Off-Peak Deliveries in the GTHA Before and During the Pandemic

Resource Document

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1 Introduction

On March 19, 2020, in response to COVID-19, the Ontario Government announced the Municipal Emergency Act 2020 which ensured that "for the near future, the delivery of goods to Ontario's businesses and consumers isn't impacted by municipal noise by-laws that may unintentionally be impeding such deliveries when they are most urgently needed." In essence, this measure permitted delivery of goods in the evening and night-time, which we term off-peak deliveries (OPD), across Ontario. On November 30, 2020, the Ontario Government assented to Bill 215, the Mainstreets Recovery Act, 2020, which states that Ontario municipalities do not have the power to prohibit and regulate with respect to noise made in the City in connection with the delivery of goods to any of the following, except as otherwise authorized by regulation:

1. Retail business establishments.
2. Restaurants, including cafes and bars.
3. Hotels and motels.
4. Goods distribution facilities.

The Mainstreets Recovery Act, 2020 came into force on September 19, 2021.

OPD have potential to improve efficiency, reduce traffic congestion during day-time periods, and reduce greenhouse gas emissions. Concerns that have been raised about OPD include noise associated with deliveries and the potential for increased truck collisions rates and severity.

The University of Toronto is conducting a research project to develop an information-base to support decision making related to this regulation. This research project is funded by the Natural Science and Engineering Research Council of Canada, The Atmospheric Fund, the Region of Peel and the City of Toronto. The geographic scope includes the City of Toronto, the Region of Peel and the Region of York.

This report describes findings from this research project. The research in this report consists of four topics, organized into report sections, as follows:

- Section 2 – Best practices in off-peak delivery
- Section 3 – Analysis of noise complaints
- Section 4 – Community noise survey
- Section 5 – Truck collision analysis

The research project is also undertaking research on two additional topics, which will be reported in a separate report, including:

- Detailed analysis of OPD for three large retail firms
- Model of impacts of broader up-take of OPD in the retail sector

2 Best Practices in Off-peak Delivery

OPD programs have been implemented in cities world-wide. Appendix A summarizes OPD case studies by location, time frame, number of shippers, carriers and receivers involved, performance measures used, strategy, technologies employed and program status. OPD policy is expected to offer benefits including increased delivery efficiency, reduced traffic congestion in peak hours, reduced greenhouse gas emission, and decreased illegal curbside parking. However, concerns exist about the challenges in implementation and continuation of the OPD programs. In this section, we provide in-depth review of best practices in OPD to identify 1) OPD methods, 2) target industries in OPD programs, 3) benefits of OPD, and 4) challenges of OPD and the mitigation strategies for reducing negative impacts.

2.1 Off-peak delivery methods

Off-peak delivery can be classified into assisted and unassisted OPD. Assisted delivery is the most common delivery method for day-time deliveries. It involves having a person present in the receiving store to accept deliveries. Assisted delivery poses a barrier to OPD if the receiver does not otherwise maintain staff in the off-peak hours.

In unassisted delivery, receivers do not maintain staff on-site during the off-peak hours and instead directly provide the carriers access to the business premises to make the deliveries. Depending on the type of product being delivered and the business setup, different methods for unassisted delivery exist. Delivery lockers or staging areas can be provided separate from the interior of the business premises allowing deliveries to be made without direct access to the business premises (Holguín-Veras et al., 2013). This approach requires additional expense for installing infrastructure for products such as perishable foods or high-value goods. As an alternative, virtual cages, which monitor a small area with sensors, can be used to limit driver access to a small area inside a store for making deliveries (Holguín-Veras et al., 2013). The driver may be given access to the virtual cage, using a key or electronic code (Holguín-Veras et al., 2013). Virtual cages are less expensive than delivery lockers because they require no additional space and limited additional infrastructure. Such a system requires a relationship of trust between carrier, driver and receiver.

2.2 OPD Target Industries

Successful policy design in OPD programs, requires that policy makers:

a) Identify industries that are more likely to accept OPD, and
b) Incentivize businesses in these industries to accept OPD (Holguín -Veras, Sánchez-Díaz, et al., 2014).

Some industries including diary product distribution, moving services, garbage collection, oil distribution, newspaper distribution, bakery services, grocery store, and beverage distribution are more inclined to have OPD operation (Sánchez-Díaz et al., 2017). Studies in New York City and Spain (Barcelona and Santander) indicate that food and beverage stores, press and book stores, clothing stores, apparel manufacturers, accommodation establishments, and non-durable wholesalers are more willing to accept OPD (Domínguez et al., 2012; Holguín-Veras et al., 2017). Holguín-Veras et al., (2008) suggest that targeting large traffic generators (e.g., facilities with centralized delivery stations), neighbourhoods with highest truck traffic, and commodities such as food and alcohol, wood, metal, textiles, clothing, furniture, computer/ electronics have the highest pay off for switching to OPD.

2.3 Benefits

OPD can improve business operations and provide societal benefits. For businesses, OPD can reduce travel time to customers and can reduce unloading time during the delivery. In general, there is less congestion during the overnight hours, leading to higher travel speed, lower idle time, and reduced fuel consumption and emissions. Holguín-Veras et al. (2011) report on a pilot OPD project that shifted deliveries of 35 food delivery businesses to off-peak hours. Truck speeds increased, on average, from 11.8 mph to 20.2 mph for trips from the depot to the first customer. A smaller speed increase was observed between customers. The time spent on off-peak deliveries was half of morning delivery times. The OPD pilot program in the Region of Peel, Ontario indicates that the average speed of the truck trips during the off-peak hours is about 18.1% faster compared to the day-time trips. This pilot program shows that the average service times for deliveries in off-peak hours are 15.2% higher compared to the day-time deliveries. Participating retailers in this pilot stated that the arrival time reliability also improved for OPD. Fu and Jenelius (2018) show that the night-time delivery program in Stockholm led to delivery speed at night-time that is 31% and 59% faster than the morning and afternoon peaks hours, respectively. In Los Angeles, night-time restrictions on truck movements existed in some areas. Improvement in travel times was reduced because of the extra travel distance to avoid restricted areas (Campbell, 1995). In Barcelona reductions in the number of trucks required to make deliveries was observed. Two large trucks could make the same deliveries made by seven smaller trucks that would be needed to maneuver through downtown peak hour traffic (Forkert & Eichhorn, 2014).

OPD can reduce congestion during peak periods. Removing truck traffic during peak periods frees up roadway capacity which has the potential to reduce commuter travel time, including transit vehicles operating in mixed traffic. However, improved peak period travel times can have the effect of attracting more commuters from other modes of transportation, which can negate some travel time improvement.

Diesel engines in trucks disproportionally produce emissions of oxides of nitrogen (NOx) and particulate matter (PM) which have harmful health effects (Minet et al., 2020). Reduction in day-time truck travel can reduce these pollutants emissions during the day. This reduction can benefit cyclists and pedestrians, who are more often present at the roadside at this time. Overall traffic emissions can also be reduced. Yannis et al. (2006) found improvements in overall traffic emissions as a result of peak hour truck restrictions. Campbell (1995) showed that emissions reductions are possible with increased average speed. Holguín-Veras et al., (2018) found that OPD can reduce emissions by 13% to 67% compared to regular-hour delivery. Similarly, the pilot OPD program in the Region of Peel revealed that the off-peak hours deliveries decrease the air pollutant emission factors by 10.8% to 15.0% compared to day-time deliveries.

Shifting freight deliveries to off-peak hours has potential to reduce conflicts between trucks and other road users including vulnerable road users such as pedestrians and cyclists, because there are fewer pedestrians and cyclists using the road at night. Vulnerable road users would therefore have less exposure to truck traffic which could enhance their safety and reduce fatalities. Xie et al. (2015) developed a safety evaluation model based on 256 road segments in Manhattan, New York

City to assess the effect of OPD on truck-involved crashes. They provide evidence that shifting truck traffic to off-peak hours does not lead to a significant change in overall truck-involved crashes.

During peak hours there is also a lack of available parking spots for trucks. Parking is prohibited on many arterial roads in the peak hours in the peak direction. For commercial vehicles, parking search time can add significantly to the total tour time, especially for vehicles that make many short stops. In addition, many deliveries require parking near the delivery location, which forces commercial vehicles to park illegally. OPD have potential to alleviate some of these parking challenges (Nourinejad et al., 2014).

2.4 Challenges

OPD can lead to several challenges, including noise due to truck travel and loading/unloading at night, higher pollutant emissions at night, and safety concerns. This section describes the most important challenges of OPD, and presents best practices, from the literature, to mitigate these challenges.

2.4.1 Stakeholder Engagement

Considerable research has shown that OPD program success is dependent on the collaboration and engagement of freight stakeholders, including shippers, carriers, receivers and communities. As mentioned in Section 2.3, it is possible for stakeholders to experience positive impacts from OPD programs, although costs and impacts are experienced by some. Due to distribution of benefits and costs of OPD programs to each stakeholder, conflicts between stakeholders' interests and uncertainty in their participation are expected (Browne et al., 2014; Holguín-Veras, Wang, et al., 2014; Verlinde & Macharis, 2016).

Inability or reluctance of receivers to accept OPD is a barrier to the success of OPD programs. While carriers usually favour OPD, due to lower urban congestion and the resulting shorter travel time, receivers are more likely to be concerned about the additional staff cost and security issues of receiving OPD. Experience in New York City shows that incentives can increase receivers' willingness to accept OPD. These include monetary incentives such as direct financial incentives and shipping discounts and non-monetary incentives such as public recognition (Holguín-Veras, 2008; Holguín-Veras et al., 2006).

Promoting unassisted delivery can also result in an increase in receiver participation in OPD. Holguín-Veras et al. (2012) suggest that, in New York City, the maximum participation in assisted OPD is about 14 to 21% while participation in unassisted OPD may increase to 40%. The role of incentives is more crucial in the case of assisted OPD. Holguín-Veras et al. (2012) show that, without incentives, receivers that accept assisted OPD are more likely to switch back to their regular delivery schedule due to the high cost of staffing for the OPD. In contrast, 90% of receivers with successful implementation of unassisted deliveries maintain their participating in OPD without requiring incentives. The study by Holguín-Veras et al. (2017) suggests that 1) a one-time incentive from the public sector, 2) public recognition of participants and business support services, and 3) availability of trusted vendors, are the most important factors in promoting unassisted OPD.

Safety and security concerns in unassisted delivery, such as the vulnerability of the receivers' establishments to damage, theft and higher risk of incorrect delivery by the carrier, are also considered by receivers. Some measures can be considered to overcoming these concerns (Holguín-Veras et al., 2012, 2013, 2017):

- Installing security equipment such as security cameras,
- Restricting access to the establishments by designing the unloading area to be separate from the main building of the establishment or providing a key to the carrier.
- Increasing the trust and partnership between carriers and receivers.
- Reducing private sector liability for potential damage during unassisted deliveries by providing public sector reimbursement or insurance funding schemes.

2.4.2 Public Sector

The public sector can play an important role in initiating and coordinating a successful OPD program. Public concerns about noise or safety, lack of stakeholder consultation, and inadequate participation of freight stakeholders are challenges to OPD programs.

To ensure legality and safety, OPD programs must be done in accordance with noise by-laws and route restrictions that often limit truck deliveries in the evening or night-time. Modifications to noise by-laws and route restrictions to allow OPD is best done in consultation with the levels of government and communities that are affected by the changes. OPD pilot programs that introduce OPD at a limited scale, with appropriate evaluation, prior to broad OPD program roll-out, would allow for the identification of appropriate exceptions (e.g. land uses that are not sensitive to night-time noise) and other unanticipated issues. Section 2.4.3 elaborates on concerns about noise and technologies for noise reduction for OPD.

As mentioned earlier in this section, incentives can increase the engagement of receivers and carriers. Public sector incentives were provided by New York Department of Transportation to carriers and receivers for adopting low-noise delivery technologies and accepting deliveries in off-peak hours, respectively. However, analysis should be conducted to compare the cost of providing incentives to benefits gained from shifting the truck traffic to off-peak hours. Otherwise, providing on-going incentives might be a burden on the public sector that outweighs the benefits (Holguín-Veras, Sánchez-Díaz, et al., 2014).

2.4.3 Noise

Night-time noise generated by truck travel, loading and unloading is an important potential impact of OPD programs. According to the World Health Organization (WHO), noise in urban areas can result in sleep disturbance, mental health issues, and adverse cardiovascular impacts especially in vulnerable populations such as the elderly and children (World Health Organization, 2011). Delivery noise is more concerning at night due to the interruption of sleep. Noise emitted from night-time deliveries is especially noticeable to residential communities due to low ambient noise levels at night (Holguín-Veras et al., 2013). In London and Denmark, concern about noise impacts resulted in opposition to OPD from local communities (Sánchez-Díaz et al., 2017). Nevertheless, previous OPD projects have shown that identifying sources of noise and mitigating strategies can greatly reduce noise and its adverse impacts on OPD (Sánchez-Díaz et al., 2017). In the rest of this section, we identify the main sources of delivery noise and the noise mitigation measures that are available to reduce their impact.

2.4.3.1 Sources of delivery noise

Although trucks engines may produce tolerable noise levels while operating on major roadways, problematic noise levels generated from other activities may occur during a delivery (Finaly, 2008; Holguín-Veras et al., 2013). These activities include moving pallets inside the trailer, positioning the tail-lift platform, crossing the pavement to the delivery location, stacking empty pallets inside the trailer, slamming doors, moving containers, refrigeration kicking in and moving the onboard forklift. Such activities produce peak noises reaching up to 85 dB (Holguín-Veras et al., 2013). Without mitigation, noise emissions from truck deliveries can cause discomfort to local residents and lead to more frequent noise complaints (Holguín-Veras, Wang, et al., 2014). However, equipment, techniques, technologies, and materials have been developed to significantly reduce noise from truck deliveries.

2.4.3.2 Trailer and truck body

Several measures are available to reduce noise coming from the trailer and the truck body. Finaly (2008) suggested the use of a thin damping material (aluminium, mild-steel and GRP) to coat the floors and kick-walls of the trailer. This material showed significant noise reduction because it absorbs impacts with resonating metal surfaces causing high frequency sounds. Finlay also developed a retro-fit "hush-kit", that attenuates the noises resulting from the handling of roll-cages that lead to a significant decrease in noise levels. Damping materials (viscoelastic strips and rubber bands and stoppers) were applied to parts of the roll-cage leading to major noise reductions.

Wang et al. (2014) found that foam coatings and aluminium flooring of trailers significantly reduce noise levels. Foam provides substantial sound-absorbing abilities, is very light and can be easily shaped. Aluminium floors can limit noise while keeping cargo spaces clean and even for easier material handling.

A solution to noise caused by refrigerator trucks is to separate the refrigeration engine from the original unit, insulate it in a box and place it under the chassis of the trailer. Using this method, Carrier Transicold completely insulated the refrigerator unit and reduced the refrigerator operation noise to 60 dB(A) (Holguín-Veras et al.; 2013). Nestle Canada's approach to reduce noise from refrigerated trucks is to use non-reefer trucks with cold plate technology (McPhee et al., 2015). This approach claims to result in noise levels that do not exceed the acceptable ambient noise level in major population centres.

2.4.3.3 Truck engine

Truck engines are an important source of noise in truck operations, alongside the gearbox and the brakes (Wang et al., 2014). A truck diesel engine operates at approximately 80 dB(A). The substitution of conventional truck engines with liquefied natural gas (LNG) or compressed natural gas (CNG) leads to lower noise levels and lower greenhouse gas emissions caused by truck engines (Holguín-Veras et al., 2013). Examples of LNG and CNG trucks are the Mercedes-Benz 1828 NGT and the Iveco Stralis, respectively, which are equipped with low-noise accessories and achieve a lower noise level of 72 dB (A). Other truck engine noise countermeasures include RPM limiters and encapsulation. An RPM limiter is a device that can be fitted to the engine to prevent it from exceeding a predefined speed limit, which can also reduce engine noise. Encapsulation of the engine reduces engine noise by isolating the engine in a special device. Encapsulation, speed limiters, hybrid, electric, LNG or CNG engines can significantly reduce truck engine-related noise (Wang et al., 2014).

2.4.3.4 Driver training and encouraging quiet handling behaviour

Increasing driver awareness is a low-cost way to reduce noise. Driver training has been advocated to provide drivers with ways to reduce high-noise activities during the evening and night hours. This includes turning off the radio when approaching a residential area at night, refraining from slamming doors, dropping the cargo storage bar and pushing or pulling carts on surfaces that cause excessive noise (Forkert & Eichhorn, 2014; Holguín-Veras et al., 2013).

Designating specific loading and unloading locations and the use of quiet unloading equipment (e.g. hand pallet trucks and roll cages to minimize wheels, bearings and collisions) can minimize possible noise emissions, although it is also associated with higher equipment cost (Wang et al., 2014).

A quiet delivery code of conduct for drivers and receivers, including attaching quality labels and the use of "quiet equipment" labels on trucks with low noise equipment is claimed to be efficient in reducing noise emissions. Transport for London has released a quiet delivery code of conduct. The measures include 1) switching off reversing alarm or modifying them with white noise, 2) Switching off the truck refrigeration unit before arriving to delivery points and switching off the truck radio before opening doors, 3) Minimizing the opening and closing of truck doors, 4) Allowing extra time to unload as quietly as possible, 5) If arriving early to a delivery site, parking far from residential locations and turning off the engine, and 6) ensuring that all colleagues are trained appropriately to follow the code of conducts for quiet delivery (Transport for London, 2018a).

2.4.3.5 PIEK standard

The PIEK standard is a national regulation in Netherlands that requires that noise levels during loading and unloading of trucks remain below 60 dB during night-time deliveries in urban areas. This program fosters quiet behaviour by developing low noise technologies, educating drivers for quiet delivery, redesigning the loading facilities, and silent handling of the delivery equipment (Goevaers, 2011).

The PIEK certification process considers two components of the delivery process and evaluates the difference in noise. The first component is vehicle movement noise from all major components of the operation of the delivery vehicle, including driving at a constant speed, braking, reversing, accelerating, and using the refrigeration system. The second component considers noise from loading and unloading operations. This component includes noise generated by the cargo body of the truck, including vehicle doors, hatches, hinged and sliding doors, and air curtains, the vehicle tailboard, and the noise from rollers, trollies, pallet trucks, and forklifts (Stichting Piek-Keur, 2018).

Despite strict noise regulations in Europe, the PIEK certificate has resulted in successful OPD programs in various European cities including London, Stockholm, and Paris by complying to the local noise regulations (Sánchez-Díaz et al., 2017).

2.4.3.6 Redesigning the delivery area

Noise to surrounding residents can be reduced by redesigning and improving the loading and unloading areas and driveways. For instance, poor pavement conditions in a driveway can result in excessive noise. A solution is to repave the driveway with a smoother material (Holguín-Veras et al., 2013). Transport for London provides the list of potential measures in building design and planning to mitigate noise. These measures include: 1. Moving the delivery bay away from the residential area and towards locations with higher ambient noise, 2. Reducing truck maneuvers by properly locating the delivery bay, 3. Designing an enclosed space for loading and unloading activities and delivery vehicle maneuvers, 4. Installing a soundproof barrier between loading areas and residential locations, and 5. Applying soundproof materials to buildings and facades around the loading areas to decrease the reflection of sound (Transport for London, 2018b).

2.4.4 Safety

Although OPD have positive effects on road safety due to reduced interactions with other road users, a key factor in truck collisions is reduced visibility due to darkness. Researchers have studied the effect of environment and light conditions on the frequency and severity of truck involved crashes. While some studies show that dark or night conditions do not affect the frequency of truck collisions, other studies find that they do. For instance, Sakai (2017) and Talbot et al. (2017) find that morning peak period collisions (from 7 to 10 AM) are more frequent than during other times of the day, mainly because of the high traffic volumes during the morning peak hours. Uddin & Huynh (2017) find that dark conditions affect the frequency of truck-involved collisions. Zhu & Srinivasan (2011) find that crashes happening in the dark with artificially lit conditions are more severe than daylight and dark unlit conditions. In terms of weather conditions that partially obstruct the sight of drivers, Pokorny et al. (2017) find that visibility conditions are frequently a factor in collisions between trucks and cyclists on the road.

However, with advances in technology and vehicle designs, countermeasures have been developed and proven to be effective in mitigating the effect of darkness and low visibility on truck involved collisions. Countermeasures include mirror installations, detection and warning systems, truck front and side barriers, traffic rules, infrastructural changes and truck driver training enhancements (Hanowski & Morgan, 2015; Kircher et al., 2020)

2.4.4.1 Detection technologies and Intelligent Transportation Systems (ITS)

Object detection and driver warning technologies have gained recent attention as means for safety improvement. For instance, warning systems for truck drivers that provide real-time weather notifications under poor visibility are found to have promising safety benefits and improved driver behaviour (Raddaoui et al., 2020). In terms of VRU safety, detection and driver warning systems that work both in light and dark conditions can successfully detect road users and significantly reduce collisions when there is no line of sight between the truck driver and the VRUs (Silla et al., 2017). Other technologies including radar, ultrasonic proximity sensors and smart cameras, that detect objects and road users and provide visual or audio warning to truck drivers, can effectively improve truck safety at night (Charlebois et al., 2019).

2.4.4.2 Truck mounted parts and truck design

To mitigate the severity of truck collisions during both the day and night, options for truck mounted parts that cover certain truck areas are proposed in literature. Feist et al. (2008) Specify four low-cost and light-weight solutions for truck front end design that can reduce injury risks without covering essential areas in the truck front (e.g. lights and vent). These include the use of polypropylene or polyurethane blocks to cover the front of the truck, the application of permanently inflatable vulcanized rubber air tubes to the front end, and covering the bumper and cabin with foam segments.

In terms of side-mounted truck parts, the installation of side underrun barriers is frequently suggested and found to be effective in preventing pedestrians and cyclists from being run over (Rechnitzer & Grzebieta, 2014).

A survey of night-time snowplow truck drivers found that ice on the truck wiper blades is the most serious problem for forward visibility (Eklund et al., 1997). Condensation and snow build-up on the windscreen were also found to significantly reduce truck driver visibility. Improving the design of wiper blades and implementing windscreen defrosting and heating systems are among the suggested countermeasures for increasing truck drivers' visibility during severe winter and snow conditions at night.

2.4.4.3 Infrastructure and road conditions

The visible distance at night can also be directly improved by enhancing roadway lighting and pavement conditions. If lighting conditions are sufficiently improved, the difference between day and night-time driving visibility distance would decrease. Schreuder (1984) provides evidence that improved road lighting reduces night-time risks and collisions. They claim that a "good" road lighting system, compared to no or very poor lighting, reduces night-time collisions by 30%. Similarly, Gibbons and Hankey (2007) provide evidence that proper lighting improves visibility and reduces the effect of glare during the night. A wet retroreflective tape as a pavement marking material is also found to provide superior improvements in visibility. A variety of other pavement materials have been studied and recommended to improve visibility under night conditions (Gibbons et al., 2012; Sagar & Gaur, 2020).

2.4.4.4 Truck driver training

Effective driver training also contributes to improved road safety as it ensures drivers have the appropriate skills to operate the vehicle in a safe manner, under different weather and light conditions. When surveyed about their opinions about current commercial vehicle training standards in Canada, truck drivers state that standards are inadequate, especially for novice drivers (Malkin et al., 2021). They find that new drivers are not prepared to drive in certain settings and contexts, e.g., in night conditions. Improvements in truck driver training including training for night conditions should be considered. Different types of training, including the use of truck simulators, can be effective in improving truck driver skills (Hirsch et al., 2017).

3 Analysis of Noise Complaints

3.1 Introduction

This section describes our analysis of noise complaints associated with OPD. Noise complaint data were requested from the City of Toronto, Region of Peel and Region of York. We received a detailed database from the City of Toronto. Evaluating noise complaints is a useful way to evaluate differences, over time, of residents' experience of noise, and can highlight specific problematic noise issues associated with by-laws related to OPD.

3.2 Caveats

Complaints are an imperfect indication of the impact of noise on residents. Not all residents that experience noise lodge a complaint. Complaints require knowledge that there is an opportunity to file a complaint, knowledge of how to lodge a complaint, and require effort. If no remedy is expected for filing a complaint, a resident may well decide it is not worth their time.

Noise by-laws were not permitted to be enforced in Ontario for truck deliveries during the pandemic. For OPD, it is possible that any reduction in noise complaints may be attributed to less frequent deliveries to the stores, instead of appropriate and quiet loading and unloading activities. That said, if OPD resulted in specific noise problems, we would expect to see an increase in noise complaints by some residents.

3.3 Analysis of City of Toronto noise complaints

A noise complaint database was obtained from the City of Toronto, with dates ranging from January 1, 2019 to April 6, 2021.

Three specific caveats are important to note in the interpretation of the City of Toronto noise complaints.

1) Between March 17 and June 24, 2020, all noise complaint intake was temporarily halted due to the redeployment of City of Toronto staff to other tasks at the onset of COVID-19. City of Toronto staff resumed intake of most noise complaints on July 21, 2020.
2) Intake of noise complaints related to goods deliveries was not officially resumed by the City of Toronto until September 19, 2021. However, some noise complaints related to goods deliveries were recorded in the period from June 24, 2021 to April 6, 2021, though at a lower rate than prior to the onset of the pandemic.
3) The recorded time of a complaint may not be a true reflection of when the noise occurred. For example, it is possible that residents heard the noise in the middle of the night but did not call until the next day.

Figure 1 shows total noise complaints (for all sources of noise) from January 1, 2019 to April 6, 2021. A total of 33,789 noise complaints were recorded. No major differences are noted between August 2020 to March 2021 (pandemic) and August 2019 to March 2020 (pre-pandemic), which are circled on Figure 1.

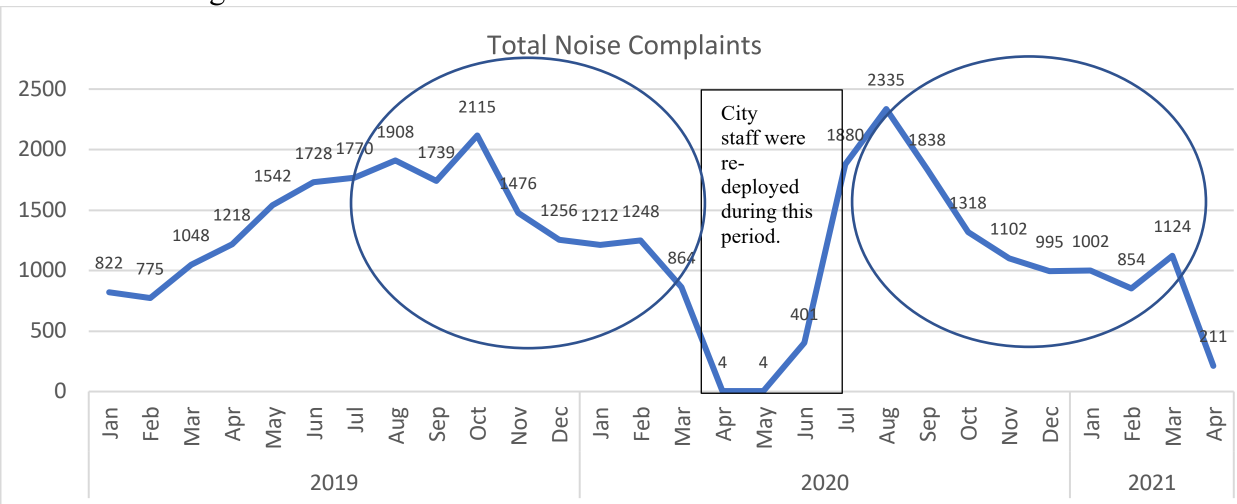


Figure 1 – Noise complaints from all sources in the City of Toronto (comparable periods circled)

City of Toronto noise complaints can be categorized into seven categories, as shown in Figure 2. Among the seven noise categories, "loading and unloading noise" and "motor vehicle noise", which together comprise approximately 7.5% of total noise complaints, could potentially be caused by trucks on delivery. Examination of comments made by the complainants indicates that most of the "loading and unloading noise" is garbage collection noise and most of the "motor vehicle noise" is caused by passenger cars or car horns.

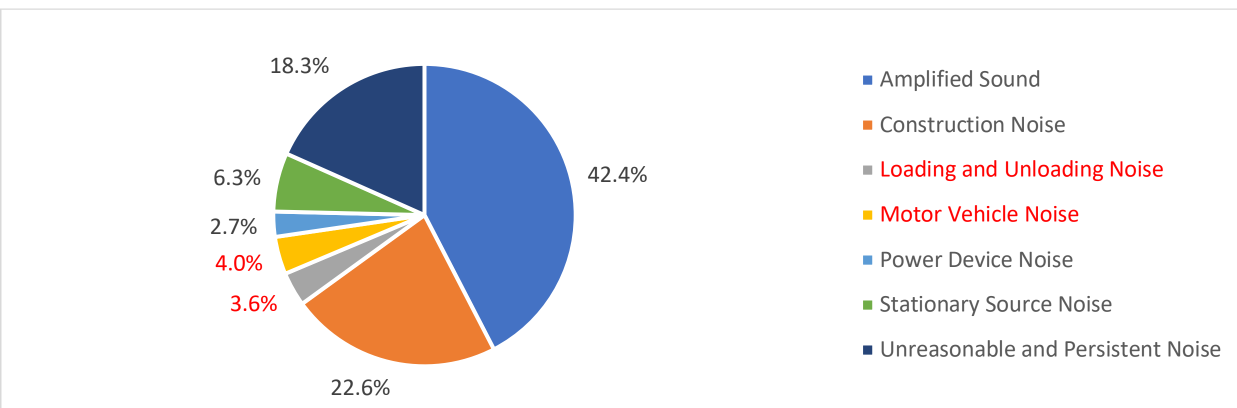


Figure 2 – Categorization of noise complaints, City of Toronto, January 1, 2019 to April 6, 2021

We assume that if a complaint is filed between 7PM and 7AM, then it is complaining about an off-peak noise. Among all noise complaints recorded, 12,347 complaints (36.5%) are filed during the hours from 7PM to 7AM.

687 noise complaints are related to off-peak (7PM to 7AM) "loading and unloading noise" and off-peak "motor vehicle noise". Figure 3 shows that, of these complaints, 183 noise complaints

(27%) are related to commercial deliveries. Our best estimate, therefore, is that 183 of the 33,789 (0.54%) total City of Toronto noise complaints from January 1, 2019 to April 6, 2021 can be specifically attributed to OPD.

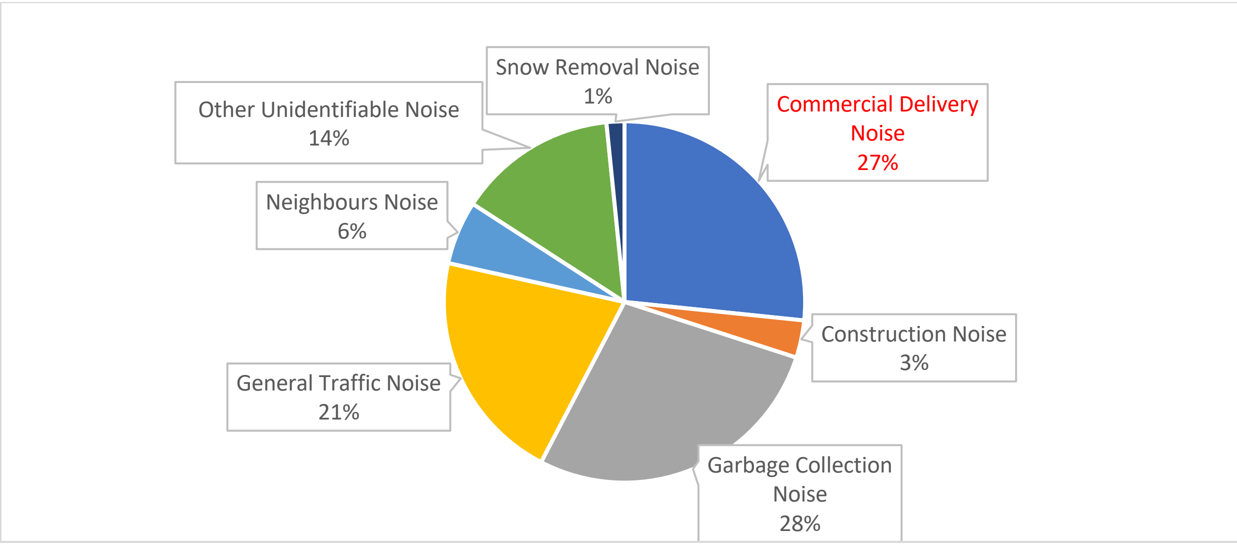


Figure 3 – Composition of off-peak loading/unloading and motor vehicle noise complaints, January 1, 2019 to April 6, 2021

Additional insights can be gained from the City of Toronto Noise By-Law Research conducted in May 2018. This research was commissioned by the City of Toronto to collect feedback from Toronto residents on their attitudes and opinions about noise and noise bylaws (Ipsos, 2018). The research investigated:

- Concerns for reducing noise pollution compared to other City of Toronto priorities;
- Preferences for the restriction of certain types of noise;
- General attitudes and opinions towards noise in the City of Toronto, including:
    - Acceptability of different types of noise at night;
    - Ideal times for restricting noise;
    - Awareness and attitudes towards noise bylaws.

The survey did not specifically ask for residents' attitudes towards commercial delivery activities at night. However, several findings of this study that are most relevant are listed as follows:

- Residents are most concerned about noise caused by construction and/or heavy equipment;
- Overall, a majority (64%) of residents believe that noise levels in the City of Toronto are reasonable and reflect life in a big city, while a minority (36%) of residents believe that more needs to be done to restrict noise because of potential negative health consequences;
- On average, residents prefer that noise be restricted before 8:00 AM and after 7:30 PM on weekdays and before 9:30 AM and after 7:00 PM on weekends;
- Of the 33% of residents that indicated noise concerns, 11% identified road traffic, and 6% identified late night or early morning noise as specific causes of concern;
- 4% of residents identified "delivery and loading of items by truck" as a most bothersome source of noise. This was the fifteenth most commonly selected source of noise.

3.4 Preliminary conclusions of noise complaints analysis

In the City of Toronto:

- No major change in total noise complaint frequency is evident in the August to March period after the pandemic began. However, we note that changes in the City of Toronto's noise intake policies during the pandemic make direct comparisons somewhat unreliable.
- Our best estimate is that 0.54% of total noise complaints were due to off-peak commercial deliveries, from January 1, 2019 to April 6, 2021.
- City of Toronto Noise By-Law Research conducted in May 2018 found that 4% of residents identified "delivery and loading of items by truck" as a most bothersome source of noise. This was the fifteenth most commonly selected source of noise.

Noise complaints from the City of Toronto indicate that OPD are a small but non-negligible portion of the noise experienced in the urban area of Toronto.

4 Community Noise Survey

4.1 Introduction

In recognition that noise complaints are potentially biased, the University of Toronto initiated a Community Noise Survey in July 2021 directed at residents that are likely to have experienced noise from OPD. The objective of this survey is to proactively engage with community members in the vicinity of locations where OPD are known to have occurred. The survey is intended to elicit response from community members that may not have been aware of or had the opportunity to register a noise complaint.

4.2 Survey design

Data are collected through an anonymous online questionnaire with 16 questions that take approximately 10 minutes to answer. The survey questions are shown in Appendix B. Participants are first asked to answer general wellbeing questions, which help the participant to warm up and get familiar with the survey. Participants are then asked community noise-related questions, generally using a Likert scale. This section asks how the participants would rate the noise coming from different sources in their community and noise levels in the community at different times of the day before and during the pandemic period. This section asks specifically how annoying different noise sources are. OPD-related questions are embedded in a list of common noise sources, which are presented in random order for each participant. Demographic information is collected, including income class, gender, racial, and postal code. Demographic information is collected for the purpose of assessing representativeness of the survey sample.

4.3 Site selection and data collection procedure

Survey sites for data collection are centred on 22 retail stores that are known to have received regular evening/night-time deliveries (this delivery information was provided by our retail industry partners) and that are nearby to residential neighbourhoods. Respondents from each survey site are separated into two groups: an experimental group and a control group. The experimental group includes respondents living in residences that are located within 150m of the loading area of the retail store. The control group includes residences that are located more than 150m from the loading area, in the same neighbourhood. The intention of this distinction is to compare the survey outcomes from the experimental group to the control group to identify if there is a greater perceived impact of noise closer to the source of commercial delivery noise.

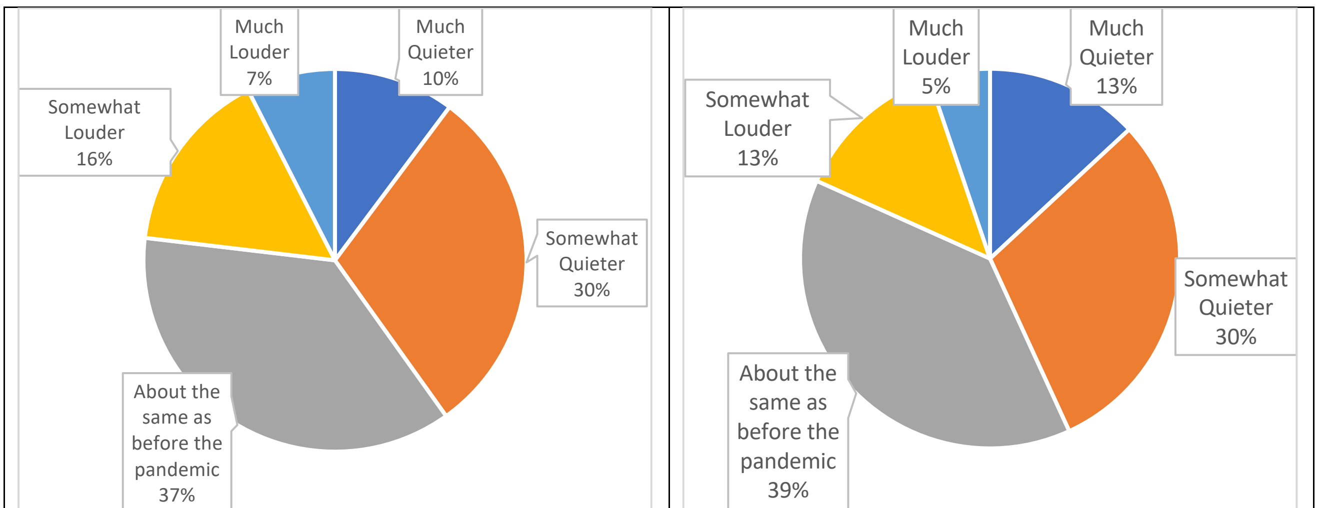
Postcards are delivered to each of the residences in these two groups. The postcards include the web address for the survey and a loonie, taped on, which acts as a pre-incentive to complete the survey.

4.4 Results

Postcards were delivered to 3346 households in July and August of 2021. 327 responses were received, a response rate of almost 10%. 48% of responses were from residents within 150m of a known site of OPD and 52% were from residents outside 150m. Highlights of the outcomes are included in the following graphs.

Figure 4 describes responses to the question "How has the noise level where you live changed since the March 2020 pandemic lockdown began?"

- Over 75% of respondents felt that the noise level was 'about the same' or quieter than before the lockdown began, despite that OPD began at that time.
- Residents within 150m of a known site of OPD were slightly more likely to report that the noise level was 'much louder', or 'somewhat louder' than before the lockdown began.



Responses within 150m of known site of OPD	Responses beyond 150m of known site of OPD

Figure 4 – How has noise level changed since the March 2020 pandemic lockdown began?

Figure 5 describes responses to the questions "Before (Q6)/Since (Q7) the March 2020 lockdown began, from inside your home, how would you rate the noise coming from…".

- For residents within and outside 150m of known site of OPD, the rating of noise coming from nearby business establishments was quieter since the March 2020 pandemic lockdown began, despite that OPD began at that time.
- The percentage of respondents within 150m of the OPD site who rate the noise coming from nearby business establishments as 'not loud' increased from 43.8% to 56.2%, since the 2020 pandemic lockdown began. Fewer respondents reported 'slightly loud', 'moderately loud', or 'very loud' ratings.
- It makes sense that a higher portion of the respondents outside 150m of the OPD site rate the noise coming from nearby business establishments as 'not loud'. The percentage increased from 61.9% to 72.1% since the 2020 pandemic lockdown began.

Responses within 150m of known site of OPD

Before the March 2020 pandemic lockdown began, from inside your home, how would you rate the noise coming from ...?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Your street	24.20%	28.80%	32.70%	11.80%	2.60%
Your neighbourhood	30.10%	26.10%	31.40%	11.10%	1.30%
Your nearby business establishments	43.80%	23.50%	20.30%	10.50%	2.00%
Inside your home	60.10%	30.70%	7.80%	1.30%	0.00%

Since the March 2020 pandemic lockdown began, from inside your home, how would you rate the noise coming from ...?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Your street	40.50%	22.20%	24.20%	9.20%	3.90%
Your neighbourhood	38.60%	27.50%	20.90%	9.80%	3.30%
Your nearby business establishments	56.20%	22.20%	13.10%	6.50%	2.00%
Inside your home	54.90%	27.50%	9.20%	7.20%	1.30%

Responses outside 150m of known site of OPD

Before the March 2020 pandemic lockdown began, from inside your home, how would you rate the noise coming from ...?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Your street	46.30%	26.50%	21.10%	6.10%	0.00%
Your neighbourhood	39.50%	33.30%	22.40%	4.10%	0.70%
Your nearby business establishments	61.90%	21.10%	11.60%	3.40%	2.00%
Inside your home	69.40%	17.00%	10.20%	2.70%	0.70%

Since the March 2020 pandemic lockdown began, from inside your home, how would you rate the noise coming from ...?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Your street	52.40%	23.10%	13.60%	8.80%	2.00%
Your neighbourhood	44.20%	31.30%	13.60%	9.50%	1.40%
Your nearby business establishments	72.10%	16.30%	9.50%	2.00%	0.00%
Inside your home	61.90%	21.10%	10.90%	4.10%	2.00%

Figure 5 – Noise ratings from source locations before and during the pandemic

Responses within 150m of known site of OPD

Before the March 2020 pandemic lockdown began, how would you rate the noise levels in your neighbourhood during these times?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	25.50%	32.70%	30.70%	8.50%	2.60%
Weekday EVENING (7pm – 11pm)	33.30%	31.40%	26.10%	7.80%	1.30%
Weekday NIGHT-TIME (11pm - 7am)	53.60%	33.30%	10.50%	2.00%	0.70%
Weekend DAY-TIME (7am – 7pm)	24.20%	36.60%	30.10%	6.50%	2.60%
Weekend EVENING (7pm – 11pm)	30.70%	33.30%	24.80%	10.50%	0.70%
Weekend NIGHT-TIME (11pm - 7am)	46.40%	35.30%	13.10%	3.90%	1.30%

Since the March 2020 pandemic lockdown began, how would you rate the noise levels in your neighbourhood during these times?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	30.70%	37.90%	22.20%	7.20%	2.00%
Weekday EVENING (7pm – 11pm)	39.90%	34.00%	17.00%	7.20%	2.00%
Weekday NIGHT-TIME (11pm - 7am)	59.50%	24.80%	11.80%	2.60%	1.30%
Weekend DAY-TIME (7am – 7pm)	33.30%	38.60%	19.60%	6.50%	2.00%
Weekend EVENING (7pm – 11pm)	39.90%	31.40%	18.30%	7.80%	2.60%
Weekend NIGHT-TIME (11pm - 7am)	54.90%	24.80%	13.10%	5.20%	2.00%

Responses outside 150m of known site of OPD

Before the March 2020 pandemic lockdown began, how would you rate the noise levels in your neighbourhood during these times?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	36.10%	39.50%	17.70%	4.10%	2.70%
Weekday EVENING (7pm – 11pm)	42.90%	33.30%	17.00%	4.80%	2.00%
Weekday NIGHT-TIME (11pm - 7am)	72.10%	16.30%	10.20%	1.40%	0.00%
Weekend DAY-TIME (7am – 7pm)	41.50%	30.60%	19.70%	6.10%	2.00%
Weekend EVENING (7pm – 11pm)	35.40%	38.10%	16.30%	8.80%	1.40%
Weekend NIGHT-TIME (11pm - 7am)	63.90%	19.00%	13.60%	2.70%	0.70%

Since the March 2020 pandemic lockdown began, how would you rate the noise levels in your neighbourhood during these times?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	46.30%	29.90%	18.40%	3.40%	2.00%
Weekday EVENING (7pm – 11pm)	48.30%	31.30%	15.00%	5.40%	0.00%
Weekday NIGHT-TIME (11pm - 7am)	70.10%	16.30%	11.60%	2.00%	0.00%
Weekend DAY-TIME (7am – 7pm)	44.90%	31.30%	16.30%	6.80%	0.70%
Weekend EVENING (7pm – 11pm)	42.20%	32.70%	15.60%	8.80%	0.70%
Weekend NIGHT-TIME (11pm - 7am)	68.00%	14.30%	12.20%	5.40%	0.00%

Figure 6 – Noise ratings by time of day, before and during the pandemic describes responses to the questions "Before (Q8) / Since (Q9) the March 2020 lockdown began, how would you rate the noise levels in your neighbourhood during these times?…". The question asks the respondents their perception of day-time (7am-7pm), evening (7pm-11pm), or night-time (11pm-7am) noise level on a weekday or weekend.

- Since the pandemic began, over 70% of respondents living within 150m of a known OPD site, reported evening and night-time noise levels as 'not loud' or 'slightly loud'.
- There was a small increase (less than 2%) in the number of respondents within 150m of a known OPD site that reported 'extremely loud' noise in the evenings and night-time.
- In general, day-time is louder than evening, which is louder than night-time.
- Generally, the noise level beyond 150m from known OPD sites was quieter than near the OPD sites.

Responses within 150m of known site of OPD

Before the March 2020 pandemic lockdown began, how would you rate the noise levels in your neighbourhood during these times?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	25.50%	32.70%	30.70%	8.50%	2.60%
Weekday EVENING (7pm – 11pm)	33.30%	31.40%	26.10%	7.80%	1.30%
Weekday NIGHT-TIME (11pm - 7am)	53.60%	33.30%	10.50%	2.00%	0.70%
Weekend DAY-TIME (7am – 7pm)	24.20%	36.60%	30.10%	6.50%	2.60%
Weekend EVENING (7pm – 11pm)	30.70%	33.30%	24.80%	10.50%	0.70%
Weekend NIGHT-TIME (11pm - 7am)	46.40%	35.30%	13.10%	3.90%	1.30%

Since the March 2020 pandemic lockdown began, how would you rate the noise levels in your neighbourhood during these times?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	30.70%	37.90%	22.20%	7.20%	2.00%
Weekday EVENING (7pm – 11pm)	39.90%	34.00%	17.00%	7.20%	2.00%
Weekday NIGHT-TIME (11pm - 7am)	59.50%	24.80%	11.80%	2.60%	1.30%
Weekend DAY-TIME (7am – 7pm)	33.30%	38.60%	19.60%	6.50%	2.00%
Weekend EVENING (7pm – 11pm)	39.90%	31.40%	18.30%	7.80%	2.60%
Weekend NIGHT-TIME (11pm - 7am)	54.90%	24.80%	13.10%	5.20%	2.00%

Responses outside 150m of known site of OPD

Before the March 2020 pandemic lockdown began, how would you rate the noise levels in your neighbourhood during these times?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	36.10%	39.50%	17.70%	4.10%	2.70%
Weekday EVENING (7pm – 11pm)	42.90%	33.30%	17.00%	4.80%	2.00%
Weekday NIGHT-TIME (11pm - 7am)	72.10%	16.30%	10.20%	1.40%	0.00%
Weekend DAY-TIME (7am – 7pm)	41.50%	30.60%	19.70%	6.10%	2.00%
Weekend EVENING (7pm – 11pm)	35.40%	38.10%	16.30%	8.80%	1.40%
Weekend NIGHT-TIME (11pm - 7am)	63.90%	19.00%	13.60%	2.70%	0.70%

Since the March 2020 pandemic lockdown began, how would you rate the noise levels in your neighbourhood during these times?

	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	46.30%	29.90%	18.40%	3.40%	2.00%
Weekday EVENING (7pm – 11pm)	48.30%	31.30%	15.00%	5.40%	0.00%
Weekday NIGHT-TIME (11pm - 7am)	70.10%	16.30%	11.60%	2.00%	0.00%
Weekend DAY-TIME (7am – 7pm)	44.90%	31.30%	16.30%	6.80%	0.70%
Weekend EVENING (7pm – 11pm)	42.20%	32.70%	15.60%	8.80%	0.70%
Weekend NIGHT-TIME (11pm - 7am)	68.00%	14.30%	12.20%	5.40%	0.00%

Figure 6 – Noise ratings by time of day, before and during the pandemic

Figure 7 describes the change of percent respondents responding to the question since the March 2020 pandemic began, compared to before the pandemic. The red cells represent reductions of percent responses, and the blue cells represent increases. We can observe the following changes.

- In general, ratings of noise levels at all times of day decreased since the pandemic began, with a few exceptions.
- Since the March 2020 pandemic lockdown began, at least 5% more respondents within 150m of known OPD site at all times, reported that noises were 'not loud'.
- Since the March 2020 pandemic lockdown began, more respondents outside 150m of known sites of OPD reported that noises were 'not loud', at almost all times. The only exception is that some respondents outside 150m of a known OPD site at night-time reported increase in noise level.

Responses within 150m of known site of OPD					
How would you rate the noise levels in your neighbourhood during these times?					
	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	5.20%	5.20%	-8.50%	-1.30%	-0.60%
Weekday EVENING (7pm – 11pm)	6.60%	2.60%	-9.10%	-0.60%	0.70%
Weekday NIGHT-TIME (11pm - 7am)	5.90%	-8.50%	1.30%	0.60%	0.60%
Weekend DAY-TIME (7am – 7pm)	9.10%	2.00%	-10.50%	0.00%	-0.60%
Weekend EVENING (7pm – 11pm)	9.20%	-1.90%	-6.50%	-2.70%	1.90%
Weekend NIGHT-TIME (11pm - 7am)	8.50%	-10.50%	0.00%	1.30%	0.70%

Responses outside 150m of known site of OPD					
How would you rate the noise levels in your neighbourhood during these times?					
	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
Weekday DAY-TIME (7am - 7pm)	10.20%	-9.60%	0.70%	-0.70%	-0.70%
Weekday EVENING (7pm – 11pm)	5.40%	-2.00%	-2.00%	0.60%	-2.00%
Weekday NIGHT-TIME (11pm - 7am)	-2.00%	0.00%	1.40%	0.60%	0.00%
Weekend DAY-TIME (7am – 7pm)	3.40%	0.70%	-3.40%	0.70%	-1.30%
Weekend EVENING (7pm – 11pm)	6.80%	-5.40%	-0.70%	0.00%	-0.70%
Weekend NIGHT-TIME (11pm - 7am)	4.10%	-4.70%	-1.40%	2.70%	-0.70%

Figure 7 – Noise rating changes by time of day, before and during the pandemic

Figure 8 describes responses to the question: "In the past year, during the pandemic, how often did you hear these sounds from inside your home?"

- On average evening truck deliveries were heard less often than day-time truck deliveries.
- 64% of respondents within 150m of a known site of OPD and 85% of respondents who live outside 150m of a known site of OPD 'never' or 'rarely' heard evening/night-time deliveries to the nearby businesses.
- Notably, 7.2% of respondents who live within 150m of a known site of OPD reported that they 'always' hear evening/night-time deliveries.

Responses within 150m of known site of OPD

In the past year during the pandemic, how often did you hear these sounds from inside your home?

	Never	Rarely	Sometimes	Often	Always
Evening / night-time truck deliveries to nearby businesses	32.70%	31.40%	19.00%	9.80%	7.20%
Day-time truck deliveries to nearby businesses	19.00%	25.50%	27.50%	20.90%	7.20%

Responses outside 150m of known site of OPD

In the past year during the pandemic, how often did you hear these sounds from inside your home?

	Never	Rarely	Sometimes	Often	Always
Evening / night-time truck deliveries to nearby businesses	55.10%	29.90%	11.60%	2.70%	0.70%
Day-time truck deliveries to nearby businesses	38.10%	33.30%	17.70%	7.50%	3.40%

Figure 8 – Noise associated with evening and day-time truck deliveries during the pandemic.

A variety of other sources of noise were presented in random order to the respondents. The ranked order of noise frequency of these sources of noise are shown in Figure 9. Evening / night-time truck deliveries to nearby business establishments were the seventh most frequently heard noise for those living near known sites of OPD, and the least often heard for those living beyond 150m from known sites of OPD.

Respondents with 150m of known site of OPD	Most often heard	**Respondents outside 150m of known site of OPD**
Ambulance, police, and fire trucks		Garbage pick-up, street sweepers
Garbage pick-up, street sweepers		Ambulance, police, and fire trucks
Road/highway traffic		Construction
Day-time truck deliveries to nearby businesses		Car horns and car alarms
Car horns and car alarms		Road/highway traffic
Construction		Loud music and party
Evening / night-time truck deliveries to nearby businesses		Day-time truck deliveries to nearby businesses
Loud music and party	Least often heard	Airport noise
Train / streetcar noise		Train / streetcar noise
Airport noise		Evening / night-time truck deliveries to nearby businesses

Figure 9 – Ranking of noise sources during the pandemic

4.5 Conclusions from community noise survey

Selected conclusions from the community noise survey are as follows:

- In the vicinity of areas where evening and night-time deliveries are known to have occurred during the pandemic, the perception of noise by most residents decreased since the March 2020 lockdown began.
- In the vicinity of areas where evening and night-time deliveries are known to have occurred during the pandemic, noise perception by most residents from 'nearby business establishments' also reduced during the pandemic.
- Since the pandemic began, over 70% of respondents living within 150m of a known OPD site, reported evening and night-time noise levels as 'not loud' or 'slightly loud'. Ratings of noise levels at all times of day decreased since the pandemic began, except for night-time, which increased for a small number of residents both within and outside 150m of a known OPD site.
- 64% of respondents within 150m of a known site of OPD and 85% of respondents who live outside 150m of a known site of OPD 'never' or 'rarely' heard evening/night-time deliveries to the nearby businesses. 7.2% of respondents within 150m of a known site of OPD 'always' heard evening/night-time truck deliveries to nearby businesses.
- Out of ten common noise sources presented to respondents, evening / night-time truck deliveries to nearby business establishments were the seventh most frequently heard noise for those living near known sites of OPD, and the least often heard for those living beyond 150m from known sites of OPD.

5 Truck Collision Analysis

5.1 Introduction

This analysis examines the difference in truck collision frequency, truck collision severity levels, fatality rates, vulnerable road user involvement, and truck collision location during the day (7AM to 7PM), evening (7PM to 11PM), and night-time (11PM to 7AM). Truck collision statistics were acquired from the Ministry of Transportation of Ontario (MTO) for the years 2010 to 2019 (before the pandemic lockdown began and noise by-law restrictions on deliveries were lifted) and are compared to those from March 19, 2020 to December 31, 2020. The geographic scope of the truck collision analysis includes the Greater Toronto and Hamilton Area, including collisions in the Cities of Toronto and Hamilton, and the Regions of Peel, York, Durham and Halton. Recognition is given to the MTO Traffic Safety Division for their analysis and cleaning of collision records in support of this analysis.

5.2 Caveats

- Collisions are infrequent events. It must be recognized that variation from year to year of collision rates, especially infrequent severe collisions, are large and may be due to random effects and factors other than OPD.
- Due to the unavailability of truck collision data after December 31, 2020, the data from March 19 to December 31, 2020 (after the pandemic was declared) have been extrapolated to a full year (multiplied by 365 and divided by the number of days covered, 287). While this extrapolation makes yearly comparisons easier, we recognize that seasonal variations in collision rates have not been considered in the comparison.
- Exposure to collisions likely reduced during the pandemic. This reduction in exposure is a result of a likely reduction in truck traffic, car traffic, and the presence of vulnerable users on the roadway system due to lockdown measures. Reduction in collisions could be due to this reduction in exposure.

5.3 Truck collision frequency

On average, a total of 7,137 truck collisions happened per year in the GTHA between 2010 and 2019, with an average rate of 19.6 truck collisions per day. In the 287 days between March 19 and December 31, 2020, a total of 3,789 truck collisions were reported, with an average rate of 13.2 truck collisions per day. The daily truck collision rate therefore decreased by 32.5% after OPD were permitted. This decrease may be partially attributed to reduced traffic after the pandemic, leading to fewer interactions between trucks and other road users.

The average hourly number of truck collisions per year before and after the allowance of OPD is shown in Figure 10**.** Data from 2010 to 2019 indicate that the average hourly number of collisions increased through the day until 8:00 AM (1.52 truck collisions/hour) and remained relatively constant until 3:00 PM (1.57 truck collisions/hour), after which hourly collision rates decreased.

After March 19, 2020, after trucks were permitted to make OPD, the collision rate declined at all times of day. The overall collision rate was lower between the hours of 5:00 AM and 11:00 PM after March 19, 2020. The pattern of collisions is also somewhat different; the collision rate increased more gradually in the morning until 12:00 PM (1.12 truck collisions/hour) and reduced after 3:00 PM (1.13 truck collisions/hour).

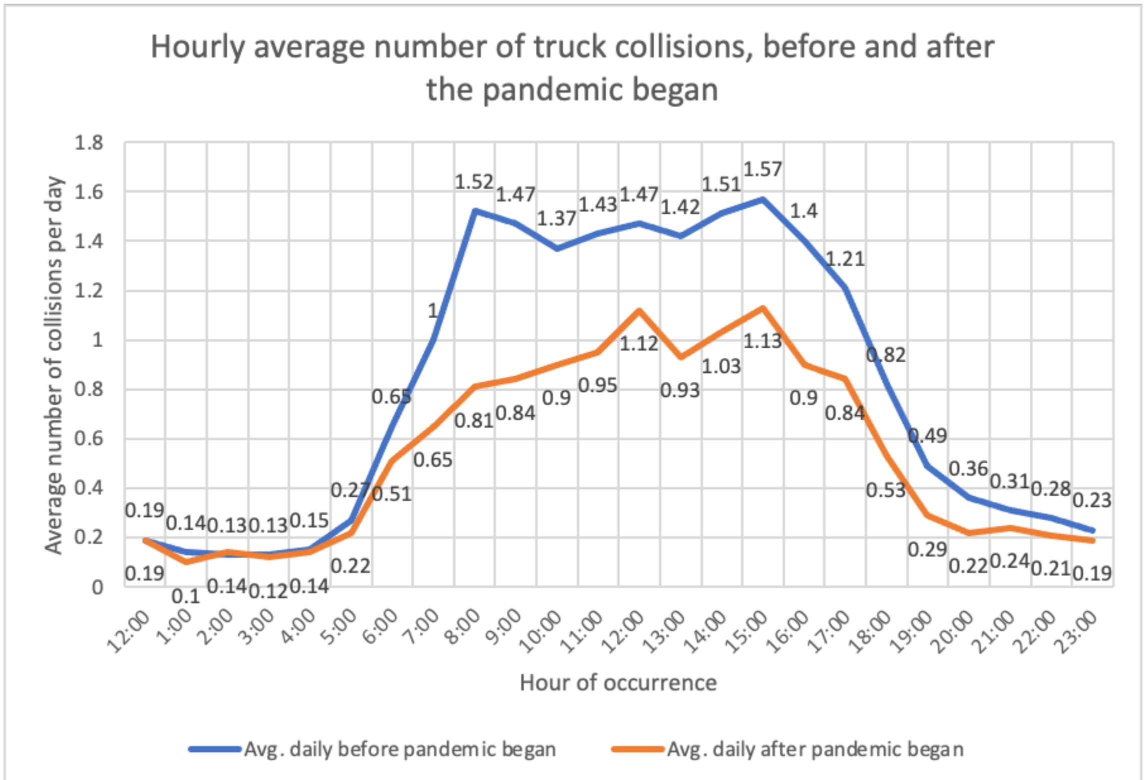


Figure 10 – Average hourly number of truck collisions before and after the pandemic began

Figure 11 shows the distribution of collisions by time period (day-time, evening and night-time). After March 19, 2020, a slight increase in the proportion of collisions occurred in the night period 11:00PM to 7:00 AM (2% increase) and a slight decrease in the proportion of truck collisions happening during the day (3% decrease). The percentage of truck collisions during the evening (7 PM to 11 PM) remained unchanged. The change in truck collision time-period distribution from before to after March 19, 2020 appears to be minor and may be partially attributed to the change in the overall traffic flows due to the pandemic.

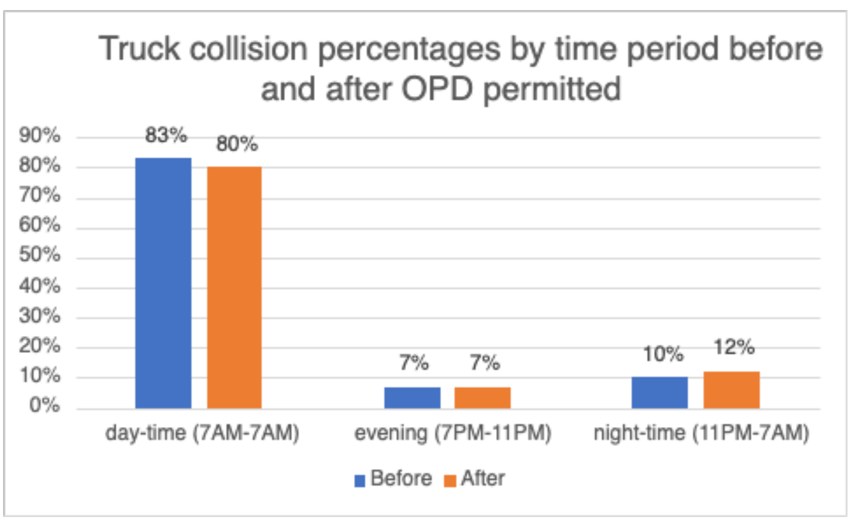


Figure 11 – Truck collisions percentages by time period, before and after off-peak deliveries were permitted on March 19, 2020

5.4 Truck collision severity and fatality rates

A fatal collision is a collision in which at least one involved person dies from collision-related injuries within 30 days of the collision. A personal injury collision is a collision in which at least one involved person sustains injury as a result of the collision, but in which no involved person dies due to collision-related injuries within 30 days of the collision.

An average of 26 fatal, 1,018 personal injury, and 6,094 property damage truck collisions occurred per year, between 2010 and 2019. After time-of-day restrictions on deliveries were lifted on March 19, 2020, the extrapolated yearly numbers of fatal, personal injury, and property damage truck collisions are 28, 560, and 4,231, respectively. Table 1 shows the percentages of truck collisions leading to different truck collision outcomes, before and after OPD were allowed.

Table 1 – Percentages of truck collisions by severity level, before and after off-peak deliveries permitted on March 19, 2020

	Property damage only	Personal injury	Fatality
Before March 19, 2020	85%	14%	0.36%
After March 19, 2020	88%	12%	0.58%

The proportion of the lowest severity collisions (property damage only collisions) has increased by 3% while personal injury collisions decreased by 2%. This is a generally favorable change, indicating that the overall truck collision severity is slightly lower after permitting trucks to make OPD. The proportion of fatalities increased after the pandemic began, although the estimated absolute yearly number of fatalities increased by two compared to previous years (this highly variable and small number makes it difficult to say this increase is due to factors other than random variation). Notably, the time-period distribution of fatal truck collisions also changed after permitting OPD. As shown in Figure 12, the percentage of fatal collisions during the evening and night periods decreased from 12% and 25% to 9% and 18%, respectively.

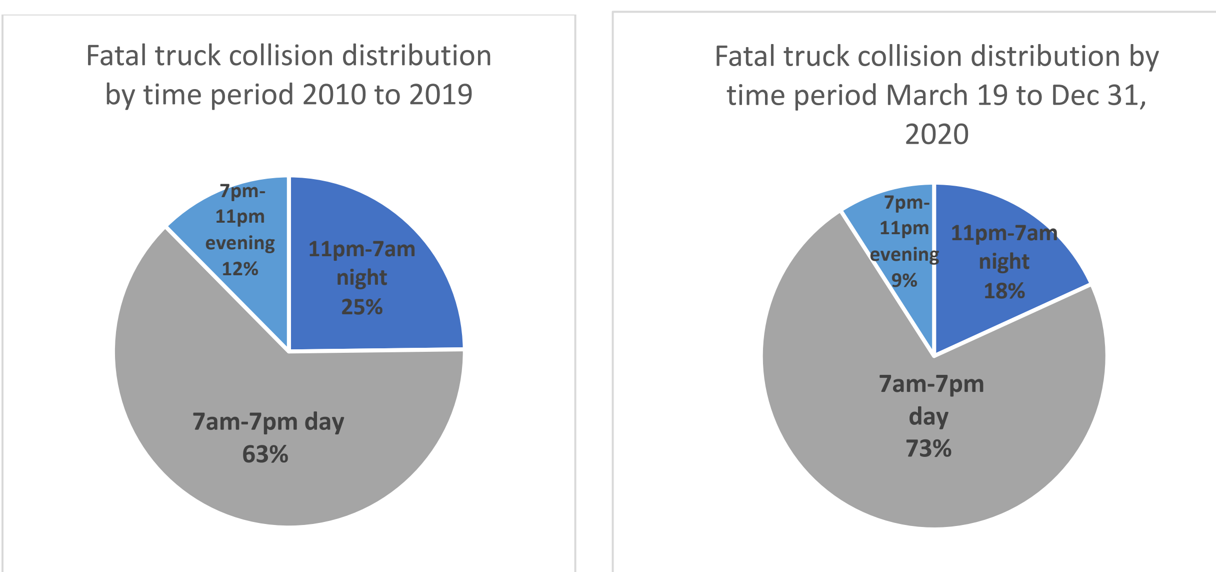


Figure 12 – Time-period distribution of fatal truck collisions, 2010 to 2019 (left), March 19 to December 31, 2020 (right)

A more detailed truck collision classification showing the proportions of truck collision severity by time period is shown in Table 2. After allowing off-peak truck deliveries, a larger portion of 'property damage only' collisions took place at night and a slightly smaller percentage of 'personal injury' collisions happened during the night. The percentages of fatal truck collisions during the evening and night-time periods have declined by 3% and 7%, respectively.

Table 2 – Proportion of truck collisions by severity level and time period, before and after off-peak deliveries permitted

	Property damage only			Personal injury			Fatality		
	Day-time	Eve-ning	Night-time	Day-time	Eve-ning	Night-time	Day-time	Eve-ning	Night-time
2010-2019	84%	7%	9%	78%	9%	13%	63%	12%	25%
Mar 19-Dec 31, 2020	81%↓	7%	12%↑	79%↑	9%	12% ↓	73% ↑	9% ↓	18%↓

The average number of yearly minimal, minor, major, and fatal injuries that happened as a result of truck collisions from 2010 to 2019 are 671 (46%), 688 (47%), 63 (4%), and 28 (2%), respectively. After the pandemic, the extrapolated data shows that 262 minimal (34%), 426 minor (56%), 46 major (6%) and 28 fatal (4%) injuries resulted from truck collisions yearly.

Figure 13 shows that the percentages of minimal, minor, major and fatal injuries resulting from truck collisions during the evening and night periods decreased after the pandemic began. The percentage of collisions of all injury severities increased (or stayed the same) during the day. Due to the infrequent movement and presence of vehicles and vulnerable road users, especially during the evening and night after the pandemic, the interactions between trucks and other vehicles and road users could have been reduced, which may be the reason for these results.

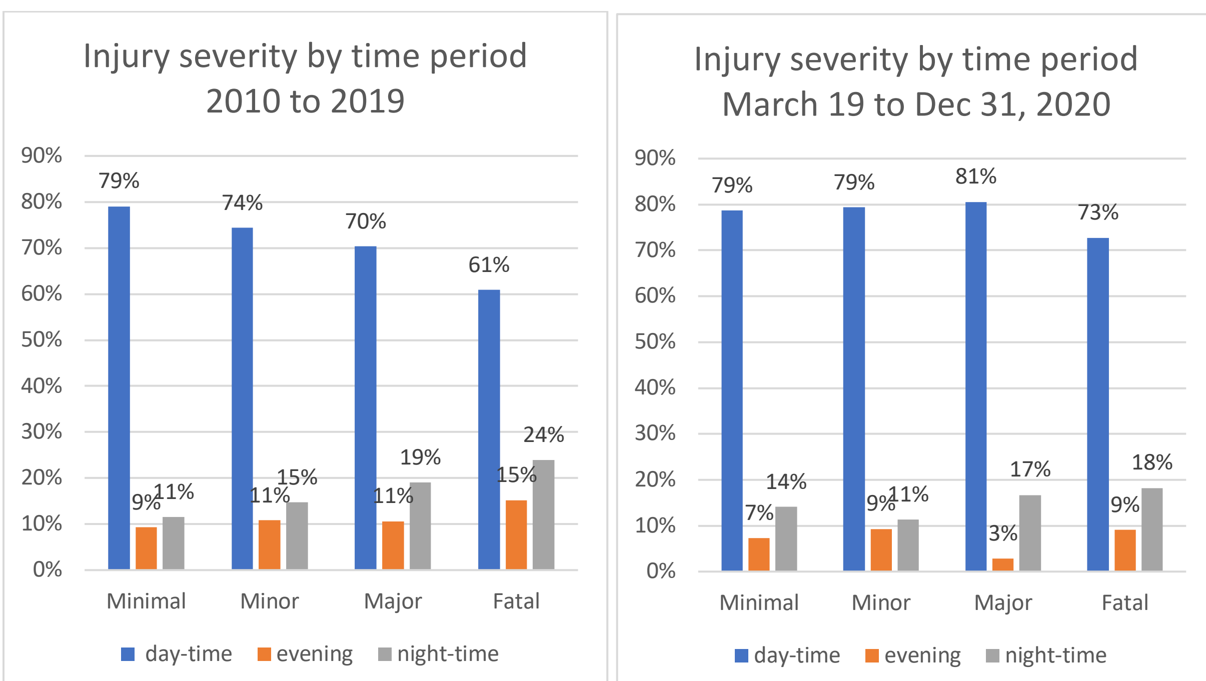


Figure 13 – Injury severity rates by time period, before (left) and after (right) off-peak deliveries were permitted

5.5 Vulnerable road user (VRU) involvement in truck collisions

Since truck-VRU collisions are generally more severe than collisions with other vehicles, this type of collision is important to investigate in detail. On average, 74 pedestrians and cyclists were involved in truck collisions per year from 2010 to 2019. According to data from March 19 to December 31, 2020, the extrapolated yearly number of VRUs involved in truck collisions slightly decreased to 72. Since fewer pedestrians and cyclists typically travel during the winter months, the extrapolation of VRU collision rates for March 19 to December 31, 2020 is likely to be an over-estimate for the annual rates.

The proportion of pedestrians and cyclists involved in truck collisions during the evening and night periods slightly increased by 2% and 1%, respectively, whereas the proportion of VRU involvement in truck collisions during the day decreased by almost 4% (Figure 14).

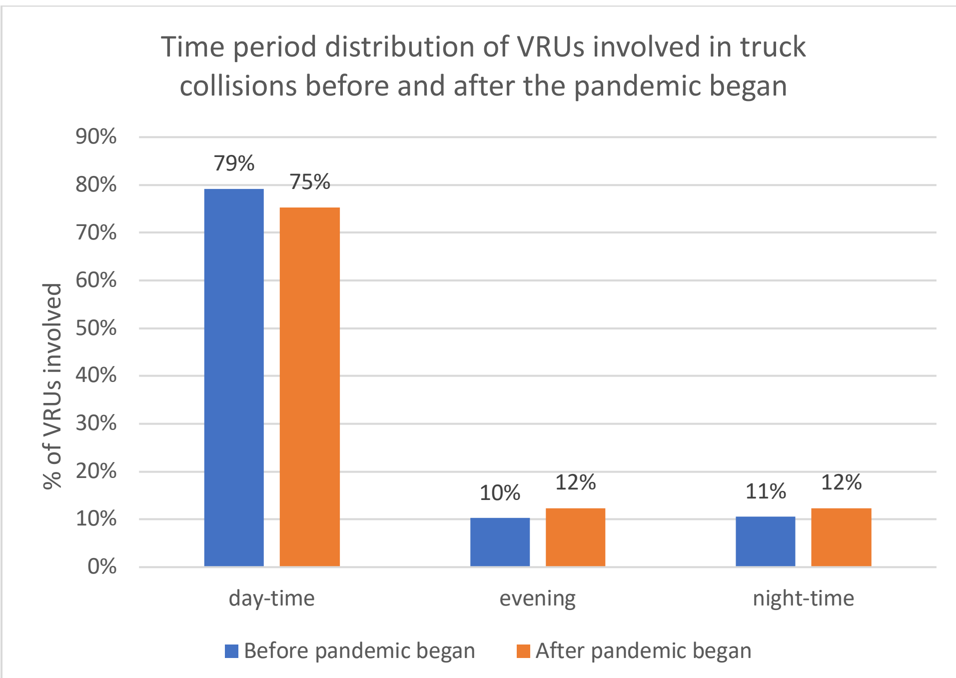


Figure 14 – Time period distribution of pedestrians and cyclists involved in truck collisions before and after the pandemic began (March 19 to December 31, 2021)

5.6 Truck collision locations

Two types of road location classifications of truck collisions are considered: 1) Whether the collisions happened at an intersection or midblock, and 2) the road jurisdiction of the collision. On average, about 34% (2,435 yearly) and 59% (4,239 yearly) of truck collisions between 2010 and 2019 were intersection-related and non-intersection related, respectively. After March 19, 2020, 32% (1,548 yearly) of truck collisions happened at intersections and 62% (2,999 yearly) of truck collisions were non-intersection related. Figure 15 shows the locations of collisions of different severity.

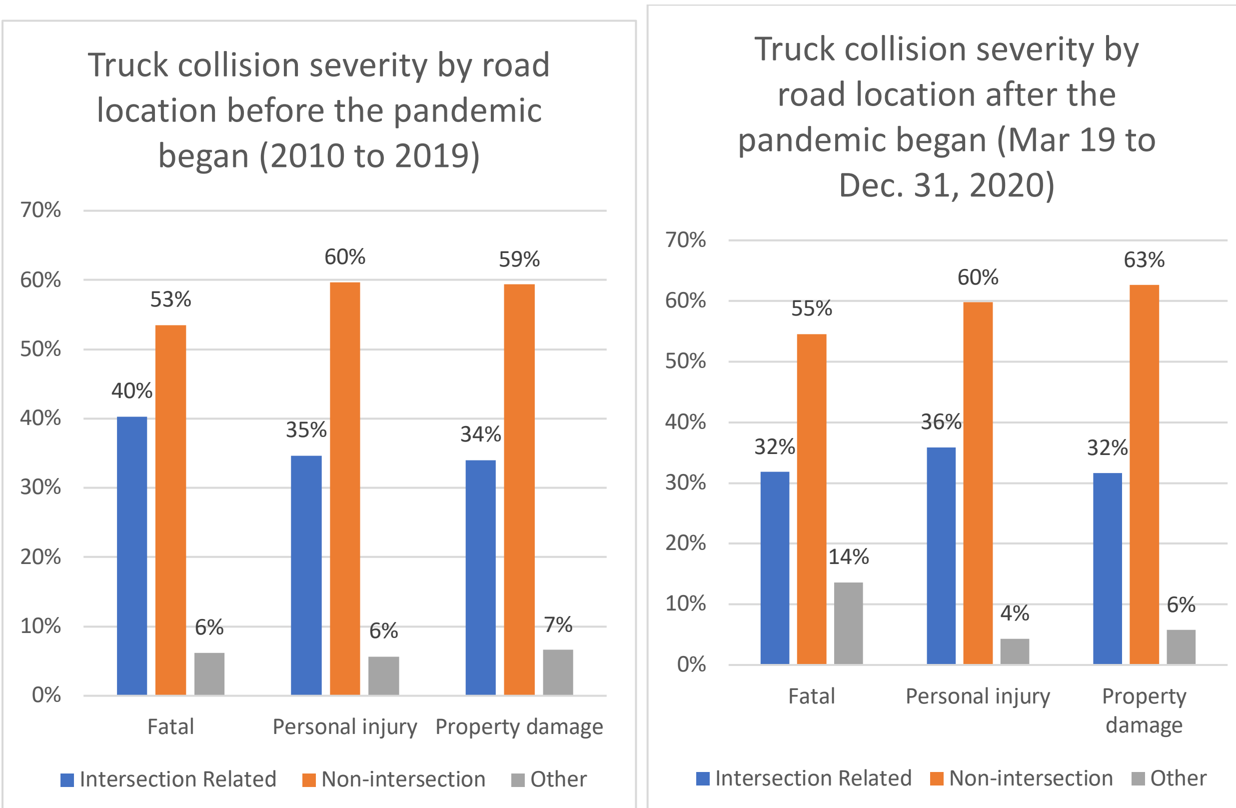


Figure 15 – Collision severity by road location, before (left) and after (right) the pandemic began

In terms of the road jurisdiction, "Municipal Road", "Provincial-Hwy", and "Regional Road" are considered in this analysis. On average, 3,578 truck collisions occurred on municipal roads yearly between 2010 to 2019, accounting for more than 50% of the annual truck collisions in the study area. Based on data from March 19 to December 31, 2020, extrapolated to a year, the yearly number of truck collisions on municipal roads is 2,203, accounting for 45.7% of the total annual truck collisions. However, 40.6% of truck collisions happened on provincial highways, compared to 36.5% before the before the pandemic began. 45% of fatal truck collisions occurred on municipal roads, 31% occurred on provincial highways and 23% of fatal truck collisions happened on regional roads.

Figure 16 shows the distribution of fatal, personal injury, and property damage truck collisions among the different road jurisdictions before and after the pandemic lockdown began.

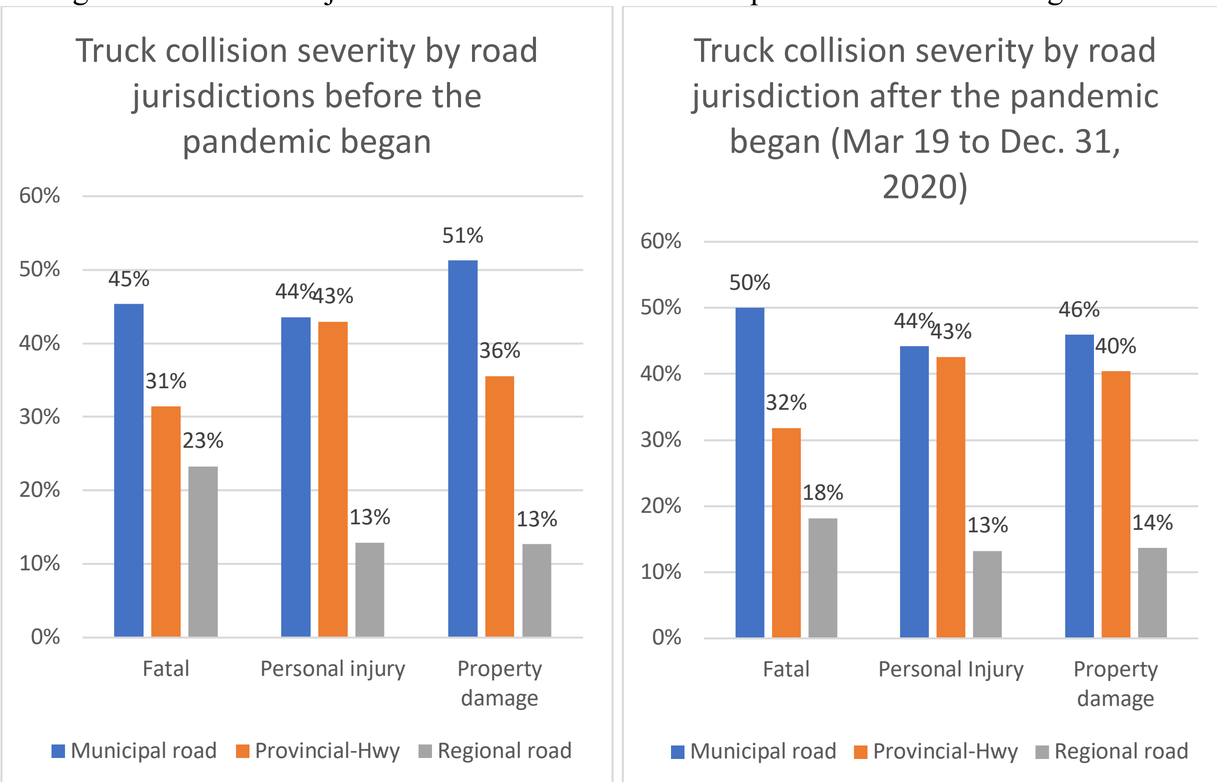


Figure 16 – Truck collision severity by road jurisdiction, before (left) and after (right) the pandemic began

The percentage of fatal collisions increased on municipal roads and decreased on both provincial highways and regional roads. In terms of property damage only collisions, the percentage of truck collisions decreased on municipal roads and increased on both provincial highways and regional roads.

5.7 Preliminary conclusions from truck collision analysis

Preliminary conclusions from the truck collision analysis are as follows:

After the March 19, 2020, when the pandemic lockdown began and OPD were permitted, the GTHA experienced:

- A 32% reduction in total annual truck collisions;
- A slight (2%) increase in the proportion of collisions occurring in the night period, a slight (3%) decrease in the proportion of truck collisions happening during the day, and little change to the percentage of truck collisions during the evening;
- Significant reduction in personal injury, and property damage truck collisions, and approximately no change in fatality rates;
- A reduced percentage of fatal collisions during the evening and night periods;
- Very little change in the number of pedestrians and cyclists involved in truck collisions;
- Little change in the distribution of collision location (intersection versus mid-block), but a decrease in the proportion of fatal accidents that occurred at intersections, an increase in the proportion of fatal collisions on municipal roads, and a decrease in the proportion of fatal collisions on regional roads.

6 Conclusions

This report describes preliminary outcomes of four streams of analysis intended to assess some impacts of the March 19, 2020 Municipal Emergency Act 2020 which prevented the enforcement of noise by-laws across Ontario to permit evening and night-time delivery of goods.

Noise complaints are one indicator of residents' experience of noise from a variety of sources. Noise complaints should be treated with caution since they can be biased, and do not reflect all residents' experience of problematic noise. Analysis of noise complaint data from the City of Toronto indicates that OPD are a small but non-negligible portion of the noise experienced in these locations.

Because noise complaints are potentially biased, the University of Toronto initiated a Community Noise Survey in July 2021 directed at residents that are likely to have experienced noise from OPD. This report describes the findings of this survey. There is little evidence from the survey results that OPD, known to have been conducted at specific retail stores during the pandemic, have been problematic for large numbers of nearby residents.

Concern exists that truck collision rate, severity or impact on vulnerable road users could increase as a result of OPD. We therefore assessed truck collisions that occurred before and during the pandemic, using a database processed by the MTO Traffic Safety Division. A 32% reduction in total annual truck collisions in the GTHA occurred during the pandemic, significant reductions in personal injury and property damage truck collisions but approximately no change in fatality rates, a reduced percentage of fatal collisions during the evening and night-time periods, and little change in the number of pedestrians and cyclists involved in truck collisions. These are encouraging outcomes which show no evidence of an increase in the truck collision rate, severity level, or impact to vulnerable road users as a result of OPD.

All of the analyses presented in this report are subject to one important caveat. Because the Municipal Emergency Act permitted OPD within days of the first pandemic lockdown that began in March 2020, it is impossible to distinguish the specific impacts of the Municipal Emergency Act from the many other broad ranging impacts of the pandemic. Both occurred at the same time. This report provides as much new information as possible, recognizing this limitation, to provide an evidence-base to support an informed off-peak delivery policy in the Province of Ontario.

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Appendix A – Summary of OPD programs

Summary of Off-peak Delivery Programs (adapted from Mousavi et al. (2020)*)*

Location, Year [Reference].	# of Carriers/Shippers	# of Receivers	Duration [1]	Performance Measures	Strategy	Technologies Used	Status of the Study
Region of Peel, Ontario (Mousavi et al., 2020).	Unknown	3 retail firms with 14 stores	6 months	-Speed -Service Time -Emission factors -Noise Complaints	-Assisted OPD -Noise by-law relaxation -No Incentive	-Truck tracking data -Monitoring noise complaints -Survey from the retail firms	The pilot was expanded to GTA OPD program.
Sao Paulo, (FIFA), 2014 (Bertazzo et al., 2016).	1 carrier (DHL) 1 shipper	2 retail outlets	2 weeks	-Speed (travel time) -Productivity (Unloading time) -Safety/Security risks (qualitative) -Noise complaints	-Assisted OPD -No cash incentive	Not mentioned	Project continued to second phase (next row)
Sao Paulo, 2014–2015 (Yushizaki & Babieri da Cunha, 2016).	Carrier: SETCESP syndicate	11 firms with 45 retail stores	12 weeks October 2014 - April 2015	-Speed -Productivity -Safety (incidents from Police data) -Noise (complaints and measurements)	-Assisted and unassisted OPD -No cash incentive	-Shadowing (measuring noise) -Armed escort in 2 cases -Truck GPS	-OPD a City policy -Entire city implementation planned for 2016 -16 large firms, 9 new
New York City, 2009 (Holguín-Veras et al., 2011).	20 trucks (8 vendors)	35 receivers	3 stages (each 1 month)	-Speed/service time -Survey satisfaction	-Assisted (50%) and unassisted (50%) -Cash incentives ($2000/receiver and $300/truck to carriers)	-GPS enable smartphones -Network models to assess to network wide impacts -Follow-up survey	-Continued to second phase (next row) -50% (unassisted) remained with OPD
New York City, 2013 (Holguín-Veras, Wang, et al., 2014).		400 receivers	Unknown	-Speed/service time -Survey satisfaction -Noise		-Low noise trucks/equipment -Noise monitoring	-175–200 companies have shifted to OPD
Denmark (Copenhagen), 2012–2013 (Kolstrup & Frank, 2016).	7 carriers	Unknown	Unknown	-Speed -Fuel consumption (data was provided by the companies)	-No cash incentives		-Most companies were happy to have participated. -2 decided to continue OPD

Colombia, 2015 (Zambrano et al., 2016).	17		8 weeks	-Cost -Time -Logistics -Environment -Safety	-Workshops -Letters -Scheduled one on one meetings -Air quality measurements	Use of GPS data loggers -Truck GPS -Air emissions sensors -Noise monitoring	-5 firms (mostly supermarkets) are continuing with OPD.
Stockholm, 2014 (Koutoulas et al., 2017).	1 shipper 1 carrier with 2 trucks (1 hybrid, 1 biogas)	~30 restaurants and hotels in downtown Stockholm	2 years (including preparation)	-Driving efficiency -Delivery reliability -Energy efficiency -Service efficiency -Noise complaints -Route efficiency -Post surveys		-Trucks equipped with noise monitor -GPS data -Fuel level measurement	-OPD was extended for this carrier. -Noise, cost benefit analysis is on-going
Barcelona, 2003 (LaBelle & Frève, 2016).	One supermarket chain -2 large trucks for OPD replacing 7 vans	2 supermarket locations	11 p.m.–12 a.m. and 5–6 a.m. For 4 months	-Noise measurements -Noise complaints	-Assisted delivery -No financial incentives -Use of larger trucks	-Noise monitor (Police)	-By 2010, the supermarket chain has expanded OPD to over 407 store locations across Spain. -Other supermarkets have considered OPD
Ontario, 2014 (Downtown Toronto) (Zimmerman & Wiginton, 2017).	5 carriers	Over 30 receivers	4 weeks	-Noise -Travel time -Participant experience	-No incentives		The downtown pilot was a successful test in advance of the Panam/Parapanam Games (next row)
Ontario, 2015 (Pan Am Games) (Zimmerman & Wiginton, 2017)	Unknown	100 businesses	6 weeks	-Noise	-No incentives		

Appendix B – Community Noise Survey

Welcome to the Community Noise Survey

We are delighted that you have accessed this survey! Thank-you!

The purpose of this survey is to improve our understanding about how noise levels have changed during the COVID-19 pandemic. We hope to benefit your community by learning about important sources of noise, and to influence noise-generating activities. This survey is conducted by the University of Toronto and is funded by the Atmospheric Fund, the Regions of Peel and York, the City of Toronto and the Natural Science and Engineering Research Council.

This voluntary survey should take about 15 minutes. You may refuse to participate or quit the survey at any time without any consequences, but after you submit, we won't be able to remove your information from the database. The information you provide in the survey won't allow us to identify you, yet we will still keep your data strictly confidential within the research team. We will only publish and present survey outcomes based on combined data from about 350 survey participants.

Please contact Prof. Matthew Roorda at matt.roorda@utoronto.ca or 416-978-5976, if you have questions about the study. You can contact ethics.review@utoronto.ca or 416-946-3273 if you have questions about your rights as a participant.

( ) I would like to participate.
( ) I would not like to participate.

Survey Questions

Please answer all the questions. If you are unsure about which response to give to a question, please choose the one that appears most appropriate. This can often be your first response.

Q1	How would you rate your quality of life?	Poor	Fair	Good	Very good	Excellent
	Before the March 2020 pandemic lockdown began	1	2	3	4	5
	Since the March 2020 pandemic lockdown began	1	2	3	4	5

Q2	How would you rate your ability to concentrate?	Poor	Fair	Good	Very good	Excellent
	Before the March 2020 pandemic lockdown began	1	2	3	4	5
	Since the March 2020 pandemic lockdown began	1	2	3	4	5

Q3	How satisfied are you with your sleep?	Very dissatisfie d	Dissatisfied	Neither satisfiednor dissatisfied	Satisfied	Very satisfied
	Before the March 2020 pandemic lockdown began	1	2	3	4	5
	Since the March 2020 pandemic lockdown began	1	2	3	4	5

Q4	How satisfied are you with your ability to perform daily activities?	Very dissatisfied	Dissatisfied	Neither satisfied nor dissatisfied	Satisfied	Very satisfied
	Before the March 2020 pandemic lockdown began	1	2	3	4	5
	Since the March 2020 pandemic lockdown began	1	2	3	4	5

Q5		Much Quieter	Somewhat Quieter	About the same as before the pandemic	Somewhat Louder	Much Louder
	How has the noise level where you live changed since the March 2020 pandemic lockdown began?	1	2	3	4	5

Before the March 2020 pandemic lockdown began

Q6	From inside your home, how would you rate the noise coming from …?	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
	Your street	1	2	3	4	5
	Your neighbourhood	1	2	3	4	5
	Your nearby business establishments	1	2	3	4	5
	Inside your home	1	2	3	4	5

Since the March 2020 pandemic lockdown began

Q7	From inside your home, how would you rate the noise coming from …?	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
	Your street	1	2	3	4	5
	Your neighbourhood	1	2	3	4	5
	Your nearby business establishments	1	2	3	4	5
	Inside your home	1	2	3	4	5

Before the March 2020 pandemic lockdown began

Q8	How would you rate the noise levels in your neighbourhood during these times?	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
	Weekday DAY-TIME (7am - 7pm)	1	2	3	4	5
	Weekday EVENING (7pm – 11pm)	1	2	3	4	5
	Weekday NIGHT-TIME (11pm - 7am)	1	2	3	4	5
	Weekend DAY-TIME (7am - 7pm)	1	2	3	4	5
	Weekend EVENING (7pm – 11pm)	1	2	3	4	5
	Weekend NIGHT-TIME (11pm - 7am)	1	2	3	4	5

Since the March 2020 pandemic lockdown began.

Q9	How would you rate the noise levels in your neighbourhood during these times?	Not Loud	Slightly Loud	Moderately Loud	Very Loud	Extremely Loud
	Weekday DAY-TIME (7am - 7pm)	1	2	3	4	5
	Weekday EVENING (7pm – 11pm)	1	2	3	4	5
	Weekday NIGHT-TIME (11pm - 7am)	1	2	3	4	5
	Weekend DAY-TIME (7am - 7pm)	1	2	3	4	5
	Weekend EVENING (7pm – 11pm)	1	2	3	4	5
	Weekend NIGHT-TIME (11pm - 7am)	1	2	3	4	5

Q10	In the past year, how often do you hear these sounds from inside your home?	Never	Rarely	Sometimes	Often	Always
	Road/highway traffic	1	2	3	4	5
	Ambulance, police, and fire trucks	1	2	3	4	5
	Car horns and car alarms	1	2	3	4	5
	Evening / night-time truck deliveries to nearby businesses	1	2	3	4	5
	Day-time truck deliveries to nearby businesses	1	2	3	4	5
	Airport noise	1	2	3	4	5
	Construction	1	2	3	4	5
	Train / streetcar noise	1	2	3	4	5
	Garbage pick-up, Street sweepers	1	2	3	4	5
	Noise from neighbours or their pets	1	2	3	4	5

*Note: The list will be randomized.

Q11. Describe sounds where you live that you find most annoying:

About you

Please answer a few general questions about yourself, to ensure we represent all members of the community.

What is your gender? ___________________

Do you identify as a member of a visible minority (non-Caucasian in race or non-white in colour)?

Yes No

What is your postal code? __________________

What is your total household income last year (select the income range that best fits you)?

1. Less than $39,999
2. $40,000 to $79,999
3. $80,000 to $119,999
4. $120,000 to $149,999
5. $150,000 o