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Cluster of respiratory illness in British Columbia linked to poor air quality at an indoor ice arena: A case report

An example of the importance of health care providers reporting disease clusters to public health authorities.

ABSTRACT: In February 2019, a 56-year-old male was admitted to Kelowna General Hospital with a respiratory illness following recreational hockey practice at an indoor ice arena. During his hospitalization, he disclosed that several of his hockey teammates had similar respiratory symptoms. This prompted the hospitalist physician to contact an Interior Health medical health officer regarding a potential cluster of respiratory illness. The investigation that was launched found toxic levels of carbon monoxide, nitrogen dioxide, and particulate matter had accumulated in the indoor ice arena. Numerous contributing factors were identified, including the use of older-model ice resurfacing and edging equipment, the unseasonably cold outdoor weather conditions at the time, and the failure of heating, ventilation, and air conditioning equipment. This case report highlights the importance of health care providers reporting disease clusters to public health authorities, even when the causative agent may not be reportable under the British Columbia Public Health Act.

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Case data

On 12 February 2019, a hospitalist physician at the Kelowna General Hospital contacted the Interior Health on-call medical health officer (MHO) to report a cluster of respiratory illness.[1] A 56-year-old male had been admitted to hospital with acute respiratory distress on 9 February after playing hockey on 8 February at an indoor ice arena. While recovering in hospital, the patient disclosed that several fellow players had developed respiratory illness with similar symptoms on 8 and 9 February.

A cluster investigation team was struck immediately to determine if the players had been exposed to a disease-causing agent. The team was led by an Interior Health MHO and included three environmental health officers, a communicable disease specialist, and an epidemiologist. The team developed case definitions **[Table]** and performed a descriptive analysis of data collected from interviews and medical records. In addition, the team conducted environmental inspections of the arena.

The Interior Health team learned that after 16 players attended a hockey practice on 8 February, 12 reported becoming ill (attack rate: 75%). The team interviewed 11 of the 12 players; 1 player was out of the country and could not be reached. Of the 11 players interviewed, all were nonsmokers and none reported any recreational drug use. The age range of those affected was 35 to 58 years (mean 52 years).

The most commonly reported symptoms were shortness of breath (91%), followed by cough (64%) and hemoptysis (36%). Of the 11 individuals interviewed, 5 (45%) sought medical care and 4 (36%) obtained chest X-rays within 24 to 72 hours from the onset of symptoms. Of the individuals who obtained chest X-rays, 3 (75%), including the patient in the index case, had a hazy lung lesion of increased density, which the radiologist reported as a patchy ground-glass nodularity in pulmonary airspace.

The patient in the index case was the only player to require hospitalization, with an initial presumptive diagnosis of community-acquired atypical pneumonia. The patient's blood cell count was normal and his chest X-ray showed patchy multifocal airspace disease most prominently involving the upper lung zones

bilaterally. Follow-up chest X-rays showed rapid and significant improvement, and the patient was fully recovered by the time of discharge on 13 February. Nasopharyngeal swabs were negative for influenza and respiratory syncytial virus. Multiplex nucleic acid testing (NAT) was negative for viruses and bacteria. Sputum culture was negative for tuberculosis after a 6-week incubation.

An inspection of the arena building and ice rink on 12 February found a number of issues. The ice resurfacing machine was in poor repair, the HVAC (heating, ventilation, and air conditioning) system was malfunctioning, and two rooftop fans for the furnace and make-up air were not working. Data from real-time air quality monitors were not available. The West Kelowna Fire Department and Fortis BC also inspected the arena on the evening of 12 February and at the time of their inspection were unable to detect any noxious gases. However, subsequent air monitoring on 4 March by Technical Safety BC (previously BC Safety Authority) identified levels of carbon monoxide (CO) well above the safety threshold, particularly near the ice surface where a four-cycle gasoline-powered edging machine was operating in idle mode.

Arena staff reported that on 8 February significant ice maintenance had been conducted from 8:15 a.m. to 2:00 p.m., with the ice resurfacing machine operating for about 3.5 hours. A gasoline-powered ice edging machine was also used at this time. Rink operators recalled that on 8 February the weather was unusually cold for the Central Okanagan at -21 °C, which led to the bay door for the ice resurfacing machine being closed during maintenance on this particular day. None of the staff members who worked that day had respiratory symptoms. Of interest, the first player to arrive at the arena on 8 February noted that he saw a yellow haze on the surface of the ice and around the ceiling lights. None of the other players interviewed reported seeing this haze.

TABLE. Case definitions.

Confirmed case	Any person present at the indoor ice arena and surrounding area on 8 February 2019 experiencing respiratory illness symptoms on or after that date: • New or worsening cough ***and*** • Additional respiratory illness symptoms (may include shortness of breath, hemoptysis, dizziness, headache, and/or fever) ***and*** • Abnormal chest X-ray results
Probable case	Any person present at the indoor ice arena and surrounding area on 8 February 2019 experiencing respiratory illness symptoms on or after that date: • New or worsening cough ***and/or*** • Additional respiratory illness symptoms (may include shortness of breath, hemoptysis, dizziness, headache, and/or fever)

Discussion

Poor indoor air quality at indoor ice arenas is known to be a source of health complaints.[2-9]

Ice rinks at indoor facilities are typically cleaned and smoothed by ice resurfacing and edging machines. Ice resurfacing machines or resurfacers are primarily fossil-fueled vehicles for maintaining the entire ice surface and are commonly referred to as Zambonis, regardless of brand or manufacturer. Ice resurfacers are used together with ice edgers, which shave and level the edge of the ice rink near the surrounding boards. Edging usually takes place once daily or every other day and is typically followed by ice resurfacing; however, ice resurfacing can take place independently of edging and is commonly done more frequently—as often as every hour.[2]

Air pollutants

Older models of ice maintenance equipment operate using an internal combustion engine fueled by either propane or gasoline, which can produce high levels of air pollutants, including carbon monoxide, nitrogen dioxide (NO_2), and ultrafine/fine particulate matter.[3-5] Studies comparing outside air with air inside arenas that use ice resurfacing machines powered by fossil fuels have found a 60-fold to 300-fold increase in CO, a 10-fold increase in NO_2, and a 20-fold increase in small particulate matter.[6-8] These contaminants can result in significant health risks.[5]

High concentrations of CO and NO_2 have been found in individuals who spend time in indoor ice arenas, including workers and hockey players.[4,8,9] Carbon monoxide poisoning produces a variety of symptoms, including headache, malaise, nausea/vomiting, and dizziness.[10,11] Signs and symptoms of nitrogen dioxide poisoning are primarily respiratory related, including cough, hemoptysis, throat irritation, dyspnea, and chest pain.[4,6,12,13]

Indoor ice rinks are used most commonly for hockey, ringette, figure skating, and general recreation.[3] During these exercise-related activities, participants increase their respiratory rate and risk inhaling more toxic gases and particulate matter, if present.[4] Compared with carbon monoxide uptake at rest, carbon monoxide uptake during exercise can increase up to 400%.[14] Furthermore, individuals exercising on an ice rink are near the cold ice surface where less-effective mixing of combustion emissions occurs with the warmer air above.[15] This puts athletes or recreational users at the highest risk for toxic exposure.[3,4,6,9] Those especially at risk for developing complications from inhaling CO, NO_2, and particulate matter are children, pregnant women, and individuals with pre-existing cardiovascular or respiratory conditions such as congestive heart failure or asthma.[8,9]

Factors influencing pollutant levels

The construction of the indoor ice arena can influence pollutant levels. Arenas with poor ventilation, including inadequate natural ventilation or inadequate mechanical ventilation, as

well as arenas with mechanical failure of existing ventilation systems, have increased levels of ambient CO and NO_2.[16] Furthermore, the size of an arena can influence pollutant levels, with smaller arenas having higher NO_2 levels than larger arenas.[17] Ice surfaces used for hockey have boards taller than many young skaters, thereby trapping the heavier-than-air NO_2 within this cooler dense air environment above the ice surface at the inhalation height of many youths. Far worse consequences could have resulted if children rather than adult males had entered the ice surface immediately after this prolonged ice maintenance activity.

In this particular cluster of respiratory illness, a number of factors likely contributed to poor air quality. Doors closed because of unseasonably cold weather conditions, prolonged ice maintenance, and HVAC equipment failure created the perfect storm opportunity for toxic levels of CO, NO_2, and particulate matter to accumulate indoors. The higher respiratory rate of players during exercise increased their exposure to pollutants over that of staff who did not report symptoms.[14]

Carbon monoxide and nitrogen dioxide emissions result when fossil-fuel-powered engines are used.[3-5] Ways to prevent or minimize emissions include decreasing the time a fossil-fuel-powered ice resurfacing machine is in operation indoors,[4] ensuring adequate ventilation to prevent buildup of toxic gas, and transitioning to electric ice resurfacing machines, although this last strategy can be cost prohibitive. Other solutions include manually running the ventilation system longer, opening doors during resurfacing, and ensuring that the ventilation system is working properly. Interestingly, shortly after the incident, the two (and only) ceiling exhaust fans were repaired and deemed to be functioning properly. However, many months later it was discovered that the air ducts had been intentionally blocked, most likely for energy conservation purposes. Therefore, the fans were not performing their designed task until the blockages were removed.

Studies show that CO levels are highest during the use of an ice resurfacer and immediately afterwards,[5] suggesting that arenas should use the ventilation system throughout the procedure and after resurfacing has been completed. As well, the machines should be stored in a well-ventilated part of the arena with direct access to the outdoors or an exhaust hose to extract and redirect the fumes outside.

Monitoring

The incident described in this case report highlights the importance of real-time air quality monitoring in indoor ice arenas and the need to follow administrative protocols such as proper ventilation maintenance. While monitoring compliance with safety standards at indoor ice arenas is the shared responsibility of employers, local governments, and WorkSafeBC,[18] a national or provincial guideline on acceptable levels of CO and NO_2, including protocols to mitigate toxic gas levels, could help maintain public safety. Of note, during the winter of 2020–21, Health Canada will be testing the efficacy of two interventions on air quality at indoor ice arenas, one in Ontario and one in Saskatchewan.[19] The impact of fuel type on CO and NO_2 concentrations will be assessed and the efficacy of various ventilation strategies on CO and NO_2 concentrations will be quantified. The impact of other factors on indoor air quality will also be studied, such as arena volume, number of ice resurfacings, temperature, and relative humidity.

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Reporting

The case study described here illustrates the importance of promptly reporting clusters of respiratory illness to an MHO. The BC Public Health Act (Section 10, Mandatory reporting of infection or exposure) requires that health care providers notify an MHO if they have reason to believe a patient is infected with a reportable communicable disease.[20] This includes suspected food or waterborne illnesses as well as clusters of gastrointestinal illness, as detailed in the Reporting Information Affecting Public Health Regulation. While a communicable disease was initially suspected in the index case, a prompt and thorough cluster investigation pinpointed a chemical exposure as the most plausible cause, allowing the MHO to make recommendations to mitigate the ongoing risk at the arena.

While suspected food or waterborne illnesses or clusters of gastrointestinal illness are reportable in BC, there is no requirement to report illnesses with causes other than those listed in the regulation as "prescribed" infectious or hazardous agents. Therefore, a health care provider could be dealing with a significant illness cluster, such as the one we investigated, yet not be required to report to the MHO. In contrast, the Alberta Public Health Act (Section 26 Notification of epidemics and other threats) requires that any disease occurring in epidemic form or at an unusually high rate, or any illness suspected to pose a public health threat, be reported to an MHO.[21] Furthermore, in Alberta, reporting requirements extend beyond health care workers to teachers and persons in charge of an institution.

This indoor ice arena incident highlights the benefit of front-line health care professionals collaborating with public health officials, and the importance of encouraging health care providers to report unusual events with possible public health implications. Efforts are underway to amend BC's regulation using language similar to Alberta's to require more inclusive reporting.

Summary

Several factors, including doors being closed due to cold weather, prolonged ice maintenance, and HVAC equipment failure, led to a buildup of toxic gases in an indoor ice arena. This caused 12 previously healthy adults to report respiratory symptoms. The treating physician contacted an Interior Health MHO about a possible respiratory illness cluster, which led to a prompt investigation, despite this reporting not being mandated by the current BC Public Health Act. The success of the investigation highlights the importance of including illness clusters in the reporting guidelines for health

personnel. In addition, as public health organizations continue to promote healthy lifestyles, including regular exercise, the buildings in which these activities take place need to be monitored to ensure public safety. It is anticipated that Health Canada's research in this area will eventually inform the development of a document detailing national best practices, monitoring, and response guidance for facility/arena managers and public health professionals to reduce human health impacts. ■

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Competing interests

None declared.

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