, 1997, have mandated that CO alarms be installed in all residences with a fuel-burning appliance or an attached garage. Specifically, on October 15, 2014, the Ontario Government formally enacted *The Hawkins-Gignac Act* (Bill 18) making CO alarms mandatory in all Ontario homes at risk of CO. This revision to the *Ontario Fire Code* superseded any existing municipal by-laws, ensuring that CO alarms are installed outside sleeping areas in residential dwellings with CO producing sources. Ontario's CO alarm law provides a consistent level of protection to all Ontarians, and should serve as a model for the rest of Canada.

In addition to addressing the issue of CO in fire codes retrospectively to certify that all current dwellings have functioning CO detectors, building codes are also an effective way of ensuring that CO detectors are installed in all constructions moving forward. This objective was supported by the National Fire Protection Association, the Fire Fighters Association of Ontario, members of the medical community, and carbon monoxide survivor groups and their families (Garis, Clare, & Hughan, 2015).

Currently, there is no requirement in British Columbia to address the risk of carbon monoxide poisoning deaths and injuries in residential dwellings with mandatory CO detector regulations in existing homes, which is preventable by having functioning CO detectors in all residential dwellings. However, legislation similar to that of Ontario is extremely important for all communities. According to the United States Center for Disease Control, 5,149 deaths resulted from unintentional CO poisoning between 1999 and 2010, an average of 430 deaths per year (Centre for Disease Control, 2014). Moreover, the average annual death rate from CO poisoning is three times higher for males compared to females, at 0.22 per 100,000 males and 0.07 per 100,000 females (Garis, Clare, & Hughan, 2015). As with fire-related fatalities, the death rates from CO poisoning were highest among those aged 65 years and over (Garis, Clare, & Hughes, 2015). CO can be emitted if fuel-burning devices are improperly installed or poorly maintained. Given this, vents and flues must be free of debris and not cracked or clogged. Carbon monoxide can originate from gas, oil, or propane furnaces, water heaters, clothes dryers, space heaters, gas ovens, and wood burning or gas fireplaces. Prolonged exposure to carbon monoxide can lead to brain damage and death.

Carbon monoxide disorients its victims and is most dangerous when people are sleeping and fail to wake up or realize they are at risk, as this gas has no colour, odour, or taste. The only way to detect the presence of the deadly gas is to install a carbon monoxide alarm. While CO alarms do not reduce the requirement to use fuel-burning appliances in a safe manner, installing and ensuring that CO alarms are functioning as intended are, therefore, critical to reducing the risks that lead to unintentional CO poisoning. This research note provides an analysis of carbon monoxide poisoning hospitalizations and deaths in Canada to demonstrate the need for specific legislation in each province and territory to mandate the installation and maintenance of functioning CO alarms in every existing residence.

NATIONAL BUILDING CODE

A building code (also referred to as building control or building regulations) is a set of regulations that specify the standards for constructed objects, such as buildings and non-building structures. Buildings must conform to the code to obtain planning permission, usually from a local government. The main purpose of building codes is to protect public health, safety, and general welfare as they relate to the construction and occupancy of buildings and structures. The building code becomes the law of a particular jurisdiction when formally enacted by the appropriate governmental or private authority.

Building codes are generally intended to be applied by architects, engineers, interior designers, constructors and regulators, but are also used for various purposes by safety inspectors, environmental scientists, real estate developers, sub-contractors, manufacturers of building products and materials, insurance companies, facility managers, tenants, and others. Importantly, in Canada, the *National Building Code* is the model building code that forms the basis for all of the provincial building codes. Some jurisdictions create their own code based on the *National Building Code*, and other jurisdictions have adopted national standards often with supplementary laws or regulations to the requirements in the *National Building Code.*

According to the National Building Code, the requirement for a CO alarm applies to every building that contains a residential occupancy, a care occupancy with individual suites, or a care occupancy containing sleeping rooms not within a suite, and that also contains a fuel-burning appliance, or a storage garage. Here, CO devices are to be equipped with an integral alarm that satisfies the audibility requirements of the policy, have no disconnect switch between the overcurrent device and the CO alarm where the CO alarm is powered by the electrical system serving the suite, and must be mechanically fixed at a height above the floor as recommended by the manufacturer.

Moreover, where a fuel-burning appliance is installed in a suite of residential occupancy or in a suite of care occupancy, a CO alarm must be installed inside each bedroom, or outside each bedroom, within five meters of each bedroom door, measured following corridors and doorways. Where a fuel-burning appliance is installed in a service room that is not in a suite of residential occupancy nor in a suite of care occupancy, a CO alarm must be installed either inside each bedroom, or if outside, within five meters of each bedroom door, measured following corridors and doorways, in every suite of residential occupancy or suite of care occupancy that shares a wall/ceiling assembly with the service room, and in the service room. For each suite of residential occupancy or suite of care occupancy that shares a wall or floor/ceiling assembly with a storage garage, or that is adjacent to an attic or crawl space to which the storage garage is also adjacent, a CO alarm must be installed inside each bedroom, or outside each bedroom, within five meters of each bedroom door, measured following corridors and doorways. Where CO alarms are installed in a house with a secondary suite including their common spaces, the CO alarms shall be wired so that the activation of any one CO alarm causes all CO alarms within the house with a secondary suite, including their common spaces, to sound. As will be demonstrated below, Ontario, Alberta, and

British Columbia are the leading provinces for the number of hospitalizations, while all three are in the top four provinces for fatalities related to carbon monoxide poisoning. As such, the codes for these three provinces will be reviewed.

BRITISH COLUMBIA

In British Columbia, on December 20, 2012, the *British Columbia Building and Plumbing Code* or "BC Building Code 2012" came into force and provided an objective-based code that identified the minimum standard within the Province of BC for buildings. It is a regulation of the *Local Government Act* and is substantially based on the model *National Building Code of Canada 2010* and the model *National Plumbing Code of Canada 2010*. While its references to CO alarms are exactly the same as those found in the *National Building Code of Canada*, it is important to note that Canadian building codes typically no longer apply once a building is occupied, unless the building is undergoing alteration or change of use, or being demolished. Still, the BC Building Code 2012 requires that an enclosed storage garage shall have a mechanical ventilation system designed to limit the concentration of carbon monoxide to not more than 100 parts per million parts of air, and where CO alarms are installed in a house with a secondary suite, including their common spaces, the CO alarms shall be wired so that the activation of any one CO alarms causes all CO alarms within the house with a secondary suite, including their common spaces, to sound.

ALBERTA

The *Alberta Building Code* (2014) sets out technical provisions for the design and construction of new buildings. It also applies to the alteration, change of use, and demolition of existing buildings. The *Alberta Building Code* (2014) complements the Alberta Fire Code (2014), and both are indispensable for building officials, educators, and professionals in the construction industry. Safety Services and the Safety Codes Council develop *Alberta Building Code* STANDATA jointly. Some are issued under the authority of the Code or the *Safety Codes Act* as province-wide variances or interpretations. Others are information bulletins that provide general advice on related matters.

The *Alberta Building Code* (2006) contains provisions requiring for CO alarms to be installed in all new residential construction containing a fuel-burning appliance, a solid-fuel-burning appliance, or a storage garage. Where a fuel-burning appliance is installed in a suite of residential occupancy, a CO alarm must be installed inside each bedroom or outside each bedroom within five meters of each bedroom door. Where a fuel-burning appliance is installed in a service room that is not in a suite of residential occupancy, each suite that shares a wall or a floor/ceiling assembly with the service room shall have a carbon monoxide alarm installed inside each bedroom or outside each bedroom within five meters of each bedroom door, and in the service room. Where a solid-fuel-burning appliance is installed in a suite of residential occupancy, a carbon monoxide alarm shall be installed on or near the ceiling in the room containing the solid-fuel-burning appliance. Each suite that shares a wall or floor/ceiling assembly with a storage garage or that is adjacent to an attic or crawl space to which the storage garage is also adjacent, a CO alarm must be installed inside each bedroom or outside each bedroom within five meters of each bedroom door.

According to the *Alberta Building Code* (2006), CO alarms must meet the requirements of the Canadian Standards Association's CAN/CSA Standard 6.19 "Residential Carbon Monoxide Alarming Devices." Labels found on certified CO alarms provide assurance that the alarm was tested and that it conforms to established safety standards. As well as being a certified product, CO alarms must be mechanically fixed to a surface at a height recommended by the manufacturer, and have no disconnect switch between the overcurrent device and the CO alarm when the CO alarm is powered by the dwelling unit's electrical system. Both battery operated alarms and alarms that are connected to the dwelling unit's electrical system are acceptable. The average lifespan of CO alarms varies. There are several models on the market with many different features, such as indicators to let the user know when they need to be replaced or power supply backups.

ONTARIO

The *2012 Building Code Compendium of Ontario* is administered by the Building and Development Branch of the Ministry of Municipal Affairs and Housing. Prior to the enactment of the first *Ontario Building Code Act* in 1974, individual municipalities were responsible for developing their own building codes, resulting in a fragmented and potentially confusing regulatory environment. The introduction of a provincial Building Code Act and a provincial Building Code addressed this problem by providing for uniform construction standards across Ontario.

With respect to CO, where a fuel-burning appliance is installed in a suite of residential occupancy, a CO alarm shall be installed adjacent to each sleeping area in the suite. Where a fuel-burning appliance is installed in a service room that is not in a suite of residential occupancy, a CO alarm shall be installed adjacent to each sleeping area in every suite of residential occupancy that is adjacent to the service room, and in the service room. Where a storage garage is located in a building containing a residential occupancy, a CO alarm shall be installed adjacent to each sleeping area in every suite of residential occupancy that is adjacent to the storage garage.

Moreover, CO alarms must be permanently connected to an electrical circuit and shall have no disconnect switch between the overcurrent device and the CO alarm, be wired so that its activation will activate all CO alarms within the suite, where located within a suite of residential occupancy, be equipped with an alarm that is audible within bedrooms when the intervening doors are closed, where located in a suite of residential occupancy, and conform to CAN/CSA-6.19, "Residential Carbon Monoxide Alarming Devices", or UL 2034, "Single and Multiple Station Carbon Monoxide Alarms". Where the building is not supplied with electrical power, CO alarms are permitted to be battery operated.

Purpose of Research Note

The purpose of this research note is to draw attention to the number of carbon monoxide poisonings and deaths in Canada, which is, to some degree, preventable through the implementation of legislation requiring all new constructions to have installed and functioning CO alarms as the current built environment does not have this requirement. In effect, this research note is a call for retrospective regulation to require the built environment to install CO alarms in all existing residences.

Current Study

In addition to building code modifications, it is important for governments to create public campaigns focused on educating people about the dangers of carbon monoxide exposure, the benefits of having properly installed and functioning CO alarms, and what to do if their CO alarm is activated.

In light of national and provincial building codes related to the prevention of CO poisoning in Canada, this report provides statistical analyses on hospitalizations and deaths in which CO poisoning was either the main diagnosis or played a part in the final diagnosis. This report uses data provided by Statistics Canada's Canadian Vital Statistics Death Database, the Canadian Institute for Health Information's Discharge Abstract Database, and Statistics Canada's Table 051-0001 - Estimates of Population for the analyses. The data on hospitalizations comprises the years 2002/2003 to 2015/2016, while the data on deaths is from 2000 to 2013.

DATA LIMITATIONS

For the mortality data, data by province was not available. Death counts are provided by geographic region. Multiple cause data was not available for Saskatchewan in 2000-2002 and the Yukon in 2000 and part of 2002. Data for the Territories was included with British Columbia. Data for deaths due to CO poisoning occurring in homes was not available.

For the hospitalization data, data for Quebec was not available. Due to small counts, hospitalization data for Yukon, Nunuvat and Northwest Territories were excluded from the figures.

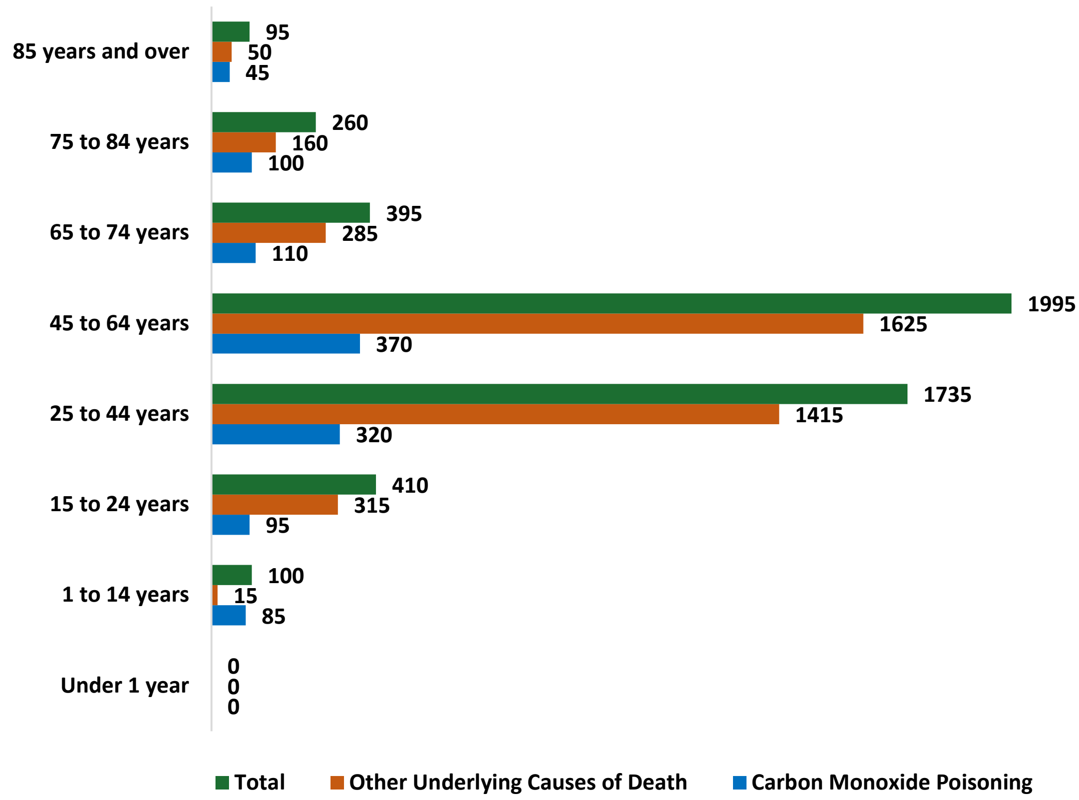
Data Analysis

CARBON MONOXIDE RELATED DEATHS

To understand the number of deaths in Canada related to CO poisoning, Statistics Canada's Canadian Vital Statistics Death Database, Multiple Cause Data was used. According to Statistics Canada, the data represents deaths of Canadian residents and non-residents that occurred in Canada that mentioned CO anywhere on the medical certificate of death, regardless of any underlying causes of death. This includes cases where the underlying cause of death was accidental or intentional poisoning, or an assault by and exposure to CO. Moreover, Statistics Canada rounds the number of deaths to five if the total number is under five to meet their internal confidentiality requirements. Of note, Statistics Canada states that missing information on the multiple causes of death might contribute to an underestimation of CO-related deaths.

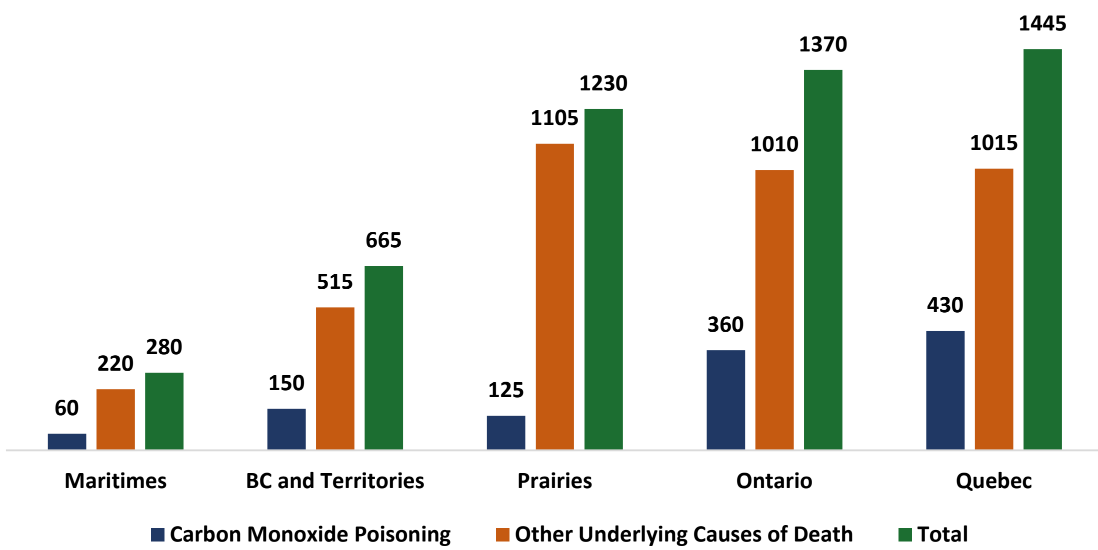
According to Statistics Canada, between 2000 and 2013, in Canada, there were 4,990 deaths associated to CO poisoning. This included 1,125 deaths where there were no other underlying causes of death and 3,865 where there were other underlying causes of death. In effect, over those 14 years, there was an average of 80 deaths per year exclusively attributed to CO poisoning, and an additional 276 deaths per year in which CO poisoning, in addition to other underlying causes of death, played a role in a person's death. Statistics Canada also provided age ranges for CO-related deaths. As demonstrated in Figure 1, in terms of the total number of deaths, 34.8% were for people between the ages of 25 and 44 years old, and an additional 40% were for those between 45 and 64 years old. Still, 15% were for people 65 years old and older, and 10.2% were for those 24 years old and younger. When considering just those instances where there were no other underlying causes of death, 7.6% were for youth 14 years old and younger, and an additional 8.4% were for victims between the ages of 15 and 24 years old. Similarly, 9.8% of deaths occurred among people between the ages of 65 and 74 years old, 8.9% of deaths were among those between 75 and 84 years old, and 4% of all carbon monoxide deaths in Canada were among people 85 years old or older (see Figure 1).

FIGURE 1: AGE RANGES FOR CARBON MONOXIDE-RELATED DEATHS IN CANADA BETWEEN 2000 – 2013 (N = 4,990)



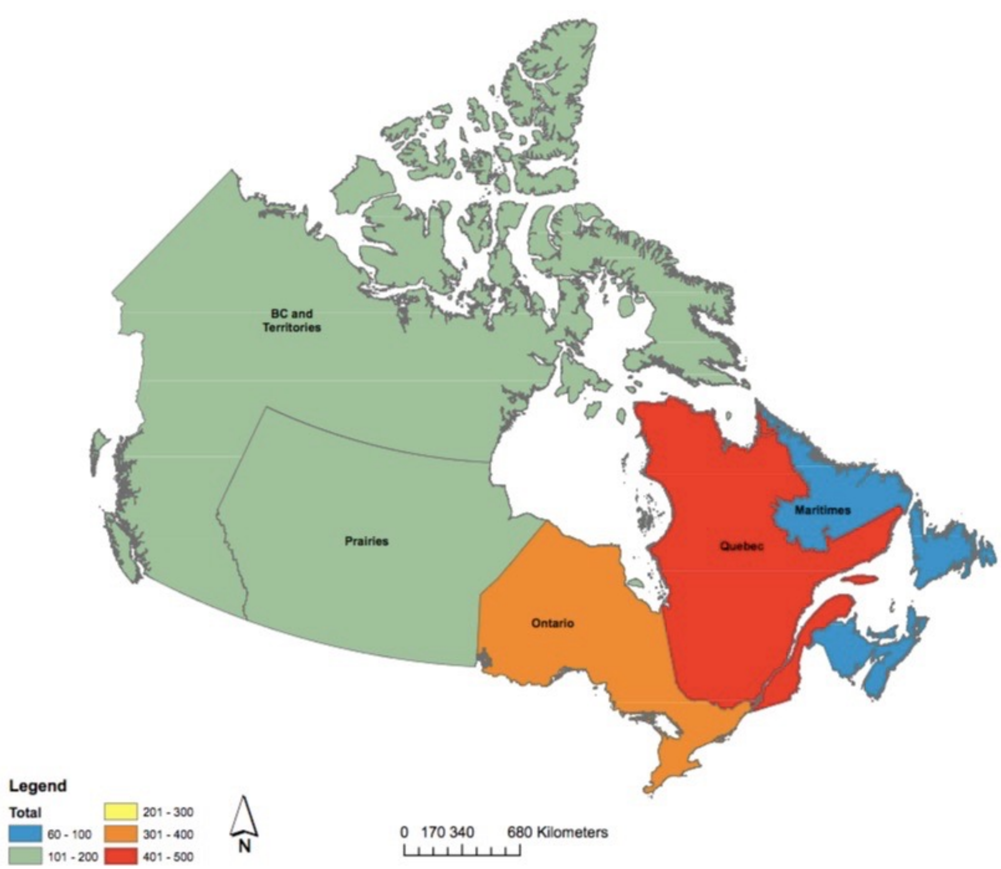
Statistics Canada grouped Canada's provinces and Territories into five large geographic areas when considering deaths related to CO poisoning. These groupings are the Maritime Provinces, Quebec, Ontario, the Prairies, and British Columbia and the Territories. Figure 2 provides the data on deaths related to CO poisoning based on these geographic groupings between 2000 and 2013. Quebec had the highest total number of carbon monoxide-related deaths (n = 1,445) that accounted for 29% of all carbon monoxide-related deaths in Canada. This was followed by Ontario (27.5 per cent) and the Prairies (24.6 per cent). British Columbia and the Territories accounted for 13.3% of all carbon monoxide-related deaths, while the Maritimes accounted for 5.6%. Of note, when considering those deaths exclusively attributed to CO poisoning, 38.2% occurred in Quebec, 32% in Ontario, 13.3% in British Columbia and the Territories, 11.1% in the Prairies, and 5.3% in the Maritimes.

FIGURE 2: CARBON MONOXIDE-RELATED DEATHS IN CANADA BY GEOGRAPHIC REGION BETWEEN 2000 – 2013 (N = 4,990)



The geographic distribution of carbon monoxide-related deaths in Canada between 2000 and 2013 is presented in Figure 3.

FIGURE 3: DEATHS FROM CARBON MONOXIDE POISONING IN CANADA (2000 TO 2013)

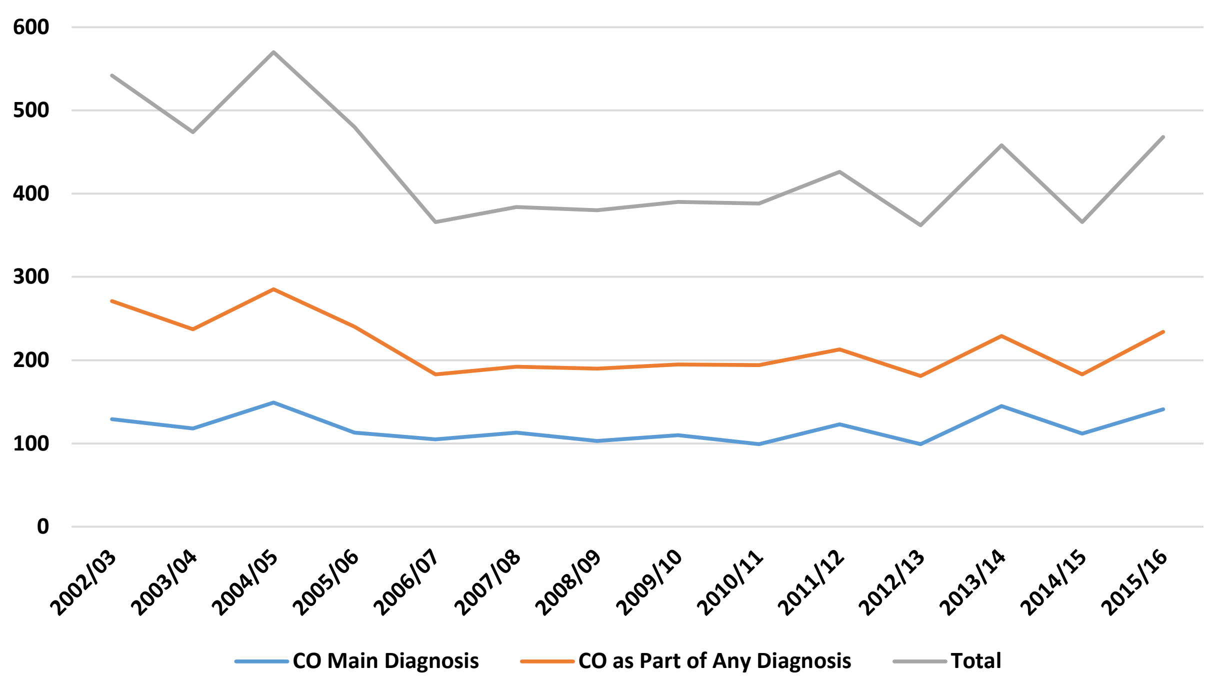


CANADIAN DATA ON HOSPITALIZATIONS RELATED WHOLLY OR PARTIALLY TO CARBON MONOXIDE POISONING

There was very little variation year over year in Canada for hospitalizations related to CO poisoning between 2002/2003 and 2015/2016 in the Discharge Abstract Database from the Canadian Institute for Health Information. According to the Canadian Institute for Health Information, the hospitalization counts presented in this report represent acute hospitalizations in Canada with mention of carbon monoxide anywhere in the discharge diagnosis, regardless of the most responsible diagnosis for the hospitalizations. The category "CO as the Main Diagnosis" refers to acute hospitalizations where CO poisoning is the most responsible diagnosis, which describes the most significant condition of the patient during hospitalization.

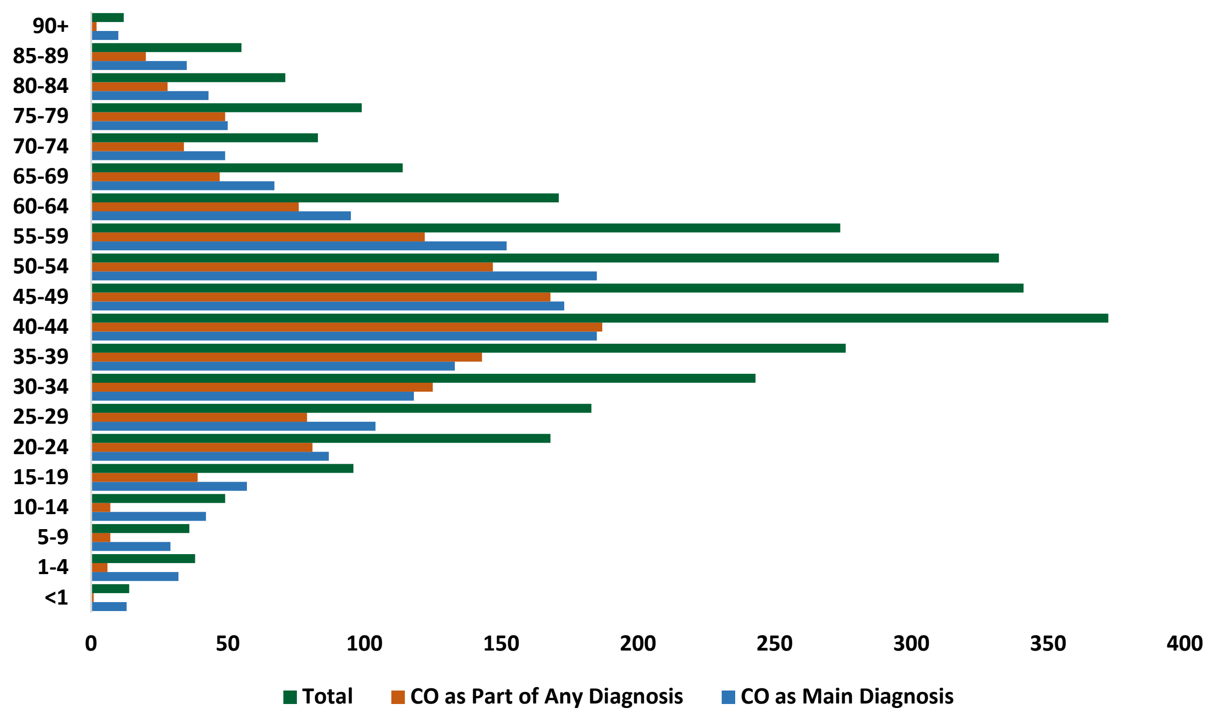
In total, there were 3,027 hospitalizations over the 14 years or, on average, 216 per year. Over that time period, 54.8% of hospitalizations had CO poisoning as the main diagnosis, while the remaining 45.2% had CO as part of the diagnosis. In effect, on average, of the 216 hospitalizations related to CO poisoning, 118.5 cases resulted in CO poisoning being the main diagnosis. Of note, there were 271 hospitalizations in 2002/2003 and 234 hospitalizations in 2015/2016, which accounts for a 13.7% decrease over the 14 years. The year by year change for all CO-related hospitalizations in Canada, those in which CO poisoning was the main diagnosis and those where CO poisoning was part of a diagnosis is represented in Figure 4.

FIGURE 4: TOTAL NUMBER OF CO-RELATED HOSPITALIZATIONS IN CANADA BETWEEN 2002/03 AND 2015/16 (N = 3,027)



In terms of the gender and age of those hospitalized, of the 3,027 cases over the 14 years, 74.2% of patients were male and those 49 years old and younger made up 48.7% of the CO-related hospitalizations. Figure 5 presents the distribution of age ranges for all CO-related hospitalizations over the 14-year time period. Of note, there was very little difference by age group between hospitalizations where CO was the main diagnosis and CO was a part of any diagnosis. Moreover, only 14.3% of CO-related hospitalizations in Canada over the 14 years were for people 65 years old or older.

FIGURE 5: AGE DISTRIBUTION OF CO-RELATED HOSPITALIZATIONS IN CANADA BETWEEN 2002/03 AND 2015/16 (N = 3,027)

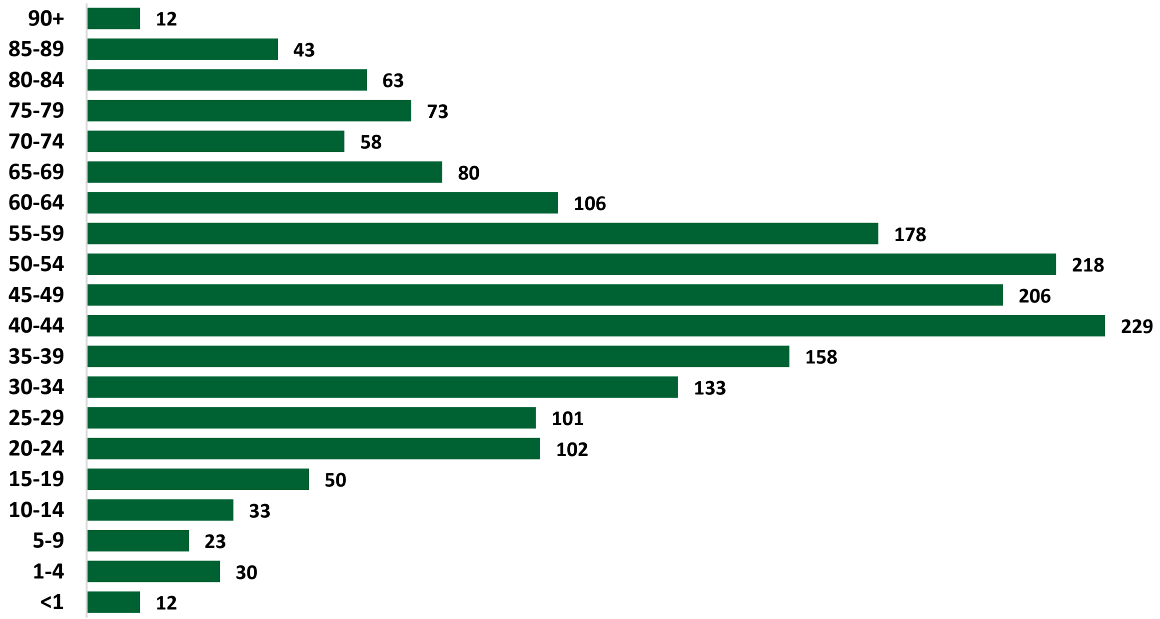


Demonstrating the benefits of mandating CO alarms in all residences, 63% of all co-related hospitalizations were the result of a poisoning that occurred in the home. Moreover, when missing data or unspecified data was removed from the analysis, 75% of CO-related hospitalizations occurred as a result of CO poisoning originating in the home. As demonstrated in Figure 6, there was little variation year over year in the number of hospitalizations for CO poisoning that originated in the home. In fact, the number of hospitalizations ranged from a high of 168 in 2004/2005 to a low of 114 in 2007/2008; a difference of 54 hospitalizations. And, between 2002/2003 and 2015/2016, the number of hospitalizations decreased by just 5.8% (see Figure 6). In other words, residences were consistently the primary location that people suffered CO poisonings that resulted in a hospitalization.

FIGURE 6: NUMBER OF CARBON MONOXIDE RELATED HOSPITALIZATIONS WHERE THE POISONING OCCURRED IN A HOME BY YEAR (N = 1,908)

Figure 7 presents the age distribution in Canada for CO-related hospitalizations where the poisoning occurred in a home between 2002/2003 and 2015/2016. As demonstrated by Figure 7, those between the ages of 30 years old and 54 years old made up 49.5% of CO-related hospital admissions where the poisoning occurred in a home. Of note, only 17.2% of hospitalizations were for people 65 years old or older.

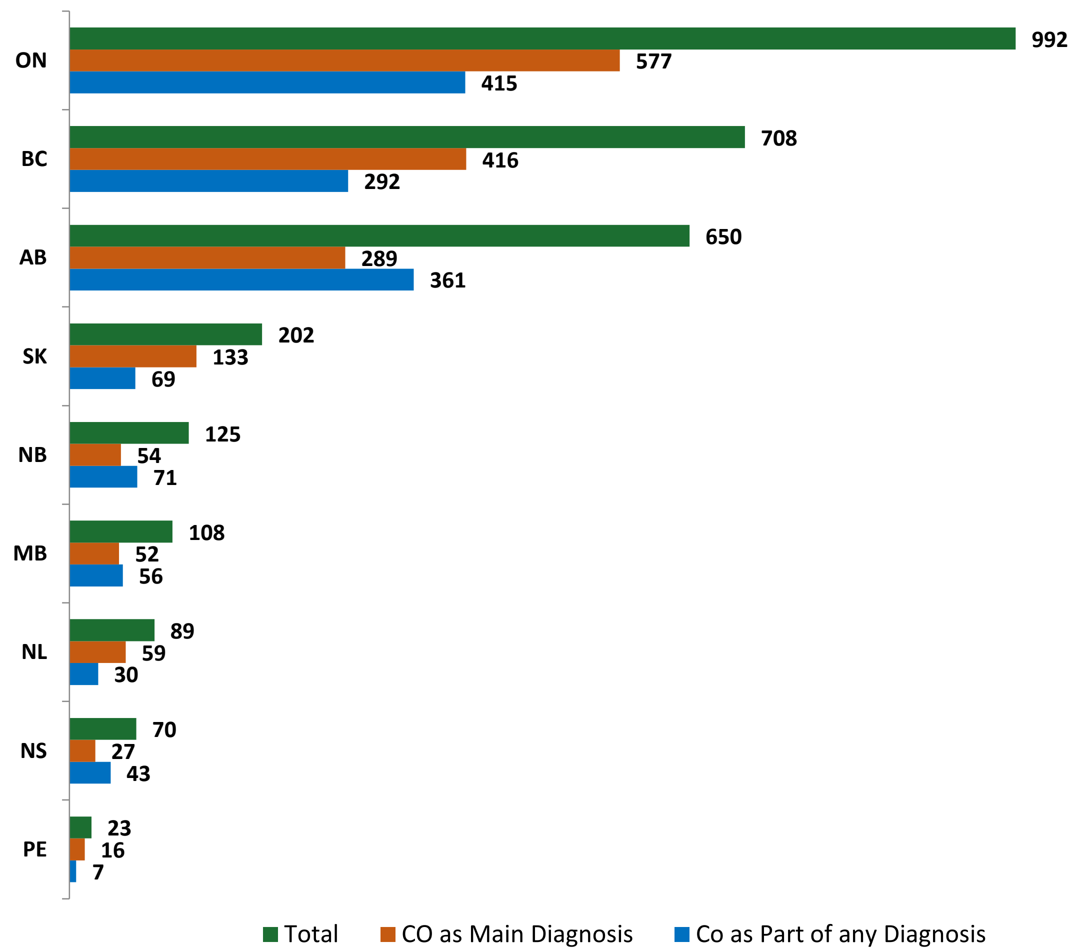
FIGURE 7: AGE DISTRIBUTION OF CARBON MONOXIDE RELATED HOSPITALIZATIONS WHERE THE POISONING OCCURRED IN A HOME BETWEEN 2002/2003 AND 2015/2016 (N = 1,908)



PROVINCIAL DATA ON HOSPITALIZATIONS RELATED WHOLLY OR PARTIALLY TO CARBON MONOXIDE POISONING

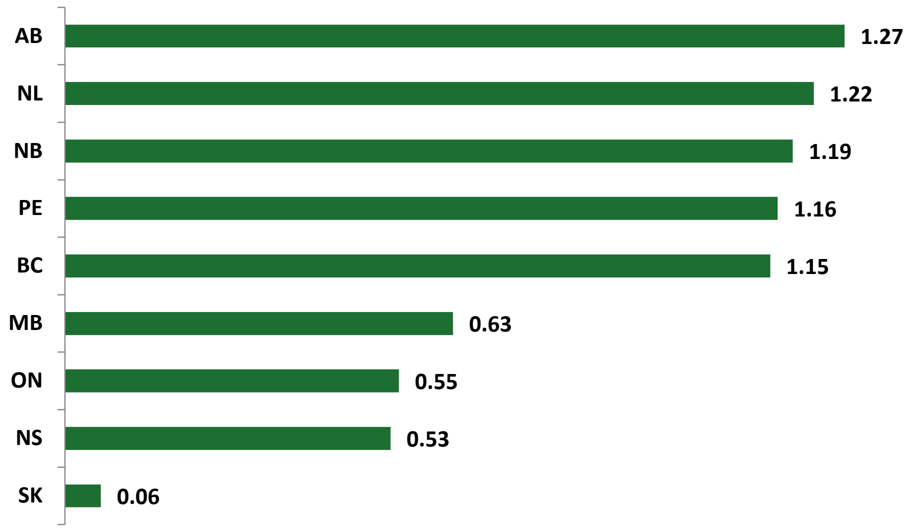
One clear way of understanding the frequency and rate of CO poisoning is by examining hospitalizations in which CO poisoning was either the main diagnosis or was a contributing factor in the final diagnosis. As demonstrated by Figure 8, 77.6% of all hospitalizations related to CO poisoning in Canada between 2002 and 2016 were in Ontario (32.7 per cent), British Columbia (23.4 per cent), and Alberta (21.5 per cent). In considering these three provinces, a majority of hospitalizations for both Ontario (58.2 per cent) and British Columbia (58.8 per cent) were cases in which CO poisoning was the main diagnosis. However, in Alberta, in only a minority (44.5 per cent) of hospitalizations was CO poisoning the main diagnosis. It should be noted that CO poisoning as the main diagnosis was also in the majority of cases for Newfoundland (66.3 per cent; n = 89), Prince Edward Island (69.6 per cent; n = 23), Quebec (64.7 per cent; n = 17), and Saskatchewan (65.8 per cent; n = 202). Regardless of whether the final diagnosis was exclusively CO poisoning or CO poisoning was part of a diagnosis, the large number of hospitalizations suggests that additional public education about the harms of CO and the need for functioning residential CO alarms is merited.

FIGURE 8: TOTAL NUMBER OF CARBON MONOXIDE HOSPITALIZATIONS BY PROVINCE (2002 – 2016)



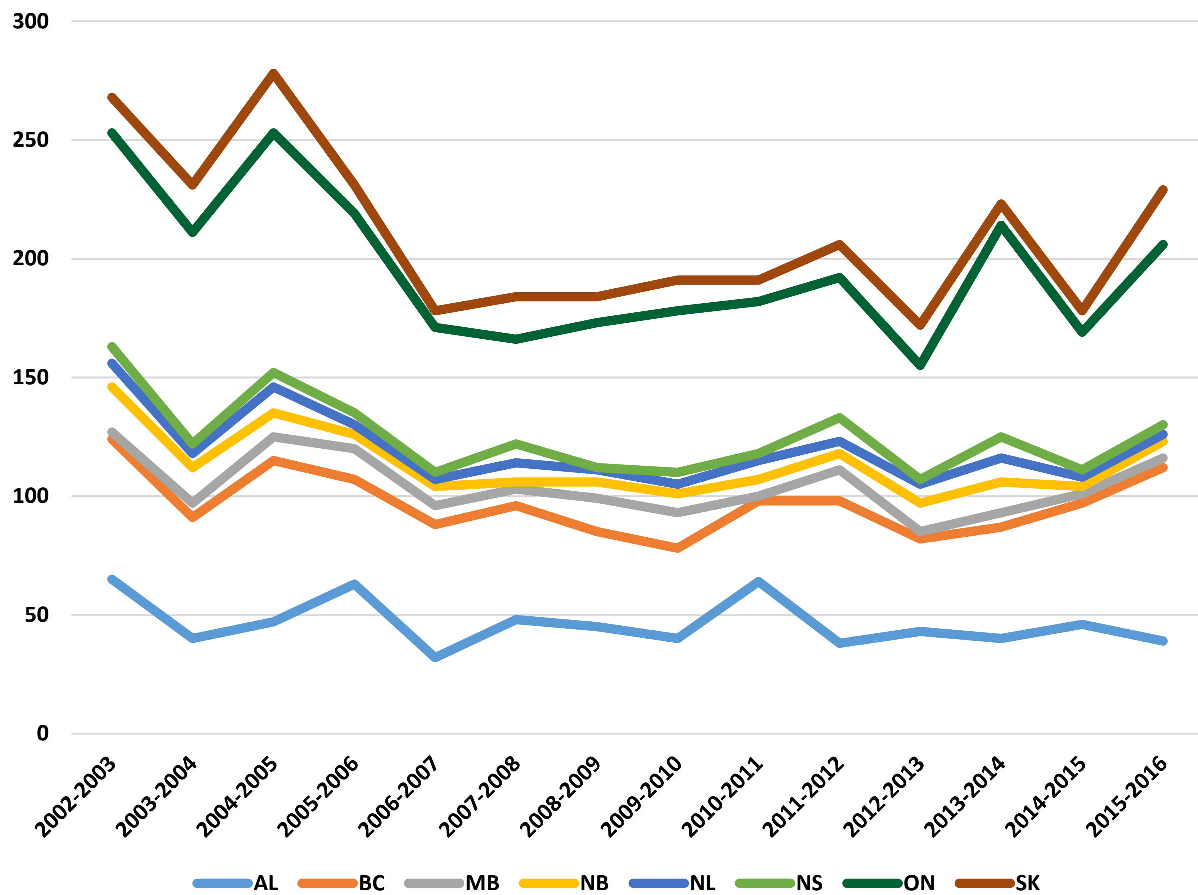
Another way to consider the hospitalization data is to control for population size. The data presented in Figure 9 is the rate of hospitalization related wholly or in part to CO poisoning per 100,000 in each province. As demonstrated in Figure 6, while Alberta had the highest per capita rate of hospitalizations (1.27 per 100,000 people), this was closely followed by Newfoundland (1.22) and New Brunswick (1.19). Of note, Ontario's per capita rate was only 0.55, suggesting that their large contribution to the overall number of hospitalizations was due to their larger population size, rather than a disproportionate number of CO-related hospitalizations.

FIGURE 9: TOTAL RATE OF CARBON MONOXIDE HOSPITALIZATIONS BY PROVINCE (2002 – 2016)



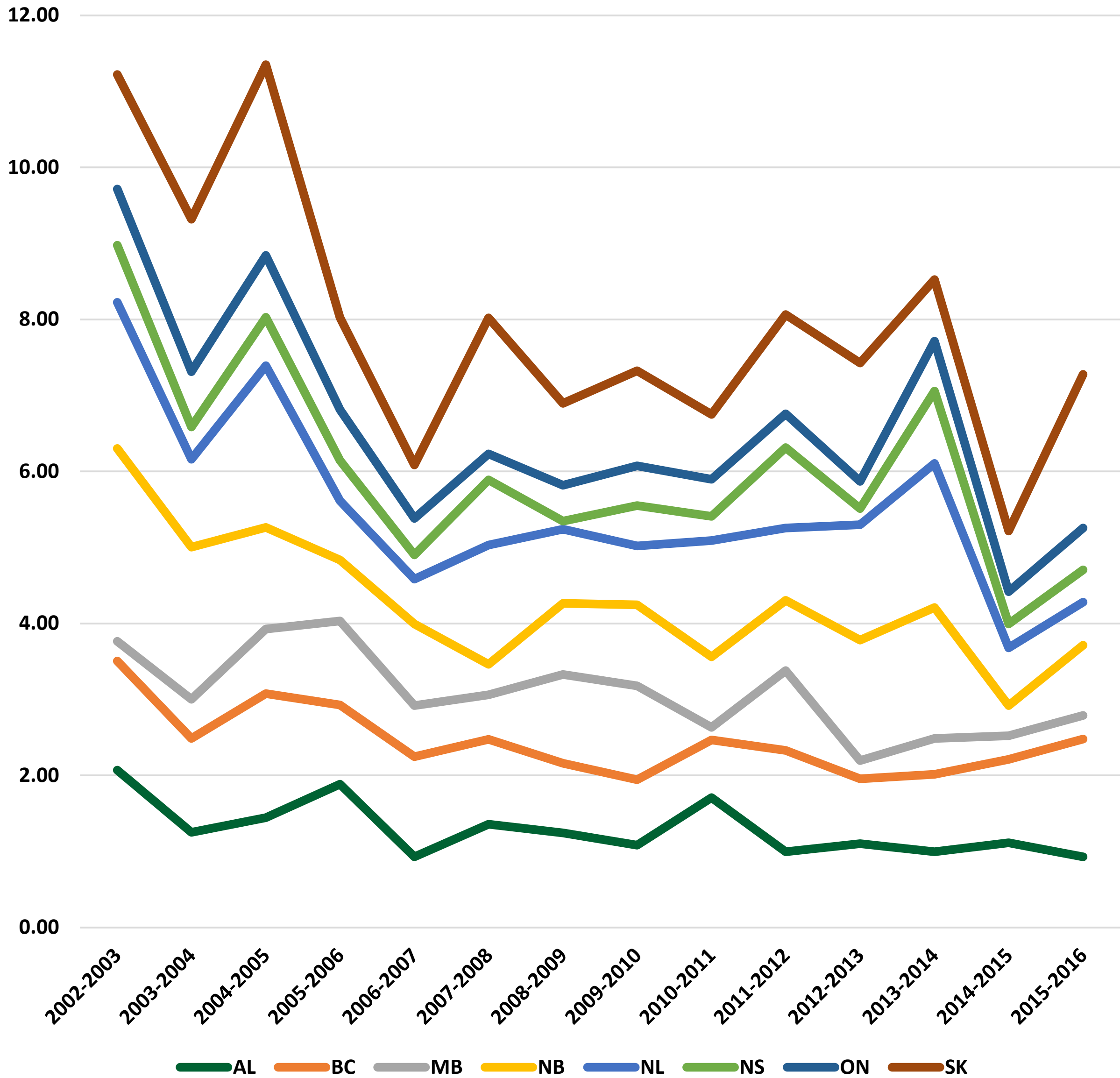
In terms of change over time, for those provinces in which data was available, on the raw number of hospitalizations related wholly or in part to CO poisoning, there was no clear pattern across provinces as some provinces saw increases between 2002/2003 and 2015/2016, while others saw decreases (see Figure 10). However, for the three provinces with the largest number of hospitalizations, Ontario had a decrease in hospitalizations over the 14 years of 15.6%, while Alberta had a 40% decrease over the same time period. Conversely, British Columbia experienced a 23.7% increase in the number of CO-related hospitalizations over the same time period. It is interesting to note that Ontario had a 31% increase in CO-related hospitalizations from 2014 to 2016, which might be the result of the legislation change mandating the installation and maintenance of CO alarms in residences.

FIGURE 10: NUMBER OF CARBON MONOXIDE HOSPITALIZATIONS BY PROVINCE (2002 – 2016)



When controlling for population sizes, again, some provinces saw increases in their per capita rate of CO-related hospitalizations, while other provinces saw decreases (see Figure 11). In terms of increases, the largest increase was found in Saskatchewan (34.7 per cent) between 2002/2003 and 2015/2016. This was followed by Manitoba (19.2 per cent), and British Columbia (7.6 per cent). Conversely, the province with the largest decrease in CO-related hospitalizations over the same time period was Newfoundland (70.5 per cent) followed by New Brunswick (63.4 per cent), Alberta (55.1 per cent), Nova Scotia (44.0 per cent), and Ontario (25.7 per cent). Again, with respect to Ontario, between 2014 and 2016, there was a 30.9% increase in the number of CO-related hospitalizations.

FIGURE 11: RATE OF CARBON MONOXIDE HOSPITALIZATIONS BY PROVINCE (2002 – 2016)



When considering the raw number of CO-related hospitalizations where the poisoning occurred in a home by province and territory in Canada over the 14-year time period, as expected, the largest number occurred in Ontario, followed by British Columbia, and Alberta (see Figure 12). In fact, these three provinces accounted for 79.7% of all the hospitalizations. The importance of CO detectors in the home is evidenced by the finding that, when removing missing or unspecified data from the analysis, for Ontario, 76.6% of all CO-related hospitalizations were the result of CO poisoning that occurred in the home. Similarly, the results for British Columbia was 73.7%, and 75% of CO-related hospitalizations in Alberta were the result of a CO poisoning that occurred in the home.

FIGURE 12: TOTAL NUMBER OF CARBON MONOXIDE RELATED HOSPITALIZATIONS IN CANADA BY PROVINCE WHERE THE POISONING OCCURRED IN A HOME (N = 1,908)

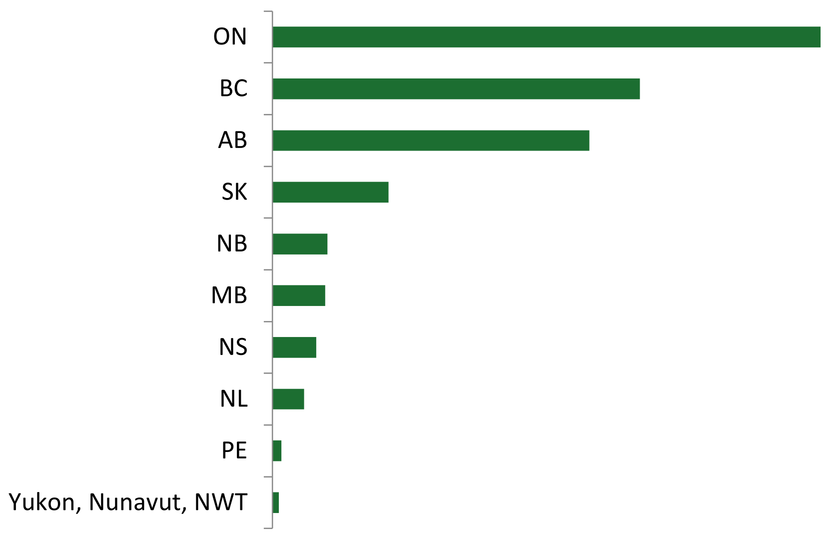
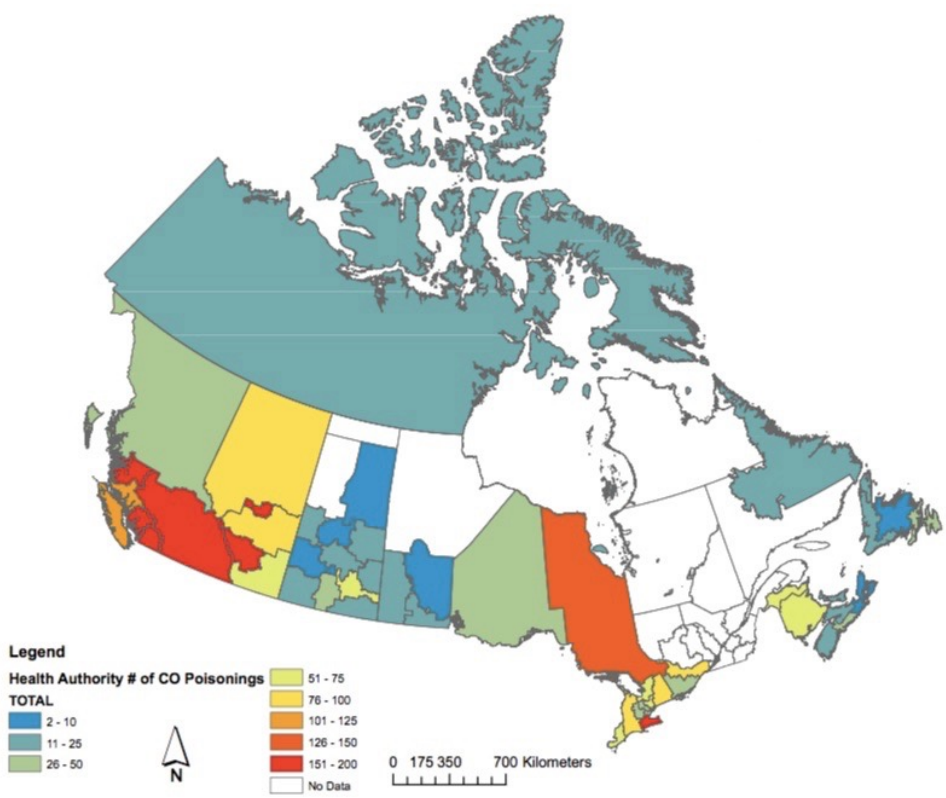


Figure 13 provides a visual representation of the distribution of hospitalizations from carbon monoxide poisonings in Canada between 2002/2003 and 2015/2016.

FIGURE 13: HOSPITALIZATIONS FROM CARBON MONOXIDE POISONING IN CANADA (2002/2003 TO 2015/2016)



Conclusion and Recommendation

This research note has provided evidence that, on average, there are more than 300 CO-related deaths per year in Canada, and more than 200 hospitalizations per year in Canada. Moreover, the vast majority of carbon monoxide poisonings occur in the home. Similar to the research on smoke alarms, CO alarms save lives and can reduce CO-related deaths. However, unlike the research on fire-related fatalities, which demonstrated a disproportionate risk for the elderly, three-quarters of the CO-related deaths in Canada were among those between the ages of 25 years old and 64 years old. However, if one only considers those deaths where there were no other underlying causes of death other than CO poisoning, the proportion decreases to 61.3%.

The province of Ontario has already mandated the installation and maintenance of CO alarms in all residential homes, retrospectively. While there has not been enough time to evaluate the full effect of this policy to date, in the short time since the implementation of the policy, hospitalizations for carbon monoxide poisoning in Ontario has increased slightly. What is needed is to determine whether this increase in hospitalizations has a corresponding decrease in fatalities. Moreover, the limited research in the United States (Hampson & Holm, 2017) has demonstrated that a combination of legislation and public education can increase the number of CO alarms in homes, which can decrease CO-related deaths. This is important because, in several provinces, such as British Columbia and Saskatchewan, the per capita number of hospitalizations for CO poisoning has increased in recent years.

While this research note could not find any research detailing the extent to which CO alarms are installed and functioning in homes across Canada, similar to fire alarms in the past, it is likely that there is a lot of variation. However, like smoke alarms, it is possible for every community to make progress on a commitment to ensure that every home has a functioning CO alarm. The first step towards this goal is to mandate this requirement in retrospective legislation throughout Canada. Again, given the success associated with smoke alarms, there is little excuse for not adequately addressing this issue. As such, the recommendation of this research note is that **all provincial governments either assist with regulating the requirement for the retrospective mandatory installation of CO detectors in all residential homes or legislate this requirement through building code amendments**.

References

[1] Canadian Institute for Health Information, Discharge Abstract Database.

[2] Center for Disease Control. *QuickStats: Average Annual Number of Deaths and Death Rates from Unintentional, Non–Fire-Related Carbon Monoxide Poisoning,*† by Sex and Age Group United States, 1999–2010*. Morbidity and Mortality Weekly Report (MMWR) 2014 [cited 2015 20 August]; Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6303a6.htm

[3] Garis, L., Clare, J., & Hughan, S. (2015). *Smoke Alarms Work, But Not Forever: Revisited. Successes and Ongoing Challenges from BC's Working Smoke Alarm Campaign*. Centre for Public Safety and Criminal Justice Research, University of the Fraser Valley.

[4] Hampson, N. B. & Holm, J. R. (2017). Compliance with Washington State's Requirement for Residential Carbon Monoxide Alarms. *Preventive Medicine Reports*. Vol. 5, pp. 232 – 235.

[5] Statistics Canada. Table 051-0001. Estimates of Population, by age group and sex for July 1, Canada, Provinces, and Territories, annual (accessed June 23, 2017).

Acknowledgements

The authors would like to thank Kidde Canada for its ongoing support in smoke and CO detection technology.

Author Biographical Information

Dr. Irwin M. Cohen is an Associate Professor in the School of Criminology and Criminal Justice at the University of the Fraser Valley (UFV) and the Director of the Centre for Public Safety and Criminal Justice Research at UFV. Contact him at Irwin.cohen@ufv.ca.

Len Garis is the Fire Chief for the City of Surrey, British Columbia, an Adjunct Professor in the School of Criminology and Criminal Justice & Associate to the Centre for Social Research at the University of the Fraser Valley (UFV), a member of the Affiliated Research Faculty at John Jay College of Criminal Justice in New York, and a faculty member of the Institute of Canadian Urban Research Studies at Simon Fraser University. Contact him at Len.Garis@ufv.ca

Fahra Rajabali holds an MSc in Health Information Science and has been a Researcher with the BC Injury Research and Prevention Unit since 2000. Contact her at frajabali@bcchr.ca

Dr. Ian Pike is Professor of Pediatrics at UBC; Investigator and Co-Lead of the Evidence to Innovation Research Theme at the Research Institute at BC Children's Hospital; Director of the BC Injury Research and Prevention Unit, and Co-executive Director, The Community Against Preventable Injuries. Dr. Pike has given over 30 continuing education sessions to physicians, nurses, public health, and safety professionals, and has over 50 peer-reviewed journal articles, and numerous invited plenary and professional presentations. Contact him at ipike@bcchr.ca

UNIVERSITY OF THE FRASER VALLEY

SCHOOL OF CRIMINOLOGY & CRIMINAL JUSTICE

UNIVERSITY OF THE FRASER VALLEY

CENTRE FOR PUBLIC SAFETY & CRIMINAL JUSTICE RESEARCH