TORONTO

REPORT FOR ACTION

Subway Health Impacts Study

Date: December 19, 2019
To: Board of Health
From: Medical Officer of Health
Wards: All

SUMMARY

In 2017, the Board of Health requested an independent study of the health impacts of air quality for passengers in the subway system, particularly in relation to mitigation measures that could be implemented.

To understand the overall impact of the Toronto subway on the health of Torontonians, Toronto Public Health carried out a Health Impact Assessment including a Human Health Risk Assessment of air quality. The Health Impact Assessment concluded that taking the subway is associated with benefits to people's health and wellbeing and is a health-supportive way to travel, especially as an alternative to personal vehicle use. Promoting the use of transit is important because it provides a safer alternative to driving, reduces outdoor air pollution and greenhouse gases, promotes physical activity, and provides access to employment, education, and social/community services.

The Health Impact Assessment also identified that improving air quality in the Toronto subway system is expected to be associated with health benefits for passengers. Air quality data collected in the Toronto subway system shows that, as is the case for other similar subway systems, levels of fine particulate matter air pollution (PM2.5) are elevated and contain high levels of some metals. The Human Health Risk Assessment, which considered subway PM2.5 overall and individual metal components, concluded that levels of subway PM2.5 warrant mitigation, particularly on Line 2. Other cities with similar systems are also identifying elevated levels of subway PM2.5 and information has been gathered on mitigation options. While a high-level jurisdictional scan shows that Toronto is demonstrating leadership in addressing subway air quality, a continuous improvement approach should be adopted by the Toronto Transit Commission Board to ensure ongoing assessment and improvement of subway air pollution levels in Toronto.

In combination with mitigation actions that can be undertaken in the short-term, developing, implementing, and funding medium- and long-term PM2.5 mitigation measures will improve air quality in the subway and further enhance the health promoting aspects of using public transit. Continued research and collaboration among health, science, transportation, and engineering agencies will fill knowledge gaps within the field of public transit. In particular, a deeper understanding about the relationship

between subway PM2.5 and the health of passengers, and identification of the most effective mitigation strategies are priority areas of study.

RECOMMENDATIONS

The Medical Officer of Health recommends that:

1. City Council request the Toronto Transit Commission Board to implement PM2.5 mitigation measures that can be delivered in the short-term, including actions related to employee awareness and training programs, state of good repair (materials, equipment, procurement, and procedures) and engineering reviews, as described in this report.

2. City Council request the Toronto Transit Commission Board to identify medium- and long-term mitigation measures that can be implemented to further improve air quality in the Toronto Transit Commission subway system, as described in this report, including:

    a. reviewing operational systems and procedures such as automatic train control, train frequency, and ventilation systems;

    b. reviewing procurement specification and deployment plans for replacement trains for future line modernization;

    c. including consideration of the potential improvements to air quality in the Toronto Transit Commission's study of platform edge doors; and

    d. monitoring levels of subway PM2.5 and evaluating the PM2.5 mitigation strategies that are implemented.

3. City Council request the Toronto Transit Commission Board to request Toronto Transit Commission staff to report to City Council on opportunities for air quality improvement in the Toronto Transit Commission subway system, including a review of emerging information and technology.

4. City Council request the Toronto Transit Commission Board to identify funding requirements through future budget processes to develop and implement further PM2.5 mitigation measures.

5. City Council request Metrolinx to proactively address air quality in future initiatives through consideration of air quality in future station/system design or redesign projects as well as station construction or renovation/reconstruction projects.

6. The Board of Health encourage Health Canada to continue its research on air quality issues in the Toronto Transit Commission subway system.

7. The Board of Health encourage the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada, the Medical Council of Canada, the Public Health Agency of Canada, and the Transportation Association of Canada to support research into potential health impacts of exposure to subway

particulate matter, with a view to informing subway air quality standards and best practices for supporting passenger health and improving subway air quality.

8. The Board of Health forward this report to the Ontario Ministry of Labour, Training and Skills Development for consideration in any future occupational health standards development.

9. The Board of Health forward this report to the Ontario Ministry of Health, the Ontario Ministry of the Environment, Conservation and Parks, and the Ontario Ministry of Transportation.

FINANCIAL IMPACT

There is no financial impact associated with this report beyond what has already been approved in the 2019 Operating Budget for Toronto Public Health.

DECISION HISTORY

At its July 10, 2019 meeting, the Toronto Transit Commission Board received for information, a report from Toronto Transit Commission staff on a 2017-2018 Toronto Transit Commission study of subway air sampling in relation to compliance with provincial Occupational Health and Safety Act occupational exposure standards for employees. This report was subsequently forwarded to the Board of Health.
http://ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2019/July_10/Agenda/index.jsp

At its September 5, 2017 meeting, the Toronto Transit Commission Board received for information, a report from Toronto Transit Commission staff outlining a plan to fulfill requests of the Toronto Transit Commission Board (on May 18, 2017) and the Board of Health (on May 17, 2017) for a study on the potential impacts of air quality issues in the Toronto Transit Commission subway system (see details below).
http://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2017/September_5/Agenda/index.jsp

At its May 18, 2017 meeting, the Toronto Transit Commission Board moved referral of a motion to request a joint report from Toronto Transit Commission and Toronto Public Health staff on ways and means to study the potential impacts of air quality issues in the subway system and whether other major subway systems have undertaken similar work.
http://www.ttc.ca/About_the_TTC/Commission_reports_and_information/Commission_meetings/2017/May_18/Agenda/index.jsp

At its May 17, 2017 meeting, the Board of Health directed that the Medical Officer of Health work with the Toronto Transit Commission (if requested and funded) to oversee an independent study of the health risks for passengers of air quality issues in the subway system, particularly in relation to mitigation measures that could be implemented.
http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2017.HL19.15

COMMENTS

Assessing health impacts of subway air quality

In 2017, Health Canada reported levels of air pollution in the Toronto Transit Commission (TTC) subway system that were elevated compared with outdoor air[1]. Also in 2017, the Toronto Board of Health requested that Toronto Public Health (TPH) oversee an independent study of the health risks of air quality for passengers in the subway system, particularly in relation to mitigation measures that could be implemented. The study does not apply to occupational exposures as these are under the jurisdiction of the TTC and outside the authority of Toronto Public Health.

The study included three components:

- Health Impact Assessment (HIA) - an established process to identify potential positive and negative public health impacts of a project or policy. In this case, the HIA was conducted to ensure a full understanding of the health impacts of using the TTC subway system, including a focused assessment of potential risks arising from exposure to subway air pollution.
- Human Health Risk Assessment (HHRA) - an established methodology to assess the type and likelihood of negative health effects occurring among people who may be exposed to environmental pollutants (in this case, subway air pollution).
- Expert Panel Consultation - used to gather advice on methodological challenges of conducting a HHRA of subway air pollution, especially with respect to characterizing the risk from subway Particulate Matter (PM2.5), which is higher in metals than outdoor air, given limited research and a lack of subway-specific health benchmarks, as well as accounting for the intermittent exposure patterns usually associated with subway use.

The full HIA report, including a summary of the HHRA findings as well a full technical HHRA report and a summary of the Expert Panel Consultation, is available at www.toronto.ca/health/reports.

In addition, TPH consulted with the TTC about potential mitigation measures that could be implemented to improve subway air quality.

The TTC subway system supports individual, community, and environmental health

The HIA found that Toronto's subway system provides a range of benefits to people's health and wellbeing. Taking the subway is a health-supportive way to travel, especially as an alternative to personal vehicle use. It is associated with fewer injuries than driving,

reduces outdoor air pollution and greenhouse gases, promotes physical activity and provides access to employment, education and social/community services.

Reducing traffic-related health impacts
Subway use benefits the health of all Toronto residents because it reduces vehicle use and congestion in Toronto. The TTC estimates that during rush hour, each subway train replaces 900-990 personal vehicles that would otherwise be on the road[2]. Vehicles emit air pollutants that contribute to heart and lung disease as well as greenhouse gases, which contribute to climate change. Local health impacts expected with climate change include increased incidence of heat-related illness and premature death; injury and water-borne diseases arising from severe weather events; increase in vector-borne diseases; food system impacts including food insecurity and food-borne illness; and cardiovascular and respiratory illness from degraded air pollution[3]. Use of public transit including the subway system reduces these risks.

Increasing active transportation and travel safety
Subway use also provides health benefits specifically for commuters. People who use transit are likely to include walking as part of their commute, resulting in an increase in regular, routine physical activity, which has been shown to reduce mortality of chronic diseases such as heart attacks, strokes, diabetes and some types of cancers[4]. As well, using the subway is associated with a lower probability of fatality or injury as compared with travel in personal vehicles. For example, in 2018, there were 66 people killed and 346 seriously injured in Toronto in personal vehicle collisions[5], whereas the TTC recorded only three non-suicide fatalities and estimated ridership injury incidents to be 1.07 per one million boardings for all injury types system-wide, with injury rates declining in recent years[6,7].

Ensuring access to health-supportive services
Access to the TTC subway system supports access to employment opportunities, education, and health services that contribute to overall health and well-being. For example, the TTC reported that 21 percent of subway rides in 2018 were between home and school[8]. In a 2012 survey, public transportation was the most commonly used mode of transportation to employment and skills training (66 percent) and language training (49 percent) amongst Toronto's immigrant and refugee population[9]. Affordable subway access to recreational and cultural programs can promote children's health and wellness, and has the potential to increase individual and social cohesion. Affordable and reliable public transportation, including subway access, is especially important for low-income families.

Air quality and health in the subway

The HIA also considered health impacts related to air quality specifically. Many indoor and outdoor air pollutants affect health. The main pollutant of concern for health in the Toronto subway system is PM2.5, or fine particulate matter[1,10]. PM2.5 includes all solid and liquid droplets suspended in air with a diameter of 2.5 micrometres or less (about 30 times smaller than that of a human hair). PM2.5 can include aerosols, smoke, fumes, dust, ash, pollen and metals. Subway PM2.5 is characterized by high levels of some metals, making it different from outdoor air.

Data about PM2.5 were collected in the TTC subway system during 2017-2018 by Health Canada through a project called the Subway Air Quality Initiative[11]. This information was used, along with information about the typical amount of time a passenger spends both on the platform and in the train to identify the average PM2.5 exposure level for a passenger on a typical subway trip. Taking these factors into account, the estimated acute PM2.5 exposure concentration for the combined system of Line 1 and Line 2 during weekday rush hours was 130 µg/m3. Other cities with similar systems are also identifying elevated levels of subway PM2.5 and information has been gathered on mitigation options. This report makes specific recommendations of short-, medium- and long-term actions for the Toronto Transit Commission Board to implement.

Characterizing health risk from subway PM2.5
The human health risk assessment (HHRA) followed established methodologies to characterize population health risk due to environmental contaminants. It considered potential long-term and short-term effects of subway PM2.5, and of individual metal components of subway PM2.5 (arsenic, barium, cadmium, chromium, cobalt, iron, manganese, nickel, and silver) that were chosen based on their presence in subway PM2.5 as well as their potential to affect health.

There are currently no health-based standards or guidelines for assessing passenger risk from subway PM2.5. Recognizing a need to pursue further studies in this area, the approach taken in the HHRA is informed by available research[12], and advice from the Expert Panel convened by TPH. Both indicate that although the composition of subway PM2.5 is different than that found in outdoor air, its health effects are assumed to be similar.

The links between exposure to outdoor PM2.5 and health include symptoms and morbidity related to heart and lung disease such as reduced lung function, asthma attacks, emergency room visits and for respiratory and cardiac causes, elevated mortality rates, and reduced life expectancy. People who are especially sensitive to PM2.5 include those with heart or lung conditions such as coronary artery disease, asthma, or chronic obstructive pulmonary disease, older adults, and children. PM2.5 is a non-threshold contaminant, which means that there is some potential for health impact at all levels of exposure, and any reductions in exposure offer health benefits.

A full discussion of the methodology and constraints related to comparing subway air quality to outdoor PM2.5 is available online in the full HHRA technical document.

There is also evidence of an association between exposure to some metals that are found in subway PM2.5 and health outcomes, including both potential cancer and non-cancer risks. The approach taken in the HHRA reflects the Expert Panel's recommendations to characterize risks from subway PM2.5 overall and also cancer and non-cancer risks related to the metals exposures, which is similar to approaches taken elsewhere[13].

Improving subway air quality offers health benefits to passengers

Overall, the results of the assessment indicate that the levels of PM2.5 and several of its metal components are high enough to warrant mitigation, particularly on Line 2. Because there is no threshold for PM2.5 health impacts, all reductions in PM2.5 levels would have potential health benefits. As well, because the metals are components of PM2.5, any efforts to mitigate PM2.5 overall will result in decreased levels of the metals.

The HHRA identified that the PM2.5 levels measured in the TTC subway are expected to be associated with both short-term and long-term health impacts, including elevated risk of mortality, respiratory and cardiovascular disease, and transient respiratory symptoms. Transient respiratory symptoms can include coughing, shortness of breath, chest tightness, general asthmatic symptoms and/or a temporary decline in lung function, particularly for sensitive groups such as children and adults with asthma and adults with chronic obstructive pulmonary disease (COPD).

Given that subway PM2.5 is comprised of a higher concentration of metals as compared with outdoor air, the potential health impacts of exposure to the metals were also explored. Of the nine metals that are found in the greatest concentrations in subway PM2.5, none of them were associated with an increased risk of non-cancer health effects. Three metals (arsenic, cadmium, and chromium) were associated with cancer risk levels above one in a million. In comparison, background incidence of cancer in Canada is approximately 4 in ten. Exposure to metals in subway PM increases this lifetime cancer risk from 4 in ten up to 4.0006 in ten. Mitigation efforts that reduce overall PM2.5 are recommended as they will also reduce the presence of metals that are components of PM2.5.

Mitigation is especially important for Line 2
The estimated health impacts from exposure to subway PM2.5 were higher for Line 2 (Bloor-Danforth) than Line 1 (Yonge-University-Spadina). Taking into account time spent both on the train and on the platform, the estimated acute PM2.5 exposure level during weekday rush hours for Line 1 is 85 µg/m3 and Line 2 is 183 µg/m3. Given this difference, Line 2 needs to be a priority for a range of mitigation measures, including future line modernization.

Further details about these findings are available online in the full HHRA technical document.

Opportunities to reduce PM2.5 levels in the subway system

There are several opportunities to reduce PM2.5 levels in the subway system. This report recommends that City Council request the Toronto Transit Commission Board to implement short-term mitigation measures to improve air quality. This includes actions related to employee awareness and staff training, for example, about braking practises given that much of the PM2.5 in the subway system is expected to be associated with friction generated during braking. Other measures include those related to state of good repair such as consideration of materials, equipment, procurement, and procedures to ensure that critical infrastructure is maintained and incorporates air quality mitigation. Incorporating PM2.5 mitigation strategies as part of engineering reviews is another

recommended action as it provides an opportunity for mitigation as part of existing problem-solving approaches and the introduction of new technologies.

In addition, TPH identified potential subway PM2.5 medium- to long-term mitigation measures based on a review of the literature and activities reported by other subway systems. Commonly suggested measures include reviewing and upgrading ventilation and filtration on platforms and in tunnels, reviewing or upgrading on-train ventilation systems, implementing platform-edge doors, adjusting tunnel and track maintenance activities, procuring and using alternative materials for moving parts, measures to reduce brake and wheel emissions, considering air quality issues in system and station design, and conducting additional research including monitoring for PM2.5 and intervention effectiveness[10,14,15]. As well, the HHRA findings for the TTC suggest that given the differences observed between Lines 1 and 2, Line 2 needs to be a priority for mitigation measures, including future line modernization. The HIA noted differences between the two Lines, including different train types on each line and the use of automatic train control on Line 1. Both are recommended for further exploration in terms of the impact on air quality.

Some mitigation initiatives are currently underway, and others warrant further exploration. Reviewing emerging research, and considering effectiveness, feasibility, and costs associated with implementation will enable the TTC to recommend and implement mitigation measures for the short, medium, and long-term to improve air quality for all riders.

Filling information gaps about subway air quality

The best available research about potential health risks from exposure to subway air was used to inform this report's recommendations. Further research to support development of subway-specific benchmarks or guidelines would enable improved understanding of the specific health risks of subway PM2.5. There is also a need to identify and evaluate mitigation activities suitable for different subway systems and environments. These challenges are not unique to Toronto, and in London UK, new exposure studies are planned and being funded by the Country's Medical Research Council[15]. Furthermore, the Paris subway system is piloting innovative PM2.5 reduction technologies such as giant filters to purify the air[16]. Canadian health, transportation, and other research agencies need to be aware of the importance of supporting new research about subway PM2.5 and its impacts on passengers. As this is an emerging area of research, the TTC's PM2.5 mitigation efforts will benefit from ongoing review of new information and technology.

In particular, Health Canada has played a role in gathering air quality data in the TTC subway system in two separate air quality monitoring campaigns, and has an interest in encouraging healthy, transit supportive environments. Their continued collaboration with the TTC to develop an increased understanding of health and air quality issues and to evaluate the effectiveness of air quality mitigation activities should be encouraged. This approach will inform the further development and implementation of effective PM2.5 mitigation measures.

The health risk assessment approach used to characterize lifetime environmental health risk for passengers, including vulnerable groups, is very different from the process for occupational assessments, which in comparison, address set timeframes for healthy workers and rely on legislated occupational standards to prevent illness or certain effects in industrial situations. Given that there are currently no established occupational limits for PM2.5 in the subway environment, it is recommended that this report be shared with the Ontario Ministry of Labour for consideration in any future standards development efforts.

Overall, a number of opportunities exist to improve subway air quality in Toronto, with benefits for health. TTC's commitment to continuous improvement is an approach that can offer benefits in the near-term and that will continue to accrue over time. As further information is gathered about the TTC subway system specifically, and by other subway air quality projects internationally, it will advance this evolving area within the field of public transit.

CONTACT

Gayle Bursey, Director, Strategy and Preventive Health, Toronto Public Health,
Tel: 416-338-0661, Email: Gayle.Bursey@toronto.ca

SIGNATURE

Dr. Eileen de Villa
Medical Officer of Health

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