International Conference on Carbon Monoxide Risk Assessment and Management

November 9 and 10, 2016

Chelsea Hotel, Toronto, Ontario, Canada

Conference and Business Proceedings

International Conference on Carbon Monoxide Risk Assessment and Management
November 9 – 10, 2016
Conference Report

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Acronyms (to be fixed)

CO	Carbon Monoxide
TSSA	Technical Standards and Safety Authority
ICD	International Classification of Disease
A&E	Ambulance and Emergency Care
IHME	Institute of Health Metrics and Evaluation
GBD	Global Burden of Disease
CDC	Centers for Disease Control
COHb	Carboxyhemoglobin
EPHT	Environmental Public Health Tracking (including….)
PRISM	Public Risk Management Institute
NPSAC	National Public Safety Advisory Committee, Canada
HVAC	Heating, Ventilation, Air Conditioning and Refrigeration
MOU	Memorandum of Understanding

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1.0 Background and Purpose

Carbon monoxide (CO) is a colourless and odourless gas resulting from the incomplete combustion of fuels used in various settings, mainly for cooking and heating purposes. CO exposure can cause a range of injuries and illnesses including headache, dizziness, nausea, unconsciousness and death.

According to the Annual State of Public Safety Report (2016 Edition) published by the Technical Standards and Safety Authority (TSSA), CO-related risks due to fuel-fired equipment continue to be the largest source of risk affecting Ontarians and are risks are far greater than any other risks that fall under their mandate.

CO exposure occurs mostly in indoor environments, through malfunctioning home-heating systems, the operation of gasoline-powered equipment such as automobiles in enclosed or semi-enclosed areas, incomplete combustion of hydrocarbon fuels used and improperly vented gas appliances.

CO occurrences and associated risks is a technical safety concern in Canada and across many parts of the world. There are concerted efforts in the USA and Europe in raising CO poisoning as significant public health burden on society. In particular, the Centers for Disease Control and Prevention, USA has mandated CO poisoning and exposure as a reportable condition by any medical examiner or emergency department and is collecting national statistics[1] for further analysis. The use of CO detectors as a mitigation measure is mandatory in Ontario[2]. However, opportunities exist to raise CO as a broader public health issue in Ontario and across Canada in a manner similar to the USA and Europe.

The first International Conference on Carbon Monoxide Risk Assessment and Management in Toronto, Ontario was held on November 9 – 10, 2016. It was organised by the TSSA to gather international speakers in the fields of public health and safety, regulators, industry, academia and other professionals involved in CO risk assessment and management.

The conference served as a platform to initiate a global dialogue to gain a common understanding of CO risks and its impacts on public health, globally and locally, and identify strategies to further enhance the learnings on CO risks and, more importantly, best practices in intervention.

Specifically, the objectives of the conference and business meeting were to facilitate the:

a. Formal recognition of CO as a public health burden;
b. Establishment of a network of collaborators, and
c. Identification of the next steps for the network to address CO-related health risks.

2.0 Conference and Business Meeting Format and Structure

The conference was organized over a period of two days. The first day (i.e. November 9, 2016) was open to the general public and featured presentations by speakers from around the world on their work on CO risk assessment and management. The second day (i.e. November 10, 2016) was a business meeting limited to the speakers and invited participants, and focused on specifically addressing the objectives of the network (listed above) to be carried out globally and nationally within Canada. The agenda for the conference and brief biographies of the speakers are available on the TSSA's Safety Exchange Blog (http://www.tssablog.org/archives/4674).

The presentations from the speakers will be made available on the website shortly.

[1] https://wwwn.cdc.gov/nndss/conditions/notifiable/2017/
[2] https://www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/Communiques/OFM_Com_2014-17.html

The second day involved business meetings with parallel sessions discussing potential opportunities for collaboration and next steps. The discussions and the outcome of the meeting is included in Section 4 & 5 of this report.

3.0 Conference Presentations

The agenda for the open conference was structured into two primary sessions.

Risk Assessment

The aim of this session was two-fold, with presentations highlighted on epidemiological studies, innovative approaches to estimating population exposures and identified challenges and limitations in uniform characterization methods.

There were eight presentations on the current methods of notification surveillance, data collection and reporting on CO mortalities and hospital admission rates across different regions of Europe, USA, Canada and New Zealand. Statistical trends, typical causes, and impacts of interventions on health burdens were also discussed.

The session also looked at initial estimates of the global mortality burden obtained from data through the global burden of disease studies. Presentations focused on epidemiological studies, innovative approaches to estimating population exposures and identified challenges and limitations in uniform characterization methods.

Risk Management

This session focused on a) regulatory and non-regulatory responses and b) risk management interventions to CO risks.

Regulatory actions and strategies focused on limiting the use of inefficient appliances, mandating the installation of detection methods and alarms, and coordinated government-stakeholder joint efforts to influence public policy decisions were highlighted.

Innovative solutions to detecting CO risks and addressing them through cost-effective technologies in the developed and the developing worlds were shared with the audience.

There were eight presentations on public awareness campaigns, behavior research and modification techniques and results from Europe and North America were presented by the speakers.

3.1 Risk Assessment Session Presentation Highlights

Highlights from the individual presentations are discussed below:

a. Maine's CO Poisoning Surveillance System

Kathy Decker from Maine's Center for Disease Control and Prevention presented on the findings and evaluation of Maine's CO poisoning surveillance system (COPSS). Kathy described Maine's case-based surveillance system wherein all cases (i.e., potential and confirmed) are reported. Interviews are conducted with survivors of confirmed/probable/suspect cases, risk factors are identified and the information is used to target interventions and advisories. 50.6% of poisonings were due to exposures from heating sources or generators. 25.9% of cases involved those working on vehicles in enclosed spaces or malfunctioning exhausts. Seasonality patterns were observed with the winter months having a higher number of cases. The percentage of homes with one or more CO detectors has increased to around 70% in rental and owned properties. When examining all cases, the mean carboxyhemoglobin (COHb) levels were found to be 2 times higher when CO detectors were not present as compared to when CO detectors were installed and functioning. The reporting has increased from 171 cases in

2008 to 675 in 2015 largely due to outreach efforts. When compared with medical records based on ICD codes for CO poisonings, it was determined that 70% of medical records were not reported to the Maine COPSS. However, only 47% of those "not reported" were deemed reportable for unintentional non-fire related CO exposures. Further outreach is being conducted to increase the level of reporting.

b. The burden of CO poisoning in England

Fred Piel from Imperial College, London presented statistics on CO poisonings in the UK. On an average, there are 40 deaths/year (England & Wales), 200 hospitalisations/year, 4,000 attendances/year at Ambulance and Emergency Care (A&E) departments for treatment for CO poisoning. Research undertaken by Imperial College indicates that the most at-risk age groups are <14 years and >65 years, with these age groups accounting for 31% and 25% of hospital admissions respectively. While impact on health likely to be underestimated (including misdiagnosis), reported data indicates that the number of deaths due to CO per year associated with natural gas have decreased from 1996 to 2009. Seasonality patterns like Maine were observed in the UK with the northern and western parts of the country having greater incidents of mortality.

Data using ICD10: T58 codes over the period of 2007/2008 – 2009/2010 were collected, analysed and presented by geographical regions, age, sex, and deprivation. The admission rates were lower in least deprived areas. Preliminary analysis of the data indicates that nearly 7% of all A&E visits were ICD10 coded. Additionally, 16% of A&E attendances for CO poisoning were admitted to hospitals. Conversely, 82% of inpatient records could be linked to A&E data. Further studies are required to better characterize morbidity levels in the UK.

c. Data Sources Exploitation for Studying the Public Health burden of CO: Italian National Databases on Mortality and Hospitalization

Susanna Conti from the Italian National Institute of Health presented information on:
a) current data sources related to population, mortality and hospitalisations;
b) methodologies to analyse mortality and hospitalization data; and
c) an overview of analysis strategies to study mortality due to CO poisoning.

Mortality data is available from the Italian Mortality Database for the period between 1980 and 2013. This database is based on official mortality and population data at a municipal level (Italian National Institute of Statistics). The International Classification of Disease (ICD) ICD-9 codification will be used to analyze data until 2002 and ICD-10 will be used from 2003 onwards. Standardized mortality ratios and causes for death for different groups will be calculated for each regional population. Information on hospitalizations are collected at all Italian hospitals and coded using ICD-9CM. Data on demographics, admissions and discharge and diagnoses are available based on this approach. Mortality and hospitalization analysis related to CO poisoning will be conducted as local, regional and national levels. Furthermore, upon finalization of a proper analysis strategy (including ICD codes), international comparisons will be possible.

d. Death Due CO Poisoning – Global Mortality Burdens

Mohsen Naghavi, representing the University of Washington and the Institute of Health Metrics and Evaluation (IHME produces the Global Burden of Disease (GBD) reports), spoke of the GBD as a systematic scientific effort to quantify the comparative magnitude of health loss due to diseases, injuries and risk factors by age, sex, geographies for specific points in time. As of 2015, it is possible to estimate 315 GBD causes including 249 causes of death, 310 causes of morbidity and 79 risk factors and across 20 age groups for males and females. The data is available across 195 countries and territories and many at sub-national levels. Data on mortality are obtained through national Vital Registration databases. Mohsen described the hierarchical pattern used by the GBD to describe the cause, sequelae, and risk factors. Indoor CO data can be tracked under causes as injuries resulting from poisoning. The specific code of X47 (accidental poisoning by and exposures to other gases and vapors) under ICD 10 is primarily used when tracking under cause. CO is also tracked using ICD9 code under E868 which is specific to CO. Where data was available under X46 (Accidental poisoning by and exposure to organic solvents and halogenated hydrocarbons and their vapours) and X47, estimates of CO deaths were presented across several countries. Using GBD's approach of assuming similar population ratios across all

countries, it is estimated that over 15,000 deaths occur per year. The data can also be analyzed through risk factors under the environmental category and the sub-category of indoor air pollution. If data is available through a combination of causes and risk factors, it is estimated that the deaths can be as high as 30,000 deaths/year. Based on estimates, highest fraction of deaths occurs at a younger age and are largely due to cooking stoves. Mohsen indicated that the international network should strongly push for CO to be included under the 2017 study to obtain formal rates of burden globally.

e. Mortality and Hospital Admission Rates for Unintentional Non-Fire Related CO Poisoning across Canada: A Trend Analysis

Eric Lavigne from Health Canada presented on the work carried to evaluate trends in mortality and admission rates from unintentional non-fire related CO poisoning in Canada which has been recognized as the country's largest source of accidental poisoning deaths. Using mortality data from Statistics Canada and adopting ICD-9 and ICD-10 codes, analysis was carried out on gender, age groups, provinces and actual locations of exposures. Hospital admission rates between 1995 and 2010 were obtained from the hospital morbidity database maintained by the Canadian Institute for Health Information (https://www.cihi.ca/en) using ICD-9 and ICD-10 codes and analyzed for similar patterns and trends. Results of the statistical analysis indicate that mortality and admission to hospital rates for unintentional non-fire related CO poisoning decreased steadily in Canada over the past decades. Rates declined among both males and females, but rates in males remained higher. Rates for all sites of occurrence of CO poisoning decreased over time, but the magnitude of the decrease for this type of poisoning that occurred in home and residential environments was the lowest. CO poisoning mostly occurred from September to April, with peaks during the winter period. Decreasing mortality and admission to hospital rates reflect the trends observed in other developed countries.

While no evidence of direct correlation is available, there have been improvements in design, use and maintenance of home products. Vehicles susceptible to the release of CO have benefited from the inclusion of catalytic converters and increased awareness.

Improved medical care for patients with CO poisoning and the use of CO alarms in homes may also have reduced the number of cases of CO poisoning.

f. National CO Poisoning Surveillance Framework (USA)

Kanta Sircar from the US Centers for Disease Control and Prevention (CDC) presented about the national CO poisoning surveillance numbers in United States.

There are three main purposes for CO poisoning surveillance. They are:

a) immediate response to a national disaster,
b) planning and evaluation of prevention programs (e.g., trends over time, identifying high risk groups and evaluating effectiveness of policies and programs), and
c) investigating new sources of exposure, such as remote ignition vehicles.

The CO Poisoning Surveillance Framework, published by the National Center for Environmental Health, adopts a five-tier pyramid structure. The definitions for each element on this pyramid is described in a position statement developed by the US Council of State and Territorial Epidemiologists (CSTE). It is recommended that all entities in the US, including state, local, territorial and federal partners who conduct CO poisoning surveillance, use these definitions. Data sources for each of the elements of the pyramids, associated data sets, and trends were presented.

There were approximately 450 deaths reported annually. Between 1999 and 2010, most CO poisoning deaths were suicides; this trend has been decreasing over time. Other sources of CO poisoning surveillance data were also identified.

g. Population exposure to CO: Some Italian experiences

Stefano Zauli and Paolo Lauriola from the Italian Centre for Environment and Health presented on different population exposure studies in Italy. Ambient CO concentrations in the outdoor environments have decreased from 10 ug/m^3 to 2 ug/m^3 between 1980 and 2013. Stefano described the SEARCH project which monitored for children exposure to CO in schools. The key findings in the study indicated that CO concentrations were observed to be highest between 8AM and 10 AM. In another study in the province of Modena, a database of COHb levels in general populations using blood samples. COHb were found to higher in those living in the mountains compared to those in the city and rural areas. Also, the levels were found to be higher in winter months compared to summers. A review of literature indicates that only seven studies have been done comparing COHb levels with CO exposures. The data from Modena's centralized laboratory for blood samples seems promising to an easy and systematic access to COHb data within a CO poisoning surveillance framework. Major strengths are the possibility to have surveillance data on COHb levels for the general population and the possibility of record linkage with other bio-chemical parameters and health databases. The relationship between COHb levels and the various CO sources of exposures and possibility to identify smoking individuals and those with pathologies leading to high COHb levels via cross analyses of available parameters need to be scrutinized.

h. Exposure to Carbon Monoxide in England

Giovanni Leonardi from Public Health England (PHE) presented the work of the Environmental Epidemiology division. In particular, he mentioned about the direction of the organization's tracking work focusing on health-related data and hazards in homes. The focus has shifted from treatment to prevention. In this regard, he shared the toolkit developed by PHE for local public health action in preventing CO exposures.

He described three alternative approaches for estimating the exposures of a population to air pollution: 1) the "direct approach," using field measurement of a representative population carrying personal exposure monitors, 2) the "indirect approach," involving computation from field data of activity patterns and measured concentration levels within microenvironments, and 3) a hybrid approach that combines the direct and indirect approaches. The environmental public health tracking (EPHT) team at the PHE are currently conducting surveillance of death events coded as having been caused by CO poisoning, in order to relate these events with known hazards associated with CO at population level (for example, building related factors such as gas appliance failures and ventilation defects).

The mortality data, provided by the Office of National Statistics' (ONS), includes accidental non-fire related deaths in England and Wales which occurred in 1998-2010 where the toxic effect of CO is mentioned anywhere on the death certificate. ONS have provided the results of a text search undertaken on the coroners' reports of these deaths, to identify the place of exposure (e.g., home or caravan), the source of CO and any behaviours associated with the exposure. Preliminary results of the sources of CO, places of exposures, and behaviours leading to such exposures were shared. CO exposures from field epidemiology studies using CO monitoring in vulnerable homes were also shared.

Previous analysis of available mortality data has been insufficient to confirm sources and locations of accidental CO poisoning. The results of the current analysis will allow EPHT to establish the exact cause of exposure in order to describe and examine the relationship between fatalities of CO poisoning and sources of CO. The overall aim of this study is to be able to target specific public health interventions designed to prevent deaths from CO and to inform agencies responsible for these interventions (local authorities, housing associations, gas companies and others) of the prevalence of deaths identified as being caused by a known hazard.

i. CO Exposure in New Zealand, Retrospective of Morbidity and Mortality

Matthew Ashworth from the Institute of Environmental Science and Research presented on statistics from New Zealand. While electricity remains the primary source for heating in New Zealand, natural gas and bottled (LPG) gas is also used. Between 2006 to 2009, there have been between 50 to 80 deaths per year, and between 2006 to 2011, there have been between 120 to 180 hospitalizations per year occur due to CO. A total of 324 deaths occurred between 2006 and 2012 and most common amongst the age groups of 25-44 and 45-64 years. The most common causes of fatalities were running vehicles in confined spaces, unflued gas heaters, burning fuel in

confined spaces, improperly functioning gas stoves, and broken or blocked chimneys. Statistics on ambient outdoor air quality indicate decreases in CO concentrations over the last decade in Auckland. Case studies involving occupational exposure to CO were also presented involving chainsaw operators in the forestry sector and fire fighters tackling barn fires.

3.2 Risk Management Session Presentation Highlights

j. Regulatory Responses to Managing CO Exposures in Ontario

John Marshall of the Technical Standards and Safety Authority (TSSA) referred to the annual state of public safety report produced by the TSSA that identifies CO risks at private and multi-unit residences as the primary sources of risk under its jurisdiction. 1,536 CO exposures involving 201 injuries and 20 fatalities have occurred in private dwellings in Ontario between 2008 and 2015. There is an increasing trend in the number of occurrences of 5%/year over this time period. Boilers, furnaces and water heaters form the three most common appliances involved in occurrences. Lack of, or improper maintenance and inappropriate use of these fuel burning appliances in private dwellings continue to be the largest contributor to the risk of injury or fatality.

There have been 309 occurrences, one fatality and 55 injuries in multi-unit residences, and there is increasing trend in the number of occurrences of 7% per year. Natural draft boilers have been involved in most of the incidents that have taken place at community housing locations, condominiums and rental properties. John also shared results of CO occurrences taking place at commercial establishments such as food service locations, and institutions such as schools and seniors' homes. TSSA is working on enhancing its advocacy through partnerships for communicating and building awareness amongst stakeholders including the public, communicating the need for maintenance, exploring innovative technology solutions, and regulatory alternatives to address the issue. In addition, The TSSA is leading the work towards building a global coalition of partners and collaborators to develop and communicate understanding of CO risks and sharing best practices in risk mitigation.

k. The Ontario Office of the Fire Marshall and Emergency Management's (OFMEM) Regulatory and Public Education Approach to Reducing CO Risks

Al Suleman of the OFMEM presented on the *Hawkins-Gignac Act* and related *Fire Protection and Prevention Act* amendments and associated details on the CO alarm regulation. In addition, he also provided details on CO alarm public education resources. The *Fire Protection and Prevention Act* of Ontario was amended to allow for mandating CO alarms within the Ontario Fire Code. It applies to existing residential occupancies that contain at least one fuel-burning appliance, fireplace or attached garage and requires the installation, maintenance and replacement of CO alarms by owners/landlords. It also has additional testing requirements for landlords. Details on these requirements, the powers for inspections and enforcement were also provided. Future amendments to legislation including extending the requirement to beyond residential occupancies were also discussed. Al also presented the various public education tools and resources produced by the OFMEM in educating the public and changing their behaviors.

l. Review of U.S. State-Level Laws in Requiring Carbon Monoxide alarms in Residential Settings

Fuyuen Yip from the US CDC presented background information on morbidity and mortality statistics in the US that include approximately 20,000 emergency department visits, 4000 hospitalizations, and 450 deaths annually. It is estimated that accidental, non-fire related poisoning accounts for over $1.3 billion annually in societal costs. Based on the 2009 National Household Interview Survey, 37% of US households reporting having a CO alarm. CO alarm laws in the US are sometimes adopted in response to CO poisoning events. They are typically adopted as part of Public health and safety laws or landlord/tenant laws. It is also common for state adoption of large national or international code(s) such as International Code Council (ICC) building, residential, and fire codes and National Fire Protection Agency (NFPA) codes and standards. The CDC undertook a preliminary study to describe state-level laws that require CO alarms in residential dwellings and to assess provisions of CO alarm laws pertaining to public health guidance for CO poisoning prevention. 71 CO alarm laws were identified across 36 states in the US. Most of the requirements were associated with new constructions or major renovations. Other unique attributes including locations of alarms, types of dwellings etc. were presented. The US CDC, in

partnership with NIST (National Institute of Standards and Technology), have carried out research on portable generators, which was shared. In particular, results of the research carried out to estimate safe distances generator placement outside the home, based on emission rates were shared.

m. CO in Government and Policy - The UK Perspective

Adrian McConnell outlined the Gas Safety Trust's (UK) work relating to CO risk research. He indicated that there is a large discrepancy for the number of incidents reported in the UK and across Europe. While the UK's Department of Health estimates that there are 30 deaths per year due to CO, speakers believe that the real number is much higher. He also noted that many incidents are not recognized as CO poisoning. He suggested some policy interventions including penalizing unregistered gas installers/encouraging registration, replacement of open-flued appliances, increased regular servicing of appliances, coordinated efforts to increase customer awareness of CO, increased usage & legislation for CO alarms, create harmonized approach across all fossil fuels that could cause CO incidents (gas, coal, wood, oil etc.), and increasing awareness amongst the medical profession about the symptoms of CO exposure.

Adrian then outlined initiatives from the UK that promote more joined up approaches across Government to tackling the issue of CO, such as the All Party Parliamentary CO Group, the All Fuels Action Forum, and the Cross-Government Group on CO. He described the progress being made in getting better coordination amongst several government and non-governmental groups who have been working in silos this area, in the UK.

n. Role of Technology in Identifying, Managing and Learning from CO Exposure Incidents

Leigh Greenham representing the Council for Gas Detection and Environmental Monitoring presented on innovations in Domestic CO alarms. Dataloggers, Medical screening instruments, Personal Protective Equipment, workers' CO detectors, Electronic Combustion Gas Analyser (aka Flue Gas Analysers, FGAs), and In-situ combustion sensors. Some of the innovations include on low concentration indication, warning displays, internet datalogging and phone applications, wireless communications and Internet of Things and Connected Homes, travel alarms and sensor formats. Medical screening instruments including breath analyzers, non-invasive pulse CO-oximetry, and low cost personal CO detectors were described.

o. Delivering Clean Cooking Solutions in Rural India

Chandra Shekhar Sinha from the World Bank presented a perspective of the problem in the developing world. He described the issue of household air pollution which accounts for 4.3 million deaths globally and nearly 1 million premature deaths occur in India and are attributed to household air pollution. More than 90% of the solid biomass-dependent households use inefficient traditional cookstoves as primary cooking devices, which cause high levels of household air pollution. The focus has therefore been on making affordable clean cooking options available. Global Alliance on Clean Cookstoves has defined a 4-tiered efficiency and emissions performance system. The effort to reduce health impact focusses on $PM_{2.5}$, and CO is a co-benefit. As a result, CO levels come down by ½ to ¼ from the baseline (Tier 0) technology for Tier 4 advanced biomass stoves. The focus is therefore on promoting and providing use of Tier 4 or better cooking solutions for achieving health, environment and gender outcomes using market based mechanisms and incentives. Additionally, low cost CO and $PM_{2.5}$ sensors are being developed and piloted as a better means of evidence collection for the purposes to test the effectiveness of the clean solutions and results based incentivization.

p. Carbon Monoxide and Behaviour Change

Isabella Myers, an independent consultant in the UK, focused her presentation on the work being done to change behaviors of healthcare professionals to aid diagnosis of CO poisoning and the public to prevent exposures. Isabella presented the health effects associated acute and chronic exposures and the toxicological mechanisms of CO. She also described the potential neurophysiological, neurobehavioural changes and delayed neurological effects associate with CO poisoning. She presented scenarios and factors that may need to be considered and questions that need to be asked to ensure proper diagnosis and showed some of the tools that have been created in the UK for this purpose. Different frameworks and models for changing public behaviors were also provided.

There are inherent problems in tackling CO poisoning because of the numerous sources, numerous locations where incidents occur or are diagnosed. While there are preventative measures, they require action from several different organisations. It is difficult to record and gather data while data needed to change behaviours. Awareness raising is the starting point of the much longer process of behaviour change and needs trusted messengers. Preventing disease and promoting health require actions and commitments from the individual, family, community, and society, as they are all interconnected. Healthcare professionals can play a key role in changing patterns of patient behaviour and influencing public policies. Health-promoting interventions from the individual level to the policy level should be developed to encourage action.

q. Innovations in Public Education Tools – Successful Case Studies for Injury Prevention

Pamela Fuselli from Parachute Canada described the organization's work as a national charitable organization focused on preventable injuries and focuses its activities on building capacity, collaboration, influencing public policy, legislation, standards, translating best practice knowledge, and creating public awareness. She described Parachute's work on CO-related public education in Canada through its website portal, creation of resources and educational material, and social media platforms. She also presented Parachute's involvement in public policy, particularly with respect to CO legislation.

4.0 Business Meeting Discussions

In recognition of the challenges and opportunities identified during the presentations and ensuing discussions in determining and managing CO-related risks, it was agreed that there was value in forming a collaborative working group. In particular, two sub-groups were formed to determine the specific objectives of a national and an international network. It was agreed that the PRISM Institute would serve as the network secretariat.

4.1 International CO Network (ICON)

International speakers who presented at the conference on November 9 had discussions regarding:

- The identification of potential and available data
- Approaches to conduct surveillance, and
- Methods to analyze and interpret CO–related data (e.g., exposures and poisonings).

The following topics were discussed:

a. <u>Surveillance and Monitoring on CO Exposures</u>

The group discussed adopting the Environmental Public Health Tracking (EPHT) approach for monitoring and surveillance applications. EPHT is structured to integrate and analyze environmental hazards, exposure, and health data. The tracking framework can serve as a platform to integrate different exposure and health data and can be adopted by any interested group. Moreover, applying the EPHT approach can be a useful pilot experience to examine the effectiveness of collaborative data interpretation in different settings throughout the world.

b. <u>Global Burden of Disease</u>

The group received a comprehensive summary on the Global Burden of Disease effort and its specific process. Based on the information, there is potential opportunity for the group to:

i. Provide expertise and "use case" for further calculating CO poisonings (which would be a subcategory of the "poisonings" analysis) by intent, or other relevant categories, and share a CO case definition (and associated methodologies, where appropriate);
ii. Assist in identifying potential CO-related exposure data that could help enhance the GBD analysis, if that becomes a topic interest for GBD; and

iii. Develop a proposal and an MOU with the GBD for collaborative initiatives.

The group agreed that this would be a parallel effort to the surveillance activities described above.

To ensure comparability, the group also discussed an initial group pilot project:

i. Assess available data and compare and develop a consistent case definition for CO-related mortality;
ii. Develop a consistent case definition (or tiered definitions, based on the US experience) that can be used by all collaborators to compare CO-related mortality across several countries; and
iii. This can serve as an initial joint effort between the UK, Italy, US, Canada, New Zealand, and any other interested groups.

Based on these efforts, it can be determined how best to expand into other larger projects as a group. Other areas suggested regarding CO-related health data include:

i. Refinement of CO-related morbidity (e.g., ED visits, hospitalizations);
ii. Examination of other CO-related health measures (e.g., DALYs) that could be used;
iii. Identifying relevant data sources to address the different levels of the surveillance pyramid (as shared by K. Sircar, CDC);
iv. Examination of indoor CO investigation data could help to lead to focus on indoor CO exposures and other pollutants; and
v. Assessing ability to capture more timely information via clinicians (e.g., GPs can be particularly important in collecting information on CO poisonings).

c. CO-related Exposure Data

The group discussed the objectives of collecting CO-related data and the types of data that should be collected. The objectives of data collection are to:

i. Provide a clearer understanding of populations most at-risk to help inform country-specific activities;
ii. Compare data across a select group of countries with greater consistency and detail; and
iii. Improve our CO-related estimates by learning from each other.

Discussions also highlighted CO-related exposure data collected currently by different groups, as well as data that could potentially be collected, that could be useful to improve our understanding of CO poisoning (e.g., media monitoring from CO-related incidents, new passive technologies to capture CO levels, etc.)

Concurrent with the pilot project, it was proposed to begin exploring different sources of exposure data and to assess opportunities to apply these data in a larger analysis

d. Next Steps

It was suggested to conduct on-line webinars to learn about how data are collected in different countries.

4.2 Canadian CO Network (CCON)

Canadian speakers and other invited participants discussed collaborative opportunities to better understand and address CO risks in Canada through a Canadian CO Network (CCON).

The objectives of CCON are to contribute to the assessment of CO risk in Canada, use global assessments to better understand public health burden, and provide guidance on threshold assessments.

Mitigation strategies predicated on regulatory and enforcement requirements, technical solutions, and public awareness and education were discussed. Regulatory and enforcement requirements considered include mandating CO detectors (new and retrofit) and associated standards.

Technical solutions based on inherently safe designs, such as safer appliances and detectors were discussed. Methods for influencing industry to come up with such solutions included incentives, mandatory requirements, and standards. The importance of understanding consumer choices and conducting cost-benefit analysis in developing technical solutions was emphasized.

Canada's contribution to building public awareness and education through innovative methods of understanding attitudes and behaviours was discussed in detail. Awareness campaigns targeted toward the following groups were identified as improvement opportunities:

- Homeowners/operators
- Service providers
- Manufacturers
- Policy makers

In particular, the group agreed that a strong approach to building awareness would be to first focus on prevention followed by detection.

The establishment of cross-functional multi-disciplinary partnerships involving the following groups was emphasized:

- Manufacturers: appliances and detectors (including component manufacturers)
- Service providers: contractors, technicians, distributors, HVAC (heating, ventilation, air conditioning and refrigeration)
- Industry: trainers, influences, installers, builders, home inspectors
- Government: local/municipal, provincial/state, federal, First Nations communities

5.0 Challenges and Opportunities for Collaboration

The presentations highlighted challenges in the characterization and management of CO risks, and identified opportunities for collaborative resolution. Key challenges and opportunities are described in this section.

5.1 Risk Assessment

a. Classification of International Classification of Diseases (ICD) Codes

Challenges: Due to a lack of standardised use of common ICD codes, it is difficult to collect, share and conduct benchmarking exercises on CO mortality and morbidity data.

Opportunities: While ICD 9 and ICD 10 were recognized as two possible versions, specific sub-categories of ICD codes may need to be created based on their intended application (i.e., benchmarking, contextualisation, causation, decision-making, etc.,).

b. Sources of Data

Current State: Presenters indicated that there are several repositories and/or sources of data regarding exposure and surveillance. Data sources for ascertaining exposures include national vital statistics, hospital admissions, emergency department visits, and blood results from routine health checks. Field experiments including environmental monitoring helped collect data on environmental exposures. In addition, data sources from fire

departments, regulatory and investigative agencies, product certification agencies were also presented describing information on causes for CO exposures. Surveillance systems at national, sub-national and local levels are being used globally.

Challenges: There is a lack of standardization in the collection and identification of data attributes (i.e., causes, risk factors, health effects, etc.,).

Opportunities: There is a need to identify required data attributes, data mining methods, and surveillance systems. Tools and incident management systems that capture the entire life cycle of the occurrences ranging from causes all the way to health effects should be shared with other jurisdictions.

c. Characterization of Exposures

Challenges: There are different definitions and certainties associated with various exposures, depending on the source of exposure (i.e., medical, biomedical, environmental). This presents challenges in establishing relationships and correlations between parameters.

Opportunities: Further research studies are required to establish relationships and correlations between the different categories of exposure (e.g., the correlation between CO concentrations and COHb levels). A major limitation and a clear opportunity is to better understand long-term health effects from both acute and low-level chronic exposures.

d. Quantification of local and global burden of injury

Challenges: Considering mortality rates alone did not necessarily represent the true significance of the public health burden and as such was not receiving attention from decision-makers (i.e., the aggregated burden of non-fatal injuries are absent across various jurisdictions).

Opportunities: There is an opportunity to create a methods for combining mortality and morbidity rates, and estimating the aggregate burden of injury. Approaches, such as the pyramid framework developed by the US as part of the larger GBD initiative, should be initiated in a collaborative manner and complementary to the above identified tasks and opportunities.

5.2 Risk Management

a. Regulatory Risk Mitigations Tools and their effectiveness

Challenges: Several regulatory risk mitigation tools were discussed that were primarily focused on the CO alarm legislation. However, evidence of the effectiveness of such pieces of legislation and the appropriate set of metrics for the purposes of measurement are not clear and standardized. It was also identified that there is a lack of information on other innovative regulatory tools.

Opportunities: There is an opportunity to undertake a broad-based mapping exercise that identifies the regulatory instruments which have been used across multiple jurisdictions, their successes and lessons learned through the process. The group also identified the need for establishing a data warehouse.

b. Technology Solutions and Behavior Modifications

Challenges: Innovative approaches to detecting and responding to CO are being developed and implemented both in the developed and developing worlds. However, efforts are not coordinated and the reliability and effectiveness of these solutions are unknown.

Opportunities: A compendium of technology solutions, evidence of their successes and lessons learned could be developed to assist jurisdictions in adopting and applying similar approaches. Innovative behavioural models have been developed that have the potential to be universally applicable. There is a need to share such models and

coordinate research to extend the application of these models to address the broader effects of indoor air pollution.

6.0 Declaration to Formally Recognise CO as a Public Health Burden

In response to the identified challenges and opportunities and as one of the objectives of the conference, the group jointly agreed to the following declaration:

- CO poisoning from unintentional exposure is considered a public health burden;
- The burden of injury associated with CO is underestimated;
- There is a need for undertaking further research in better understanding the acute and chronic health effects of CO (including at low levels of exposure), and its burden on regional and global populations; and
- There is need to collaborate locally and internationally to reduce risks from CO poisoning globally by developing cost-effective and innovative technology solutions, and identifying best practices in behavioural research, public awareness and education.

7.0 Recommendations

The following recommendations have been made, with the intent of leading to action-oriented strategies moving forward.

a. Harness public health resources to shed greater light on CO as a public health burden that would help lead to better technical safety regulations.
b. Harmonize and ensure consistency in information and statistics on CO risks.
c. Improve knowledge of long-term health effects from CO including impacts from low level exposures
d. Support research to identify appropriate biomarkers and indicators of CO health effects in coordination with appropriate environmental measures.
e. Present CO risks through the lens of indoor air pollution. CO could become a better proxy for indoor air pollution.
f. Strengthen support and resources for environmental public health tracking of CO in the developed and developing worlds.
g. Promote research on integrated approaches to assessing and managing CO risks considering other contexts such as climate change, energy efficiencies, etc.
h. Identify treatments with the vision of considering CO poisoning as a totally preventable public health issue.
i. Build on, and partner with other existing networks in public health, public safety, and the environment.
j. Involve other key stakeholders, including industry and standards development/certification bodies.
k. Identify gaps in shared data, and determine means by which to obtain and/or generate missing, but necessary data.
l. Create and provide easy access to knowledge and data using a web based portal such as the one developed by the UK Gas Safety Trust.
m. Create a standard for terminology relevant and applicable to CO risk assessment and management.
n. Establish thresholds and standards for reporting on causes, risk factors, and health effects.
o. Establish tools and methods to measure and report on the effectiveness of intervention and risk mitigation strategies.
p. Establish the network as an action oriented body with clear and transparent work plans, mechanisms for rapid dissemination of information.
q. Facilitate the identification of funding sources and disbursement of funding for research on CO risk assessment and management through the network.

r. Coordinate research efforts to benefit all partners of the network and avoid duplication of research and development work.
s. Evolve the network into become a credible global authority on CO risk assessment and management.
t. Promote the network as an independent advisory group to funding agencies, public health agencies, governments, regulators, industry and other stakeholder groups.
u. Promote the network as a model for collaboration on other similar public health and safety issues.

8.0 Next Steps

In response to the recommendations provided by the speakers, the following were identified as immediate next steps:

a. Establish a governance framework for the Network;
b. Obtain seed funding for Secretariat and initial work of the network; and
c. Identification of priorities and establishing work plans for the Network.

A task group involving NPSAC/TSSA, INPHET, and PRISM Institute will work towards developing a draft governance framework. Parallel facilitated sessions took place at the conference to identify preliminary priorities for the network globally and in Canada. A report was developed that captured the draft governance framework and identified priorities. This report was circulated to the speakers for comments in early January 2017. In parallel, a proposal is being developed to seek funding from potential sources for establishing the secretariat and initiating work for the network.

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