Roundabouts for Public Health

January 2013

Briefing Note

For up-to-date knowledge relating to healthy public policy

This briefing note is focused on modern roundabouts – also referred to as roundabouts in this document. As our review of the literature on the effects of traffic calming indicates, roundabouts can, under certain conditions, offer significant advantages regarding some health determinants (Bellefleur & Gagnon, 2011).

In Canada, roundabouts have been in use since the early 2000s, in varying degrees from region to region. Their use is becoming increasingly common. This briefing note is intended to provide public health actors with a frame of reference by:

(1) Summarizing some of the significant characteristics of this intervention (history, design, reasons for and conditions of implementation);

(2) Briefly summarizing the evaluative literature concerning the effects of roundabouts on a few public health determinants;

(3) Identifying some potential courses of action for their promotion, along with some related considerations.

The briefing note takes the form of questions and answers.

What is a roundabout?

A roundabout a specific type of installation built at public road intersections. Its precursor is often identified as the "traffic circle" – a device now rarely constructed, though several examples still exist. The Arc de Triomphe, in Paris (France), is a well-known example.

The two types of installation, in fact, share certain characteristics, including a circular shape with multiple entrances and exits and a central island. This island is sometimes accessible to pedestrians in the case of traffic circles. In general, these two devices are also characterized by the absence of stop signs or traffic lights.[1]

Figure 1 The traffic circle at the Arc de Triomphe, in Paris

The roads are at right angles to the circle. Priority is given to cars entering the circle. Pedestrians have access to the centre.

Source: commons.wikimedia.org. Photograph: BrokenSphere.

Figure 2 A multi-modal roundabout

In Brest, France, a roundabout designed for all modes of circulation on public roads: active transportation, public transportation, individual motorized transportation. Other types of roundabouts exist. Some variations are presented in the Appendix.

Source: commons.wikimedia.org. Photograph: Brest.

Video of how a roundabout functions: http://www.leeengineering.com/roundabouts/Southlake.wmv

[1] Traffic circles and roundabouts with traffic lights do exist. Roundabouts on paths for cyclists or pedestrians also exist. This briefing note does not examine these somewhat exceptional cases.

However, roundabouts differ distinctly from traffic circles in several ways. For one thing, roundabouts include islands that always forcibly deflect vehicles toward the right on entry.[2] This feature is not systematically integrated into the design of traffic circles. Next, with roundabouts, priority is always given to vehicles already in the circle, whereas with traffic circles, priority is given to entering vehicles (Maquis, Lacasse, & Guimond, 2004, pp. 3-4). Also, it is possible to park vehicles in some traffic circles, whereas this is not the case for roundabouts. Finally, roundabouts are usually smaller than traffic circles and vehicles move at slower speeds than in the latter.[3]

Under what circumstances are roundabouts installed?

Roundabouts are equally likely to be installed in rural as in suburban or urban environments. Three particular cases arise. In the first case, intersections with existing signalization (stop signs, traffic lights) are replaced with a roundabout. In the second case, new sections of the road network are developed and roundabouts are installed at the outset. Finally, in the third case, the roundabout is employed within the broader context of a through road/main street intervention.[4] The goal of this third type of intervention is to mitigate the impact of motorized regional, provincial or other traffic flowing through villages or cities on public roads that also function as the main streets of these urban areas; that is, streets where residential or commercial buildings are located. In such contexts, roundabouts are used as traffic-calming devices and as transition markers. They signal the need to reduce vehicle speeds at the point of transition between a high-speed section of the road and a section with a lower speed limit. Inversely, they indicate that speed can be increased at the exit from an urban area.

Why are roundabouts installed?

Several reasons justifying such interventions were identified through a survey of Canadian engineering professionals: improving road safety; increasing or "optimizing" the capacity of a road network or an intersection (the traffic capacity of a roundabout is substantially higher than that of a signalized intersection); improving roadside aesthetics; reducing construction and maintenance costs; increasing drivers' fields of vision; and improving environmental performance (energy, air and noise pollution) (Bahar, Smahel, & Smiley, 2009).

For each specific installation, the reasons given and their relative importance vary. There is also a general tendency to privilege certain reasons over others in some jurisdictions. For example, it has been noted that in the United Kingdom, Australia and Scandinavia, in particular, increasing road capacity or efficiency tends to be prioritized. Meanwhile, in France, Germany and the Netherlands, among other places, concern for road safety is generally the impetus behind the development of roundabouts (Persaud, Retting, & Lord, 2001, pp. 9-10). According to the same analysis, concern for road safety guides roundabout design practices, and it can also be presumed to inform the choice of intersections to be outfitted. Moreover, it seems plausible that these priorities can influence the results of evaluations. For example, one could presume that roundabouts designed primarily to ensure road safety would produce more significant results in this area. Thus, when assessing the rather variable results of evaluations, one should keep in mind the varying priorities guiding the development of roundabouts, even though the evaluations almost never make these priorities explicit.

Why are roundabouts of interest to public health actors?

Firstly, roundabouts are appearing with increasing frequency on Canadian roads and highways. In addition, existing evaluations indicate that they produce effects that are of interest to those concerned with road injuries, active travel, ambient noise levels, air quality and energy-related issues, in particular. The documented effects are not all clearly positive with respect to all of these health determinants under all circumstances. Some, however, are quite generally positive, and in cases

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2 In countries where traffic drives on the right.

3 These distinctions were suggested by Paul Mackey (Rue Sécure) following his reading of an earlier draft of this briefing note.

4 We are not aware of an equivalent standard term in English for "traversée d'agglomération" (France) or "traversée de localité." A term often used in English is "context sensitive design," but this does not designate specifically main roads that also serve as "main streets" in smaller communities, as it applies to any kind of public way situated in any kind of village, town or city. An option is to use "context sensitive through road design," but in this case the expression obliterates the street function, which is rather counter-meaningful. That is why we have used "through road/main street" here. We will be devoting another briefing note to this type of intervention.

where the results are more variable, they can generally be associated with modifiable characteristics of the roundabouts' design. For example, it seems that the effects on road safety are generally clearly positive, but various roundabout designs can be associated with effects that vary according to the category of road user, such as cyclists. Thus, public health actors promoting cycling may have an interest in ensuring that roundabouts are designed in the manner best adapted to cycling.

What effects do roundabouts have on collisions and the resulting injuries?

In general, the evaluative literature supports the conclusion arrived at by the National Cooperative Highway Research Program (NCHRP) in the United States:

> …roundabouts have improved (…) injury crash rates in a wide range of settings (urban, suburban, and rural) for all previous forms of traffic control (Rodegerdts et al., 2007, p.109).

Despite their variable methodologies, the evaluations that we reviewed are quite clear on this point.[5] In fact, after pooling the results of studies comparing the effects before and after the installation of a roundabout and those comparing signalized intersections and intersections with roundabouts, the evaluations indicate reductions in personal injury collisions (from 34%[6] to 80%[7]), collisions causing minor injury (30%[8]), collisions causing serious injury (17%[9] to 38%[10]), collisions causing serious injury or death (46%[11] to 89%[12]) and those resulting in death (76%).[13]

Despite these overall results, some reduction in the beneficial effects expected – or even a comparative worsening of the situation – was reported in certain evaluations, particularly when:

- The roundabouts had multiple lanes (Fortuijn, 2009) and/or;
- Considering the effects of roundabouts on collisions between motor vehicles and particularly vulnerable categories of road users, such as cyclists (Brüde & Larsson, 2000, in De Brabander & Vereeck, 2007, p. 592) and pedestrians (Stone 2002, in De Brabander & Vereeck, 2007, p. 592).

How can these results be explained?

The overall effects of roundabouts on personal injury collisions are variously attributed, depending on the study consulted, to several mechanisms of action, including: a reduction in the speed of motorized vehicles (frequency and severity of collisions); a reduction in the number of conflict points (frequency of collisions – see Figure 3); the elimination of right-angle collisions (severity of collisions) and; the elimination of collisions involving left-turning vehicles (frequency and severity of collisions).

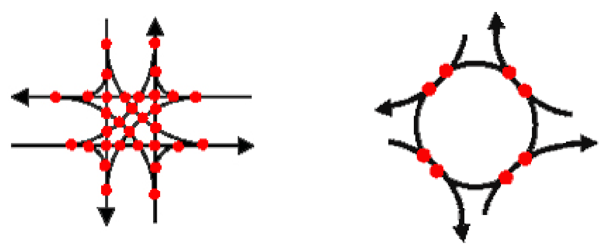

Figure 3 Reduced number of conflict points

The number of potential conflict points is reduced in roundabouts (diagram on right), as compared with signalized intersections (on left).

Source: Ministère des transports du Québec.

As regards the more mitigated results, that is, those concerning multi-lane roundabouts and sub-groups of public road users, it seems that these can be explained in large part by the design characteristics of roundabouts and the reasons justifying them. For example, roundabouts with two or more traffic lanes

5 In seeking studies addressing the subject of road safety, French-language evaluations were identified using Google Scholar and SantéCom ("carrefour" AND "giratoire") and using 360, the search engine for the INSPQ's scientific articles. English-language evaluations were located using the TRID database ("roundabout" AND "safety" and not "mini" and not "cost"). We invite readers to send us any overlooked references so that we may take them into consideration. It should be noted that we did not retain studies published prior to 2000 nor, for reasons relating to validity and reliability explained in our review of the literature on traffic calming, did we consider before-after studies that do not control for regression to the mean.

6 De Brabander, Nuyts & Vereeck, 2005, p.293.

7 Persaud et al., 2001, p.7.

8 De Brabander et al., 2005, p.293.

9 De Brabander & Vereeck, 2007, p.596.

10 De Brabander et al., 2005, p.293.

11 Churchill, Stipdonk & Bijleveld, 2010, p.22 (95% CI 32%-57%).

12 Persaud et al., 2001, p.8.

13 Churchill et al., 2010, p.22 (95% CI 49%-89%).

within their circle (referred to as “multi-lane roundabouts” – the number of lanes being distinct from the number of entrance and exit points) installed at intersections where there are also multiple lanes converging have higher rates of personal injury collision than single-lane roundabouts.

Are there ways to improve results in cases where the effects are less favourable?

It seems likely that precautions taken during the design of roundabouts could improve the less favourable or outright undesirable results referred to above. As one possible way, among others, of improving road safety in multi-lane roundabouts, engineers have developed what are known as “turbo” roundabouts, an example of which can be found in Figure 4. By integrating physical barriers between the circular lanes, this design prevents motor vehicles from changing lanes inside the roundabout.[14]

According to a study carried out in the Netherlands, this type of roundabout reduced the number of personal injury collisions by 76% - a result similar in magnitude to that produced by single-lane roundabouts evaluated at the same time (Fortuijn, 2009, p. 23).

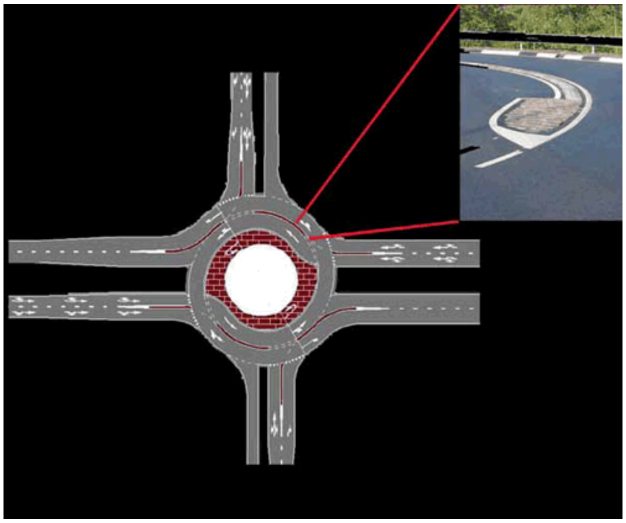

Figure 4 A “turbo” roundabout

The two lanes inside this roundabout are separated in places by road dividers, preventing cars from changing lanes. Thus, users who enter the roundabout from the left lane cannot exit the roundabout at the first exit, for example. The number of points of conflict is thus reduced.

Source: Fong, G. et al., 2003.

A video simulation of this type of installation: http://www.youtube.com/watch?v=iMYib3IR43I.

As regards injuries sustained by cyclists, the evaluations report results following the installation of single-lane roundabouts (-21%) that differ substantially from those following the installation of multi-lane roundabouts (+112%).[15] Moreover, it seems reasonable to assume that “continental” type roundabouts (i.e., roundabouts whose reduced dimensions force motor vehicles to slow down more) are safer for cyclists than larger roundabouts constructed primarily to increase traffic flow or fluidity.

There are at least four ways of managing bicycle traffic in roundabouts, including:

- Cyclists can be allowed to circulate on the public lanes, and be provided with no specific facilities.
- They can also be provided with any of three types of facilities:
  - a bike lane on the roadway;
  - a bike path off the roadway;[16] or,

[14] It is possible that snow conditions would not permit any channelling device apart from pavement markings.

[15] Brüde & Larsson, 2000, in De Brabander, 2007, p.592.

[16] For an example of this type of facility, see: http://www.youtube.com/watch?v=wEXD0guLQY0&feature=related

– a grade-separated bike path passing over or under the roadway (this option may be particularly appropriate for multi-lane roundabouts).[17]

Figure 5 A bike path outside the lanes of a roundabout

These are generally set back one or two car lengths from the entrances into the roundabout. Pedestrians use the same lane.

Source: commons.wikimedia.org. Photograph: Atelier Tinga.

Of these four options, the bike lane on the roadway seems to produce the least desirable results. For this option, in fact, one study recorded a 93% increase in the number of personal injury collisions, whereas each of the three other options resulted in a similar decrease of 17% when the results were pooled (Daniels, Brijs, Nuyts & Wets, 2009). In the Netherlands, one of the safest countries in the world for cyclists, these three other options are frequently employed.

Below are links to practical guides to the installation of cycling facilities. Although they do not all rest on the same standard criteria, and consequently propose guidelines that differ to some extent, they may be of interest nonetheless:

France (CERTU): http://www.circulationsdouces91.org/scans_PDF/CERTU-fiche10v-velogiratoire[1].pdf

New Zealand (particularly concerns multi-lane roundabouts, produced by Land Transport New Zealand): http://www.nzta.govt.nz/resources/research/reports/287/docs/287.pdf

United Kingdom (Nottinghamshire County Council): http://www.nottinghamshire.gov.uk/enjoying/countryside/cycling/cycling-strategy/

As regards pedestrians, it seems that the most recent standards of practice have corrected the situation relatively well. The new standard is to set pedestrian passages back from the entrances and exits to roundabouts (see Figures 2 and 5). In addition, the NCHRP in the United States has published a practical guide particularly concerned with visually-impaired pedestrians (Schroeder et al. 2011).

What is known about the effects of roundabouts on other health determinants?

Some evaluations have examined the effects of roundabouts on sound and air emissions.[18] According to Ahn and colleagues: "…the literature presents mixed results on the environmental impacts of roundabouts" (Ahn, Kronprasert, & Rakha, 2009, p. 55). In other words, it is not possible to observe as clear a trend as in the case of personal injury collisions and roundabouts. Some studies report an improvement in the situation, while others report little or no effect, and still others report a deterioration of the situation. As regards sound emissions, the evaluations report improvements of between 4.2 and 1.6 dB(A).[19] As regards air emissions, it was possible to observe increases of up to 4% (CO) and 6% (NOx)[20] and decreases of up to 42% (CO), 59% (CO2), 48% (NOx) and 65% (HC).[21]

These mixed results arise because the effects on particulate and sound emissions of motorized traffic on a given geographic and temporal scale depend on numerous factors, including speed, speed variations, traffic volumes and vehicle-km travelled, as well as the composition of motorized traffic (cars,

17 For an example of this type of facility, see: http://www.youtube.com/watch?v=tDN0anOVRRQ.

18 These documents were located by associating the terms "roundabouts," "noise," "air," "environment," and their equivalents in French, and searching the same databases on the same dates as those identified in note 5.

19 Hydén & Várhelyi, 2000, p. 21.

20 Várhelyi, 2002, pp. 68-70.

21 Mandavilli, Rys, & Russell, 2008, pp. 140-141.

trucks, etc.) circulating in the roundabouts, including on the entrance and exit lanes. Moreover, roundabouts, depending on the situations that prevailed before their installation and their specific design characteristics, are likely to influence these parameters in many ways.

Thus, for example, the study cited above (Várhelyi, 2002) examined a scheme involving the installation of 21 mini-roundabouts in a Swedish municipality.[22] The study established that one roundabout, which replaced a signalized intersection, decreased air emissions, whereas the other roundabouts, which replaced intersections with stop signs on roads with the lowest traffic volumes, where right of way had been regulated by yielding rules, led to an overall increase in emissions. This led the author to observe that the reduction produced by the first roundabout had, in a sense, compensated for the increase caused by the 20 others. To explain the results observed in the case of the roundabout that replaced traffic lights, the author pointed to: a reduction in (1) speeds, (2) speed variation within the roundabout's zone of influence, (3) the time needed to cross the intersection, and (4) the number of vehicles stopping at the intersection.

Are there other issues that public health actors should consider?

In the case just discussed, the author of the study noted that, overall, the roundabout scheme did not modify the volume of vehicles travelling through the intersections where the roundabouts were installed. This led the study's author to observe that with existing evaluations generally focusing on the effects of one or a few specific roundabouts, it is impossible to eliminate the possibility that they have "systemic effects" – that is, synergistic effects involving other intersections outside the more or less immediate vicinity of a roundabout or group of roundabouts. Thus, while such effects may not be documented or discussed in the evaluative literature, it would not be surprising to find that they are produced in cases where there is large-scale installation of roundabouts in urban settings, for example – especially if they are intended to increase road capacity and fluidity.

In fact, the large-scale adoption of this type of roundabout has the potential to significantly increase road capacity. Moreover, there is debate over what is generally referred to as the induction effect of road capacity expansion. While some maintain that increasing road capacity simply meets an existing demand for motorized travel without modifying it, others maintain that by improving the level of service of the road network, an increase in road capacity itself leads to an increase in the number and length of trips than would have been expected under the status quo. Since these debates concern the increase of road capacity in urban settings, any strategy involving the large-scale installation of roundabouts in this type of setting should probably be subject to this type of questioning. If such a strategy were to produce an induction effect, this could impede efforts to produce a modal shift, in particular away from the use of automobiles and toward active modes of transportation such as cycling and walking, one of the determinants of these being the danger caused by excessively high volumes of automobile traffic.

There is another issue to consider, although it has not been the subject of evaluation: pedestrian walkways. Although roundabouts can be designed to ensure adequate pedestrian safety, their configuration can oblige pedestrians to make a significant detour. On the other hand, pedestrians do not have to wait at traffic lights for what is often a rather long time. Since utilitarian pedestrian travel is sensitive to travel time, plans to install roundabouts in areas where there is a lot of this type of travel should be examined with an eye to such predictable effects.

How can public health actors promote roundabouts?

To become more familiar with current practices, one can begin by consulting a particularly relevant guide produced by the NCHRP in the United States (Rodegerdts et al., 2010). Also, in provinces and municipalities that rarely use these installations, public health actors can help introduce them into discussion at forums where issues related to road safety are discussed, such as consultations concerning provincial, regional and municipal transportation plans, or at specialized issue tables, such as the Table de sécurité routière, in Québec.

[22] The different types of roundabouts will be discussed in greater detail in another document.

In addition, when residents or representatives of municipalities describe some of the problems linked to through traffic on their main streets, public health actors can propose roundabouts as devices that can potentially reduce speeds within the context of an intervention aimed at adapting through roads/main streets to their contexts.

What type of opposition can roundabouts elicit?

Without claiming to cover the issue exhaustively, one can divide forms of opposition into two categories: those tied to inertia and those tied to opposing interests.

Inertia can take many forms. It is easier to follow existing practices in engineering (or in any field) than to do things in a new way. Innovation requires the will to change and additional resources (expertise, capital), at least temporarily. Moreover, some public road users are opposed to roundabouts because they are nervous about learning how to use them.

Modifying an intersection to incorporate a roundabout requires additional space and can affect nearby usage (residences, businesses). Residents or business owners along the road may be opposed to roundabouts because of their interest in preserving current usages and spaces. Some road users (cyclists, the visually impaired) may also be opposed to roundabouts, and these reactions can be expected, especially if roundabouts are designed primarily to improve the traffic capacity-fluidity of intersections and the issue of road safety is, in a sense, secondary.

What is the status of roundabouts in Canada?

It seems that, in Canada, roundabouts are as often built primarily to improve road safety as to improve capacity-fluidity. Although there are clearly more of them in British Columbia and Québec, roundabouts can be found in all the provinces on provincial or municipal road networks (Bahar et al., 2009). The following provinces even have web pages devoted to these devices: Alberta;[23] British Columbia;[24] Prince Edward Island;[25] Nova Scotia;[26] Ontario;[27] and Québec.[28] Moreover, at least two provinces and one regional authority have developed policies that favour the use of roundabouts during the development of road networks under their responsibility. In British Columbia[29] and in Québec, it seems to have become common to view roundabouts as the default option for new intersections on the provincial road network (Bahar et al., 2009, p. iv). On the regional level, authorities in Waterloo, Ontario have, for their part, developed guidelines requiring that roundabouts be considered when development of the arterial network necessitates the creation of new intersections.

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25 See: http://www.gov.pe.ca/tir/index.php3?number=1032950&lang=F.
26 See: http://www.gov.ns.ca/tran/hottopics/roundabout/TPWRoundabout.pdf.
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