

Urban Traffic Calming and Air Quality: Effects and Implications for Practice

May 2012

This summary is the second in a series of five¹ short documents based on a literature review published in 2011.² In what follows, we first present the mechanisms of action underlying traffic-calming strategies,³ as these mechanisms help to explain and predict the effects of calming interventions on air pollution produced by traffic. Next, we summarize the results of studies having evaluated two approaches to traffic calming⁴ (please refer to the brief descriptions of black-spots and area-wide approaches below). Lastly, we consider the implications of such results for public health actors.

Two approaches to traffic calming

The black-spots approach is typically aimed at improving road safety. It encompasses strategies advocating the installation of calming measures (speed humps, roundabouts, etc.) at one or more specific locations considered to be at high risk for collision.

The area-wide approach, while it also often includes road-safety objectives, aims more generally to improve the living environment. It encompasses intervention strategies whose scope of application is a network comprising more than one street.

Mechanisms of action underlying traffic-calming strategies

Three mechanisms of action help to explain and predict the effects of traffic-calming strategies on ambient air quality and on quantities of the main air pollutants (carbon monoxide [CO], carbon dioxide [CO₂], nitrogen oxides [NO_x], volatile organic compounds [VOCs], and particulate matter [PM]) emitted by motorized vehicles.⁵

Reduction of vehicle speeds

As illustrated in Figure 1, reducing vehicle speeds to less than 50 km/h produces an increase in emissions of the main air pollutants per kilometre travelled (World Health Organization [WHO] Regional Office for Europe, 2005).

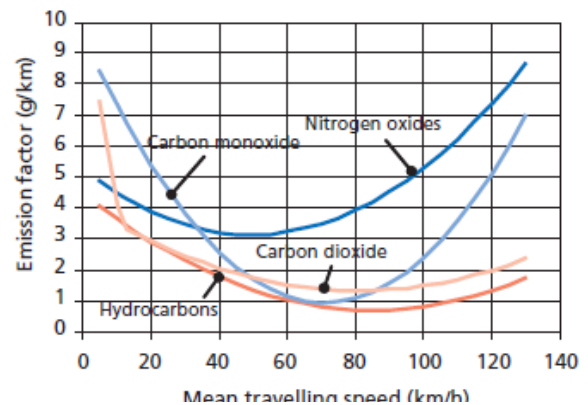


Figure 1 Effect of mean travelling speed on emission levels from passenger cars with catalysts

Note: Values for nitrogen oxides (NO_x) and hydrocarbons (HC) have been multiplied by 10 and those for carbon dioxide (CO₂) have been divided by 100.

Sources: adapted from Ntziachristos & Samaras, 2000, in WHO Regional Office for Europe, 2005, p. 25. Copyright 2000, reprinted with permission from Elsevier.

⁵ It is important to distinguish between the emission of air pollutants by vehicles and ambient air quality, because a variation in emissions does not necessarily produce a linear variation in air quality. In reality, the relationship between the two is mediated by, for example, ambient temperature, prevailing winds, the presence of other reactive molecules, etc.

¹ The four other documents focus on road safety, environmental noise, active transportation and inequalities.

² To consult the comprehensive version of the literature review, please see our document entitled *Urban Traffic Calming and Health: A Literature Review* at: http://www.ncchpp.ca/175/publications.ccnpps?id_article=686.

³ Our definition of "traffic calming" is presented in the introduction to our literature review, and its historical origins are detailed in our document entitled *Traffic Calming: An Equivocal Concept* available at: http://www.ncchpp.ca/175/publications.ccnpps?id_article=648.

⁴ For a detailed description of the two approaches and the political contexts surrounding them, please see our document entitled *Traffic calming: Political Dimensions* at: http://www.ncchpp.ca/175/Publications.ccnpps?id_article=670.



Consequently, slowing vehicles down (typically from 50 km/h to about 30 km/h) at one spot on the street network or throughout an area should produce an increase in vehicle emissions (Transportation Research Board, 1995).

Reduction of speed variations

Speed variations affect fuel consumption as well as degree of combustion. Thus, a combustion engine consumes more fuel when it is turning slowly or accelerating than when it is turning at a constant speed (Environmental Protection Agency [EPA] & U.S. Department of Energy [DOE], 2010; Bahar, Smahel, & Smiley, 2009). Moreover, combustion is less complete when such an engine is turning slowly or accelerating (Houwing, 2003; Sergerie et al., 2005). These two factors explain why an increase in the number of accelerations, decelerations and time spent idling increases the amount of pollutants emitted for a given distance travelled (Owen, 2005; EPA & DOE, 2010; Houwing, 2003).

It is thus reasonable to expect that calming schemes which reduce speed variations help decrease emissions, whereas, inversely, those which increase speed variations lead to an increase in emissions.

Reduction of traffic volume

Air pollutant emissions from motor vehicles vary in accordance with traffic volume. Typically, the expression “traffic volume” refers to the number of trips made or the distance travelled in motor vehicles. Given the reduced effectiveness of catalytic converters during the first few minutes of driving and the emissions caused by initial acceleration, the number of trips taken tends to have a greater effect on total emissions than an increase or decrease in distances travelled (WHO Regional Office for Europe, 2005).

The reduction of traffic volume is typically an objective of strategies based on the area-wide approach and not an objective of those based on the black-spots approach. Consequently, area-wide strategies that help reduce traffic volumes by increasing walking, for example, should lead to a decrease in pollutant emissions, whereas those that reduce volume in an area by diverting traffic to another area are likely to simply shift emissions elsewhere.

Results of evaluative studies

Study results are categorized according to the two approaches described to highlight their respective effects.

EFFECTS OF THE BLACK-SPOTS APPROACH

Increase in per-vehicle emissions

The studies consulted report that the majority of discrete interventions produce an increase in vehicle emissions at the intervention sites (Boulter & Webster, 1997; Boulter et al., 2001; Daham et al., 2005; Ahn & Rakha, 2009). Nevertheless, it remains the case that interventions which reduce speeds and speed variations, such as mini-roundabouts replacing stop signs at intersections, can decrease vehicle emissions (Ahn & Rakha, 2009).

Slight deterioration of air quality

The only study having evaluated air quality on calmed streets reports a slight deterioration in air quality following interventions, but traffic volumes had increased on most of the streets studied (Boulter et al., 2001). The study in question does not explain these increases.

Favourable perception

One article reports that the residents of a calmed street were less unhappy about vehicle emissions after the introduction of calming measures (Morrison, Thomson & Petticrew, 2004).

EFFECTS OF THE AREA-WIDE APPROACH

Variable effects on per-vehicle emissions

The studies consulted do not converge and report both increases and decreases as well as the absence of change with respect to per-vehicle emissions of the various pollutants following the implementation of area-wide schemes (Boulter & Webster, 1997; Cloke et al., 1999; Owen, 2005; Várhelyi, 2002).

Importance of traffic volume

The two studies that take into account increases and decreases in traffic volume in the calmed areas report reductions for emissions of all pollutants in the areas where traffic volumes decreased, with the exception of one area where there was a very slight increase (+3%) of benzene emissions despite a

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reduction in traffic volume (Cloke et al., 1999; Owen, 2005). Only one of the seven areas studied saw an increase in traffic volume (+8%) and in pollutant emissions (+8% NO_x and +22% benzene) following the interventions (Cloke et al., 1999). The study in question does not explain this increase in traffic volume.

No significant effect on air quality

Regardless of the variation in emissions in the calmed areas, neither of the two studies having measured the effect of calming schemes on air quality report significant changes (Cloke et al., 1999; Owen, 2005).

Variable perception

Two reports indicate that a majority of residents had not observed any change in air quality following the interventions (Cloke et al., 1999; Hemsing & Forbes, 2000). Regarding those who perceived a change, one report indicates that more people perceived an improvement in air quality than a deterioration (Hemsing & Forbes, 2000), but the other report indicates the opposite (Cloke et al., 1999).

Implications for practice

It is important to first underline the fact that traffic calming is mainly promoted as a way of reducing collisions, injuries and deaths, and not of improving air quality. While many studies demonstrate the effectiveness of traffic calming for improving road safety, studies are less conclusive concerning the effects of calming on air pollutant emissions and ambient air quality. It should be noted, however, that none of the studies reviewed measured a significant variation in air quality following traffic calming interventions, even though these studies demonstrate that such interventions can positively or negatively influence the quantity of air pollutants emitted by motor vehicles.

This said, the results of the evaluative studies indicate that **the black-spots approach** often leads to an increase in per-vehicle emissions of the main pollutants. These results are linked to reduced traffic speeds and to an increase in speed variations caused by most discrete interventions. Nevertheless, it remains true that interventions which reduce speeds and speed variations can also reduce vehicle emissions. This, for example, is what can be expected when stop signs at intersections are

replaced by mini-roundabouts (Ahn & Rakha, 2009). This particular isolated intervention thus shows promise, given certain conditions.

Replacing stop signs with **mini-roundabouts** can reduce per-vehicle pollutant emissions.



Figure 2 A mini-roundabout

Source: www.pedbikeimages.org. Photographer: Dan Burden.

With regard to studies examining the **area-wide approach**, these highlight the advantage of reducing traffic volume as well as speed variations. In fact, despite the variable effects of area-wide strategies on per-vehicle emissions of most pollutants, these strategies offer the advantage of having the potential to reduce emissions of all pollutants in a given area by reducing its traffic volume. It seems reasonable to assume that the extent to which an area-wide strategy encourages driving at low, constant speeds is the extent to which it will or could easily improve air quality. To sum up, it is possible to conclude that the optimal area-wide strategy, as regards air quality, is one which reduces traffic volume, while encouraging low, constant speeds, or which is implemented in conjunction with interventions that do so.

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As Figure 3 illustrates, the impact of calming strategies on air-pollutant emissions depends on the effects of the strategies on two main factors: the average quantity of pollutants emitted per kilometre travelled and the number of kilometres travelled (traffic volume).⁶

For public health actors who consider it relevant to promote the area-wide approach, the manner in which it allows these two factors to be addressed indicates that it carries greater potential, for urban environments, than the black-spots approach. In fact:

1. Because it involves implementing interventions on an entire section of a street network and not only at specific points on the network, the area-wide approach is better adapted than the black-spots approach to **encouraging low, constant speeds**, and thus minimizing emissions resulting from speed variations;
2. Because it often aims to **reduce traffic volume** in areas targeted for intervention, the area-wide approach employs an important mechanism of action that is not generally employed by the black-spots approach: This mechanism makes it possible to reduce emissions of all pollutants.

This said, it is important to distinguish between **two ways of reducing the volume of traffic** in a given area, because they have potentially varying effects on health and its determinants:

- The first is predicated on **modal shift**, that is, it aims to reduce the number of trips made by automobile, in particular, by increasing active

(cycling, walking, etc.) and collective (subway, tramway, etc.) transportation. In addition to having beneficial effects on other health determinants (physical activity, injuries, noise levels, etc.), reducing the number of trips made in motor vehicles is the most effective manner in which to reduce the quantity of pollutants generated by road transportation.

- The second way consists of **redirecting some of the traffic** using local residential streets toward the main road network (arteries, highways). This approach, often at the heart of area-wide calming strategies, is sometimes promoted as a way to encourage a modal shift toward cycling or walking, for example. Nevertheless, in certain contexts, this approach carries the risk of increasing **health inequalities** by simply shifting pollutant emissions to arteries and highways. In reality, persons with less favourable socioeconomic circumstances tend to be overrepresented as residents close to these roads (Smargiassi, Berrada, Fortier, & Kosatsky, 2006). Thus, when a calming strategy is designed to divert some portion of traffic, it is important to examine the potential effects of this traffic on the roads toward which it is redirected (risk of congestion, traffic volume, air quality, etc.) and on their residents (presence or absence of residents, health status, socioeconomic status, etc.). In some cases, this examination may make it necessary to seek ways to offset these effects (redirection toward arteries located far from any residents, demand management initiatives⁷ focused on the affected sections of arterial and highway networks or on the network as a whole, etc.).

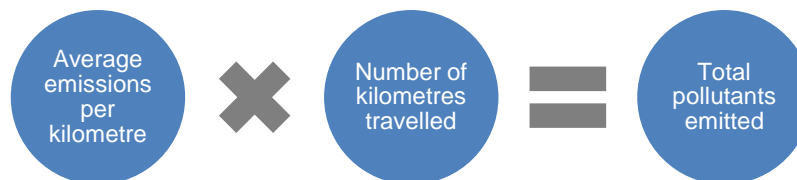


Figure 3 Main factors influencing the quantity of air pollutants emitted

⁶ It is important to note that this diagram does not directly take into account the number of trips made in motor vehicles, which can affect per-kilometre emission averages, especially when a large number of short trips is included.

⁷ Demand management refers to strategies aimed at increasing people's mobility by increasing road capacity by less than anticipated demand, by preserving existing capacity, or even by reducing it. In concrete terms, this often consists of diversifying travel options (subway, tramway, carpooling, cycling, walking, etc.) to reduce car travel.

Channelling traffic on residential streets toward transit roads may reduce emissions on residential streets, but increase them on transit roads. In certain cases, this type of intervention can contribute to an increase in **health inequalities**, because the residents close to these roads tend to have less favourable socioeconomic characteristics than those along adjacent residential streets. Therefore, it is necessary to search for ways to mitigate these effects – for example, by redirecting traffic toward transit roads far from any residents or by integrating efforts to manage traffic demand on these roads.

In addition, traffic calming often results in the recovery of space formerly devoted to automobile traffic, which provides opportunities for greening. Taking advantage of these opportunities can produce beneficial effects including, in particular, improvement of air quality, mitigation of heat islands and reduction of greenhouse gases in cities.

Even though the effects of calming strategies on air quality are not always positive, the decision to promote such a strategy should be based on a **global perspective** that also takes into consideration its effects on other health determinants. The literature review we carried out demonstrates that, in general, the interventions evaluated: (1) substantially reduced the number and severity of collisions; (2) reduced environmental noise levels, except for certain strategies which affected heavy vehicles and; (3) were, in some cases, accompanied by an increase in active travel, although it was not possible to determine why this increase was not observed in other cases (Bellefleur & Gagnon, 2011). In urban environments, the mechanisms of action point toward the conclusion that better results can be expected from strategies based on the area-wide approach. However, excepting the effects on air pollutant emissions, the evaluative studies are inconclusive in this regard.

Bibliography

- Ahn, K. & Rakha, H. (2009). A field evaluation case study of the environmental and energy impacts of traffic calming. Transportation Research Part D: Transport and Environment, 14, 411-424. doi: 10.1016/j.trd.2009.01.007.
- Bahar, G., Smahel, T., & Smiley, A. (2009). *Study of the environmental, economic, safety & social benefits of roundabouts for Transport Canada*. Human Factors North Inc. and Navigats Inc.
- Bellefleur, O. & Gagnon, F. (2011). *Urban Traffic Calming and Health: A Literature Review*. Montréal: National Collaborating Centre for Healthy Public Policy. Retrieved from: http://www.ncchpp.ca/175/publications.ccnpps?id_article=686.
- Boulter, P. G., Hickman, A. J., Latham, S., Layfield, R., Davidson, P., & Whiteman, P. (2001). *The impacts of traffic calming measures on vehicle exhaust emissions* (Report No. TRL 482). Crowthorne, Berkshire: Transport Research Laboratory.
- Boulter, P. G. & Webster, D. C. (1997). *Traffic calming and vehicle emissions: A literature review* (Report No. TRL 307). Crowthorne, Berkshire: Transport Research Laboratory.
- Cloke, J., Webster, D., Boulter, P., Harris, G., Stait, R., Abbott, P. & Chinn, L. (1999). *Traffic Calming: Environmental assessment of the Leigh Park Area Safety Scheme in Havant* (Report No. TRL 397). Crowthorne, Berkshire: Transport Research Laboratory.
- Daham, B., Andrews, G. E., Li, H., Partridge, M., Bell, M. C., & Tate, J. (2005). *Quantifying the Effects of Traffic Calming on Emissions Using On-road Measurements* (Report No. 2005-01-1620). Warrendale, U.S.: SAE International. Retrieved from: http://eprints.whiterose.ac.uk/2050/1/2005-01-1620SOrion_peedbump.pdf.
- Environmental Protection Agency & U.S. Department of Energy. (2010). *Fuel Economy Guide*. U.S. Environmental Protection Agency and U.S. Department of Energy. Retrieved from: <http://www.fueleconomy.gov/feg/pdfs/guides/FEG2010.pdf>.
- Hemsing, S. & Forbes, G. (2000). *Ottawa-Carleton Traffic Calming Evaluation Study* (Report No. 99041). Synectics.

- Houwing, S. (2003). Traffic calming: engineering measures. In Ingrid van Schagen (Ed.), *Traffic calming schemes: Opportunities and implementation strategies* (pp. 27-34). The Netherlands: Swov Institute for Road Safety Research. Retrieved from: <http://www.swov.nl/rapport/R-2003-22.pdf>.
- Hyden, C. & Várhelyi, A. (2000). The effects on safety, time consumption and environment of large scale use of roundabouts in an urban area: a case study. *Accident Analysis & Prevention*, 32, 11-23.
- Morrison, D. S., Thomson, H., & Petticrew, M. (2004). Evaluation of the health effects of a neighbourhood traffic calming scheme. *Journal of Epidemiology and Community Health*, 58, 837-840. doi: 10.1136/jech.2003.017509.
- Ntziachristos, L. & Samaras, Z. (2000). Speed-dependent representative emission factors for catalyst passenger cars and influencing parameters. *Atmospheric Environment*, 34(27), 4611-4619. doi: 10.1016/S1352-2310(00)00180-1.
- Owen, B. (2005). Air quality impacts of speed-restriction zones for road traffic. *Science of The Total Environment*, 340, 13-22. doi: 10.1016/j.scitotenv.2004.08.011.
- Sergerie, D., King, N., Drouin, L., Fortier, I., Smargiassi, A., & Maurice, P. (2005). Road Speed: Health Impact and Counteractive Measures. *Scientific Review*. Institut national de santé publique du Québec. Retrieved from: http://www.inspq.qc.ca/pdf/publications/847_road_speed.pdf.
- Smargiassi, A., Berrada, K., Fortier, I., & Kosatsky, T. (2006). Traffic intensity, dwelling value, and hospital admissions for respiratory disease among the elderly in Montreal (Canada): a case-control analysis. *Journal of Epidemiology and Community Health*, 60(6), 507-512. doi: 10.1136/jech.2005.037044.
- Transportation Research Board. (1995). *Expanding Metropolitan Highways: Implications for Air Quality and Energy Use* (Special report No. 245). Washington, D.C.: National Academy Press. Retrieved from: http://www.nap.edu/openbook.php?record_id=9676.
- World Health Organization Regional Office for Europe. (2005). *Health effects of transport-related air pollution*. Copenhagen. Retrieved from: http://www.euro.who.int/_data/assets/pdf_file/0006/74715/E86650.pdf.

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