Appendix 1 Evidence Tables

Question 2: Are interventions to develop public transport routes and services effective at reducing the health impact of, or people’s exposure to, traffic-related air pollution? Modelling studies

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr>
<td>Full citation
Alam, Ahsan, Diab, Ehab, El-Geneidy, Ahmed M., Hatzopoulou, Marianne, A Simulation of Transit Bus Emissions along an Urban Corridor: Evaluating Changes under Various Service Improvement Strategies, Transportation Research: Part D: Transport and Environment, 31, 189-98, 2014

Quality score
-

Aim of the study
To investigate the individual and combined effects of a range of transit service improvement on emissions along a busy transit corridor.

Source of data
Data was collected over a 2 week period in October 2013.</td>
<td>Number of participants
n/a

Participant description
A busy transit corridor which runs north-south over a 5.8 mile length in the east side of Montreal. The majority of the corridor consists of 3 lanes in each direction. Two types of bus service run concurrently along the corridor: a regular route and an express route. The regular route has an average stop spacing of 241 m and 255 m in the southbound (SB) and northbound (NB) directions respectively, whereas the stop spacing for the express route is 611 m and 623 m in the SB and NB directions, respectively.

A sub-segment of the corridor, including 28 signalised intersections equipped with Transit Signal Priority (TSP) system, was the subject of the analysis.

Inclusion criteria
n/a</td>
<td>Intervention / Comparison
The study assessed the impact of bus service improvements on $PM_{2.5}$ bus emissions.

The improvements assessed were:
• A smart card fare collection system
• An express bus service (limited stops)
• Reserved bus lanes (operated during peak periods)

Emissions were estimated at a segment level (including running and idling) and stop level (only idling).</td>
<td>Type of model
Emissions generated during bus operations were estimated using MOVES2010a, developed by the United States Environmental Protection Agency (USEPA).

To capture the effects of various service improvement strategies and bus attributes on emissions, a linear regression is estimated.</td>
<td>Outcomes

Linear regression results for $PM_{2.5}$ emissions (mg/bus mile)
<table>
<tr><th></th><th>Coefficient</th><th>Std. error</th><th><i>t</i></th></tr>
<tr><td>Constant</td><td>28.19***</td><td>1.049</td><td>26.871</td></tr>
<tr><td>Express bus route</td><td>-4.27***</td><td>0.444</td><td>-9.626</td></tr>
<tr><td>Reserved lane</td><td>-4.44***</td><td>0.440</td><td>-10.084</td></tr>
<tr><td>PM peak</td><td>4.04***</td><td>0.428</td><td>9.444</td></tr>
<tr><td>Southbound</td><td>1.25***</td><td>0.446</td><td>2.809</td></tr>
</table>
$R^2 = 0.755$; N = 132 segments
***Significant at 99%
*Significant at 90%

Analysis
The largest positive impact on $PM_{2.5}$ emissions is associated with the introduction of reserved bus lanes that can reduce $PM_{2.5}$ emissions by 4.44mg/mile of bus travel. The express bus service had the second largest impact, reducing $PM_{2.5}$ emissions by 4.27mg/mile.

Time of day and direction of travel were also observed to significantly affect bus emissions. If the bus runs southbound, total emissions were 1.25mg /mile less than the northbound trips. Emissions from trips made during the PM peak period were also 4.04mg/mile higher than the AM peak period.</td>
<td>Limitations identified by the author
None reported

Limitations identified by the review team
The time horizon is insufficient to assess the longer term impact on emissions. No uncertainties in the model design or results described. Strengths and limitations were not discussed.</td>
</tr>
</table>

Study details	Population	Intervention / Comparator	Method of analysis	Model results	Notes
- Collection of bus speed profile: instantaneous bus speed were collected using GPS devices. Two separate devices were used for quality control. - Collection of bus-stop based data: data were collected by research assistants riding the buses. Data was collected on the number of individuals boarding and alighting, idling time at each stop, fare payment type, and crowding near the door. The allocation of research assistants and GPS devices to trips/buses were randomised. Following a data cleaning process, a total of 132 segment level and 1556 stop level observations remained for analysis.	**Exclusion criteria** n/a				

Study details	**Population**	**Intervention / Comparator**	**Method of analysis**	**Model results**	**Notes**
The model required the following additional inputs: • Link length for each segment • Fuel type and formulation – all current buses are articulated and run on ultra low sulfur diesel (ULSD) • Vehicle type • Vehicle model year • Meteorology including temperature and relative humidity **Location and setting** Montreal, Canada **Length of study** Not reported **Source of funding** The research was supported by federal funding through the Natural Sciences and Engineering Research Council of Canada (NSERC).					
Full citation Alam, Ahsan, Hatzopoulou, Marianne, Reducing transit bus emissions: Alternative fuels or	**Number of participants** n/a **Participant description** The study corridor runs	**Intervention / Comparison** $PM_{2.5}$ emissions for two different fuels - Ultra Low Sulfur Diesel (ULSD - currently used)	**Type of model** Microsimulation of bus transit flow along the CDN corridor was conducted for the morning peak period (7-9 AM) using the	**Outcomes** **Running emissions under base-case operations (not including idling at bus stops) for different fuels (g/mile bus)**	**Limitations identified by the author** None reported **Limitations identified by the review team** Insufficient time

	SB			**NB**		
	Diesel	**CNG**	**Reduction**	**Diesel**	**CNG**	**Reduction**

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr>
<td>traffic operations?, Atmospheric Environment, 89, 129-139, 2014

Quality score
-

Aim of the study
To explore the effect of alternative fuel technologies and transit improvement scenarios on bus emissions.

Source of data
Local input data describing the vehicle fleet and ambient conditions:
Traffic volumes were collected at three instances over three weeks during the spring 2011.
Turning movements at each intersection were observed for 10 min and the proportion of directional traffic was calculated.
Road geometry information such as number of lanes,</td>
<td>North-South with respect to the downtown(located south of the corridor). The length of the corridor is about 5.1km with various grades ranging from -17%to +8%. The corridor has a high frequency of buses (4-5 min) during peak periods compared to other routes and it has one of the highest transit ridership in Montreal. It has significant differences in traffic flow between the northbound (NB) and southbound (SB) directions as well as between morning and afternoon peak periods. Along the route there are 31 bus stops in the NB direction and 35 stops in the SB direction.

Inclusion criteria

Exclusion criteria</td>
<td>and compressed natural gas (CNG) - were modelled for buses operating along a busy transit corridor in both the northbound (NB) and southbound (SB) directions.
In addition, emissions were simulated under 5 different operational scenarios. In each scenario, the emissions for ULSD and for CNG were compared in order to identify the additional impact of an alternative technology under various bus operations.

The operational scenarios were:
Transit signal priority (TSP) - use of technology to reduce dwell time at bus stops and intersections
Relocation of bus-stops without TSP - relocation of bus stops away from intersection to mid-block to reduce exposure of passengers to air pollutant concentrations.
Relocation of bus-stop with TSP - Near-side bus stops were relocated to mid-block and TSP was applied at each signalised</td>
<td>PTV VISSIM platform. Emissions generated during bus operations were estimated using MOVES, a USEPA emission modeling tool. In order to simulate emissions, MOVES requires instantaneous speeds for each segment along the route.Therefore the speed profiles of all buses running in the morning peak period were allocated to individual segments corresponding to the individual links in the traffic simulation. In addition, the model required the following inputs: bus age distribution, fuel formulation and meteorological data.</td>
<td>
<table>
<tr><td></td><td></td><td></td><td>(%)</td><td></td><td></td><td>(%)</td></tr>
<tr><td>PM2.5</td><td>0.04631</td><td>0.00704</td><td>84.79</td><td>0.03562</td><td>0.00403</td><td>88.68</td></tr>
</table>
Dwell emissions (during boarding/alighting of passengers) at bus stops under base-case operations for different fuels (g/mile bus)
<table>
<tr><td></td><td colspan="3">SB</td><td colspan="3">NB</td></tr>
<tr><td></td><td>Diesel</td><td>CNG</td><td>Reduction (%)</td><td>Diesel</td><td>CNG</td><td>Reduction (%)</td></tr>
<tr><td>PM2.5</td><td>0.03544</td><td>0.00486</td><td>86.28</td><td>0.01379</td><td>0.00189</td><td>86.28</td></tr>
</table>
Comparison of PM2.5 emissions (g/mile bus) under different operational scenarios and fuels
<table>
<tr><td>Scenario</td><td colspan="2">PM2.5 (g/mile bus) for diesel</td><td colspan="2">PM2.5 (g/mile bus) for CNG</td></tr>
<tr><td></td><td>SB</td><td>NB</td><td>SB</td><td>NB</td></tr>
<tr><td>Base-case</td><td>0.046311</td><td>0.035621</td><td>0.007042 (-84.79%)</td><td>0.004032 (-88.68%)</td></tr>
<tr><td>1</td><td>0.039047 (-16%)[1]</td><td>0.032501 (-8.76%)</td><td>0.003521 (-92.40%)</td><td>0.003521 (-90.12%)</td></tr>
<tr><td>2</td><td>0.041733 (-9.89%)</td><td>0.035621 (0.00%)</td><td>0.003521 (-92.40%)</td><td>0.004032 (-88.68%)</td></tr>
<tr><td>3</td><td>0.038784 (-16.25%)</td><td>0.035361 (-0.73%)</td><td>0.003521 (-92.40%)</td><td>0.004032 (-88.68%)</td></tr>
<tr><td>4</td><td>0.038177 (-17.56%)</td><td>0.035124 (-1.40%)</td><td>0.003484 (-92.48%)</td><td>0.004 (-88.77%)</td></tr>
<tr><td>5</td><td>0.03781 (-18.36%)</td><td>0.034887 (-2.06%</td><td>0.003384 (-92.69%)</td><td>0.004001 (-88.77%)</td></tr>
</table>
[1] Percentage reduction compared to base case

Analysis
The results for running and dwell emissions show that $PM_{2.5}$ emissions are higher in the SB approach than the NB approach. The results also demonstrate the reduction in $PM_{2.5}$ achieved when switching from ULSD to CNG.

The results of the operational scenario simulations demonstrate that there is a greater reduction benefit for CNG compared to operational changes. The authors suggest that this is because CNG emits very little particulates compared to diesel and therefore the switch to CNG will</td>
<td>horizon to allow for the assessment of longer term impacts. It was unclear if the model was based on the best available evidence. There was no discussion regarding the strengths and limitations of the model and the results.</td>
</tr>
</table>

Study details	Population	Intervention / Comparator	Method of analysis	Model results	Notes
slope, and parking lots were collected from various sources in order to best represent the road configuration of the CDN corridor. - The bus schedule for the morning peak period and passenger information at each stop (boarding and alighting) were obtained from the local transit operator. This information was validated by onboard GPS data collection in the morning peak period (conducted over one week in the Spring 2011). **Location and setting** Montreal, Canada **Length of study** **Source of funding** Not reported		intersection. 4. Queue jumper lane without TSP - Queue jumper lanes were introduced at each intersection without relocating bus-stops. 5. Queue jumper lane, relocation of bus-stop and TSP strategy - This scenario combines all the previous improvements under one scenario: Near-side bus stops are moved to mid-block and queue jumper lanes are introduced with TSP. A transit specific signal-phase is installed on the jumper lane so that at the start of the green phase, the transit vehicle can move before other vehicles. Jumper lanes are also given priority over general traffic so that the bus can easily enter general traffic flow.		induce reductions in particulate emissions that are higher than reductions obtained by any operational scenarios.	

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr>
<td>Full citation
Stamos, Iraklis, Kitis, George, Basbas, Socrates, THE IMPLEMENTATION OF A CONTRA FLOW BUS LANE IN THE CITY OF THESSALONIKI: ENERGY AND ENVIRONMENTAL IMPACTS, Fresenius Environmental Bulletin, 22, 2191-2196, 2013

Quality score
-

Aim of the study
To assess the impact of a contra flow bus lane in the city centre of Thessaloniki

Source of data
Data used for the development of the model derive from Thessaloniki's General Transportation Study

Location and setting
Central business district in Thessaloniki, Greece

Length of study
n/a</td>
<td>Number of participants
n/a

Participant description
n/a

Inclusion criteria
n/a

Exclusion criteria
n/a</td>
<td>Intervention / Comparison
Partial replacement of a mixed-flow traffic lane on a 4-lane, one direction, high traffic volume road, with a 0.9km contra flow bus lane. Environmental impacts were calculated before and after the implementation of the proposed bus lane.</td>
<td>Type of model
The SATURN (Simulation and Assignment of Traffic to Urban Road Networks) traffic simulation model was used.</td>
<td>Outcomes

Environmental indicators before and after the implementation of the contra flow bus lane - results for where the contra flow bus lane was planned and examined
<table>
<tr><th>Indicator</th><th>Before</th><th>After</th><th>Difference %</th></tr>
<tr><td>NO_x emissions (kg)</td><td>27</td><td>27</td><td>-</td></tr>
<tr><td>Fuel consumption (l/hr)</td><td>1.998</td><td>2.143</td><td>7.2%</td></tr>
</table>
Environmental indicators before and after the implementation of the contra flow bus lane - results for the buffer zone (adjacent streets) of the contra flow bus lane
<table>
<tr><th>Indicator</th><th>Before</th><th>After</th><th>Difference %</th></tr>
<tr><td>NO_x emissions (kg)</td><td>95</td><td>93</td><td>-2.1%</td></tr>
<tr><td>Fuel consumption (l/hr)</td><td>8092</td><td>8169</td><td>0.9%</td></tr>
</table>

Analysis
In the area where the intervention was implemented, there is no change in NO_x emissions. However, total fuel consumption in the proposed contra flow bus lane increases by 7.2%.

Within the buffer zone of the scheme (adjacent streets plus on major arterial road north of the proposed lane), the was a reduction of 2.1% in NO_x emissions, and an increase in overall fuel consumption of 0.9%.</td>
<td>Limitations identified by the author
Not reported

Limitations identified by the review team
Insufficient time horizon to allow for the assessment of longer term impacts.
Insufficient details of the modelling used.</td>
</tr>
</table>

Study details	Population	Intervention / Comparator	Method of analysis	Model results	Notes
Source of funding Not reported					

Question 3: Are interventions to develop routes and infrastructure to support low emission modes of transport effective at reducing the health impact of, or people’s exposure to, traffic-related air pollution?

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Full citation
Bean, T., Carslaw, N., Ashmore, M., Gillah, A., Parkinson, C., How does exposure to nitrogen dioxide compare between on-road and off-road cycle routes?, Journal of Environmental Monitoring, 13, 1039-1045, 2011

Quality score
-

Study type
Comparative study

Aim of the study
To compare exposure of NO_2 to cyclists when using on-road or off-road cycle routes.

Location and setting
UK

Length of study
2 months

Source of funding
Not reported</td>
<td>Number of participants
Not reported

Participant characteristics
Route 1
On-road: 7km including busy roads into and around the city centre
Off-road: 7.8km including off-road cycle paths and less trafficked roads
Route 2
On-road: 3.5km including roads in the city centre
Off-road: 4.5km including designated off-road cycle paths
Route 3
On-road: 8.6km including busy road or travelling adjacent to roads where the speed limit is ≥60mph
Off-road: 8.7km including predominantly designated off-road cycle paths

Inclusion criteria
N/A

Exclusion criteria
N/A</td>
<td>Intervention / Comparison
Three journeys, representative of typical commuter routes, cycled on a daily basis were selected for monitoring. For each journey, an 'on-road' and 'off-road' version of the routes were used, giving six in total. Measurement of NO_2 concentrations were made in August and September 2008.</td>
<td>Outcomes

Average calculated time-weighted concentration of NO_2 (ppb) for each route.
<table>
<tr><th></th><th colspan="3">August</th><th colspan="3">September</th></tr>
<tr><th>Route</th><th>On-road</th><th>Off-road</th><th>% Decrease</th><th>On-road</th><th>Off-road</th><th>% Decrease</th></tr>
<tr><td>1</td><td>13.9</td><td>8.7</td><td>37</td><td>15.9</td><td>9.6</td><td>40</td></tr>
<tr><td>2</td><td>15.9</td><td>9.6</td><td>40</td><td>17.1</td><td>10.1</td><td>41</td></tr>
<tr><td>3</td><td>14.3</td><td>10.2</td><td>29</td><td>15.5</td><td>9.7</td><td>37</td></tr>
<tr><td>All routes (mean)</td><td>14.7</td><td>9.5</td><td>35</td><td>16.2</td><td>9.8</td><td>40</td></tr>
</table>
Exposure to NO_2 (ppb h) and journey time for each route
<table>
<tr><th></th><th></th><th colspan="3">August</th><th colspan="3">September</th></tr>
<tr><th>Route</th><th>Journey time: on-road/off-road (minutes)</th><th>On-road</th><th>Off-road</th><th>% Decrease</th><th>On-road</th><th>Off-road</th><th>% Decrease</th></tr>
<tr><td>1</td><td>20:01 / 23:27</td><td>5.3</td><td>3.6</td><td>32</td><td>5.9</td><td>4.0</td><td>32</td></tr>
<tr><td>2</td><td>9:45 / 15:08</td><td>2.8</td><td>2.7</td><td>4</td><td>3.0</td><td>2.8</td><td>7</td></tr>
<tr><td>3</td><td>23:00 / 23:51</td><td>5.8</td><td>4.1</td><td>29</td><td>6.4</td><td>4.2</td><td>34</td></tr>
<tr><td>All routes (mean)</td><td></td><td>4.6</td><td>3.5</td><td>24</td><td>5.1</td><td>3.7</td><td>27</td></tr>
</table>
Analysis
Cycling the off-road rather than the on-road route significantly decreased the average time-weighted concentration of NO_2 by between 37 and 41%, with a mean of 37.5%. A paired t-test using pooled mean data for each on-road and off-road route showed that the difference between average concentrations on the on-road route and equivalent off-road route was significant (t=11.78; p<0.01).

Exposure was higher for the on-road than off-road routes of Routes 1 and 3, but for Route 2 the difference was much smaller. A paired t-test showed that the mean difference in exposure between on and off-road routes was significant (t=3.50; p=0.017).</td>
<td>Limitations identified by the author
The off-road routes had a lower density of sampling tubes than the on-road routes.

Limitations identified by the review team
The authors selected the routes to be monitored.
The on-road and off-road routes were different lengths and took different times to cycles which could bias the results.</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr>
<td>**Full citation**
Boogaard, H., Borgman, F., Kamminga, J., Hoek, G., Exposure to ultrafine and fine particles and noise during cycling and driving in 11 Dutch cities, Atmospheric Environment, 43, 4234-4242, 2009

Quality score
-

Study type
Non-randomised controlled study

Aim of the study
To compare real time exposure to particle numbers and fine particles during car driving and cycling.

Location and setting
11 medium-sized cities, the Netherlands

Length of study
11 weekdays (excluding Fridays) in late August until October 2006

Source of funding
Not reported</td>
<td>**Participant characteristics**
The routes were of approximately 10-20 minutes duration with the same origin and destination for each transport mode. The shortest way was chosen for both driving and cycling therefore they did not follow exactly the same route. A total of circa 40 km was undertaken per city.

Inclusion criteria
The routes were all in a radius of 2.5km within the city centre and were selected to give a representative picture of the infrastructure for cyclists.</td>
<td>**Intervention / Comparison**
Exposure of particle number concentrations (PNC) and PM2.5 were measured while driving and cycling the predefined routes. Sampling time was between 12:00 - 19:00, excluding morning rush hours.
Driving conditions were standardised as much as possible.</td>
<td>**Outcomes**

Distribution of 1-min averages of particle number concentrations (particles cm^3) and fine particle concentrations (µg m^{-3}) during cycling and car driving per city
<table>
<tr><th></th><th></th><th colspan="3">Particle number concentration</th><th colspan="3">Fine particulates</th></tr>
<tr><th></th><th></th><th>N (NR)</th><th>Mean (SD)</th><th>Max</th><th>N (NR)</th><th>Mean (SD)</th><th>Max</th></tr>
<tr><td rowspan="2">**Apeldoorn**</td><td>**Car**</td><td>163 (12)</td><td>20,796 (17,485)</td><td>119,071</td><td>163 (12)</td><td>14 (6)</td><td>49</td></tr>
<tr><td>**Bicycle**</td><td>167 (12)</td><td>17,070 (10,184)</td><td>77,472</td><td>168 (12)</td><td>11 (5)</td><td>36</td></tr>
<tr><td rowspan="2">**Delft**</td><td>**Car**</td><td>112 (12)</td><td>24,460 (11,336)</td><td>79,061</td><td>117 (12)</td><td>33 (17)</td><td>96</td></tr>
<tr><td>**Bicycle**</td><td>153 (12)</td><td>27,998 (14,610)</td><td>94,558</td><td>155 (12)</td><td>26 (11)</td><td>89</td></tr>
<tr><td rowspan="2">**Den Bosch**</td><td>**Car**</td><td>170 (12)</td><td>23,012 (14,761)</td><td>84,185</td><td>170 (12)</td><td>95 (30)</td><td>151</td></tr>
<tr><td>**Bicycle**</td><td>147 (12)</td><td>21,191 (11,178)</td><td>65,330</td><td>149 (12)</td><td>99 (33)</td><td>155</td></tr>
<tr><td rowspan="2">**The Hague**</td><td>**Car**</td><td>184 (11)</td><td>15,430 (11,596)</td><td>87,113</td><td>184 (11)</td><td>15 (11)</td><td>87</td></tr>
<tr><td>**Bicycle**</td><td>131 (9)</td><td>15,697 (9,643)</td><td>61,811</td><td>154 (11)</td><td>6 (4)</td><td>34</td></tr>
<tr><td rowspan="2">**Eindhoven**</td><td>**Car**</td><td>102 (12)</td><td>23,461 (16,069)</td><td>99,620</td><td>102 (12)</td><td>34 (1)</td><td>85</td></tr>
<tr><td>**Bicycle**</td><td>143 (12)</td><td>28,141 (14,235)</td><td>80,695</td><td>145 (12)</td><td>39 (14)</td><td>84</td></tr>
<tr><td rowspan="2">**Groningen**</td><td>**Car**</td><td>170 (12)</td><td>22,234 (15,652)</td><td>108,437</td><td>170 (12)</td><td>20 (9)</td><td>59</td></tr>
<tr><td>**Bicycle**</td><td>138 (12)</td><td>21,326 (10,817)</td><td>79,262</td><td>138 (12)</td><td>13 (6)</td><td>38</td></tr>
<tr><td rowspan="2">**Haarlem**</td><td>**Car**</td><td>167 (12)</td><td>34,739 (22,847)</td><td>151,182</td><td>167 (12)</td><td>36 (11)</td><td>116</td></tr>
<tr><td>**Bicycle**</td><td>175 (12)</td><td>30,369 (13,367)</td><td>71,309</td><td>176 (12)</td><td>29 (4)</td><td>44</td></tr>
<tr><td rowspan="2">**Maastricht**</td><td>**Car**</td><td>202 (12)</td><td>35,538 (20,574)</td><td>97,536</td><td>202 (12)</td><td>31 (28)</td><td>148</td></tr>
<tr><td>**Bicycle**</td><td>87 (8)</td><td>28,220 (17,851)</td><td>112,219</td><td>148 (12)</td><td>20 (40)</td><td>452</td></tr>
</table>
</td>
<td>**Limitations identified by the author**
In the city of Zwolle, air pollution data from 4 routes were totally missing. Also PNC data of a few (cycling) routes were missing due to equipment failure in The Hague, Maastricht and Nijmegen.

Limitations identified by the review team
The driving and cycling routes were not same which would impact the results of the study.</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td rowspan="2">Nijmegen</td><td>Car</td><td>131 (11)</td><td>24,064 (20,966)</td><td>125,375</td><td>131 (11)</td><td>93 (68)</td><td>806</td></tr>
<tr><td>Bicycle</td><td>121 (11)</td><td>20,244 (12,466)</td><td>74,396</td><td>122 (11)</td><td>95 (16)</td><td>148</td></tr>
<tr><td rowspan="2">Utrecht</td><td>Car</td><td>186 (12)</td><td>29,722 (20,086)</td><td>123,168</td><td>186 (12)</td><td>122 (37)</td><td>316</td></tr>
<tr><td>Bicycle</td><td>173 (12)</td><td>27,246 (14,770)</td><td>88,220</td><td>174 (12)</td><td>112 (45)</td><td>190</td></tr>
<tr><td rowspan="2">Zwolle</td><td>Car</td><td>89 (8)</td><td>23,583 (19,171)</td><td>117,159</td><td>102 (8)</td><td>45 (14)</td><td>79</td></tr>
<tr><td>Bicycle</td><td>101 (8)</td><td>31354 (16690)</td><td>99,907</td><td>103 (8)</td><td>44 (16)</td><td>100</td></tr>
</table>
Analysis

Particle number concentrations
Large variations in minute averages of PNC were observed within cities and between cities/sampling days. The overall mean of car drivers was 5% higher than the mean of cyclists (25,545 in the car and 24,329 particles cm^{-3} on the bicycle).

Fine particulates
The overall mean concentration of PM2.5 in the car was 11% higher than during cycling.
</td><td></td></tr>
<tr><td>Full citation
Burgard, D. A., Provinsal, M. N., On-road, in-use gaseous emission measurements by remote sensing of school buses equipped with diesel oxidation catalysts and diesel particulate filters, Journal of the Air and Waste Management Association, 59, 1468-1473, 2009

Quality score
-

Study type</td>
<td>Number of participants
Total n=289
Control fleet (n=162)
Retrofit fleet fitted with continuously regenerating technology, DPF (n=74) or fitted with Purimuffler, DOC (n=53)

Participant characteristics
Control fleet with most comparable engines yet to be retrofitted with soot-reducing devices
Retrofit fleet fitted with continuously regenerating technology (DPF) or with Purimuffler (DOC)

Inclusion criteria
Not reported

Exclusion criteria
Not reported</td>
<td>Intervention / Comparison
NO_2 emissions were compared between a fleet of retrofitted school buses and a fleet not retrofitted with anti-soot technology.</td>
<td>Outcomes
Average emissions for the control fleet and the retrofit fleet with 95% confidence intervals and n values.
<table>
<tr><th></th><th colspan="2">Retrofit fleet average (g/kg)</th><th>Control fleet average (g/kg)</th></tr>
<tr><td></td><td>DPF (n=74)</td><td>DOC (n=53)</td><td>All buses (n=162)</td></tr>
<tr><td>NO_2*</td><td>17.2 ± 4.5</td><td>4.4 ± 1.1</td><td>3.8 ± 0.8</td></tr>
<tr><td>Modal year</td><td>2000</td><td>1993 - 1995</td><td>1995 - 2002</td></tr>
</table>
* there were 37 NO_2 measurements for the control fleet

Analysis
There is an increase in emitted NO_2 for the DPF and DOC equipped buses when compared with the control fleet.</td>
<td>Limitations identified by the author
The DOC, DPF, and control fleets are composed of buses spanning many model years which were built to different emissions standards, making comparison difficult

Limitations identified by the review team
NO_2 initial measurements were lost for the control fleet and so had to be revisited to measure at the end of the study period.
Measurements were</td></tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Non-randomised controlled study

Aim of the study
To determine the effect of School Buses Equipped with Diesel Oxidation Catalysts and Diesel Particulate Filters on emissions

Location and setting
Washington, USA

Length of study
4.5 months

Source of funding
Not reported</td>
<td></td>
<td></td>
<td></td>
<td>taken on different dates for the control and intervention fleets.</td>
</tr>
<tr>
<td>Full citation
Burr, M. L., Karani, G., Davies, B., Holmes, B. A., Williams, K. L., Effects on respiratory health of a reduction in air pollution from vehicle exhaust emissions, Occupational and environmental medicine, 61, 212-218, 2004

Quality score
-

Study type
Controlled before and after

Aim of the study
To determine whether respiratory health improves following a</td>
<td>Number of participants
Questionnaire of symptoms - No. of participants who provided information provided before & after
Congested streets = 165
Uncongested streets = 283

Participant characteristics
<table>
<tr><th></th><th colspan="2">Congested streets</th><th colspan="2">Uncongested streets</th></tr>
<tr><th></th><th>Original group</th><th>Subset</th><th>Original group</th><th>Subset</th></tr>
<tr><td>Number</td><td>386</td><td>165</td><td>425</td><td>283</td></tr>
<tr><td>Mean age (SD), y</td><td>37.9 (20.0)</td><td>47.9 (16.5)</td><td>38.4 (23.2)</td><td>40.2 (22.9)</td></tr>
<tr><td>Aged >65 y (%)</td><td>33 (8.5)</td><td>22 (13.3)</td><td>62 (14.6)</td><td>41 (14.5)</td></tr>
</table>

Inclusion criteria
Residents and workers in the uncongested and congested streets. Subjects who recorded peak</td>
<td>Intervention / Comparison
The construction of a by-pass.
Measurements of PM$_{10}$ and PM$_{2.5}$ were recorded in a congested and uncongested street before and after the opening of the by-pass.
A respiratory survey was conducted among the residents, together with the residents of nearby uncongested streets, at baseline and again a year after the by-pass opened. Adult subjects were issued with Peak flow meters for 2-3 weeks and asked to record their peak expiratory</td>
<td>Outcomes

Mean hourly PM$_{10}$ and PM$_{2.5}$ concentrations
<table>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><th></th><th>Before by-pass opened</th><th>After by-pass opened</th><th>Change</th><th>Before by-pass opened</th><th>After by-pass opened</th><th>Change</th></tr>
<tr><td>PM$_{10}$ (mg/m^3)</td><td>35.2</td><td>27.2</td><td>-22.7%</td><td>11.6</td><td>8.2</td><td>-28.9%</td></tr>
<tr><td>PM$_{2.5}$ (mg/m^3)</td><td>21.2</td><td>16.2</td><td>-23.5%</td><td>6.7</td><td>4.9</td><td>-26.6%</td></tr>
</table>

Net improvement in symptom prevalence in congested and uncongested streets
<table>
<tr><th></th><th colspan="4">Congested streets</th><th colspan="4">Uncongested streets</th><th rowspan="2">Difference* in net % better (95% CI)</th></tr>
<tr><th></th><th>Total no.</th><th>Better</th><th>Worse</th><th>Net % better</th><th>Total no.</th><th>Better</th><th>Worse</th><th>Net % better</th></tr>
<tr><td>Wheeze</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Any</td><td>165</td><td>17</td><td>16</td><td>0.6</td><td>283</td><td>35</td><td>15</td><td>7.1</td><td>-6.5 (-14.9 to 2.0)</td></tr>
<tr><td>No. attacks</td><td>163</td><td>21</td><td>21</td><td>0</td><td>282</td><td>45</td><td>21</td><td>8.5</td><td>-8.5 (-18.2 to 1.2</td></tr>
</table></td>
<td>Limitations identified by the author
Many of the subjects who participated moved away during the study.

Limitations identified by the review team
Participants self measured their PEFR results.</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>reduction in exposure to traffic related air pollutants.

Location and setting
UK

Length of study

Source of funding
Department of Health</td>
<td>expiratory flow rate (PEFR) before the intervention recorded the measurements again after the intervention at the same times of year as before.

The questionnaire was readministered to the subjects who participated in the first phase of the study.</td>
<td>flow rate (PEFR) on getting up in the morning and on coming in later in the day. Subjects who had recorded PEFR were issued with peak flow meters at the same times of year as before.</td>
<td>
<table>
<tr><td>Disturbs sleep</td><td>164</td><td>12</td><td>11</td><td>0.6</td><td>283</td><td>26</td><td>18</td><td>2.8</td><td>-2.2 (-9.9 to 5.5)</td></tr>
<tr><td>Limits speech</td><td>164</td><td>4</td><td>2</td><td>1.2</td><td>282</td><td>12</td><td>7</td><td>1.8</td><td>-0.6 (-5.2 to 4.5)</td></tr>
<tr><td>Affects activities</td><td>165</td><td>13</td><td>12</td><td>0.6</td><td>281</td><td>26</td><td>14</td><td>4.3</td><td>-3.7 (-11.3 to 4.0)</td></tr>
<tr><td>Without a cold</td><td>162</td><td>12</td><td>15</td><td>-1.9</td><td>281</td><td>17</td><td>18</td><td>-0.4</td><td>1.5 (-6.2 to 9.3)</td></tr>
<tr><td>Treated</td><td>163</td><td>8</td><td>5</td><td>1.8</td><td>264</td><td>18</td><td>11</td><td>2.7</td><td>-0.8 (-7.1 to 5.6)</td></tr>
</table>
*Difference is expressed as value in congested streets minus value in uncongested streets.

Coefficients of variation of peak flow rates (matched data - persons who recorded their PEFR on at least five days in both phases of the study)
<table>
<tr><th></th><th>Congested streets</th><th>Uncongested streets</th></tr>
<tr><td>On getting up</td><td></td><td></td></tr>
<tr><td>No. subjects</td><td>81</td><td>99</td></tr>
<tr><td>Mean CV (Before) (SD)</td><td>5.09 (3.31)</td><td>6.17 (3.88)</td></tr>
<tr><td>Mean CV (After) (SD)</td><td>5.32 (4.35)</td><td>4.99 (3.54)</td></tr>
<tr><td>Mean change in CV (SD)</td><td>+0.23 (4.52)</td><td>-1.18 (3.83)</td></tr>
<tr><td>95% CI</td><td>-0.75, +1.21</td><td>-1.93, -0.43</td></tr>
<tr><td>On coming in</td><td></td><td></td></tr>
<tr><td>No. subjects</td><td>79</td><td>95</td></tr>
<tr><td>Mean CV (Before) (SD)</td><td>5.09 (3.47)</td><td>5.77 (3.60)</td></tr>
<tr><td>Mean CV (After) (SD)</td><td>5.25 (4.07)</td><td>5.22 (3.67)</td></tr>
<tr><td>Mean change in CV (SD)</td><td>+0.16 (3.60)</td><td>-0.55 (3.36)</td></tr>
<tr><td>95% CI</td><td>-0.63, +0.95</td><td>-1.23, +0.13</td></tr>
</table>

Analysis
There was an overall decrease in both PM_{10} and $PM_{2.5}$ concentration levels after the intervention. The peak flow rates of participants from congested streets generally increased after the intervention. For indices of wheeze, the subjects in the congested streets showed a lower net improvement than those in the uncongested streets, although the differences between the areas were small.
</td>
<td></td>
</tr>
<tr>
<td>Full citation
Gramsch, E., Le Nir, G., Araya, M., Rubio, M. A., Moreno, F.,</td>
<td>Number of participants
Measurements of black carbon were taken before (June-July 2005) and after (June-July 2007) the</td>
<td>Intervention / Comparison
Implementation of 'Transantiago'. Before</td>
<td>Outcomes

Summary of Black Carbon (BC) measurements
<table>
<tr><th>Site</th><th>Year</th><th>Sampling</th><th>BC</th><th>Min (µg m^{-3})</th><th>Max (µg m^{-3})</th><th>n</th></tr>
</table>
</td>
<td>Limitations identified by the author
The measurements at the control site (E.</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Oyola, P., Influence of large changes in public transportation (Transantiago) on the black carbon pollution near streets, Atmospheric Environment, 65, 153-163, 2013

Quality score
-

Study type
Controlled before and after study

Aim of the study
To determine the effect of a large change in the public transportation system (Transantiago) on levels of black carbon air pollution.

Location and setting
Santiago, Chile

Length of study
Not reported

Source of funding
Airparif and the Department for Scientific and Technological Research (Dicyt) of the University of Santiago</td>
<td>intervention along 4 roads (3 crossing the city with main avenues directly affected by the intervention - Usach, Alameda and Departamental) and 1 where no public transportation was available before or after the intervention - E. Yañez.

Participant characteristics
Not reported

Inclusion criteria
Not reported

Exclusion criteria
Not reported</td>
<td>Transantiago, the city had a fleet of about 7000 diesel buses which were reduced to about 5900, from which about 1500 of them were new (Euro III). All Euro I buses were taken out of circulation after implementation.</td>
<td>
<table>
<tr><th></th><th></th><th>period</th><th>average ± s.d. ($\mu g\ m^{-3}$)</th><th></th><th></th><th></th></tr>
<tr><td rowspan="2">Usach</td><td>2005</td><td>June 1 - July 29</td><td>7.91 ± 5.69</td><td>0.00</td><td>33.55</td><td>1303</td></tr>
<tr><td>2007</td><td>June 1 - July 31</td><td>8.29 ± 5.78</td><td>0.05</td><td>47.02</td><td>1437</td></tr>
<tr><td rowspan="2">Alameda</td><td>2005</td><td>June 1 - July 4</td><td>19.31 ± 9.50</td><td>0.64</td><td>59.68</td><td>801</td></tr>
<tr><td>2007</td><td>June 6 - July 31</td><td>11.93 ± 7.64</td><td>0.40</td><td>59.80</td><td>1317</td></tr>
<tr><td rowspan="2">Departamental</td><td>2005</td><td>June 2 - July 2</td><td>9.36 ± 5.67</td><td>0.00</td><td>26.71</td><td>715</td></tr>
<tr><td>2007</td><td>June 4 - July 31</td><td>10.21 ± 7.93</td><td>0.00</td><td>124.65</td><td>1389</td></tr>
<tr><td rowspan="2">E. Yañez</td><td>2005</td><td>June 1 - July 2</td><td>5.05 ± 2.87</td><td>0.03</td><td>19.76</td><td>753</td></tr>
<tr><td>2007</td><td>June 29 - July 31</td><td>5.93 ± 3.81</td><td>0.16</td><td>23.71</td><td>483</td></tr>
</table>

Analysis
The only site which showed a decrease in average BC levels after the intervention was Almeda street. No other sampling sites showed a decrease in average levels.</td>
<td>Yañez) in 2007 had considerably more errors than the other stations. There were many electricity failures in this station resulting in loss of data.
The sampling period is short compared to the total time during which BC emissions occur (1 hr 20 min) and during this period large or very low emissions may occur and introduce a bias in the measurements.

Limitations identified by the review team
Time period and dates when data taken at E. Yañez site in 2007 were different to all other sites.</td>
</tr>
<tr>
<td>Full citation
Hatzopoulou, Marianne, Weichenthal, Scott, Dugum, Hussam,</td>
<td>Number of participants
n=4

Participant characteristics
Routes ranged from 16 to 19 km in</td>
<td>Intervention / Comparison
Four participants cycled on weekdays (Monday to Thursday)</td>
<td>Outcomes

Personal exposures to air pollution during morning and evening cycling trips
<table>
<tr><th>Pollutant</th><th>Mean (SD)</th><th>Median</th><th>Range</th><th>Mean (SD)</th><th>Median</th><th>Range</th><th>Mean difference (95% CI)</th></tr>
</table>
</td>
<td>Limitations identified by the author
Did not have traffic count data for each count point on</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Pickett, Graeme, Miranda-Moreno, Luis, Kulka, Ryan, Andersen, Ross, Goldberg, Mark, The impact of traffic volume, composition, and road geometry on personal air pollution exposures among cyclists in Montreal, Canada, Journal of Exposure Science & Environmental Epidemiology, 23, 46-51, 2013

Quality score
-

Study type
Comparative study

Aim of the study
Evaluate personal exposures to multiple air pollutants among cyclists and potential determinants of exposure such as the type of cycling lane (separated vs non-separated)

Location and setting
Montreal, Canada

Length of study
32 days

Source of funding
Not reported</td>
<td>length and included several different types of cycling facilities including lanes completely separated from traffic, lanes separated from traffic by parked cars, and lanes immediately adjacent to vehicle lanes with no physical barrier in between.

Inclusion criteria
Not reported

Exclusion criteria
Cycling did not take place during rainy days.</td>
<td>during the morning (0800-1000 hours) and evening commutes (1500–1700 hours). Cycling lanes were categorised as either separated (including fully separated lanes and lanes separated by parked cars) or not separated (on-road lanes with no physical barrier between the cycling lane and traffic). In total, 8 different routes were cycled in total (4 reflected high-traffic areas and 4 low-traffic). All routes were cycled on 4 different days, twice each day (am and pm) for a total of 64 observation periods.</td>
<td>
<table>
<tr><td>Black carbon (ng/m^3) n=57</td><td>1999 (1130)</td><td>1516</td><td>398-4612</td><td>1052 (630)</td><td>948</td><td>196-2506</td><td>947 (450, 1445)</td></tr>
<tr><td>$PM_{2.5}$ (μg/m^3) n=50</td><td>10.4 (7.0)</td><td>8.8</td><td>4.3-28.7</td><td>11.1 (9.8)</td><td>7.6</td><td>2.8-38.2</td><td>-0.65 (-5.5, 4.2)</td></tr>
</table>

Mixed-effect models for the relationship between personal air pollution exposures and separated cycling lane
<table>
<tr><th>Pollutant</th><th colspan="2">Analysis</th></tr>
<tr><th></th><th>Limited to day of traffic counts percent change (95% CI)</th><th>Entire data set percent change (95% CI)</th></tr>
<tr><td>Black Carbon (ng/m^3)</td><td>-12% (-43, 14)</td><td>-9.0% (-31, 10)</td></tr>
<tr><td>$PM_{2.5}$ (μg/m^3)</td><td>7.8% (-17, 35)</td><td>2.0% (-14, 19)</td></tr>
</table>

Impact of cycling lane distance from the nearest traffic lane
Each 5 m separation of the cycling lane was associated with a decrease in exposure of 2.5% (95% CI: -17, 12) for black carbon. However, the same separation was linked with a 3.5% (95% CI: -9.1, 18) increase in personal exposure to $PM_{2.5}$.

Analysis
Exposures were similar during the morning and evening commutes for PM2.5 but exposure to Black carbon were higher during the morning commute.
Use of separated cycling lanes and increased cycling lane distance from traffic were associated with a decrease in exposure to Black Carbon. In contrast, there was increased exposure to $PM_{2.5}$ with separated cycling lane use and increased distance from traffic. However, these associations were imprecise and not statistically significant.
</td>
<td>every cycling day and as a result in some analyses the authors assumed a constant traffic flow at each count point which may have biased results if traffic counts varied between days. Wind speed data were based on a fixed monitoring site located outside of the downtown area. The authors did not have detailed information for wind speed at various points along each route; therefore, measurement error might have resulted in underestimation of the true impact of wind speed on personal air pollutant exposures.

Limitations identified by the review team
14 $PM_{2.5}$ and 7 Black Carbon sets of measurements during the study were lost due to instrument malfunction or technician error.
Routes differed in length.</td>
</tr>
<tr>
<td>Full citation
Jarjour, S., Jerrett, M., Westerdahl, D., De</td>
<td>Number of participants
n=15</td>
<td>Intervention / Comparison
Two cycle routes – a</td>
<td>Outcomes

Paired t-test by subject. Average pollutant exposure for each subject's high-</td>
<td>Limitations identified by the author
A major limitation of</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Nazelle, A., Hanning, C., Daly, L., Lipsitt, J., Balmes, J., Cyclist route choice, traffic-related air pollution, and lung function: A scripted exposure study, Environmental Health: A Global Access Science Source, 12, 2013

Quality score
-

Study type
Non controlled comparative study

Aim of the study
To compare high and low traffic cycle routes on exposure to traffic related air pollution and lung function

Location and setting
Berkeley, California

Length of study
3 months

Source of funding
Not reported</td>
<td>**Participant characteristics**
Healthy adults (4 Female, 11 Male), Mean age = 32

Inclusion criteria
Healthy adults (non asthmatic)

Exclusion criteria
Adults with respiratory health conditions, cardiovascular conditions, recent or current smoking habits.</td>
<td>low-traffic Bicycle Boulevard route which followed busy streets with more truck and bus traffic and a high-traffic route which followed residential streets. All routes were designated by the City of Berkeley as bicycle boulevards. Each participant cycled on the low-traffic route once and the high-traffic route once.</td>
<td>**traffic ride vs. low-traffic ride average**
<table>
<tr><th></th><th>N*</th><th colspan="2">Mean</th><th colspan="2">Standard error of the mean</th><th></th><th colspan="2">95% CI of difference</th></tr>
<tr><td></td><td></td><td>Low-traffic</td><td>High-traffic</td><td>Low-traffic</td><td>High-traffic</td><td>p-value</td><td>Lower</td><td>Higher</td></tr>
<tr><td>$PM_{2.5}$ (µg/m^3)</td><td>8</td><td>4.88</td><td>4.53</td><td>0.40</td><td>0.39</td><td>0.60</td><td>-1.90</td><td>1.19</td></tr>
<tr><td>Black Carbon (µg/m^3)</td><td>15</td><td>1.73</td><td>2.10</td><td>0.90</td><td>0.15</td><td>0.06</td><td>-0.02</td><td>0.77</td></tr>
</table>
*N = number of subjects with high and low measurements for pollutant (i.e number of pairs)

Average measurements and changes in lung function
<table>
<tr><th>Measurement</th><th>Low-traffic</th><th>High-traffic</th></tr>
<tr><td>**FVC (litres)**
baseline ± SD
Post-ride (difference from baseline)
4-hour (difference from baseline)</td><td>4.90 ± 0.71
4.88 (-0.02)
4.87 (-0.03)</td><td>5.01 ± 0.83
5.01 (0.00)
4.96 (-0.05)</td></tr>
<tr><td>**FEV_1 (litres)**
baseline ± SD
Post-ride (difference from baseline)
4-hour (difference from baseline)</td><td>3.91±0.60
3.93 (0.02)
3.95 (0.04)</td><td>3.95 ± 0.62
4.00 (0.05)
3.94 (-0.01)</td></tr>
<tr><td>**FEV_1 / FVC (litres)**
baseline ± SD
Post-ride (difference from baseline)
4-hour (difference from baseline)</td><td>0.81 ± 0.07
0.81 (0.00)
0.81 (0.00)</td><td>0.79 ± 0.06
0.80 (0.01)
0.81 (0.02)</td></tr>
<tr><td>**$FEF_{25-75\%}$ (litres)**
baseline ± SD
Post-ride (difference from baseline)
4-hour (difference from baseline)</td><td>3.87 ± 0.94
3.77 (-0.10)
3.94 (0.07)</td><td>3.61 ± 0.91
3.78 (0.17)
3.85 (0.24)</td></tr>
</table>
Baseline average forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), their ratio (FEV_1 / FVC =%FEV_1), and forced expiratory flow rate between 25-75% of vital capacity ($FEF_{25-75\%}$)

Analysis
There was a slightly higher concentration of $PM_{2.5}$ along the low-traffic route, additionally there was a higher concentration of Black Carbon along the high-traffic route. There were no significant changes in pulmonary function after cycling on either route

Compared the average high-traffic to low-traffic exposures by subject using a pairwise t-test and excluding subjects who were missing pollutant</td>
<td>this study was variable wind speed and other meteorological conditions, which affected measured concentrations independent of road traffic volume. Equipment failure also reduced the number of viable pollutant measurements. Participants did not cycle to the study site, but pre-study exposure and potential exposure between the post-ride and 4-hour follow-up spirometry measurements were not otherwise controlled. Allowing participants to drive to the study site may have influenced their pre-exposure to vehicle-related air pollutants. Due to equipment failure, fine particulate matter measurements were missing for five study days. Two days of measurement were excluded due to rain and a flat tire.

Limitations identified by the review team
There were a limited number of participants included in the study</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr><td></td><td></td><td></td><td>measurements from one or both rides due to equipment malfunctions.
Stata (Version 10, StataCorp, College Station, TX) for all statistical analyses.</td><td></td></tr>
<tr>
<td>Full citation
Kendrick Christine, M., Moore, Adam, Haire Ashley, Raye, Bigazzi Alexander, York, Figliozzi, Miguel, Monsere Christopher, M., George, Linda, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Impact of Bicycle Lane Characteristics on Bicyclists' Exposure to Traffic-Related Particulate Matter, Transportation Research Board 90th Annual MeetingTransportation Research Board, 15

Quality score
-

Study type
Controlled study

Aim of the study
To assess the impact of traffic levels and bicycle lane characteristics on bicyclists’ exposure to ultrafine particles.

Location and setting
A multi-lane, one-way southbound street in downtown Portland, USA</td>
<td>Number of participants
n/a

Participant characteristics
Measurements for the study were undertaken on a road with 2 traffic lanes (in addition to the cycle track), with an offset row of parallel parking providing a buffer to the cycle track, approximately 10 -11 feet in width. Traffic composition and volumes vary at this location throughout the day.</td>
<td>Intervention / Comparison
Ultrafine particle exposure concentrations were compared in 2 settings:

1. A traditional bicycle lane adjacent to the vehicular traffic lanes
2. A cycle track design with a parking lane separating bicyclists from vehicular traffic lanes.

Particle number concentrations and traffic measurements were made over 4 days across several months. On each study day particle counters were placed in a parked car in the parallel parking zone on the west side adjacent to the cycle track. The car was parked to compare simultaneous measurements of exposure concentrations that would be experienced in a conventional bicycle lane versus a cycle track</td>
<td>Outcomes

Mean Particle Number Concentrations, Ranges, Percent Differences, and t-test results for Bicycle Lane and Cycle Track Exposure Concentration Comparisons
<table>
<tr><th></th><th></th><th colspan="3">Bicycle lane</th><th colspan="3">Cycle track</th><th></th><th></th><th></th></tr>
<tr><th>Date</th><th>Time</th><th>Median</th><th>Mean</th><th>Range</th><th>Median</th><th>Mean</th><th>Range</th><th>Mean diff</th><th>p-value</th><th>% diff</th></tr>
<tr><td>Nov 24, 2009</td><td>5:45-10:45 AM</td><td>31,400</td><td>43,788</td><td>14,500-500,000</td><td>30,500</td><td>37,498</td><td>15,000-365,000</td><td>6,125</td><td><0.01</td><td>15</td></tr>
<tr><td>Nov 24, 2009</td><td>10:58 AM -1:52 PM</td><td>28,200</td><td>56,845</td><td>4,510-500,000</td><td>26,000</td><td>35,802</td><td>13,600-500,000</td><td>21,043</td><td><0.01</td><td>38</td></tr>
<tr><td>Nov 24, 2009</td><td>2:05-4:51 PM</td><td>25,400</td><td>37,476</td><td>9,980-500,000</td><td>20,600</td><td>24,618</td><td>2,230-312,000</td><td>12,589</td><td><0.01</td><td>35</td></tr>
<tr><td>Feb 8, 2010</td><td>5:31-10:49AM</td><td>30,600</td><td>47,601</td><td>12,300-500,000</td><td>29,500</td><td>44,245</td><td>3,340-500,000</td><td>3,309</td><td><0.01</td><td>8</td></tr>
<tr><td>June 7, 2010</td><td>6:53 AM-2:20 PM</td><td>14,700</td><td>25,271</td><td>3,340-500,00</td><td>14,200</td><td>20,805</td><td>5,750-500,000</td><td>4,465</td><td><0.01</td><td>18</td></tr>
<tr><td>July 13, 2010</td><td>7:24 AM-9:42 PM</td><td>8,290</td><td>13,839</td><td>2,390-500,000</td><td>7,660</td><td>10,558</td><td>5,620-500,000</td><td>3,309</td><td><0.01</td><td>24</td></tr>
</table>

Analysis
Bicycle lane exposure concentrations were significantly greater than the cycle track exposure levels although there was a wide range in the mean of the differences and percent differences.
Particle number distributions showed bicycle lane measurements greater than 300,000-500,000pt/cc occurred more frequently compared to cycle track measurements. This may have been an under estimate due to the inability of the equipment to capture peaks greater than 500,000pt/cc.</td>
<td>Limitations identified by the author
None reported

Limitations identified by the review team
The study compared exposure concentration in 2 settings: a traditional bicycle lane; and a cycle track design with a parking lane separating bicyclists from vehicular traffic. However, the measurements were collected with sensors placed on either side of a parked car, rather than placing sensors within the two cycle lanes – this could impact on the results of the study, particularly as the passenger-side measurements were located a few feet from the actual cycle track. The placement of the study vehicle was also different on one of the experiment days than the other days. Particle number concentrations and traffic measurements were made over four days in the span of several months with different combinations of equipment and study durations depending on</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Length of study
8 months

Source of funding
Not reported</td>
<td></td>
<td>lane. Measuring exposure on the driver's side represented the exposure concentration in a traditional bicycle lane; exposure measured on the passenger-side represented the cycle track exposure concentration.</td>
<td></td>
<td>availability of equipment and personnel.</td>
</tr>
<tr>
<td>Full citation
MacNaughton, P., Melly, S., Vallarino, J., Adamkiewicz, G., Spengler, J. D., Impact of bicycle route type on exposure to traffic-related air pollution, Science of the total environment, 490, 37-43, 2014

Quality score
-

Study type
Comparative study

Aim of the study
To determine the impact of bicycle route type on exposure to traffic related air pollution.

Location and setting
Boston, USA

Length of study
2 months

Source of funding
NIEHS Grant</td>
<td>Number of participants
3 bike route types

Participant characteristics
Length in km of sampling routes and bike route type
<table>
<tr><th>Route type</th><th colspan="6">Route</th></tr>
<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>Total</th></tr>
<tr><td>Bike path: a separated lane from vehicle traffic</td><td>1.4</td><td>5.7</td><td>5.7</td><td>4.4</td><td>0</td><td>17.3</td></tr>
<tr><td>Bike lane: adjacent to vehicle traffic</td><td>10.2</td><td>10.7</td><td>9.4</td><td>7.7</td><td>10.6</td><td>48.6</td></tr>
<tr><td>Designated bike lane: a shared traffic lane for bicycles and buses</td><td>0</td><td>0</td><td>0</td><td>2.6</td><td>0</td><td>2.6</td></tr>
<tr><td>Total</td><td>11.6</td><td>16.4</td><td>15.2</td><td>14.6</td><td>10.6</td><td>68.4</td></tr>
</table>

Inclusion criteria
Not reported

Exclusion criteria
Not reported</td>
<td>Intervention / Comparison
Exposure to NO_2 and black carbon (BC) was measured during morning (7:00am to 10:00am) and evening (15:00 to 18:00) commutes along 5 pre-designated bike routes, selected to represent travel over a variety of bike route types during variable traffic and atmospheric conditions.
Each route was monitored 4 times using monitoring equipment towed behind a bicycle on a mobile monitoring platform.</td>
<td>Outcomes
<table>
<tr><th>Route type</th><th colspan="2">Mean (standard error)</th></tr>
<tr><th></th><th>Black Carbon (ng/m^3)</th><th>NO_2 (ppb)</th></tr>
<tr><td>Sampled concentration
Bike path
Bike lane
Designated bike lane</td><td>
1670 (101)
2360 (85.1)
1980 (336)</td><td>
14.7 (0.582)
19.5 (0.343)
24.2 (1.72)</td></tr>
<tr><td>Background concentration
Bike path
Bike lane
Designated bike lane</td><td>
640 (16.9)
641 (9.35)
1020 (129)</td><td>
16.1 (0.115)
15.8 (0.102)
15.9 (0.245)</td></tr>
</table>

Analysis
The highest concentration (compared to background) of Black Carbon was found in the Bike lane, for NO_2 this was found in the designated bike lane.</td>
<td>Limitations identified by the author
Measurements of $PM_{2.5}$ interrupted by vibrations, resulting in incomplete data sets.

Limitations identified by the review team
Route lengths differed across the 5 routes assessed and between route types.</td>
</tr>
</table>

Study details	**Population**	**Intervention / Comparator**	**Results**	**Notes**
1R44ES018494-01				

Question 3: Are interventions to develop routes and infrastructure to support low emission modes of transport effective at reducing the health impact of, or people’s exposure to, traffic-related air pollution? Modelling studies

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr>
<td>Full citation
Chong, U., Yim, S. H. L., Barrett, S. R. H., Boies, A. M., Air quality and climate impacts of alternative bus technologies in Greater London, Environmental Science and Technology, 48, 4613-4622, 2014

Quality score
+

Aim of the study
To assess the impact of alternative bus technologies on air quality emissions.

Source of data
Publicly available bus schedule and bus stop location data covering 700 bus routes and 19,500 bus stop</td>
<td>Number of participants
n/a

Participant description
n/a

Inclusion criteria

Exclusion criteria</td>
<td>Intervention / Comparison
The study assessed the impact of alternative propulsion technology (lean-burn compressed natural gas, hybrid electric buses) and emissions control strategies (continuously regenerating trap, exhaust gas recirculation and selective catalytic reduction with trap) in the Greater London bus fleet relative to the existing diesel bus fleet.
Four scenarios were defined, as well as the current baseline. The baseline represented the 2010 composition of 8624 Euro-II to Euro V buses with particle filters to meet Euro IV PM limits. The other scenarios are set out in the table below.

Definition of bus scenarios by percentage of drive train and emissions control strategies
<table>
<tr><th></th><th>BASE</th><th>SCRT</th><th>EGRD</th><th>CNGL</th><th>HYBR</th></tr>
<tr><td>Euro-II +CRT</td><td>23.9%</td><td>-</td><td></td><td></td><td></td></tr>
<tr><td>Euro-II +SCR +CRT</td><td>-</td><td>23.9%</td><td></td><td></td><td></td></tr>
<tr><td>Euro-II +EGR +DPF</td><td>-</td><td>-</td><td>23.9%</td><td></td><td></td></tr>
<tr><td>Euro-III +CRT</td><td>48.5%</td><td>-</td><td></td><td></td><td></td></tr>
<tr><td>Euro-III +SCR +CRT</td><td>-</td><td>48.5%</td><td></td><td></td><td></td></tr>
<tr><td>Euro-III +EGR +DPF</td><td>-</td><td>-</td><td>48.5%</td><td></td><td></td></tr>
<tr><td>Euro-IV +SCR +CRT</td><td>15.9%</td><td>15.9%</td><td>15.9%</td><td></td><td></td></tr>
<tr><td>Euro-IV +EGR +DPF</td><td>3.6%</td><td>3.6%</td><td>3.6%</td><td></td><td></td></tr>
<tr><td>Euro-V +SCR +CRT</td><td>6.7%</td><td>6.7%</td><td>6.7%</td><td></td><td></td></tr>
<tr><td>Euro-V +EGR +DPF</td><td>1.4%</td><td>1.4%</td><td>1.4%</td><td></td><td></td></tr>
<tr><td>Lean burn CNG</td><td>-</td><td></td><td></td><td>100%</td><td></td></tr>
<tr><td>Hybrid electric diesel</td><td>-</td><td></td><td></td><td></td><td>100%</td></tr>
</table>
</td>
<td>Type of model
A bus traffic model was created to spatially simulate the Greater London bus network. A baseline and 4 future technology adoption scenarios were defined. Emissions inventories were calculated for each scenario and the air quality impact quantified. The Weather Research and Forecasting Model (WRF) was applied to provide meteorological fields for air quality simulations.</td>
<td>Outcomes
Air quality impacts of alternative bus technologies in Greater London (metric tonnes per year)
<table>
<tr><th></th><th></th><th>BASE</th><th>SCRT</th><th>EGRD</th><th>CNGL</th><th>HYBR</th></tr>
<tr><td>NO_2</td><td>Mean</td><td>2371</td><td>765</td><td>1499</td><td>901</td><td>1167</td></tr>
<tr><td></td><td>5th PRC</td><td>1696</td><td>539</td><td>1076</td><td>673</td><td>835</td></tr>
<tr><td></td><td>95th PRC</td><td>3021</td><td>978</td><td>1908</td><td>1156</td><td>1499</td></tr>
<tr><td>Black Carbon</td><td>Mean</td><td>0.43</td><td>0.36</td><td>0.43</td><td>-</td><td>0.25</td></tr>
<tr><td></td><td>5th PRC</td><td>0.35</td><td>0.30</td><td>0.35</td><td>-</td><td>0.15</td></tr>
<tr><td></td><td>95th PRC</td><td>0.52</td><td>0.44</td><td>0.52</td><td>-</td><td>0.37</td></tr>
<tr><td>Organic carbon</td><td>Mean</td><td>7.79</td><td>6.56</td><td>7.79</td><td>2.02</td><td>4.52</td></tr>
<tr><td></td><td>5th PRC</td><td>6.65</td><td>5.80</td><td>6.71</td><td>1.17</td><td>2.82</td></tr>
<tr><td></td><td>95th PRC</td><td>8.80</td><td>7.37</td><td>8.91</td><td>3.03</td><td>6.43</td></tr>
</table>

Population exposure to PM and NOx in London due to emissions from buses
<table>
<tr><th></th><th colspan="4">Reduction in exposure (µg/m3 X people)</th></tr>
<tr><th></th><th>PM2.5</th><th>Black Carbon</th><th>Organic carbon</th><th>NO2</th></tr>
<tr><td>Base</td><td>7.5x10^7</td><td>1.8x106</td><td>2.9 x107</td><td>2.0 x107</td></tr>
<tr><td>SCRT</td><td>6.2 x10^7</td><td>1.6 x106</td><td>2.5 x107</td><td>1.2 x107</td></tr>
<tr><td>EGRD</td><td>7.3 x10^7</td><td>1.9 x106</td><td>3.0 x107</td><td>1.7 x107</td></tr>
<tr><td>CNGL</td><td>1.2 x10^7</td><td>2.2 x106</td><td>7.8 x106</td><td>-2.2 x107</td></tr>
<tr><td>HYBR</td><td>5.3 x10^7</td><td>1.1 x106</td><td>1.7 x107</td><td>1.4 x107</td></tr>
</table>

Analysis
The table presents the numerical emissions results from the model: In the diesel emission control scenarios (SCRT and EGRD), there were reductions in NO_2 (SCRT: 68%; EGRD: 37%), Black Carbon (SCRT: 16%) and Organic Carbon (SCRT: 16%) compared to baseline.

In the HYBR scenario, there were reductions in NO_2 (51%), Black Carbon (42%) and Organic Carbon (42%). In the CNGL scenario, there were reductions in NO_2 (62%) and Organic Carbon (74%).</td>
<td>Limitations identified by the author
Non reported

Limitations identified by the review team</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr><td>locations were used.

Location and setting
London, UK

Length of study
n/a

Source of funding
Engineering and Physical Sciences Research Council funded the Energy Efficient Cities Initiative (EP/F034350/1)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Full citation
Goncalves, M., Jimenez-Guerrero, P., Baldasano, J. M., High resolution modeling of the effects of alternative fuels use on urban air quality: Introduction of natural gas vehicles in Barcelona and Madrid Greater Areas (Spain),</td><td>Number of participants
2 cities

Participant description

Inclusion criteria
n/a

Exclusion criteria
n/a</td><td>Intervention / Comparison
To assess the impact of the introduction of NGV a number of scenarios were modelled:
(E1) Scenario 1. Substitution of 100% of urban buses fleet by NGV;
(E2) Scenario 2. Substitution of 50% of taxis fleet by NGV;
(E3) Scenario3. Substitution of 50% of inter city buses fleet by NGV;
(E4) Scenario 4. Substitution of 50% of light commercial vehicles fleet by NGV;
(E5) Scenario 5. Substitution of 10% of private cars fleet by NGV;
(E6) Scenario 6. Substitution of 100% of heavy duty freight transport vehicles fleet by NGV;
(E7) Scenario 7. Combined scenario.
The base case was defined taking into account the year 2004 data.</td><td>Type of model
Changes in air quality are assessed by means of the WRF-ARW/HERMES/CMAQ modeling system.</td><td>Outcomes
Changes in 24-hour average NO2 and PM10 levels, Barcelona and Madrid for base case and 7 natural gas substitution scenarios
<table>
<tr><th></th><th colspan="6">Barcelona area</th><th colspan="6">Madrid area</th></tr>
<tr><th></th><th colspan="3">NO2 24-h average</th><th colspan="3">PM10 24-h average</th><th colspan="3">NO2 24-h average</th><th colspan="3">PM10 24-h average</th></tr>
<tr><th></th><th>Conc (μg m-3)</th><th>Δ conc</th><th>Variation (%)</th><th>Conc (μg m-3)</th><th>Δ conc</th><th>Variation (%)</th><th>Conc (μg m-3)</th><th>Δ conc</th><th>Variation (%)</th><th>Conc (μg m-3)</th><th>Δ conc</th><th>Variation (%)</th></tr>
<tr><td>Base case</td><td>35.0</td><td></td><td></td><td>10.4</td><td></td><td></td><td>22.2</td><td></td><td></td><td>4.9</td><td></td><td></td></tr>
<tr><td>E1</td><td>34.8</td><td>-0.20</td><td>-0.56%</td><td>10.4</td><td>-0.05</td><td>-0.48%</td><td>21.8</td><td>-0.44</td><td>-1.98%</td><td>4.9</td><td>-0.06</td><td>-1.21%</td></tr>
<tr><td>E2</td><td>34.9</td><td>-0.15</td><td>-0.15%</td><td>10.4</td><td>-0.07</td><td>-0.66%</td><td>22.0</td><td>-0.28</td><td>-1.24%</td><td>4.8</td><td>-0.08</td><td>-1.64%</td></tr>
<tr><td>E3</td><td>34.9</td><td>-</td><td>-0.11%</td><td>10.4</td><td>-</td><td>-0.29%</td><td>21.6</td><td>-</td><td>-2.73%</td><td>4.8</td><td>-</td><td>-1.79%</td></tr>
</table></td><td>Limitations identified by the author
None reported

Limitations identified by the review team
There are meteorological differences between the locations studied and the UK.

Other</td></tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr>
<td>Science of the total environment, 407, 776-790, 2009
Quality score
-

Aim of the study
To investigate the impact on urban air quality of different scenarios of emissions reduction, which consider the introduction of natural gas vehicles (NGV) to Barcelona and Madrid.

Source of data
Modelling was based on weather conditions of 17-18 June 2004.

Location and setting
Barcelona and Madrid, Spain

Length of study
n/a

Source of</td>
<td></td>
<td></td>
<td></td>
<td>
<table>
<tr><td></td><td></td><td>0.11</td><td></td><td></td><td>0.03</td><td></td><td></td><td>0.61</td><td></td><td></td><td>0.09</td><td></td></tr>
<tr><td>E4</td><td>34.1</td><td>-0.89</td><td>-0.89%</td><td>10.0</td><td>-0.42</td><td>-3.99%</td><td>21.1</td><td>-1.12</td><td>-5.04%</td><td>4.6</td><td>-0.31</td><td>-6.24%</td></tr>
<tr><td>E5</td><td>34.6</td><td>-0.46</td><td>-0.46%</td><td>1034</td><td>-0.08</td><td>-0.74%</td><td>20.4</td><td>-1.82</td><td>-8.2%</td><td>4.7</td><td>-0.17</td><td>-3.49%</td></tr>
<tr><td>E6</td><td>34.8</td><td>-0.19</td><td>-0.29%</td><td>10.4</td><td>-0.05</td><td>-0.44%</td><td>22.0</td><td>-0.21</td><td>-0.96%</td><td>4.9</td><td>-0.08</td><td>-0.54%</td></tr>
<tr><td>E7</td><td>32.9</td><td>-2.15</td><td>-2.15%</td><td>9.7</td><td>-0.69</td><td>-6.6%</td><td>17.7</td><td>-4.58</td><td>-20.56%</td><td>4.2</td><td>-0.73</td><td>-14.92%</td></tr>
</table>

Analysis
Compared to the base case scenario, the introduction of 50% of natural gas commercial light vehicles (scenario E4) is the most effective individual scenario in reducing NOx and PM10 in Barcelona, while in Madrid substituting 10% of private cars (scenario E5) involves larger reductions of NOx emissions. The largest variation in traffic emissions is obtained in the combined scenario.
</td>
<td>comments</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr><td>**funding**
This work was funded by the projects CICYTCGL2006-08903 and CGL2006-11879 of the Spanish Ministry of Education and Science and CALIOPE project 441/2006/3-12.1 of the Spanish Ministry of the Environment.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>**Full citation**
Goncalves, Maria, Jimenez-Guerrero, Pedro, Baldasano, Jose M., Emissions variation in urban areas resulting from the introduction of natural gas vehicles: application to Barcelona and Madrid greater areas (Spain), The Science of the total environment, 407, 3269-81,</td><td>**Number of participants**
2 cities
Participant description
There is a larger overall vehicle fleet in Madrid than Barcelona (1.7m compared to 1m vehicles), while economic activity in Madrid is dominated by the service sector and in Barcelona is predominantly industrial. Thus contribution to NOx emissions from road traffic is higher in Madrid than in Barcelona (94%</td><td>**Intervention / Comparison**
The study assess several scenarios of natural gas vehicle introduction in Barcelon and Madrid.
The base case scenario (EB) was based on the vehicle fleet composition for the year 2004 in Barcelona and Madrid. Modelling was undertaken to assess the impact on air quality of different scenarios in vehicle fleet composition changed according to the type and percentage of Natural Gas Vehicle (NGV) introduced in each case. The scenarios were:
• E1: transformation to NGV (natural gas vehicles) of 1005 of urban bus fleet
• E2: transformation of 50% of taxi fleet
• E3: transformation of 50% of intercity bus fleet
• E4: transformation of 50% of light commercial vehicle fleet
• E5: transformation of 10% of private car fleet
• E6: transformation of 100% of heavy duty freight fleet</td><td>**Type of model**
The HERMES emissions model, specific for the Iberian Peninsula was used to evaluate the change in traffic emissions for each scenario.</td><td>**Outcomes**
Emissions reduction from road traffic for each scenario
<table>
<tr><th></th><th>Barcelona</th><th></th><th>Madrid</th><th></th></tr>
<tr><th></th><th>NOx (kg d-1), % change</th><th>PM10 (kg d-1), %change</th><th>NOx (kg d-1), % change</th><th>PM10 (kg d-1), %change</th></tr>
<tr><td>**Base case**</td><td>23,949</td><td>7,356</td><td>66,700</td><td>18,238</td></tr>
<tr><td>**E1**</td><td>-3.6%</td><td>-3.1%</td><td>-2.7%</td><td>-2.9%</td></tr>
<tr><td>**E2**</td><td>-2.8%</td><td>-4.2%</td><td>-1.8%</td><td>-3.9%</td></tr>
<tr><td>**E3**</td><td>-2.0%</td><td>-1.8%</td><td>-3.8%</td><td>-4.3%</td></tr>
<tr><td>**E4**</td><td>-15.1%</td><td>-24.5%</td><td>-6.7%</td><td>-13.9%</td></tr>
<tr><td>**E5**</td><td>-7.8%</td><td>-4.6%</td><td>-10.9%</td><td>-8.1%</td></tr>
<tr><td>**E6**</td><td>-3.4%</td><td>-2.8%</td><td>-1.3%</td><td>-1.3%</td></tr>
<tr><td>**E7**</td><td>-34.7%</td><td>-41.0%</td><td>-27.3%</td><td>-34.3%</td></tr>
</table>
Analysis
The most effective individual scenario in reducing NOx and PM10 emissions in Barcelona was E4, changing the 50% of light commercial vehicles, and E5 in Madrid, changing 10% of private cars. The overall combined scenario (E7) reduced NOx by 35% and 27% and PM10 by 41% and 34% in Barcelona and Madrid, respectively.</td><td>**Limitations identified by the author**
The available information about emission factors for new technology vehicles or alternative fuels is sparse.
Limitations identified by the review team
There are meteorological differences</td></tr>
</table>

Study details	Population	Intervention / Comparator	Method of analysis	Model results	Notes
2009 **Quality score** - **Aim of the study** To assess the impact on emissions of the introduction of Natural Gas as an alternative fuel in Barcelona and Madrid. **Source of data** Data on the vehicle fleet was provided for the year 2004 by data the national traffic management organisation of Spain **Location and setting** Madrid and Barcelona, Spain **Length of study** Emissions data was gathered on 1 day selected on the basis of a poor air	and 81% respectively). **Inclusion criteria** n/a **Exclusion criteria** n/a	• E7 combined scenario (when up to 26% of the vehicle fleet transformed in Barcelona and up to 23% in Madrid)			between the locations studied and the UK. **Other comments**

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr><td>quality episode and usual traffic circulation pattern (working days), in order to obtain representative results.

Source of funding
The work was funded by the projects CICYT CGL2006-08903 and CICYTCGL2006-11879 of the Spanish Ministry of Education and Science and CALIOPE project 441/2006/3-12.1 of the Spanish Ministry of the Environment.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Full citation
Soret, A., Guevara, M., Baldasano, J. M., The potential impacts of electric vehicles on air quality in the urban areas of</td><td>Number of participants
2 cities

Participant description
The total vehicle-kilometres-travelled are estimated as 13,462,321 (Barcelona) and</td><td>Intervention / Comparison
Three fleet electrification scenarios (low, medium and high levels of electrification) were compared with a Base Case scenario (the current situation in 2011 with no fleet electrification) for an air pollution episode (worse-case) that affected the Iberian Peninsula during 2011.
The 3 scenarios electrification were:
• Low: ~13 % electrification. VKT in electric drive mode (passenger cars (PCs), light duty vehicles (LDVs),</td><td>Type of model
The air quality impacts of fleet electrification were analysed using the Community Multiscale Air Quality (CMAQ) model. The meteorological fields for CMAQ were generated by the Weather Research and Forecasting (WRF)</td><td>Outcomes
Total emissions and corresponding change for each scenario relative to the base case scenario
<table>
<tr><th></th><th colspan="3">Barcelona</th><th colspan="3">Madrid</th></tr>
<tr><th>Scenario</th><th>NOx</th><th>PM10</th><th>PM2.5</th><th>NOx</th><th>PM10</th><th>PM2.5</th></tr>
<tr><td>Total Base Case scenario</td><td>31.42</td><td>3.06</td><td>2.50</td><td>41.27</td><td>5.89</td><td>4.66</td></tr>
<tr><td>Total Low scenario</td><td>30.30</td><td>3.02</td><td>2.46</td><td>38.90</td><td>5.83</td><td>4.59</td></tr>
<tr><td>Total Medium scenario</td><td>29.18</td><td>2.98</td><td>2.41</td><td>36.52</td><td>5.77</td><td>4.52</td></tr>
<tr><td>Total High scenario</td><td>28.06</td><td>2.95</td><td>2.37</td><td>34.13</td><td>5.71</td><td>4.45</td></tr>
</table></td><td>Limitations identified by the author
Not reported

Limitations identified by the review team
There are meteorologic</td></tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr>
<td>Barcelona and Madrid (Spain), Atmospheric Environment, 99, 51-63, 2014
Quality score
-

Aim of the study
To analyse the impact of fleet electrification on urban emissions in Barcelona and Madrid.

Source of data
Information by road stretches for traffic intensity (daily average traffic and average circulation speed) were obtained from a digitised traffic network from observation stations and real circulation data.

Location and setting
Barcelona and Madrid,</td>
<td>25,787,145 (Madrid).

Inclusion criteria
n/a

Exclusion criteria
n/a</td>
<td>buses, mopeds and motorcycles) are 9.7 and 9.1% in Barcelona and Madrid, respectively. The percentages in hybrid drive mode (PCs, LDVs and buses) are 3.6 and 4.3% in Barcelona and Madrid, respectively.
Medium: ~26% electrification. VKT in electric drive mode: 19.4 and 18.1%, and in hybrid drive mode: 7.1 and 8.6% in Barcelona and Madrid, respectively.
High: ~40% electrification. VKT in electric drive mode: 29.2 and 27.2%, and in hybrid drive mode: 10.6 and 12.9% in Barcelona and Madrid, respectively</td>
<td>meteorological model. The High Elective Resolution Emission Modelling System v2.0 (HERMESv2.0) provided the emissions for CMAQ.</td>
<td><table>
<tr><td>Δ Low - EB</td><td>-4%</td><td>-1%</td><td>-2%</td><td>-6%</td><td>-1%</td><td>-2%</td></tr>
<tr><td>Δ Medium - EB</td><td>-7%</td><td>-3%</td><td>-3%</td><td>-12%</td><td>-2%</td><td>-3%</td></tr>
<tr><td>Δ High - EB</td><td>-11%</td><td>-4%</td><td>-5%</td><td>-17%</td><td>-3%</td><td>-5%</td></tr>
</table>
Analysis
The results show that fleet electrification of approximately 40% (high scenario) led to reductions of 11% and 17% of the total NOx emissions in Barcelona and Madrid respectively. Only small changes were observed for PM10 and PM2.5 emissions.</td>
<td>al differences between the locations studied and the UK. The study period selected was a critical episode of air pollution affecting the entire Iberian Peninsula which would not be relevant to the UK.

Other comments</td>
</tr>
</table>

Study details	Population	Intervention / Comparator	Method of analysis	Model results	Notes
Spain **Length of study** **Source of funding** Grant SEV-2011-00067 of Severo Ochoa Program awarded by the Spanish Government.					

Question 3: Are interventions to develop routes and infrastructure to support low emission modes of transport cost effective at reducing the health impact of, or people's exposure to, traffic-related air pollution?

<table>
<tr><th>Study details</th><th>Inclusion / Exclusion criteria</th><th>Population</th><th>Intervention / Comparison</th><th>Method of analysis</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Full citation
Cohen, Joshua T., Diesel vs. compressed natural gas for school buses: a cost-effectiveness evaluation of alternative fuels, Energy Policy, 33, 1709-1722, 2005

Quality score
+

Study type
Health economics (comparative)

Aim of the study
To quantify the health damages, expressed in terms of lost quality adjusted life years (QALYs) and cost effectiveness of two alternative fuel school bus fleets

Location and setting
USA

Length of follow up
N/A

Source of funding
International Truck and Engine Corporation.</td>
<td>Inclusion criteria
Not reported

Exclusion criteria
Not reported</td>
<td>Number of participants
Not reported

Participant characteristics
School Buses
(CD) Conventional Diesel engines
(ECD) Emission controlled diesel (diesel buses equipped with continuously regenerating particle filters).
(CNG) Compressed natural gas (engines fueled by CNG)</td>
<td>Intervention / Comparison
Compare ECD and CNG fueled buses in terms of QALYs lost and cost effectiveness for school bus fleets against conventional diesel (CD)
''dense urban'', is based on the 95th percentile values for population density (1600/km^2), annual distance traveled (38,000 km/bus), and number of large buses (1428). This scenario assumes that heavy land use makes land acquisition for new infrastructure ''expensive''<br>''moderate urban'', is based on median values, including a population density of approximately 400/km^2, annual distance traveled of 23,000 km/bus, and 455 large buses.
This analysis assumes that moderate land use makes</td>
<td>Method of analysis
Cost-effectiveness ratio (CE_{alt}). That ratio is defined to be ($Cost_{alt}$ - $Cost_{CD}$) / ($QALYs_{CD}$ - $QALYs_{alt}$); where quality adjusted life years (QALYs) is a measure of health damages, including reductions in longevity and impaired health status.
(alt indicates alternative fuel, CD indicates Conventional Diesel)</td>
<td>Primary outcomes

Central estimate cost-effectiveness ratios
<table>
<tr><th>Scenario</th><th>Cost-effectiveness of ECD ($/QALY)</th><th>Cost-effectiveness of CNG ($/QALY)</th></tr>
<tr><td>Dense urban</td><td>$450,000</td><td>$4,200,000</td></tr>
<tr><td>Moderate urban</td><td>$640,000</td><td>$3,600,000</td></tr>
<tr><td>Small system</td><td>$900,000</td><td>$4,000,000</td></tr>
</table>
ECD and CNG produce very similar reductions in health damages compared to Conventional Diesel (CD) engines. However, ECD is far more cost effective($400,000–900,000 cost per QALY saved) than CNG (around $4 million per QALY saved).</td>
<td>Limitations identified by author
The model used makes a series of simplifying assumptions and because emissions data and cost data for school buses are very limited the results are uncertain</td>
</tr>
</table>

Study details	Inclusion / Exclusion criteria	Population	Intervention / Comparison	Method of analysis	Results	Notes
			land acquisition for infrastructure ‘‘inexpensive’’ "small system", is based on the characteristics of Kenton, Ohio (20 buses, of which 15 are used daily. Total daily bus travel amounts to 1400km. Total annual travel for the fleet amounts to 250,000 km. Averaged over all 20 buses, this distance amounts to around 13,000km/bus each year. Population density, 26/km^2.			
Full citation Cohen, J. T., Hammitt, J. K., Levy, J. I., Fuels for urban transit buses: A cost-effectiveness analysis, Environmental Science & Technology, 37, 1477-84 **Quality score** + **Study type** Health Economics (comparative) **Aim of the study** To compare the	**Inclusion criteria** Not reported **Exclusion criteria** Not reported	**Number of participants** Not reported **Participant characteristics** Urban Transit Bus fleet (CD) Conventional Diesel engines (ECD) Emission controlled diesel (diesel buses equipped with continuously regenerating particle filters). (CNG) Compressed natural gas (engines fueled by CNG)	**Intervention / Comparison** Compare ECD and CNG fueled buses in terms of QALYs annually per 1000 buses and cost-effectiveness, in terms of $ per QALY), for urban fleets against conventional diesel (CD)	**Method of analysis** Cost-effectiveness ratio (CE_{alt}). That ratio is defined to be ($Cost_{alt}$ - $Cost_{CD}$) / ($QALYs_{CD}$ - $QALYs_{alt}$); where quality adjusted life years (QALYs) is a measure of health damages , including reductions in longevity and impaired health status. (**alt** indicates alternative fuel, **CD** indicates Conventional Diesel)	**Primary outcomes** CNG provides larger health benefits (nine QALYs per 1000 buses) than ECD (six QALYs per 1000 buses). However, ECD ($270,000 per QALY) is more cost-effective than CNG ($1.7 million to 2.4 million per QALY)	**Limitations identified by author** The estimates are subject to much uncertainty: emissions data limited to small data set made on buses **Limitations identified by review team** Analysis based on a hypothetical transit district using estimated relationships between exposure and QALY lost

Study details	Inclusion / Exclusion criteria	Population	Intervention / Comparison	Method of analysis	Results	Notes
cost effectiveness of two alternative fuel systems to conventional diesel in urban transit buses **Location and setting** USA **Length of follow up** N/A **Source of funding** International Truck and Engine Corporation						
Full citation Krutilla, Kerry, Graham, John D., Are Green Vehicles Worth the Extra Cost? The Case of Diesel-Electric Hybrid Technology for Urban Delivery Vehicles, Journal of Policy Analysis and Management, 31, 501-32, 2012 **Quality score** + **Study type** Cost-benefit **Aim of the study** To determine the incremental costs and benefits of diesel-electric hybrid vehicles	**Inclusion criteria** Not reported **Exclusion criteria** Not reported	**Number of participants** N/A **Participant characteristics** Hybrid technology used to propel urban pick up and delivery vehicles, often referred to as PUADs.	**Intervention / Comparison** Comparing the economic and fiscal effects of promoting diesel-electric hybrid technology in urban delivery vehicles at different percentage discount rates	**Method of analysis** An economic model is used to simulate the net present values (NPVs) of diesel-electric hybrid PUADs annually from 2012 to 2030	**Primary outcomes** Promoting the technology does not lead to positive expected EHNPVs (Event-horizon net present values) at a 7 percent discount rate under a significant range of assumptions about the probability of higher or lower fuel prices, more or less rapid technology cost decline, or more or less rapid improvements in relative fuel economy. However, evaluated at a 3 percent societal discount rate, expected EHNPVs are positive in five out of eight simulations. Thus, promoting diesel-electric hybrids seems reasonably likely to yield positive economic net benefits from a societal perspective. The fiscal impact of promoting hybrids at a 3 percent discount rate was shown to be significant in 5 of the model scenarios. The total fiscal effect varies between –$4,983 and –$12,156 on an annualized per-truck basis. These figures include both the net effect on tax receipts and the financing required to cover the losses of transportation firms purchasing the hybrid technology.	**Limitations identified by author** The results of the study are based on standard technology and data averages (e.g. a reference hybrid model with an assumed driving cycle, average tax rates and fuel prices. Different PUAD applications involving more or less driving, or geographic variation in tax rates and fuel prices, could yield more or less favourable economic and fiscal effects.

Study details	Inclusion / Exclusion criteria	Population	Intervention / Comparison	Method of analysis	Results	Notes
Location and setting USA **Length of follow up** Not reported **Source of funding** Navistar International Inc.						

Question 4: Are measures to promote absorption, adsorption or impingement deposition, and catalytic action effective at reducing the health impact of, or people’s exposure to, traffic-related air pollution?

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Full citation
Al-Dabbous, A. N., Kumar, P., The influence of roadside vegetation barriers on airborne nanoparticles and pedestrians exposure under varying wind conditions, Atmospheric Environment, 90, 113-124, 2014
Quality score
-

Study type
Controlled study

Aim of the study
To determine the effect of roadside vegetation on particulate exposure for pedestrians under different wind directions

Location and setting
A busy roadside in Guildford, UK

Length of study
6 days

Source of funding
Kuwait Institute for Scientific Research (KISR) for the PhD fellowship.</td>
<td>Number of participants
N/A

Participant characteristics
2.20 m wide vegetation barrier consisting of coniferous plants in one straight line around 0.30 m from the road.
Height of vegetation was around 3.40 m (sampling height 1.60 m above ground level and 0.3 m above street level)
Openings within the barrier were provided naturally by the space between tree leaves and branches.

Inclusion criteria
Not reported

Exclusion criteria
Not reported</td>
<td>Intervention / Comparison
The effect of a roadside vegetation barrier was examined on particle number concentration (PNC). The barrier consisted of many convergent trees situated in one straight line. Four measuring sites were used:
• L1 was in a vegetation-free point parallel to the front of the barrier
• L2 was parallel to L1 at the front of the vegetation
• L3 and L4 were in the middle and back of the barrier respectively.</td>
<td>Outcomes

Summary of average PNC at various sampling locations during different wind directions; the “±”sign shows the standard deviation values
<table>
<tr><th></th><th></th><th></th><th colspan="4">Sampling locations</th></tr>
<tr><th>Wind Sector</th><th>Wind description</th><th>PNC (cm-3)</th><th>L_1</th><th>L_2</th><th>L_3</th><th>L_4</th></tr>
<tr><td rowspan="7">NW-SW</td><td rowspan="7">Cross-road</td><td>N_{5-560}</td><td>1.78 ± 1.64 x 10^5</td><td>1.99 ± 1.77 x 10^5</td><td>1.71 ± 1.70 x 10^5</td><td>1.25 ± 1.02 x 10^5</td></tr>
<tr><td>N_{5-30}</td><td>1.02 x 10^5</td><td>1.11 x 10^5</td><td>9.82 x 10^4</td><td>7.22 x 10^4</td></tr>
<tr><td>N_{30-100}</td><td>5.42 x 10^4</td><td>6.30 x 10^4</td><td>5.20 x 10^4</td><td>3.73 x 10^4</td></tr>
<tr><td>$N_{100-300}$</td><td>2.12 x 10^4</td><td>2.50 x 10^4</td><td>2.07 x 10^4</td><td>1.50 x 10^4</td></tr>
<tr><td>$N_{300-560}$</td><td>0.04</td><td>5.64</td><td>0.33</td><td>0.04</td></tr>
<tr><td>Max</td><td>2.04 x 10^6</td><td>4.05 x 10^6</td><td>2.27 x 10^6</td><td>9.74 x 10^5</td></tr>
<tr><td>Min</td><td>7.40 x 10^3</td><td>1.54 x 10^4</td><td>8.95 x 10^3</td><td>5.28 x 10^3</td></tr>
<tr><td rowspan="7">NE-SE</td><td rowspan="7">Cross foot-path</td><td>N_{5-560}</td><td>6.17 ± 2.58 x 104</td><td>6.26 ± 3.31 x 104</td><td>1.80 ± 1.01 x 104</td><td>1.46 ± 0.91 104</td></tr>
<tr><td>N_{5-30}</td><td>5.09 x 10^4</td><td>5.36 x 10^4</td><td>1.26 x 10^4</td><td>9.89 x 10^3</td></tr>
<tr><td>N_{30-100}</td><td>8.50 x 10^3</td><td>7.06 x 10^3</td><td>4.06 x 10^3</td><td>3.46 x 10^3</td></tr>
<tr><td>$N_{100-300}$</td><td>2.22 x 10^3</td><td>1.94 x 10^3</td><td>1.33 x 10^3</td><td>1.21 x 10^3</td></tr>
<tr><td>$N_{300-560}$</td><td>4.75</td><td>5.71</td><td>6.41</td><td>5.11</td></tr>
<tr><td>Max</td><td>1.28 x 10^6</td><td>3.25 x 10^6</td><td>2.82 x 10^5</td><td>1.28 x 10^5</td></tr>
<tr><td>Min</td><td>3.24 x 10^3</td><td>3.48 x 10^3</td><td>5.39 x 10^3</td><td>1.39 x 10^3</td></tr>
<tr><td rowspan="7">NW-NE</td><td rowspan="7">Along-road</td><td>N_{5-560}</td><td>1.94 ± 0.25 x 10^5</td><td>1.95 ± 0.60 x 10^5</td><td>6.10 x 10^4</td><td>8.89 ± 4.24 x 10^4</td></tr>
<tr><td>N_{5-30}</td><td>1.68 x 10^5</td><td>1.71 x 10^5</td><td>4.58 x 10^4</td><td>7.67 x 10^4</td></tr>
<tr><td>N_{30-100}</td><td>2.12 x 10^4</td><td>1.97 x 10^4</td><td>1.15 x 10^4</td><td>9.52 x 10^3</td></tr>
<tr><td>$N_{100-300}$</td><td>5.31 x 10^3</td><td>4.67 x 10^3</td><td>3.71 x 10^4</td><td>2.68 x 10^3</td></tr>
<tr><td>$N_{300-560}$</td><td>7.73</td><td>8.98</td><td>27.15</td><td>12.29</td></tr>
<tr><td>Min</td><td>2.37 x 10^6</td><td>4.46 x 10^6</td><td>4.44 x 10^5</td><td>8.75 x 10^5</td></tr>
<tr><td>Max</td><td>9.08 x 10^3</td><td>9.60 x 10^3</td><td>1.06 x 10^4</td><td>8.28 x 10^3</td></tr>
</table>
Sampling locations: L_1 = sited in gap between row of vegetation (0.3m from road), L_2 = front of vegetation (0.3m from road), L_3 = middle of vegetation (1.1m from road) and L_4 = back of vegetation (2.2m from road)
PNC data are divided into four size ranges: 5-30 nm (N_{5-30}; nucleation mode), 30-</td>
<td>Limitations identified by the author
Security issues as well as practical constraints, such as the access to power supply at the site, only allowed the authors to make intermittent measurements during the day times.

Limitations identified by the review team
No standard deviation for L_3 (along-road wind) N_{5-560} levels published.</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr><td></td><td></td><td></td><td>100 nm (N_{30-100}; Aitken mode), 100-300 nm ($N_{100-300}$; accumulation mode) and 300-560 nm ($N_{300-560}$; coarse mode).

Analysis
The total PNCs at the sampling locations L_2, L_3 and L_4 were found to decrease gradually with the increasing distance from the edge of the road through the vegetation barrier.
Comparison of the PNCs at two parallel locations (with and without the vegetation barrier) showed approximately 11% higher PNCs at L_2 than those at L_1 during cross-road winds. Such differences were insignificant during the remaining wind directions.
For cross-road winds, the PNCs were decreased by 14 and 37% at L_3 and L_4, respectively, compared with L_2.
For cross-footpath winds a decrease in PNCs were seen at L_3 and L_4 compared with L_2.
The PNCs at these locations showed modest differences during the cross-footpath and along-road winds.</td><td></td></tr>
<tr><td>Full citation
Amato, Fulvio, Karanasiou, Angeliki, Cordoba, Patricia, Alastuey, Andres, Moreno, Teresa, Lucarelli, Franco, Nava, Silvia, Calzolai, Giulia, Querol, Xavier, Effects of road dust suppressants on PM levels in a Mediterranean urban area, Environmental Science & Technology, 48, 8069-77, 2014

Quality score
-

Study type
Controlled before and after

Aim of the study</td><td>Number of participants
N/A

Participant characteristics
2.5 km of trafficked road with homogeneous traffic flow, seven store building height and 4000 vehicles/day. Traffic on the road is in one direction heading north east and distributed over 3 lanes, with the right hand lane exclusively for buses and taxis and an additional parking lane on the left side.

Inclusion criteria
Other requirements were related to orientation of the road (parallel to the coastline) and no cycle lanes present.

Exclusion criteria
Not reported</td><td>Intervention / Comparison
The test road was treated in 3 phases:
Phase 1: 25% CMA aqueous solution was spread on a 1400m stretch on 3 consecutive mornings.
Phase 2: 25% CMA aqueous solution was spread on a 2300m stretch on 7 mornings over a 2 week period 4 days after the last stage of Phase 1.
Phase 3: 20% $MgCl_2.6H_2O$ aqueous solution was spread on a 2300m stretch on 2 mornings 8 days after the last stage of Phase 2.
The calendar for suppressant application was based on the weather forecast (no rain, temperature above 0^{o}c) and to maximize effectiveness</td><td>Outcomes

Average and ratio (compared to control) of PM_{10} concentrations (µg/m^3)
<table>
<tr><th></th><th colspan="2">Before CMA</th><th colspan="2">Phase 1: CMA (1400m)</th><th colspan="2">Phase 2: CMA (2300m)</th><th colspan="2">Phase 3: $MgCl_2$ (2300m)</th></tr>
<tr><td>Sample point</td><td>Mean (SD)</td><td>Ratio</td><td>Mean (SD)</td><td>Ratio</td><td>Mean (SD)</td><td>Ratio</td><td>Mean (SD)</td><td>Ratio</td></tr>
<tr><td>I3</td><td>28 (3)</td><td>1.3 (0.1)</td><td>43 (3)</td><td>-</td><td>35 (7)</td><td>1.1 (0.2)</td><td>27 (-)</td><td>1.3 (-)</td></tr>
<tr><td>I2</td><td>32 (3)</td><td>1.1 (0.1)</td><td>n/a</td><td>n/a</td><td>36 (3)</td><td>1.1 (0.1)</td><td>31 (4)</td><td>1.1 (0.1)</td></tr>
<tr><td>I1</td><td>28 (4)</td><td>1.3 (0.2)</td><td>42 (1)</td><td>1.1 (0.1)</td><td>34 (3)</td><td>1.2 (0.1)</td><td>24 (1)</td><td>1.5 (0.1)</td></tr>
<tr><td>Control (V)</td><td>36 (4)</td><td>n/a</td><td>46 (5)</td><td>n/a</td><td>39 (3)</td><td>n/a</td><td>36 (1)</td><td>n/a</td></tr>
<tr><td>Urban Background (UB)</td><td>24 (4)</td><td>n/a</td><td>31 (2)</td><td>n/a</td><td>30 (7)</td><td>n/a</td><td>23 (6)</td><td>n/a</td></tr>
</table>
Average and ratio (compared to control) of $PM_{2.5-10}$ concentrations (µg/m^3)
<table>
<tr><th></th><th colspan="2">Before CMA</th><th colspan="2">Phase 1: CMA (1400m)</th><th colspan="2">Phase 2: CMA (2300m)</th><th colspan="2">Phase 3: $MgCl_2$ (2300m)</th></tr>
<tr><td>Sample point</td><td>Mean (SD)</td><td>Ratio</td><td>Mean (SD)</td><td>Ratio</td><td>Mean (SD)</td><td>Ratio</td><td>Mean (SD)</td><td>Ratio</td></tr>
<tr><td>I2</td><td>12 (2)</td><td>1.6 (0.4)</td><td>-</td><td>n/a</td><td>9 (2)</td><td>1.0 (0.3)</td><td>9 (3)</td><td>1.0 (0.5)</td></tr>
</table></td><td>Limitations identified by the author
No results obtained

Limitations identified by the review team
Intersections and pedestrian crossings were not treated with suppressant.
For traffic safety, a number of measures were taken including change of speed limit signals on the treated roads from 50 to 30 km/h. This could have impacted on the results of the study.</td></tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>To evaluate the effectiveness of dust suppressants in reducing road dust emissions in a Mediterranean city.

Location and setting
2.5km of trafficked road in a commercial district in Barcelona, Spain

Length of study
2 months

Source of funding
AIRUSE LIFE+ ENV/ES/584 project.
Spanish Ministry of Sciences and Innovation.
City Hall of Barcelona
Generalitat de Catalunya and AGAUR</td>
<td></td>
<td>during the most polluted hours, solutions were spread between 5 and 9am.
Three sampling sites (I1, I2, and I3) were positioned along the test road where concentrations of PM_{10} and $PM_{2.5-10}$ were measured.
During phase 1, only stations I1 and I2 were inside the section of road treated; during phase 2 and 3, all stations were inside the section treated.

Comparator
Two sites served as control:
• A kerbside sampling site was installed on a parallel untreated road (11000 vehicles/day) at a perpendicular distance of 650m from the test road.
• An urban background (UB) monitoring station was located 5.5km from the test road.</td>
<td>
<table>
<tr><td>Control (V)</td><td>12 (2)</td><td>n/a</td><td>16 (6)</td><td>n/a</td><td>9 (4)</td><td>n/a</td><td>9 (7)</td><td>n/a</td></tr>
<tr><td>Urban Background (UB)</td><td>12 (3)</td><td>1.1 (0.3)</td><td>15 (3)</td><td>n/a</td><td>12 (5)</td><td>1.3 (0.4)</td><td>13 (7)</td><td>1.5 (0.4)</td></tr>
</table>
Analysis
Phase 1: There was no decrease in PM_{10} or $PM_{2.5-10}$ concentrations seen at any of the intervention sites when compared to the control.

Phase 2: PM_{10} concentrations after the intervention did not decrease at sites I1 and I3. There was a decrease in both PM_{10} and $PM_{2.5-10}$ concentrations at site I2 but only in relation to the UB site and these decreases were not statistically significant ($p>0.05$).

Phase 3: Concentrations of PM_{10} did not decrease at sites I2 and I3 but there was a decrease at site I1. Additionally, the concentration of $PM_{2.5-10}$ decreased at site I2 but only in relation to the UB site and this was not statistically significant ($p>0.05$).

The results indicated that there was no significant reduction in PM as a result of the interventions.</td>
<td>There was a difference in the number of vehicles travelling on the intervention and control roads per day - control road had 11000 vehicles/day travelling on it, whereas the test road had 4000 vehicles/day. Phase 1 corresponded with construction work nearby and a Saharan dust event which raised PM levels and may have affected the efficacy of CMA.

Other comments
In addition to road traffic (the main source of PM in Barcelona), other local and regional sources of air pollution have been identified in the area.</td>
</tr>
<tr>
<td>Full citation
Amato, F., Querol, X., Alastuey, A., Pandolfi, M., Moreno, T., Gracia, J., Rodriguez, P.,</td>
<td>Number of participants
N/A

Participant characteristics
Main 19 m wide, 5 lane city centre road (mean traffic flow of 19,000</td>
<td>Intervention / Comparison
Street washing with water was carried out 8 times on a 500 m section of the test road, additionally for the last 3 washings, a mechanical</td>
<td>Outcomes

Mean concentrations of PM_{10} at both measurement sites
<table>
<tr><th>Measurement site</th><th colspan="2">PM_{10} ($\mu g/m^3$)</th></tr>
<tr><td></td><td>Days with street wash</td><td>Days without street wash</td></tr>
</table></td>
<td>Limitations identified by the author

Limitations identified by</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Evaluating urban PM10 pollution benefit induced by street cleaning activities, Atmospheric Environment, 43, 4472-4480, 2009

Quality score
-

Study type
Controlled trial

Aim of the study
To determine the effect of mechanical sweeping/water flushing of roads on ambient PM$_{10}$ concentrations.

Location and setting
A commercial and residential street in Barcelona, Spain

Length of study
4 weeks

Source of funding
Spanish Ministry of Environment and the Spanish Ministry of Education and Sciences</td>
<td>vehicles/day). 1 lane reserved for parking lots and 1 was a bus lane. Building height varies from 6-7 storeys.

Inclusion criteria
Site selection was due to the fact that traffic flow is unidirectional, parallel to the coast and fairly constant across the whole road.

Exclusion criteria
Not reported</td>
<td>sweeper was also used. Two sampling stations were installed, 1 within the street washing section and one outside of the section.
2 mobile laboratories were installed in two different sites of the road at a distance of approximately 1200m from each other. The first one (DO-W), was installed in a downwind position with respect to the second one (UP-W). PM$_{10}$ concentrations were continuously measured at both sites.

Comparator
No street washing or mechanical sweeping.</td>
<td><table>
<tr><td>Section without street washing (DO-W)</td><td>44.4</td><td>53.2</td></tr>
<tr><td>Section with street washing (UP-W)</td><td>50.3</td><td>54.0</td></tr>
</table>
Average daily concentrations of PM$_{10}$
The average daily concentration of PM$_{10}$ during street washing days decreased 8.8 µg mg^3 at the downwind measurement site with respect to days without street washing. The decrease was only 3.7 µg mg^3 at the upwind measurement site.
An analysis of meteorological variables found that at two of the background monitoring sites there was a decrease of between 3.7 and 4.9 µg mg^3 during street washing days.

Analysis
There was a decrease in mean PM$_{10}$ concentration at both sampling sites on the days where street washing had taken place. Average daily concentration of PM$_{10}$ during street washing days decreased by 8.8 µg mg^3 at the downwind site and 3.7 µg mg^3 at the upwind site. Taking into account a regional daily decrease in PM$_{10}$ concentrations, it was concluded that there was an effective decrease of 4–5 µg mg^3 (7–10%) of kerbside PM$_{10}$ concentrations induced by street washing activities in the 24h after the treatment.</td>
<td>the review team
Mechanical sweeping was not undertaken for all study days.
The intervention (8 washes) was spaced irregularly over a 4 week period and were not always undertaken on concurrent days.

Other comments</td>
</tr>
<tr>
<td>Full citation
Baldauf, R.W. Isakov, V.. Deshmukh, P Venkatram, A. Yang, B. Zhang K.M. Influence of</td>
<td>Number of participants
2 segments of highway

Participant characteristics
One segment was located on the west side and 1 segment on the east side of the highway within 1 km from one</td>
<td>Intervention / Comparison
Concentrations of NO$_2$, ultrafine particles (UFPs), and black carbon (BC) were measured using a mobile platform and fixed sites along two limited access</td>
<td>Outcomes

Median and mean reduction in near-road pollutant concentrations measured under all meteorological and temporal conditions<table>
<tr><th>Pollutant</th><th>Sampling section</th><th>Distance range (m)</th><th>Median reduction (%)</th><th>Mean reduction (%)</th></tr>
</table></td>
<td>Limitations identified by the author
Not reported.

Limitations identified by</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>solid noise barriers on near-road and on-road air quality. Atmospheric Environment 129 (2016) 265-276.
Quality score
-
Study type
Non-randomised controlled trial
Aim of the study
To assess the impact of noise barriers on both on-road and downwind pollutant concentrations.
Location and setting
A large highway in Phoenix, Arizona, USA.
Length of study
1 month (October – November 2013)
Source of funding
U.S. Environmental Protection Agency</td>
<td>another.
Each segment was approximately 2km in length and 500m in width and primarily residential.
The noise barriers were approximately 4.5m in height, less than 1m thick, approximately 3m from the nearest travel lane, and had an access road immediately behind the wall.
Inclusion criteria
Not reported
Exclusion criteria
Not reported</td>
<td>stretches of highway that contained a section of noise barrier and a section with no noise barrier.
The choice of monitoring either the east or west segment each day was based on predicted wind directions for the sampling period.
22 valid sampling periods were collected during the study. The majority (18) of the sampling occurred along the western section of the highway to capture downwind pollutant concentrations during wind events from the east, which typically occurred between 9:00am and 12:00pm. The remaining sampling periods (4) occurred along the eastern section of the highway, typically during the afternoon hours of 2:00pm to 5:00pm.</td>
<td>
<table>
<tr><td>**NO_2**</td><td>**East**</td><td>**0-50**</td><td>**37**</td><td>**37**</td></tr>
<tr><td></td><td></td><td>**50-150**</td><td>**41**</td><td>**39**</td></tr>
<tr><td></td><td></td><td>**150-300**</td><td>**33**</td><td>**28**</td></tr>
<tr><td></td><td>**West**</td><td>**0-50**</td><td>**34**</td><td>**34**</td></tr>
<tr><td></td><td></td><td>**50-150**</td><td>**20**</td><td>**17**</td></tr>
<tr><td></td><td></td><td>**150-300**</td><td>**19**</td><td>**11**</td></tr>
<tr><td>**BC**</td><td>**East**</td><td>**0-50**</td><td>**53**</td><td>**43**</td></tr>
<tr><td></td><td></td><td>**50-150**</td><td>**63**</td><td>**49**</td></tr>
<tr><td></td><td></td><td>**150-300**</td><td>**26**</td><td>**18**</td></tr>
<tr><td></td><td>**West**</td><td>**0-50**</td><td>**57**</td><td>**48**</td></tr>
<tr><td></td><td></td><td>**50-150**</td><td>**55**</td><td>**30**</td></tr>
<tr><td></td><td></td><td>**150-300**</td><td>**37**</td><td>**24**</td></tr>
<tr><td>**UFP**</td><td>**East**</td><td>**0-50**</td><td>**48**</td><td>**50**</td></tr>
<tr><td></td><td></td><td>**50-150**</td><td>**34**</td><td>**44**</td></tr>
<tr><td></td><td></td><td>**150-300**</td><td>**16**</td><td>**15**</td></tr>
<tr><td></td><td>**West**</td><td>**0-50**</td><td>**54**</td><td>**66**</td></tr>
<tr><td></td><td></td><td>**50-150**</td><td>**27**</td><td>**31**</td></tr>
<tr><td></td><td></td><td>**150-300**</td><td>**12**</td><td>**23**</td></tr>
</table>
Analysis
The table shows the median and mean reduction in near-road pollutant concentrations by distance range. The calculations represent the reductions for all data collected in each distance range as compared to the previous distance range closer to the road (e.g. the reduction in the 0-50m range represents the difference between the on-road and 0-50m measurements).
In general, the greatest reductions in pollutant concentrations were seen nearest to the barrier (between on-road and 0-50m measurements).</td>
<td>**the review team**
There were potential differences in vehicle volumes at different parts of the highway sections and adjacent access roads which could affect results.</td>
</tr>
<tr>
<td>**Full citation**
Brantley, H. L., Hagler, G. S. W., J. Deshmukh P, Baldauf, R. W., Field assessment of the effects of roadside vegetation on near-road black carbon and particulate matter, Science of</td>
<td>**Number of participants**
N/A
Participant characteristics
An area of vegetation barrier adjacent to an area without any obstructions to air flow along the same stretch of limited-access highway. Both the clearing and the tree stand were separated from the highway by a bike lane. The tree stand ranged from</td>
<td>**Intervention / Comparison**
The study assessed the effects of an existing, mixed-species tree barrier on near-road black carbon (BC) and particulate matter concentrations.
Measurements of BC were taken at two sites using portable samplers</td>
<td>**Outcomes**
Summary statistics of Black Carbon (µg m^{-3}) by wind category
<table>
<tr><th>Wind category*</th><th>N</th><th>Mean concentration (Clearing)</th><th>95% CI</th><th>Mean concentration (Tree barrier)</th><th>95% CI</th><th>% difference</th></tr>
<tr><td>Low speed</td><td>1201</td><td>1.27</td><td>1.23-1.31</td><td>1.20</td><td>1.16-1.24</td><td>-5.9% (NS)</td></tr>
<tr><td>Downwind</td><td>2762</td><td>1.70</td><td>1.66-1.74</td><td>1.49</td><td>1.46-1.53</td><td>-12.4% (S)</td></tr>
<tr><td>Parallel</td><td>1598</td><td>0.93</td><td>0.89-0.96</td><td>0.85</td><td>0.83-0.88</td><td>-7.8% (S)</td></tr>
</table></td>
<td>**Limitations identified by the author**
None reported
Limitations identified by the review team
Background concentrations</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>the total environment, 468-469, 120-129, 2013

Quality score
-

Study type
Controlled trial

Aim of the study
To determine the effects of a vegetation barrier on near-road black carbon (BC) and particulate matter concentrations.

Location and setting
Roadside area adjacent to a six-lane highway in Detroit, Michigan, USA

Length of study
28 days

Source of funding
Not reported</td>
<td>approximately 5–78 min width at the locations where sampling occurred, and consisted primarily of maple and oak trees extending to 10 min height with underbrush creating a barrier from ground-level to the top of the tree canopy.

Inclusion criteria
High roadway traffic volume and the avoidance of other known confounding emission sources.

Exclusion criteria
Not reported</td>
<td>during May and June 2011 for a total of 28 days:
1. Site 1 was at a clearing approximately 30 m from the highway, without any obstructions to air flow between the highway and the sampler or within 15 m in all other directions. The site was approximately 40 m from the beginning of the vegetative barrier section.
2. Site 2 was approximately 340 m north, at an equal distance from the highway and behind an approximately 15 m thick tree barrier with a measured leaf area index (LIA) of 3.9</td>
<td>
<table>
<tr><td>Upwind</td><td>1863</td><td>0.69</td><td>0.66-0.71</td><td>0.64</td><td>0.62-0.67</td><td>-6.0%
(NS)</td></tr>
</table>
* Direction is relative to highway.
NS — not significant difference, 95% confidence intervals overlapped.
S — significant difference, 95% confidence intervals did not overlap.

Summary statistics for $PM_{0.5-2.0}$
<table>
<tr><th>Wind category*</th><th>N</th><th>Mean concentration (Clearing)</th><th>95% CI</th><th>Mean concentration (Tree barrier)</th><th>95% CI</th><th>% difference</th></tr>
<tr><td>Low speed</td><td>1440</td><td>158</td><td>150-167</td><td>156</td><td>148-165</td><td>-1.1%(NS)</td></tr>
<tr><td>Downwind</td><td>3326</td><td>155</td><td>151-160</td><td>151</td><td>147-156</td><td>-2.5%(NS)</td></tr>
<tr><td>Parallel</td><td>2468</td><td>76</td><td>72-80</td><td>76</td><td>72-80</td><td>-0.1%(NS)</td></tr>
<tr><td>Upwind</td><td>2476</td><td>86</td><td>82-90</td><td>89</td><td>85-93</td><td>4/3%(NS)</td></tr>
</table>
Summary statistics for $PM_{2.0-10.0}$
<table>
<tr><th>Wind category*</th><th>N</th><th>Mean concentration (Clearing)</th><th>95% CI</th><th>Mean concentration (Tree barrier)</th><th>95% CI</th><th>% difference</th></tr>
<tr><td>Low speed</td><td>1440</td><td>9.2</td><td>8.9-9.6</td><td>8.6</td><td>8.3-9</td><td>-6.7%(NS)</td></tr>
<tr><td>Downwind</td><td>3326</td><td>8.9</td><td>8.7-9.1</td><td>8.9</td><td>8.7-9.1</td><td>0.3%(MS)</td></tr>
<tr><td>Parallel</td><td>2468</td><td>5.5</td><td>5.3-5.6</td><td>5.7</td><td>5.5-5.9</td><td>4.4%(NS)</td></tr>
<tr><td>Upwind</td><td>2476</td><td>5.7</td><td>5.5-5.8</td><td>6.1</td><td>5.9-6.3</td><td>8.2%(S)</td></tr>
</table>

Analysis
The sampling showed statistically significant reductions in Black Carbon behind the barrier, relative to a clearing, during downwind (12.4% lower) and parallel (7.8% lower) wind conditions. No difference between the vegetation site and the clearing site was observed during up wind or low speed wind conditions. During upwind conditions, $PM_{2.0-10}$ levels were 8.2% higher behind the vegetation barrier, suggesting a contribution from sources on the golf course side.
</td>
<td>of black carbon were not recorded which could have impacted on the reductions reported in the paper.</td>
</tr>
<tr>
<td>Full citation
Gillies, J. A., Watson, J. G., Rogers, C. F., DuBois, D., Chow, J. C., Langston, R., Sweet, J., Long-term efficiencies of dust suppressants to reduce PM10 emissions from</td>
<td>Number of participants
N/A

Participant characteristics
The road for the test site was chosen because it possessed a straight length of 3 km, an east-west direction so the dominant valley winds would be perpendicular to the road, and relatively level topography. It also had moderate traffic from light-duty</td>
<td>Intervention / Comparison
The following dust suppressants were tested:
1. EMC^2 (a biocatalyst stabiliser – BS) 2. Soil Sement (a polymer emulsuion – PE) 3. Coherex (petroleum with emulsion – PEP) 4. NHCO (non-hazardous crude oil containing material).</td>
<td>Outcomes

Average PM_{10} emission factors at 40 km/hr and 55 km/hr for each test during the three intensive monitoring periods.
<table>
<tr><th></th><th></th><th colspan="5">Average Emissions Factors (g-PM_{10} / VKT) with Standard deviations (SD)</th></tr>
<tr><th>Test period</th><th>Vehicle speed (km/hr)</th><th>Untreated</th><th>EMC^2 (BS)</th><th>Coherex (PEP)</th><th>Soil Sement (PE)</th><th>NHCO</th></tr>
<tr><td>1</td><td>40</td><td>566 (204)</td><td>352 (152)</td><td>4 (6)</td><td>44 (38)</td><td>N/A</td></tr>
</table>
</td>
<td>Limitations identified by the author
None reported

Limitations identified by the review team
It is not reported why the NHCO</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>unpaved roads, Journal of the Air and Waste Management Association, 49, 3-16, 1999

Quality score
-

Study type
Controlled trial

Aim of the study
To determine the long term efficiency of four dust suppressants to reduce the emission of PM_{10} from unpaved roads

Location and setting
An unpaved road in California, USA

Length of study
12 months

Source of funding
San Joaquin Valley Unified Air Pollution Control District with Department of Motor Vehicle surcharge fees through the Districts REduce MOtor Vehicle Emissions (REMOVE) program and the Western States Petroleum Association</td>
<td>vehicles.

Inclusion criteria
Not reported

Exclusion criteria
Not reported</td>
<td>One test section approximately 500 m in length on a standard unpaved road was assigned to each suppressant and each was applied according to their standard procedures.

PM_{10} emissions from the test sections were created by a 3/4-ton pick-up truck traveling back and forth along the roadway for 100 passes over each six-hour sampling interval. Constant vehicle speeds of 40 km/hr and 55 km/hr were maintained and alternated from day to day. PM_{10} was measured at each test section. Emission tests were conducted on 6 consecutive days in July 1995, October 1995 and June 1996.

Comparator
A section of untreated road.</td>
<td>
<table>
<tr><td></td><td>55</td><td>754 (353)</td><td>460 (60)</td><td>9 (10)</td><td>23 (31)</td><td>N/A</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>40</td><td>382 (85)</td><td>434 (36)</td><td>123 (5)</td><td>22 (10)</td><td>N/A</td></tr>
<tr><td></td><td>55</td><td>857 (868)</td><td>596 (464)</td><td>151 (122)</td><td>0.5 (1)</td><td>N/A</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>40</td><td>167 (39)</td><td>184 (57)</td><td>75 (10)</td><td>20 (4)</td><td>17 (14)</td></tr>
<tr><td></td><td>55</td><td>522 (226)</td><td>861 (441)</td><td>290 (123)</td><td>78 (8)</td><td>31 (29)</td></tr>
</table>

Average PM_{10} suppression efficiencies for each test during three intensive monitoring periods.
<table>
<tr><th></th><th></th><th colspan="4">Suppressant Efficiency (%) with Standard deviations (SD)</th></tr>
<tr><td>Test period</td><td>Vehicle speed (km/hr)</td><td>EMC^2 (BS)</td><td>Coherex (PEP)</td><td>Soil Sement (PE)</td><td>NHCO</td></tr>
<tr><td>1</td><td>40</td><td>38 (18)</td><td>100 (1)</td><td>92 (8)</td><td>N/A</td></tr>
<tr><td></td><td>55</td><td>28 (36)</td><td>98 (3)</td><td>97 (3)</td><td>N/A</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>40</td><td>-17 (26)</td><td>67 (6)</td><td>94 (3)</td><td>N/A</td></tr>
<tr><td></td><td>55</td><td>13 (34)</td><td>79 (8)</td><td>100 (0)</td><td>N/A</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>40</td><td>-11 (26)</td><td>54 (11)</td><td>88 (2)</td><td>90 (7)</td></tr>
<tr><td></td><td>55</td><td>-64 (25)</td><td>44 (7)</td><td>83 (6)</td><td>95 (3)</td></tr>
</table>
Negative values denote emissions greater than the untreated section.

Analysis
There was a general increase in PM_{10} emission factors as vehicle speed increased. Additionally, the majority of the suppressants showed a reduction in PM_{10} emissions when compared to the untreated road at both vehicle speeds tested. Only EMC^2 (BS) at test periods 2 and 3 showed higher levels than untreated.
The measured efficiencies of the suppressant products varied widely both between each other and at differing vehicle speed testing.
</td>
<td>was not applied at the same time point as all the other suppressants and thus no data available for the first 2 test periods. However the paper notes that for NHCO the section was graded before application with subsequent grading and rolling.

EMC^2 is a biocatalyst stabilizer (BS); Coherex is a petroleum emulsion with polymer (PEP); Soil Sediment is a polymer emulsion (PE). NHCO is non-hazardous crude oil containing material.</td>
</tr>
<tr>
<td>Full citation
Hagler, G. S. W.,</td>
<td>Number of participants
3 roadside locations</td>
<td>Intervention / Comparison
Comparing 3 roadside</td>
<td>Outcomes</td>
<td>Limitations identified by</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr>
<td>Lin, M. Y., Khlystov, A., Baldauf, R. W., Isakov, V., Faircloth, J., Jackson, L. E., Field investigation of roadside vegetative and structural barrier impact on near-road ultrafine particle concentrations under a variety of wind conditions, Science of the total environment, 419, 7-15, 2012
Quality score
-

Study type
Controlled study

Aim of the study
To determine the effect of roadside vegetation and barriers on Ultrafine particulate (UFP) concentrations.

Location and setting
Major roadways and near-road locations at 3 locations in North Carolina, USA

Length of study
Sampling was conducted during the early-autumn to winter, 2008

Source of funding
Not reported</td>
<td>Participant characteristics
Site 1: Chapel Hill - primarily evergreen tree stand and located along an expressway
Site 2: Mebane - primarily deciduous tree stand and located along an interstate highway
Site 3: Raleigh - has a brick noise barrier and is located along an interstate highway
Mebane and Chapel Hill roadways were bordered by residential zones with one and two-story houses, while the Raleigh site had a mixture of one and two-story residential and commercial buildings in the near-road area
At all sites, background areas were designated as residential locations with minimal traffic and located at least 200m from the major roadway

<table>
<tr><th></th><th>Chapel Hill</th><th>Mebane</th><th>Raleigh</th></tr>
<tr><td>Barrier type</td><td>Evergreen tree stand (Pine, Cedar, Magnolia)</td><td>Deciduous tree stand (Maple, Birch, Elder)</td><td>Brick noise barrier</td></tr>
<tr><td>Barrier height</td><td>6.1 ± 2.3 m [a]</td><td>7.2 ± 1.3 m [b]</td><td>6 m</td></tr>
<tr><td>Barrier thickness</td><td>3.6 ± 1.6 m [a]</td><td>4.5 ± 1.0 m [b]</td><td>0.5 m</td></tr>
<tr><td>Distance from road to barrier [c]</td><td>3.2 ± 0.7 m [a]</td><td>7.7 ± 1.7 m [b]</td><td>5 m</td></tr>
<tr><td>Leaf area index [d]</td><td>Early fall (autumn): 3.3 ± 1.0
Winter: 2.8 ± 1.6</td><td>Early fall (autumn): 3.0 ± 0.8
Winter: 1.0 ± 0.5</td><td>n/a</td></tr>
<tr><td>Major roadway traffic (AADT) [e]</td><td>38,000</td><td>84,000</td><td>108,000</td></tr>
</table>
a Average and standard deviation values measured for 11 trees or shrubs along barrier.
b Average and standard deviation values measured for 10 trees or shrubs</td>
<td>barrier types (Evergreen vegetative, Deciduous vegetative and brick noise barrier) measuring particulate levels behind each one and comparing to background (no barrier) levels.
Sampling took place during weekday morning commute periods (7–9 AM) for a consecutive series of approximately 6–10 days over a two week period.
Two sampling sessions were conducted for each of the vegetative barrier sites – in the early-fall and then again in the late-fall/winter.
One sampling session was conducted at the Raleigh site with the brick noise barrier during the mid-fall season.</td>
<td>On-road and background average and standard deviation concentrations at each location.
<table>
<tr><th></th><th colspan="2">Chapel Hill</th><th colspan="2">Mebane</th><th colspan="2">Raleigh</th></tr>
<tr><td></td><td colspan="2">Average wind speed: 1.5 m/s</td><td colspan="2">Average wind speed: 1.25 m/s</td><td colspan="2">Average wind speed: 1.27 m/s</td></tr>
<tr><td></td><td>Major road</td><td>Background</td><td>Major road</td><td>Background</td><td>Major road</td><td>Background</td></tr>
<tr><td>$PM_{2.5}$ (μg m^{-3})[a]</td><td>6.2 (1.8)[b]</td><td>4.7 (0.9)</td><td>8.1 (1.8)</td><td>4.7 (1.7)</td><td>8.7 (2.6)</td><td>7.5 (1.9)</td></tr>
<tr><td>PM_{10} (μg m^{-3})[a]</td><td>9.8 (7.1)</td><td>6.2 (3.9)</td><td>12.1 (5.9)</td><td>6.6 (4.5)</td><td>11.0 (5.0)</td><td>8.9 (3.3)</td></tr>
<tr><td>BC (μg m^{-3})</td><td>2.3 (3.5)</td><td>1.1 (2.0)</td><td>6.0 (5.1)</td><td>0.7 (0.4)</td><td>5.0 (3.4)</td><td>1.7 (1.5)</td></tr>
<tr><td>UFPs (cm^{-3})</td><td>$4.3 x 10^4$ ($4.1 x 10^4$)</td><td>$1.1 x 10^4$ ($8.5 x 10^3$)</td><td>$1.5 x 10^5$ ($1.0 x 10^5$)</td><td>$1.0 x 10^4$ ($9.0 x 10^3$)</td><td>$1.1 x 10^5$ ($9.0 x 10^4$)</td><td>$2.0 x 10^4$ ($1.1 x 10^4$)</td></tr>
</table>
[a] PM values are estimated from size-resolved particle counts.
[b] Standard deviation is calculated as the average of the standard deviations calculated for each individual session.

Analysis
For all pollutants and barriers, the concentrations are higher than the background values.
After accounting for background concentration, the solid (Raleigh) barrier reduced UFP concentrations by 49-53% (downwind conditions), by 30-61% in parallel wind conditions and by 33-50% with variable winds. The mean reduction of road-attributed concentrations for the non-upwind cases is 47%.
The UFP trends at the vegetative barrier sites were variable and the barrier effect was uncertain.</td>
<td>the author
$PM_{2.5}$ and PM_{10} concentrations were estimated. The $PM_{2.5}$ and PM_{10} values should thus be considered estimates of the relative range of concentrations at these sites and not considered comparable to federal reference method (FRM) derived values or ambient air quality standards.
<i>Due to failure of the internal motherboard, the APS (Aerodynamic Particle Sizer) data are available only for approximately half of the field sessions</i>

Limitations identified by the review team
Large variation in barrier height, thickness, distance sited from road and average daily traffic of road sited next to Author</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Results</th><th>Notes</th></tr>
<tr><td></td><td>along barrier.
c Distance from edge of road to roadside edge of barrier
d LAI values were measured on two separate days in the fall and in the winter.
e Annual Average Daily Traffic (AADT) from North Carolina Department of Transportation 2008/2009 maps

Inclusion criteria
The road sampling sites were selected based on roadside barrier properties: a stretch of roadway having a vegetative buffer or structural noise wall as well as an adjacent roadside area without a barrier for comparison and moderate to heavy traffic during morning commute periods. In addition, relatively thin vegetative buffers were sought (<10 m in thickness). A final site requirement was a low degree of side road traffic.

Exclusion criteria
Not reported</td><td></td><td></td><td>compares measurements behind the barrier to those in a 'clearing', but no data published on 'clearing' values</td></tr>
<tr><td>**Full citation**
Ning, Z., Hudda, N., Daher, N., Kam, W., Herner, J., Kozawa, K., Mara, S., Sioutas, C., Impact of roadside noise barriers on particle size distributions and pollutants concentrations near freeways, Atmospheric Environment, 44, 3118-3127, 2010

Quality score
-

Study type
Controlled trial</td><td>**Number of participants**
N/A

Participant characteristics
Two highly trafficked freeways with different traffic fleet compositions were selected.
The barrier and non-barrier sites had similar meteorological and traffic conditions allowing for direct comparison between the results of the 2 sites.

Inclusion criteria
None reported

Exclusion criteria
None reported</td><td>**Intervention / Comparison**
Pollution levels were measured at 2 sampling sites (one with roadside noise barrier and the other without) located along the span of each freeway.</td><td>**Outcomes**

Average pollutant concentrations measured in immediate proximity of the freeway
<table>
<tr><th>Pollutant</th><th></th><th colspan="2">Freeway 1</th><th colspan="2">Freeway 2</th></tr>
<tr><td></td><td></td><td>Non-noise barrier</td><td>Noise barrier</td><td>Non-noise barrier</td><td>Noise barrier</td></tr>
<tr><td>Black Carbon (μg m^{-3})</td><td>Average
Standard deviation</td><td>11.0
6.3</td><td>11.6
1.4</td><td>10.6
4.2</td><td>9.5
1.5</td></tr>
<tr><td>NO_2 (ppb)</td><td>Average
Standard deviation</td><td>152.2
38.0</td><td>87.3
8.2</td><td>93.9
31.2</td><td>79.3
4.9</td></tr>
</table>
Particle number concentrations without barriers in the immediate proximity of the highways were 1.2e5 particles cm^{-3} for the I-710 and 8.0e4 particles cm^{-3} for the I-5. Levels fell exponentially, reaching background levels within 200m for I-710 and 180m for I-5. With barriers, concentrations were 4.8e4 particles cm^{-3} for I-710 and 3.1e4 particles cm^{-3} for I-5. These are 43% and 45% lower than those measured at 20m without a barrier. As downwind distance increases, particle concentrations increase to a maximum at 100m and 80m for I-710 and I-5 respectively. Peak</td><td>**Limitations identified by the author**
None reported

Limitations identified by the review team
The noise barriers were not the same height on both freeways.
Average pollutant concentrations were measured at different times on sampling dates</td></tr>
</table>

Study details	Population	Intervention / Comparator	Results	Notes
Aim of the study To investigate the effect of noise barriers on the dispersion of particles and pollutants emitted from freeways. **Location and setting** Two major freeways in the greater Los Angeles area, USA **Length of study** 2 months **Source of funding** EPA under the STAR program through grant RD-8324-1301-0 and by California Air Resources Board through ARB Contact 05-317 to the University of Southern California			concentrations are 2.4 and 2.2 times higher than those observed at the corresponding distance for non-barrier sites. Levels reach background levels at around 400m. **Analysis** There was a decrease in the concentration of NO_2 in the immediate vicinity of the freeway with the presence of the roadside noise barrier but Black Carbon concentrations showed conflicting results with an increase in one test site and a decrease in the other.	which could impact on the results.

Question 4: Are measures to promote absorption, adsorption or impingement deposition, and catalytic action effective at reducing the health impact of, or people’s exposure to, traffic-related air pollution? Modelling studies

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr>
<td>Full citation
Pugh, Thomas A. M., Robert MacKenzie, A., Duncan Whyatt, J., Nicholas Hewitt, C., Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons, Environmental Science & Technology, 46, 7692-7699, 2012

Quality score
-

Aim of the study
To model street-canyon chemistry and deposition to identify the effect of the use of enhanced-deposition surfaces in concert with the urban form on air quality at street level in
street canyons.

Source of data
Air pollution concentrations taken from London Bloomsbury urban background site

Location and setting
Central London, based on a scaling-up of the single canyon run to represent the large area of generic street canyons

Length of study
N/A

Source of funding</td>
<td>Number of participants
N/A

Participant description
N/A

Inclusion criteria
N/A

Exclusion criteria
N/A</td>
<td>Intervention / Comparison
Control stat was canyon with brick walls and roof; interventions were green wall (100%) and green roof.</td>
<td>Type of model
Atmospheric chemistry model CiTTyCAT, enhanced to simulate mixing and dry deposition within street canyons.</td>
<td>Outcomes

Modelled vegetation scenarios and expected in-canyon concentration reductions under different canyon configurations and meteorological conditions.
<table>
<tr><th></th><th></th><th></th><th colspan="4">Concentration change relative to control scenario (%)</th></tr>
<tr><th></th><th></th><th></th><th colspan="3">Wind speed = 2ms-1</th><th>Wind speed = 0.5ms-1</th></tr>
<tr><th></th><th colspan="2">Deposition velocities (cm s-1)</th><th colspan="2">Aspect ratio = 1 (h/w ratio)</th><th colspan="2">Aspect ratio = 2 (h/w ratio)</th></tr>
<tr><th></th><th>NO_2</th><th>PM10</th><th>Numerous canyons</th><th colspan="3">Single canyon</th></tr>
<tr><td>Green walls (100%)</td><td>Walls: 0.3</td><td>Walls: 0.64</td><td rowspan="2">NO_2: -8.9%
PM10: -13.1%</td><td rowspan="2">NO_2: -6.4%
PM10: -10.8</td><td rowspan="2">NO_2: -19.9%
PM10: -32.0%</td><td rowspan="2">NO_2: -42.9%
PM10: -61.9%</td></tr>
<tr><td></td><td>Roof: 0.05</td><td>Roof: 0.2</td></tr>
<tr><td>Green roof</td><td>Walls: 0.05</td><td>Roof: 0.02</td><td rowspan="2">NO_2: -0.9
PM10: -1.1</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Roof: 0.3</td><td>Roof: 0.64</td><td></td><td></td><td></td></tr>
</table>

Using an idealised city of uniform street canyons with a height to width ratio of 1, annual average concentrations of NO2 and PM10 were reduced by 9% and 13% respectively by greening of canyon walls across large areas. Reductions for a single canyon were 7% and 11%, increasing to 20% and 31% when the height/width ratio was increased to 2.

Analysis
Adoption of green walls on large areas of street canyons resulted in a reduction of NO2 and PM10 of up to 15% and 23% respectively (wind speed 1 ms-1, canyon height to width (h/w) ratio 1). The reduction was dependent on residence time (dependent on wind speed and canyon geometry) and the fraction of canyon wall greened but not the initial pollutant concentration. The net pollutant flux out of the canyon was reduced by 2-11% for NO2 and became inward for PM10, leading to small concentration reductions in the urban boundary layer.
For surfaces with comparable leaf indexes (and hence deposition velocities) greening in-canyon surfaces is more effective at reducing street-level pollutant concentrations than green roofs as it acts on the relatively small volume of air inside the canyon rather than via the urban boundary layer.</td>
<td>Limitations identified by the author
Simulation of effect on central London limited to a scaling-up of effect of single canyon run.
Single deposition velocity in middle of range for commonly reported values for different species used.
Secondary processes (resuspension and deposition limitation) not explicitly modelled.</td>
</tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr><td>UK EPSRC Sustainable Urban Environment Program, grant number EP/F007426/1</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>**Full citation**
Vos, Peter E. J., Maiheu, Bino, Vankerkom, Jean, Janssen, Stijn, Improving local air quality in cities: to tree or not to tree?, Environmental pollution (Barking, Essex : 1987), 183, 113-22, 2013

Quality score
-

Aim of the study
Examination of the impact on pollution of a variety of real-life examples of urban vegetation.

Source of data
Default values used and varied by sensitivity analysis.
Default pollution values used in sensitivity analysis
<table>
<tr><td>Line source emissions</td><td>NO2</td><td>51µg/(ms)</td></tr>
<tr><td></td><td>PM10</td><td>27 µg/(ms)</td></tr>
<tr><td></td><td>EC</td><td>10 µg/(ms)</td></tr>
<tr><td>Background concentration</td><td>NO2</td><td>21 µg/m3</td></tr>
<tr><td></td><td>PM10</td><td>24 µg/m3</td></tr>
<tr><td></td><td>EC</td><td>1.3 µg/m3</td></tr>
</table>
Location and setting</td>
<td>**Number of participants**
N/A

Participant description
N/A

Inclusion criteria
N/A

Exclusion criteria
N/A</td>
<td>**Intervention / Comparison**
19 real life urban vegetation designs based on designs for implementation in Belgium and the Netherlands. Each modelled with and without vegetation.</td>
<td>**Type of model**
ENVI-met model, a three dimensional computational fluid dynamics model tailored for simulating different urban atmospheric process such as dispersion and microclimate effects.</td>
<td>**Outcomes**

Analysis
Trees have less influence on PM10 than on NO2 or EC due to the higher contribution to PM10 from other sources.
Trees significantly increase pollutant concentrations. A deterioration in air quality is also seen with hedges. Green barriers improve air quality at the footpath due to their impermeable core.
Simulations with 5 times higher deposition speeds than default show no significant difference in results, suggesting that it is the aerodynamic effect that determines the overall impact on air quality rather than the pollutant removal capacity.</td>
<td>**Limitations identified by the author**
In the examination of 19 different real-life urban vegetation designs only one wind direction (perpendicular to the street) was considered.

Limitations identified by the review team

Other comments
Data is presented graphically for each pollutant and design. It is not possible to extract individual data from these figures so only the overall commentary on the results is given.</td></tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr><td>Belgium and the Netherlands

Length of study
N/A

Source of funding
European Interreg IV-A project 'Functioneel Groen'. Partial support from Flemish Agency for Innovation by Science and Technology (IWT) in the framework of the Climaqs project.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>**Full citation**
Vranckx, S., Vos, P., Maiheu, B., Janssen, S., Impact of trees on pollutant dispersion in street canyons: A numerical study of the annual average effects in Antwerp, Belgium, Science of the total environment, 532, 474-483, 2015

Quality score
-

Aim of the study
To quantify the annual average effect of trees on the air quality in street canyons

Source of data
Meteorological data from Luchtbal (near Antwerp), Belgium.
Urban background concentrations of PM10 and EC for 2009 from Antwerp.</td><td>**Number of participants**
N/A

Participant description
N/A

Inclusion criteria
N/A

Exclusion criteria
N/A</td><td>**Intervention / Comparison**
Comparison of annual average pollution concentrations with and without influence of urban trees.</td><td>**Type of model**
OpenFOAM CFD package</td><td>**Outcomes**

Annual average effect of 9 types of vegetation on PM10 concentration. Background annual average concentrations PM10 29.32µgm-3; PM10 emission strength 22.45µgs-1.
<table>
<tr><th></th><th></th><th colspan="3">W-E orientation</th><th colspan="3">N-S orientation</th><th colspan="3">NE-SW orientation</th><th colspan="3">NW-SE orientation</th></tr>
<tr><th>C_x</th><th>LAD$_{vd}$</th><th>Wall A</th><th>Wall B</th><th>Ave</th><th>Wall A</th><th>Wall B</th><th>Ave</th><th>Wall A</th><th>Wall B</th><th>Ave</th><th>Wall A</th><th>Wall B</th><th>Ave</th></tr>
<tr><td>**0**</td><td>**0**</td><td>31.5</td><td>32.1</td><td>31.8</td><td>31.9</td><td>31.4</td><td>31.7</td><td>31.4</td><td>31.6</td><td>31.5</td><td>32.1</td><td>31.8</td><td>31.9</td></tr>
<tr><td>**0.24**</td><td>**0**</td><td>1.4%</td><td>2.0%</td><td>1.7%</td><td>1.7%</td><td>1.6%</td><td>1.6%</td><td>1.5%</td><td>1.4%</td><td>1.5%</td><td>2.0%</td><td>1.6%</td><td>1.8%</td></tr>
<tr><td>**0.24**</td><td>**0.008**</td><td>1.2%</td><td>1.8%</td><td>1.5%</td><td>1.5%</td><td>1.4%</td><td>1.4%</td><td>1.3%</td><td>1.2%</td><td>1.3%</td><td>1.8%</td><td>1.3%</td><td>1.5%</td></tr>
<tr><td>**0.24**</td><td>**0.08**</td><td>0.5%</td><td>1.2%</td><td>0.8%</td><td>0.7%</td><td>0.7%</td><td>0.7%</td><td>0.6%</td><td>0.5%</td><td>0.6%</td><td>1.0%</td><td>0.6%</td><td>0.7%</td></tr>
<tr><td>**0.53**</td><td>**0**</td><td>1.9%</td><td>2.6%</td><td>2.3%</td><td>1.9%</td><td>1.8%</td><td>1.8%</td><td>1.8%</td><td>1.7%</td><td>1.5%</td><td>1.6%</td><td>2.3%</td><td>2.0%</td></tr>
<tr><td>**0.53**</td><td>**0.0088**</td><td>1.6%</td><td>2.3%</td><td>1.9%</td><td>1.8%</td><td>1.8%</td><td>1.8%</td><td>1.7%</td><td>1.5%</td><td>1.6%</td><td>2.3%</td><td>1.6%</td><td>2.0%</td></tr>
<tr><td>**0.53**</td><td>**0.088**</td><td>0.7%</td><td>1.5%</td><td>1.1%</td><td>0.8%</td><td>1.0%</td><td>0.9%</td><td>0.9%</td><td>0.6%</td><td>0.8%</td><td>1.5%</td><td>0.5%</td><td>1.0%</td></tr>
<tr><td>**1.33**</td><td>**0**</td><td>1.9%</td><td>2.6%</td><td>2.2%</td><td>1.8%</td><td>2.3%</td><td>2.1%</td><td>2.1%</td><td>1.6%</td><td>1.9%</td><td>2.9%</td><td>1.9%</td><td>2.4%</td></tr>
</table></td><td>**Limitations identified by the author**
Conclusions for the annual average effect of trees on air quality in urban street canyons based on the following assumptions:
Isolated street canyon
Artificial trees (dimensions, vegetation parameters and seasonal effects)
Touching tree crowns
Solutions for a single in flow profile
No wall deposition and resuspension of pollutants
No emissions from vegetation
No deposition of back ground emissions in the</td></tr>
</table>

<table>
<tr><th>Study details</th><th>Population</th><th>Intervention / Comparator</th><th>Method of analysis</th><th>Model results</th><th>Notes</th></tr>
<tr>
<td>Location and setting
Antwerp, Belgium

Length of study
N/A

Source of funding
Partially funded by the LIFE+ programme of the EU through the Atmosys project (LIFE+ 2009 project ENV/BE/000409).</td>
<td></td>
<td></td>
<td></td>
<td>
<table>
<tr><td>1.33</td><td>0.022</td><td>1.4%</td><td>2.1%</td><td>1.8%</td><td>1.3%</td><td>1.8%</td><td>1.6%</td><td>1.6%</td><td>1.1%</td><td>1.4%</td><td>2.3%</td><td>1.3%</td><td>1.8%</td></tr>
<tr><td>1.33</td><td>0.22</td><td>0.5%</td><td>1.1%</td><td>0.8%</td><td>0.3%</td><td>0.9%</td><td>0.6%</td><td>0.7%</td><td>0.2%</td><td>0.4%</td><td>1.3%</td><td>0.3%</td><td>0.8%</td></tr>
</table>

Analysis
The annual effect of trees ranges from increase of around 1% to an increase of 13%, depending on orientation and type of vegetation. For PM10, emissions from within the canyon contribute around 7.5% of the total. The effect of trees on PM10 is therefore smaller, around an increase of 0.2% to 2.6%.</td>
<td>street canyon
No thermal effects

Limitations identified by the review team

Other comments</td>
</tr>
</table>

Appendix 2 Quality of included studies

EPOC Checklist

	Question									Score
	1	2	3	4	5	6	7	8	9	
Al-Dabbous et al., 2014	-	-	NA	+	+	NA	NA	++	-	-
Amato et al., 2009	-	NA	Unclear	NA	Unclear	++	+	++	-	-
Amato et al., 2014	-	-	Unclear	-	-	++	NA	++	-	-
Bean 2011	-	-	NA	Unclear	Unclear	+	-	++	-	-
Boogaard 2009	-	-	NA	-	-	+	+	++	-	-
Brantley et al., 2014	-	NA	NA	+	++	NA	-	++	-	-
Burgard 2009	-	-	-	NA	-	NA	-	++	-	-
Burr 2004	-	-	NA	NA	+	+	Unclear	++	-	-
Bandaulf	-	-	Unclear	-	unclear	+	unclear	++	++	-
Gillies et al., 1999	-	NA	Unclear	NA	Unclear	NA	-	++	-	-
Gramsch 2013	-	-	-	+	Unclear	NA	+	++	-	-
Hagler et al., 2012	-	-	NA	+	+	NA	NA	++	-	-
Hatzopoulou 2013	Unclear	Unclear	NA	-	-	+	Unclear	++	-	-
Jarjour 2013	-	-	Unclear	NA	-	+	NA	++	-	-
Kendrick 2009	-	-	NA	Unclear	+	+	-	++	-	-
MacNaughton 2014	-	-	Unclear	-	Unclear	+	-	++	-	-
Ning et al., 2010	-	-	NA	+	+	NA	NA	++	-	-

Key to questions:

1. Was the allocation sequence adequately generated?
2. Was the allocation adequately concealed?
3. Were baseline outcome measurements similar?
4. Were baseline characteristics similar?
5. Were incomplete outcome data adequately addressed?
6. Was knowledge of the allocated interventions adequately prevented during the study?
7. Was the study adequately protected against contamination?
8. Was the study free from selective outcome reporting?
9. Was the study free from other risks of bias?

Modelling checklist

	Relevance					Credibility												Score
	1	2	3	4	Overall	5	6	7	8	9	10	11	12	13	14	15	Overall	
Alam 2014	Yes	No	No	Yes	Sufficient	Not reported	Yes	No	Not reported	Not reported	Yes	No	Not enough info	No	Not reported	Not reported	Insufficient	-
Alam 2014b	Yes	No	No	Yes	Sufficient	Not reported	Not reported	No	Not enough info	Not reported	Yes	No	Not enough info	No	Not enough info	Not reported	Insufficient	-
Chong 2014	Yes	No	No	Yes	Sufficient	Yes	Not enough info	Yes	Not enough info	Yes	Yes	Yes	Yes	Yes	Not enough info	Not enough info	Sufficient	+
Goncalves 2009	Yes	No	Yes	No	Sufficient	Not reported	Not reported	Yes	Not enough info	Yes	Yes	Not reported	Not enough info	No	Not reported	Not reported	Insufficient	-
Goncalves 2009a	Yes	No	Yes	No	Sufficient	Yes	Not reported	Not enough info	Not enough info	Not reported	Yes	Yes	Not enough info	No	Not reported	Not reported	Insufficient	-
Pugh 2012	Yes	No	No	Yes	Sufficient	Not enough info	Not enough info	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	NA	Sufficient	+
Soret 2014	Yes	No	Yes	No	Sufficient	Yes	Not reported	Not enough info	Not enough info	Not enough info	Yes	Not reported	Yes	Yes	Not reported	Not reported	Insufficient	-
Stamos 2013	Yes	No	No	Yes	Sufficient	Not reported	Not reported	Not enough info	Not enough info	Not enough info	Not enough info	Not reported	Not reported	No	Not reported	Not reported	Insufficient	-
Vos 2013	Yes	No	No	Yes	Sufficient	Yes	Not enough info	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not enough info	Not enough info	Sufficient	+
Vranckx 2015	Yes	No	No	Yes	Sufficient	Yes	Yes	Yes	Not enough info	Yes	Yes	Yes	Yes	Yes	Not enough info	Not enough info	Sufficient	+

Key to questions:

Relevance

1. Is the population relevant?
2. Are any critical interventions missing?
3. Are any relevant outcomes missing?
4. Is the context (settings and circumstance) applicable?
5. Is external validation of the model sufficient to make its results credible for your decision?
6. Is internal verification of the model sufficient to make its results credible for your decision?
7. Does the model have sufficient face validity to make its results credible for your decision?
8. Is the design of the model adequate for your decision problem?

9. Are the data used in populating the model suitable for your decision problem?
10. Were the analyses performed using the model adequate to inform your decision problem?
11. Was there an adequate assessment of the effects of uncertainty?
12. Was the reporting of the model adequate to inform your decision problem?
13. Was the interpretation of results fair and balanced?
14. Were there any potential conflicts of interest?
15. If there were potential conflicts of interest, were steps taken to address these?

Economic studies

	Question																					Overall Assessment
	Section 1										Section 2											
	1	2	3	4	5	6	7	8	9		1	2	3	4	5	6	7	8	9	10	11	
Cohen 2003	+	++	+	+	+	-	+	-	+		+	+	+	+	+	+	+	+	++	++	-	+
Cohen 2005																						+
Krutilla 2012	NA	+	-	++	+	++	-	++	+		Unclear	++	++	+	+	+	+	+	-	+	-	+

Section 1: Applicability

1. Is the study population appropriate for the review question?
2. Are the interventions appropriate for the review question?
3. Is the system in which the study was conducted sufficiently similar to the current UK context?
4. Are the perspectives clearly stated and are they appropriate for the review question?
5. Are all direct effects on individuals included, and are all other effects included where they are material?
6. Are all future costs and outcomes discounted appropriately?
7. Is QALY used as an outcome, and was it derived using NICE's preferred methods? If not, describe rationale and outcomes used in line with analytical perspectives taken (item 1.4 above).
8. Are costs and outcomes from other sectors fully and appropriately measured and valued?
9. Overall judgement

Section 2: Study limitations

1. Does the model structure adequately reflect the nature of the topic under evaluation?
2. Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?
3. Are all important and relevant outcomes included?
4. Are the estimates of baseline outcomes from the best available source?
5. Are the estimates of relative intervention effects from the best available source?
6. Are all important and relevant costs included?
7. Are the estimates of resource use from the best available source?
8. Are the unit costs of resources from the best available source?
9. Is an appropriate incremental analysis presented or can it be calculated from the data?
10. Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?
11. Is there any potential conflict of interest?
12. Overall assessment

Appendix 3 Search strategy

Strategy

Database: Ovid MEDLINE(R) <1946 to September Week 4 2015>

Search Strategy:

----

1 ((fuel or emission* or diesel or petrol or exhaust or fume*) adj3 (road* or vehicle* or motor* or car or cars or traffic)).ti,ab. (2942)

2 ("transport pollution" or "street pollution").ti,ab. (15)

3 Air Pollution/ or Air Pollutants/ (51623)

4 Inhalation Exposure/ (7037)

5 Smog/ (388)

6 Vehicle Emissions/ (7631)

7 (particle* or particulate* or "fine particle*" or "ultrafine particle*" or PM10 or PM5 or PM2* or "particulate matter" or "PM emission*").ti,ab. (208946)

8 Particulate Matter/ (9185)

9 ("nitrogen oxide*" or "nitrogen dioxide*" or NO2 or ozone or nox or "black carbon").ti,ab. (26714)

10 Carbon Dioxide/ (76818)

11 Nitrogen Dioxide/ (3775)

12 ("concentrated ambient air particle*" or smog or "air pollut*" or "air toxics" or "inhalation exposure" or "roadside concentration*").ti,ab. (20250)

13 air quality.ti,ab. (5761)

14 or/1-13 (354248)

15 exp Motor Vehicles/ (16179)

16 Automobile Driving/ (14997)

17 Transportation/ (7264)

18 (car or cars or bus or buses or truck* or van or vans or lorry or lorries or taxi or taxis or motorbike* or motorcycle* or automobile* or "motor vehicle*").ti,ab. (54779)

19 fleet.ti,ab. (988)

20 (road* or street* or kerb* or pavement* or highway* or motorway* or "trunk route*" or traffic or multistorey).ti,ab. (62214)

21 (driver* or driving or passenger* or commut* or pedestrian* or cyclist*).ti,ab. (78434)

22 (commut* or traffic or congest* or "rush hour" or tailback* or idling or "school run" or "tail back*" or tail-back* or "rush hour*" or rush-hour*).ti,ab. (80246)

23 or/15-22 (236690)

24 14 and 23 (12222)

25 ((infrastructure* or plan* or develop* or design* or allocat* or control* or space*) adj3 (route* or road* or walkway* or street* or pavement* or urban or city or cities or town* or transport* or green or environment* or building*)).ti,ab. (46847)

26 City Planning/ or Environment Design/ (5687)

27 ("health impact assessment*" or "environmental impact assessment*").ti,ab. (768)

28 Health Impact Assessment/ (230)

29 "cycle route*".ti,ab. (12)

30 ((bus or buses or "public transport*") and (lane* or route* or trip* or service* or plan*)).ti,ab. (795)

31 (("zero emission*" or "ultralow nox" or "ultra low nox" or "ultra-low nox") and (route* or service* or mode or modes or facilit* or develop* or design*)).ti,ab. (17)

32 ("clean bus technology" or "low carbon vehicle procurement" or "city air" or "green bus*").ti,ab. (85)

33 ("green technolog*" or "emission* standard*" or "Euro 6" or Euro6 or "Euro VI").ti,ab. (418)

34 (barrier* or "urban greening" or vegetation or hedge* or planting* or tree* or foliage or "urban woodland*" or "ecological engineering" or ecosystem*).ti,ab. (281199)

35 Trees/ (20220)

36 ((dispersion or deposition or absorption or adsorption or impingement) adj3 (road* or street* or kerb* or pavement* or highway* or

motorway* or intersection or traffic or vehicle*)).ti,ab. (212)

37 ("road surface*" or "dust suppressant*" or "porous asphalt" or "very open asphalt" or "calcium magnesium acetate" or "surface treatment*" or "titanium oxide*" or "titanium dioxide*").ti,ab. (5984)

38 (("catalytic action" or photocataly*) and (road* or highway* or street* or pavement* or paving or concrete or asphalt)).ti,ab. (16)

39 or/25-38 (346576)

40 ((traffic or road) adj2 (sign or signal* or light*)).ti,ab. (760)

41 ((continuous adj2 flow*) or "green wave").ti,ab. (7582)

42 ((traffic or road* or vehicle*) adj2 (flow* or control* or ban or manage* or restrict* or enforce* or calm*)).ti,ab. (11872)

43 (speed* adj2 (limit* or restric* or reduc* or charg* or fine*)).ti,ab. (2468)

44 ((charg* or toll* or pay or payment) and (road* or vehicle* or congestion or zone*)).ti,ab. (3061)

45 ("low emission zone*" or "ultra-low emission zone*" or LEZ or ULEZ).ti,ab. (21)

46 ((parking or idling or waiting or loading) and (charg* or restrict* or enforce* or zone* or control*)).ti,ab. (28440)

47 or/40-46 (53669)

48 ("travel plan*" or "journey plan*").ti,ab. (69)

49 (car adj (use* or trip* or journey*)).ti,ab. (143)

50 (((mode* or modal) adj2 (shift* or change* or choice*)) or "active travel*" or "active transport*" or walk* or cycle or cycling or cyclist* or bicycl* or pedestrian* or bike* or "travel mode" or "travel behaviour" or "travel behavior").ti,ab. (448890)

51 (Bikability or "Cycling Cities and Towns").ti,ab. (2)

52 (vehicle occupancy or "CarLite" or ((car or cars or vehicle* or bike or lift) adj2 (pool* or shar* or club*))).ti,ab. (79)

53 or/48-52 (449093)

54 ((educat* or aware* or inform* or advice or advise or develop* or promot* or initiative* or intervention*) and (travel* or fuel or driver* or driving or car or cars)).ti,ab. (50165)

55 ("alternative fuel*" or "compressed natural gas" or CNG or "liquid petroleum gas" or "liquified petroleum gas" or "liquefied petroleum gas" or biofuel* or biodiesel* or "low carbon transport fuel*" or LPG).ti,ab. (7548)

56 ("plugged-in" or ((hybrid or electric*) adj2 (car or cars or bus or buses or taxi or taxis or vehicle*))).ti,ab. (262)

57 ((driver* or driving) adj2 (style* or behaviour* or behavior* or training)).ti,ab. (1751)

58 ("fuel consumption" or "fuel economy" or "fuel choice*" or "stop go driving" or acceleration or deceleration or braking or eco-driving).ti,ab. (37386)

59 ((miles or mileage or vehicle* or route* or travel*) and (habit* or pattern* or drive* or choice* or reduc* or behavior* or behaviour*)).ti,ab. (80986)

60 Hotlines/ or Mass Media/ or Social Media/ (13630)

61 ((warning* or advice or advisory or forecast* or alerts or alerting or telehealth) adj3 (health or risk* or exposure)).ti,ab. (4207)

62 or/54-61 (185282)

63 39 or 47 or 53 or 62 (991405)

64 24 and 63 (3971)

65 letter/ or historical article/ or comment/ or editorial/ or congress/ (1731561)

66 64 not 65 (3931)

67 animals/ not humans/ (4021057)

68 66 not 67 (3659)

69 limit 68 to english language (3441)

70 limit 69 to yr="1995 -Current" (3211)

Appendix 4 Excluded studies

Study	Reason for Exclusion
Abhijith, K. V., Gokhale, Sharad, Passive control potentials of trees and on-street parked cars in reduction of air pollution exposure in urban street canyons, Environmental pollution (Barking, Essex : 1987), 204, 99-108, 2015	Modelling study
Abou Zeid, Maya, Rossi Thomas, F., Gardner, Brian, Modeling Time-of-Day Choice in Context of Tour- and Activity-Based Models, Transportation Research Record: Journal of the Transportation Research Board, 42-49	No relevant outcomes
Abou-Senna, Hatem, Radwan, Essam, VISSIM/MOVES Integration to Investigate the Effect of Major Key Parameters on CO2 Emissions, Transportation Research: Part D: Transport and Environment, 21, 39-46, 2013	Outcomes not in protocol; No intervention
Acero, J. A., Simon, A., Padro, A., Santa Coloma, O., Impact of local urban design and traffic restrictions on air quality in a medium-sized town, Environmental Technology, 33, 2467-77, 2012	Modelling study
Acha Daza, J. A., Mahmassani, H. S., University of Texas, Austin Center for Transportation Research Red River Suite Austin T. X. U. S. A. Southwest Region University Transportation Center Texas Transportation Institute Texas A., M University, College Station T. X. U. S. A., USER'S RESPONSE TO PRICING IN A TRAFFIC NETWORK, Supported by a grant from the Office of the Governor of the State of Texas	No relevant outcomes
Adamou, Adamos, Sclerides, Sofronis, Zachariadis, Theodoros, Designing Carbon Taxation Schemes for Automobiles: A Simulation Exercise for Germany, 2011	Out of scope
Adams, H. S., Nieuwenhuijsen, M. J., Colvile, R. N., Determinants of fine particle (PM2.5) personal exposure levels in transport microenvironments, London, UK, Atmospheric Environment, 35, 4557-4566, 2001	No intervention
Adams, H. S., Nieuwenhuijsen, M. J., Colvile, R. N., McMullen, M. A. S., Khandelwal, P., Fine particle (PM2.5) personal exposure levels in transport microenvironments, London, UK, Science of the total environment, 279, 29-44, 2001	No intervention
Adar, S. D., D'Souza, J., Sheppard, L., Kaufman, J. D., Hallstrand, T. S., Davey, M. E., Sullivan, J. R., Jahnke, J., Koenig, J., Larson, T. V., Liu, L. J. S., Adopting clean fuels and technologies on school buses: Pollution and health impacts in children, American journal of respiratory and critical care medicine, 191, 1413-1421, 2015	No true comparator Outcomes measured outside of scope
Addison, Paul S., Currie, John I., Low, David J., McCann, Joanna M., An Integrated Approach to Street Canyon Pollution Modelling, Environmental Monitoring & Assessment, 65, 333-342, 2000	No intervention
Affum, J. K., Brown, A. L., Chan, Y. C., The urban footprint and pollution prediction modelling, ROAD SYSTEM AND ENGINEERING TECHNOLOGY FORUM, 2005, BRISBANE, QUEENSLAND, 22P	Conference abstract
Affum, J. K., Brown, A. L., Chan, Y. C., Integrating air pollution modelling with scenario testing in road transport planning: The TRAEMS approach, Science of the total environment, 312, 1-14, 2003	Description of a modelling tool

Agar, Betsy J., Baetz, Brian W., Wilson, Bruce G., Fuel consumption, emissions estimation, and emissions cost estimates using global positioning data, Journal of the Air & Waste Management Association (1995), 57, 348-54, 2007	No intervention
Ahlvik, P., Swedish experiences from low emission city buses: Impact on health and environment, 39p	Review No intervention
Ahn, Kyoungho, Rakha Hesham, Ahmed, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Energy and Environmental Effects of Traffic Calming Measures, Transportation Research Board 87th Annual MeetingTransportation Research Board, 16	Conference abstract
Ahn, Kyoungho, Rakha Hesham, Ahmed, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Energy and Environmental Impacts of Route Choice Decisions, Transportation Research Board 86th Annual MeetingTransportation Research Board, 21	Conference abstract
Ahn, Kyoungho, Rakha, Hesham, The effects of route choice decisions on vehicle energy consumption and emissions, Transportation Research: Part D, 13, 151-167, 2008	Modelling study
Ahn, Kyoungho, Rakha, Hesham A., Network-Wide Impacts of Eco-routing Strategies: A Large-Scale Case Study, Transportation Research: Part D: Transport and Environment, 25, 119-30, 2013	Modelling study
Alam, Ahsan, Hatzopoulou, Marianne, Investigating the Isolated and Combined Effects of Congestion, Roadway Grade, Passenger Load, and Alternative Fuels on Transit Bus Emissions, Transportation Research: Part D: Transport and Environment, 29, 12-21, 2014	No intervention
Alexandrova, Olga, Kaloush Kamil, E., Allen Jonathan, O., Impact of Asphalt Rubber Friction Course Overlays on Tire Wear Emissions and Air Quality Models for Phoenix, Arizona, Airshed, Transportation Research Record: Journal of the Transportation Research Board, 98-106	Outcomes measured not in protocol
Allen Jonathan, O., Alexandrova, Olga, Kaloush Kamil, E., Arizona State University, Tempe Department of Civil, Environmental Engineering, P. O. Box Tempe A. Z. U. S. A. Arizona Department of Transportation South th Avenue Phoenix A. Z. U. S. A., Tire Wear Emissions for Asphalt Rubber and Portland Cement Concrete Pavement Surfaces, 42	Outside of scope
Alqhatani, M., Setunge, S., Mirodpour, S., Can a polycentric structure affect travel behaviour? A comparison of Melbourne, Australia and Riyadh, Saudi Arabia, Journal of Modern Transportation, 22, 156-166	No intervention
Amato, F., Nava, S., Lucarelli, F., Querol, X., Alastuey, A., Baldasano, J. M., Pandolfi, M., A comprehensive assessment of PM emissions from paved roads: Real-world Emission Factors and intense street cleaning trials, Science of the total environment, 408, 4309-4318, 2010	Modelling study
Amirjamshidi, Glareh, Mostafa, Toka S., Misra, Aarshabh, Roorda, Matthew J., Integrated Model for Microsimulating Vehicle Emissions, Pollutant Dispersion and Population Exposure, Transportation Research: Part D: Transport and Environment, 18, 16-24, 2013	No data to extract
Amorim, J. H., Rodrigues, V., Tavares, R., Valente, J., Borrego, C., CFD modelling of the aerodynamic effect of trees on urban air pollution dispersion, Science of the total environment, 461-462, 541-551, 2013	Outcomes modelled not in protocol
Arvidsson, Niklas, Browne, Michael, A Review of the Success and Failure of Tram Systems to Carry Urban Freight: The Implications for a Low Emission Intermodal Solution Using Electric	Out of scope

Vehicles on Trams, European Transport/Trasporti Europei, 0, 2013	
Asadi, Somayeh, Hassan, Marwa, Kevern John, T., Rupnow, Tyson, Nitrogen Oxide Reduction and Nitrate Measurements on TiOsubscript two Photocatalytic Pervious Concrete Pavement, International Journal of Pavement Research and Technology, 7, 273-279	No intervention / lab study
Asadi, Somayeh, Hassan, Marwa, Nadiri, Ataallah, Dylla, Heather, Artificial intelligence modeling to evaluate field performance of photocatalytic asphalt pavement for ambient air purification, Environmental science and pollution research international, 21, 8847-57, 2014	Modelling study
Baik, J. J., Kwak, K. H., Park, S. B., Ryu, Y. H., Effects of building roof greening on air quality in street canyons, Atmospheric Environment, 61, 48-55, 2012	Outcomes modelled not clear
Baker, J., Walker, H. L., Cai, X., A study of the dispersion and transport of reactive pollutants in and above street canyons - A large eddy simulation, Atmospheric Environment, 38, 6883-6892, 2004	No intervention
Baldasano, J. M., Goncalves, M., Soret, A., Jimenez-Guerrero, P., Air pollution impacts of speed limitation measures in large cities: The need for improving traffic data in a metropolitan area, Atmospheric Environment, 44, 2997-3006, 2010	Modelling study
Ballardin, Giorgio, Environmental Benefits and Economic Rationale of Expanding the Italian Natural Gas Private Car Fleet, Economia delle Fonti di Energia e dell'Ambiente/Economics and Policy of Energy and the Environment, 48, 103-23, 2005	Out of scope
Bandeira, J. M., Coelho, M. C., Sa, M. E., Tavares, R., Borrego, C., Impact of land use on urban mobility patterns, emissions and air quality in a Portuguese medium-sized city, Science of the total environment, 409, 1154-1163, 2011	No intervention
Bandeira, Jorge, Almeida, Tiago, Khattak Asad, J., Rouphail Nagui, M., Coelho Margarida, Cabrita, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Generating Emission Information for Route Selection: Experimental Monitoring and Route Characterization, Transportation Research Board 90th Annual MeetingTransportation Research Board, 19	Modelling study
Bandeira, Jorge, Coelho, Margarida, Pimentel, Miguel, Khattak, Asad, Impact of Intercity Tolls in Portugal - An Environmental Perspective, Transport Research Arena 2012European CommissionFrench Institute of Science and Technology for Transport, Development and Networks (IFSTTAR), 48, 1174-1183	Emissions modelled
Baptista, Patricia C., Silva, Carla M., Farias, Tiago L., Heywood, John B., Energy and Environmental Impacts of Alternative Pathways for the Portuguese Road Transportation Sector, Energy Policy, 51, 802-15, 2012	Out of scope
Barlow, J. F., Dobre, A., Smalley, R. J., Arnold, S. J., Tomlin, A. S., Belcher, S. E., Referencing of street-level flows measured during the DAPPLE 2004 campaign, Atmospheric Environment, 43, 5536-5544, 2009	Model evaluation
Barlow, T., Boulter, P., McCrae, I., Sivellet, P., Non-exhaust particulate matter emissions from road traffic: summary report, 11, 2007	Modelling study
Barrett, Julia R., Air Pollution Intervention: Study Links Use of Face Masks to Improved Cardiovascular Outcomes, Environmental health perspectives, 120, A122-A122, 2012	Outside of scope
Barros, N., Fontes, T., Silva, M. P., Manso, M. C., How wide should be the adjacent area to an	No intervention

urban motorway to prevent potential health impacts from traffic emissions?, TRANSPORTATION RESEARCH PART A: POLICY AND PRACTICE, 50, 113-128	
Bartle, C., Avineri, Erel, Personalised travel plans in the workplace: a case study, Proceedings of the Institution of Civil Engineers - Municipal Engineer, 167, 183-190, 2015	Outcome measures not in scope
Bearman, Nick, Singleton Alex, D., Modelling the Potential Impact on CO2 Emissions of an Increased Uptake of Active Travel for the Home to School Commute Using Individual Level Data, Journal of Transport & Health, 1, 295-304	Outcomes not in protocol
Beck, Matthew J., Rose, John M., Hensher, David A., Behavioural Responses to Vehicle Emissions Charging, Transportation, 38, 445-63, 2011	No relevant intervention
Beck, Matthew J., Rose, John M., Hensher, David A., Environmental Attitudes and Emissions Charging: An Example of Policy Implications for Vehicle Choice, Transportation Research: Part A: Policy and Practice, 50, 171-82, 2013	Survey / modelling
Bedsworth Louise, Wells, Public Policy Institute of California, Washington Street Suite San Francisco C. A. U. S. A., Climate Change Challenges: Vehicle Emissions and Public Health in California, 40	No interventions outlined
Beevers, S. D., Carslaw, D. C., The impact of congestion charging on vehicle speed and its implications for assessing vehicle emissions, Atmospheric Environment, 39, 6875-6884, 2005	Outcomes not in protocol
Beevers, S. D., Carslaw, D. C., The impact of congestion charging on vehicle emissions in London, Atmospheric Environment, 39, 1-5, 2005	Modelling study
Bel, Germa, Rosell, Jordi, Effects of the 80 km/h and variable speed limits on air pollution in the metropolitan area of barcelona, Transportation Research Part D: Transport and Environment, 23, 90-97	Modelling study
Bell, Margaret, Ayodele, Emmanuel, Galatioto, Fabio, Its America, th Street N. W. th Floor Washington D. C. U. S. A., Creating an Evaluation Platform to Deliver Sustainable Urban Networks using Bluetooth Technology, 19th ITS World CongressERTICO - ITS EuropeEuropean CommissionITS AmericaITS Asia-Pacific, 11	Not a comparative study
Bender, F. A., Bosse, T., Sawodny, O., An investigation on the fuel savings potential of hybrid hydraulic refuse collection vehicles, Waste Management, 34, 1577-1583, 2014	Out of scope
BenDor, Todd, Ford, Andrew, Simulating a combination of feebates and scrappage incentives to reduce automobile emissions, Energy, 31, 1197-1214, 2006	No relevant interventions
Bento, Antonio, Kaffine, Daniel, Roth, Kevin, Zaragoza-Watkins, Matthew, The Effects of Regulation in the Presence of Multiple Unpriced Externalities: Evidence from the Transportation Sector, American Economic Journal: Economic Policy, 6, 1-29, 2014	No relevant intervention
Beusen, Bart, et al.,, Using On-Board Logging Devices to Study the Longer-Term Impact of an Eco-driving Course, Transportation Research: Part D: Transport and Environment, 14, 514-20, 2009	Outside of scope
Beuving, E., De Jonghe, T., Goos, D., Lindahl, T., Stawiarski, A., Fuel efficiency of road pavements, PROCEEDINGS OF THE 3RD EURASPHALT AND EUROBITUME CONGRESS HELD VIENNA, MAY, 983-92	Outside of scope
Bigazzi Alexander, Y., Figliozzi Miguel, A., Clifton Kelly, J., Traffic Congestion and Air Pollution	No relevant intervention

Exposure for Motorists: Comparing Exposure Duration and Intensity, International Journal of Sustainable Transportation, 9, 443-456	
Bigazzi, Alexander Y., Figliozzi, Miguel A., Marginal Costs of Freeway Traffic Congestion with On-Road Pollution Exposure Externality, Transportation Research: Part A: Policy and Practice, 57, 12-24, 2013	No relevant intervention
Biluck, Joe, Jr., The use of biodiesel in a school transportation system: the case of Medford Township, New Jersey, Inhalation toxicology, 19, 1041-3, 2007	no relevant outcomes
Bishop, G. A., Stedman, D. H., Hutton, R. B., Bohren, L., Lacey, N., Drive-by motor vehicle emissions: Immediate feedback in reducing air pollution, Environmental Science and Technology, 34, 1110-1116, 2000	Non-UK based qualitative study
Black, J., Golzar, R., Environmental transport pricing based on air quality criteria, AUSTRALASIAN TRANSPORT RESEARCH FORUM (ATRF), 25TH, 2002, CANBERRA, ACT, A, 15P	No relevant intervention
Blake, P., Reducing greenhouse emissions by improving traffic signal operations, ARRB CONFERENCE, 23RD, 2008, ADELAIDE, SOUTH AUSTRALIA, AUSTRALIA, 15P	Outcomes measured not in the protocol - emissions modelled based on outcomes
Boddy, J. W. D., Smalley, R. J., Dixon, N. S., Tate, J. E., Tomlin, A. S., The spatial variability in concentrations of a traffic-related pollutant in two street canyons in York, UK - Part I: The influence of background winds, Atmospheric Environment, 39, 3147-3161, 2005	Outside of scope
Boddy, J. W. D., Smalley, R. J., Goodman, P. S., Tate, J. E., Bell, M. C., Tomlin, A. S., The spatial variability in concentrations of a traffic-related pollutant in two street canyons in York, UK-Part II: The influence of traffic characteristics, Atmospheric Environment, 39, 3163-3176, 2005	Outside of scope
Boongrapue, N., Dia, H., Zito, R., Modelling of vehicle emissions using traffic simulation, CONFERENCE OF AUSTRALIAN INSTITUTES OF TRANSPORT RESEARCH (CAITR), 27TH, 2, 16P	Conference abstract
Borck, Rainald, Will Skyscrapers Save the Planet? Building Height Limits and Urban Greenhouse Gas Emissions, 2014	Modelling study
Boriboonsomsin, Kanok, Barth Matthew, J., Vu, Alexander, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Evaluation of Driving Behavior and Attitude Toward Eco-Driving: Southern California Limited Case Study, Transportation Research Board 90th Annual MeetingTransportation Research Board, 14	Not evaluating intervention
Bos, I., Jacobs, L., Nawrot, T. S., de Geus, B., Torfs, R., Int Panis, L., Degraeuwe, B., Meeusen, R., No exercise-induced increase in serum BDNF after cycling near a major traffic road, Neuroscience Letters, 500, 129-132, 2011	No intervention
Bosetti, Valentina, Longden, Thomas, Light Duty Vehicle Transportation and Global Climate Policy: The Importance of Electric Drive Vehicles, Energy Policy, 58, 209-19, 2013	No relevant intervention
Botwright, D., LOCAL AUTHORITY FLEETS: THE IPSWICH EXPERIENCE, CONFERENCE PAPERS FROM CONFERENCE ON CLEANER FUELS, CLEANER FLEETS: THEIR, 3P	Conference abstract
Boubaker, Samia, Rehimi, Férid, Kalboussi, Adel, Effect of vehicular technology on energy consumption and emissions, International Journal of Environmental Studies, 72, 667-684, 2015	No relevant intervention

Boulter, P. G., Cox, J. A., A review of European emission measurements and model for diesel-fuelled buses, TRL REPORT 378, 28p	No relevant intervention
Boulter, P. G., McCrae,, OSCAR:Final summary report, PUBLISHED PROJECT REPORT PPR137, 48p	No relevant intervention
Boulter, P. G., Wayman, M., McCrae, I., Harrison, R. M., A review of abatement measures for non-exhaust particulate matter from road vehicles, PUBLISHED PROJECT REPORT PPR230, 31p	Not a comparative study
Bowker, G. E., Baldauf, R., Isakov, V., Khlystov, A., Petersen, W., The effects of roadside structures on the transport and dispersion of ultrafine particles from highways, Atmospheric Environment, 41, 8128-8139, 2007	Modelling study
Bowker, G. E., Baldauf, R., Isakov, V., Khlystov, A., Petersen, W., Thoma, E., Bailey, C., Pulugurtha Srinivas S, O'Loughlin Robert Hallmark Shauna, American Society of Civil Engineers, Alexander Bell Drive Reston V. A. U. S. A., The Influence of a Noise Barrier and Vegetation on Air Quality Near a Roadway, Transportation Land Use, Planning, and Air QualityFederal Highway AdministrationTransportation Research BoardIowa State University, AmesUniversity of North Carolina, CharlotteAmerican Society of Civil Engineers, 372-381	modelling
Brady, John, O'Mahony, Margaret, Travel to Work in Dublin: The Potential Impacts of Electric Vehicles on Climate Change and Urban Air Quality, Transportation Research: Part D: Transport and Environment, 16, 188-93, 2011	No relevant intervention
Brazil, William, Caulfield, Brian, Rieser-Schussler, Nadine, Understanding Carbon: Making Emissions Information Relevant, Transportation Research: Part D: Transport and Environment, 19, 28-33, 2013	survey
Brebbia, C. A., Martin Duque, J. F., Wadhwa, L. C., Antonucci, E., Garzia, F., The Sustainable City II. Urban regeneration and sustainability. The automatic vehicles access control system of the historical centre of Rome, 853-61	No outcomes measured relating to the impact of the system on emissions etc.
Bresser, Coen, Rooke, Andy, Traffic Management in Holland. Improving Network Conditions using Effective Road Side Messaging, TRAFFIC ENGINEERING AND CONTROL, 52, 410-411	news article. no relevant outcomes
Bright, V. B., Bloss, W. J., Cai, X., Urban street canyons: Coupling dynamics, chemistry and within-canyon chemical processing of emissions, Atmospheric Environment, 68, 127-142, 2013	No intervention
Brinkman, G. L., Denholm, P., Hannigan, M. P., Milford, J. B., Effects of plug-in hybrid electric vehicles on ozone concentrations in Colorado, Environmental Science and Technology, 44, 6256-6262, 2010	Out of scope
Buccolieri, Riccardo, Gromke, Christof, Di Sabatino, Silvana, Ruck, Bodo, Aerodynamic effects of trees on pollutant concentration in street canyons, The Science of the total environment, 407, 5247-56, 2009	outcomes modelled not in protocols
Buliung, Ron N., Soltys, Kalina, Bui, Randy, Habel, Catherine, Lanyon, Ryan, Catching a Ride on the Information Super-Highway: Toward an Understanding of Internet-Based Carpool Formation and Use, Transportation, 37, 849-73, 2010	Modelling study
Bulteau, Julie, Tradable Emission Permit System for Urban Motorists: The Neo-classical Standard Model Revisited, Research in Transportation Economics, 36, 101-09, 2012	Out of scope
Bureau, Benjamin, Glachant, Matthieu, Distributional Effects of Road Pricing: Assessment of	No relevant outcomes reported

Nine Scenarios for Paris, Transportation Research: Part A: Policy and Practice, 42, 994-1007, 2008	
Burge, P., Munro, C., Read, P., Heywood, C., Investigating the likely behavioural responses to alternative congestion charge schemes in London, PROCEEDINGS OF THE EUROPEAN TRANSPORT CONFERENCE 2007 HELD 17-19 OCTOBER 2	No relevant outcomes reported
Cairns, A., Monitoring the social impacts of the central London congestion charge, PROCEEDINGS OF ETC 2005, STRASBOURG, FRANCE 18-20 SEPTEMBER 2005 - TRANSPO, 16p	Outside of scope
Camus, R., Longo, G., An integrated UTCS/AVM pollution control system, TRAFFIC MANAGEMENT, SAFETY AND INTELLIGENT TRANSPORT SYSTEMS. PROCEEDINGS, 261-71	No relevant outcomes reported
Cao, Xinyu, Mokhtarian, Patricia L., Handy, Susan L., Neighborhood Design and Vehicle Type Choice: Evidence from Northern California, Transportation Research: Part D: Transport and Environment, 11, 133-45, 2006	Out of scope
Carnovale, Maria, Gibson, Matthew, The Effects of Driving Restrictions on Air Quality and Driver Behavior, 2013	Modelling study
Carslaw, D. C., Priestman, M., Williams, M. L., Stewart, G. B., Beevers, S. D., Performance of optimised SCR retrofit buses under urban driving and controlled conditions, Atmospheric Environment, 105, 70-77, 2015	No clear control
Carslaw, David C., Beevers, Sean D., The Efficacy of Low Emission Zones in Central London as a Means of Reducing Nitrogen Dioxide Concentrations, Transportation Research: Part D: Transport and Environment, 7, 49-64, 2002	Modelling study
Caton, F., Britter, R. E., Dalziel, S., Dispersion mechanisms in a street canyon, Atmospheric Environment, 37, 693, 2003	No intervention
Caulfield, Brian, Estimating the Environmental Benefits of Ride-Sharing: A Case Study of Dublin, Transportation Research: Part D: Transport and Environment, 14, 527-31, 2009	modelling
Centers for Disease, Control, Prevention,, Corporate action to reduce air pollution--Atlanta, Georgia, 1998-1999, MMWR. Morbidity and mortality weekly report, 49, 153-6, 2000	No outcomes measured / modelling
Cesaroni, Giulia, Boogaard, Hanna, Jonkers, Sander, Porta, Daniela, Badaloni, Chiara, Cattani, Giorgio, Forastiere, Francesco, Hoek, Gerard, Health benefits of traffic-related air pollution reduction in different socioeconomic groups: the effect of low-emission zoning in Rome, Occupational & Environmental Medicine, 69, 133-139, 2012	Modelling study
Chakour, Vincent, Eluru, Naveen, Examining the Influence of Urban form and Land Use on Bus Ridership in Montreal, 2nd Conference of Transportation Research Group of India (2nd CTRG)Transportation Research Group of India, 104, 875-884	Out of scope
Chang, Y. M., Chou, C. M., Su, K. T., Tseng, C. H., Effectiveness of street sweeping and washing for controlling ambient TSP, Atmospheric Environment, 39, 1891-1902, 2005	Non-OECD/EU
Chatterton, T. J., Coulter, A., Musselwhite, C., Lyons, G., Clegg, S., Understanding how transport choices are affected by the environment and health: views expressed in a study on the use of carbon calculators, Public Health, 123, e45-9, 2009	Intervention outside of scope

Chen, D., Traffic reallocation impacts and automobile toxic pollutants emission for a general network in urban highway system: A second-best congestion pricing analysis, International Journal of Environment and Pollution, 53, 64-86, 2013	Modelling study
Chen, Hong, Goldberg, Mark S., Crouse, Dan L., Burnett, Richard T., Jerrett, Michael, Villeneuve, Paul J., Wheeler, Amanda J., Labrèche, France, Ross, Nancy A., Back-extrapolation of estimates of exposure from current land-use regression models, Atmospheric Environment, 44, 4346-4354, 2010	No relevant intervention
Chen, M., Liu, Y., NOx removal from vehicle emissions by functionality surface of asphalt road, Journal of Hazardous Materials, 174, 375-379, 2010	Not a comparative study
Chien Steven, I. Jy, Fallat, George, New Jersey Department of Transportation, Parkway Avenue Trenton N. J. U. S. A. Federal Highway Administration New Jersey Avenue S. E. Washington D. C. U. S. A., Computer Modeling and Simulation of New Jersey Signalized Highways, 149	No relevant outcomes reported
China, S., James, D. E., Influence of pavement macrotexture on PM10 emissions from paved roads: A controlled study, Atmospheric Environment, 63, 313-326, 2012	no intervention
Chiquetto, S., THE ENVIRONMENTAL IMPACTS FROM THE IMPLEMENTATION OF A PEDESTRIANIZATION SCHEME, TRANSPORTATION RESEARCH, PART D, 2D, 133-46	Modelling study
Chowdhury Md, Shoab, Varma Amiy, Gosling Geoffrey D., American Society of Civil Engineers, Alexander Bell Drive Reston V. A. U. S. A., Easing Congestion with Pedestrian Crossing at Midblock, Second Transportation & Development Congress 2014American Society of Civil Engineers, 430-436	Conference abstract
Cifuentes, L., Borja-Aburto, V. H., Gouveia, N., Thurston, G., Davis, D. L., Assessing the health benefits of urban air pollution reductions associated with climate change mitigation (2000-2020): Santiago, Sao Paulo, Mexico City, and New York City, Environmental health perspectives, 109, 419-425, 2001	No relevant intervention
Cloke, J., Harris, G, Latham, S., Quimby, A, Smith, L. , Baughan, C., Reducing the environmental impact of driving: a reivew of training and in-vehicle technologies, 32, 1999	Not an intervention study, not a systematic review
Coelho, Margarida C., Farias, Tiago L., Rouphail, Nagui M., Impact of Speed Control Traffic Signals on Pollutant Emissions, Transportation Research: Part D: Transport and Environment, 10, 323-40, 2005	no data to extract
Collet, S., Kidokoro, T., Sonoda, Y., Lohman, K., Karamchandani, P., Chen, S. Y., Minoura, H., Air quality impacts of motor vehicle emissions in the south coast air basin: Current versus more stringent control scenario, Atmospheric Environment, 47, 236-240, 2012	No relevant interventions
Colls, J. J., Micallef, A., Measured and modelled concentrations and vertical profiles of airborne particulate matter within the boundary layer of a street canyon, The Science of the total environment, 235, 221-33, 1999	No intervention
Colls, J. J., Namdeo, A. K., Baker, C. J., Dispersion and re-suspension of fine and coarse particulates in an urban street canyon, Science of the total environment, 235, 3, 1999	no intervention.
Conquest, J., Patey, I., Holt, A., Sustainability and road technology schemes, Traffic Engineering & Control, 48, 391-393	Commentary
Conquest, John, Patey, Ian, Holt, Aidan, Its America, th Street N. W. Washington D. C. U. S.	Outside of scope

A., Using ITS to Cut Carbon Costs, 15th World Congress on Intelligent Transport Systems and ITS America's 2008 Annual MeetingITS AmericaERTICOITS JapanTranscore, 10	
Cowie, C. T., Rose, N., Gillett, R., Walter, S., Marks, G. B., Redistribution of traffic related air pollution associated with a new road tunnel, Environmental Science and Technology, 46, 2918-2927, 2012	Road infrastructure project - out of scope
Cowie, H, Crawford, J, Davis, A, Steinle, S, Reis, S, Dixon, K, Morris, G, Hurley, F, Air Quality, Health, Wellbeing and Behaviour, 1-102, 2015	Not an intervention study, not a systematic review
Cruickshank, Samantha, Kendall, Michaela, Low-emission vehicle adoption in a UK local authority fleet: economic barriers and air quality benefits, International Journal of Low Carbon Technologies, 7, 16-22, 2012	Modelling study
Currie, Janet, Walker, Reed, Traffic Congestion and Infant Health: Evidence from E-ZPass, American Economic Journal: Applied Economics, 3, 65-90, 2011	Modelling study
Cyrys, Josef, Peters, Annette, Soentgen, Jens, Wichmann, H. Erich, Low emission zones reduce PM 10 mass concentrations and diesel soot in German cities, Journal of the Air & Waste Management Association (Taylor & Francis Ltd), 64, 481-487, 2014	Review, not comparative study
Czogalla, Olaf, Herrmann, Andreas, Its Japan, Tokyo Japan, Estimation of Vehicle Emissions of Improved Traffic Management Performance using Microsimulation, 20th ITS World CongressITS Japan, 11	Conference abstract
Dahlgren, J., HIGH OCCUPANCY VEHICLE LANES: NOT ALWAYS MORE EFFECTIVE THAN GENERAL PURPOSE LANES, TRANSPORTATION RESEARCH, PART A, 32A, 99-114	No relevant outcomes reported
Daniel, Joseph I., Bekka, Khalid, The Environmental Impact of Highway Congestion Pricing, Journal of Urban Economics, 47, 180-215, 2000	Modelling study
Davis, Lucas W., The Effect of Driving Restrictions on Air Quality in Mexico City, Journal of Political Economy, 116, 38-81, 2008	Modelling study
De Coensel, B., Can, A., Degraeuwe, B., De Vlieger, I., Botteldooren, D., Effects of traffic signal coordination on noise and air pollutant emissions, Environmental Modelling & Software, 35, 74-83, 2012	No data to extract
de Nazelle, A., Fruin, S., Westerdahl, D., Martinez, D., Ripoll, A., Kubesch, N., Nieuwenhuijsen, M., A travel mode comparison of commuters' exposures to air pollutants in Barcelona, Atmospheric Environment, 59, 151-159, 2012	No intervention
de Nazelle, Audrey, Rodríguez, Daniel A., Crawford-Brown, Douglas, The built environment and health: Impacts of pedestrian-friendly designs on air pollution exposure, Science of the total environment, 407, 2525-2535, 2009	out of scope
De Nicola, Flavia, Murena, Fabio, Costagliola, M. Antonietta, Alfani, Anna, Baldantoni, Daniela, Prati, M. Vittoria, Sessa, Ludovica, Spagnuolo, Valeria, Giordano, Simonetta, A multi-approach monitoring of particulate matter, metals and PAHs in an urban street canyon, Environmental science and pollution research international, 20, 4969-79, 2013	No relevant intervention
de Palma, Andre, Kilani, Moez, De Lara, Michel, Piperno, Serge, Cordon Pricing in the Monocentric City: Theory and Application to Paris Region, Recherches Economiques de Louvain/Louvain Economic Review, 77, 105-24, 2011	No relevant outcomes reported

DeCorla-Souza, Patrick, Creating a Financially Feasible High-Performance Metropolitan Transportation System, Journal of the Transportation Research Forum, 49, 21-38, 2010	Outcomes measured not in scope
Delhomme, P., Chappe, J., Grenier, K., Pinto, M., Martha, C., Reducing air-pollution: a new argument for getting drivers to abide by the speed limit?, Accident; analysis and prevention, 42, 327-38, 2010	outcomes measured out of scope
Department for Transport Local, Government, Personalised travel planning: evaluation of 14 pilots part funded by DfT, 77, 2005	Not a comparative study / don't measure outcomes in the protocol
Department for Transport Local, Government, Making personal travel planning work: research report, 163, 2007	Not a comparative study / don't measure outcomes in the protocol
Dogan, Ebru, Bolderdijk, Jan Willem, Steg, Linda, Making Small Numbers Count: Environmental and Financial Feedback in Promoting Eco-driving Behaviours, Journal of Consumer Policy, 37, 413-22, 2014	Survey
Donaghy, K. P., Schintler, L. A., MANAGING CONGESTION, POLLUTION, AND PAVEMENT CONDITIONS IN A DYNAMIC TRANSPORTATION NETWORK MODEL, TRANSPORTATION RESEARCH, PART D, 3D, 59-80	No relevant intervention
Dong, Jing, Lin, Zhenhong, Within-Day Recharge of Plug-In Hybrid Electric Vehicles: Energy Impact of Public Charging Infrastructure, Transportation Research: Part D: Transport and Environment, 17, 405-12, 2012	Outcomes not relevant
Dons, E., Temmerman, P., Van Poppel, M., Bellemans, T., Wets, G., Int Panis, L., Street characteristics and traffic factors determining road users' exposure to black carbon, Science of the total environment, 447, 72-79, 2013	Outside of scope
Dzierzanowski, Kajetan, Popek, Robert, Gawronska, Helena, Sæbø, Arne, Gawronski, Stanislaw W., Deposition of Particulate Matter of Different Size Fractions on Leaf Surfaces and in Waxes of Urban Forest Species, International Journal of Phytoremediation, 13, 1037-1046, 2011	not an intervention.
Egbue, Ona, Long, Suzanna, Barriers to Widespread Adoption of Electric Vehicles: An Analysis of Consumer Attitudes and Perceptions, Energy Policy, 48, 717-29, 2012	No intervention
El Assar, H., Institute of Transportation Engineers, th Street N. W. Washington D. C. U. S. A., A PROACTIVE APPROACH TO TRAFFIC SIGNAL OPERATION IMPROVEMENTS, ITE 2004 Annual Meeting and ExhibitInstitute of Transportation Engineers, 7	Outcomes measured not in protocol
Ellison Richard, B., Greaves Stephen, P., Hensher David, A., Five years of London's low emission zone: Effects on vehicle fleet composition and air quality, Transportation Research Part D: Transport and Environment, 23, 25-33	Not a comparative study; insufficient data to extract
Eppstein, Margaret J., Grover, David K., Marshall, Jeffrey S., Rizzo, Donna M., An Agent-Based Model to Study Market Penetration of Plug-In Hybrid Electric Vehicles, Energy Policy, 39, 3789-3802, 2011	Out of scope
Erdem, Cumhur, Senturk, Ismail, Simsek, Turker, Identifying the Factors Affecting the Willingness to Pay for Fuel-Efficient Vehicles in Turkey: A Case of Hybrids, Energy Policy, 38, 3038-43, 2010	Out of scope
Faria, Marta V., Baptista, Patricia C., Farias, Tiago L., Electric Vehicle Parking in European and American Context: Economic, Energy and Environmental Analysis, Transportation Research:	Outcomes reported not relevant

Part A: Policy and Practice, 64, 110-21, 2014	
Fellendorf, Martin, Hirschmann, Karin, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., A Toolbox to Quantify Emission Reductions due to Signal Control, Transportation Research Board 89th Annual MeetingTransportation Research Board, 12	Conference abstract
Fiorello, Davide, Martino, Angelo, Options for Road User Charges--Two Italian Case Studies, European Transport/Trasporti Europei, 0, 49-63, 2009	No data to extract
Fishman, Elliot, Washington, Simon, Haworth, Narelle, Bike Share's Impact on Car Use: Evidence from the United States, Great Britain, and Australia, Transportation Research: Part D: Transport and Environment, 31, 13-20, 2014	Outside of scope
Fontes, T., Pereira, S. R., Impact Assessment of Road Fleet Transitions on Emissions: The Case Study of a Medium European Size Country, Energy Policy, 72, 175-85, 2014	No relevant intervention
Fontes, Tania, et al.,, Are HOV/Eco-lanes a Sustainable Option to Reducing Emissions in a Medium-Sized European City?, Transportation Research: Part A: Policy and Practice, 63, 93-106, 2014	Modelling study
Frank Lawrence, D., Sallis James, F., Conway Terry, L., Chapman James, E., Saelens Brian, E., Bachman, William, Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality, JOURNAL OF THE AMERICAN PLANNING ASSOCIATION, 72, 75-87	Modelling
French, Jim, French Millie, S., Institute of Transportation Engineers, Eye Street N. W. Suite Washington D. C. U. S. A., Development and Application of Microsimulation in Congested Corridor Analysis, ITE 2007 Annual Meeting and ExhibitInstitute of Transportation Engineers, 16	Conference abstract
Frey, H. C., Rouphail, N. M., Zhai, H., Farias, T. L., Goncalves, G. A., Comparing real-world fuel consumption for diesel- and hydrogen-fueled transit buses and implication for emissions, TRANSPORTATION RESEARCH PART D, 12, 281-291	Modelling study
Friedman, M. S., Powell, K. E., Hutwagner, L., Graham, L. M., Teague, W. G., Impact of changes in transportation and commuting behaviors during the 1996 Summer Olympic Games in Atlanta on air quality and childhood asthma, JAMA, 285, 897-905, 2001	Insufficient detail provided on the interventions used
Friesz Terry, L., Han, Ke, Liu, Hongcheng, Yao, Tao, Dynamic Congestion and Tolls with Mobile Source Emission, Procedia - Social and Behavioral Sciences, 80, 818-836	Modelling study
Fu, Miao, Andrew Kelly, J., Peter Clinch, J., King, Fearghal, Environmental Policy Implications of Working from Home: Modelling the Impacts of Land-Use, Infrastructure and Socio-demographics, Energy Policy, 47, 416-23, 2012	Outcomes not in protocol
Fuller, Stephen, Robinson, John, Fraire, Francisco, Vadali, Sharada, Feasibility of an Intermodal Terminal in Rural Texas to Enhance Marketing and Transportation Efficiency, Journal of the Transportation Research Forum, 51, 25-42, 2012	Modelling
Gaines, Linda, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Energy Use and Emissions Comparison of Idling Reduction Options for Heavy-Duty Diesel Trucks, Transportation Research Board 88th Annual MeetingTransportation Research Board	Modelling
Galatioto, Fabio, Bell, Margaret, Hill, Graeme, Rose, Paul, Hodges, Nick, Its America, th Street N. W. th Floor Washington D. C. U. S. A., Evaluation of Carbon Reduction Traffic Measures	Conference abstract

Employing a Novel Approach to Micro-simulation Modelling of Real-world Emissions, 19th ITS World CongressERTICO - ITS EuropeEuropean CommissionITS AmericaITS Asia-Pacific, 9	
Galatioto, Fabio, Huang, Yue, Parry, Tony, Bird, Roger, Bell, Margaret, Traffic Modelling in System Boundary Expansion of Road Pavement Life Cycle Assessment, Transportation Research: Part D: Transport and Environment, 36, 65-75, 2015	Out of scope
Gallagher, J., Gill, L. W., McNabola, A., Optimizing the use of on-street car parking system as a passive control of air pollution exposure in street canyons by large eddy simulation, Atmospheric Environment, 45, 1684-1694, 2011	Outcomes not in protocol
Gallagher, J., Gill, L. W., McNabola, A., Numerical modelling of the passive control of air pollution in asymmetrical urban street canyons using refined mesh discretization schemes, Building & Environment, 56, 232-240, 2012	Outcomes not in protocol
Gallagher, J., Gill, L. W., McNabola, A., The passive control of air pollution exposure in Dublin, Ireland: A combined measurement and modelling case study, Science of the total environment, 458-460, 331-343, 2013	Modelling study
Genon, G., Brizio, E., Poggio, M., Mander U, Brebbia C. A. Tiezzi E., Wit Press, Bridge Street Billerica M. A. U. S. A., Use of Atmospheric Modelling for the Territorial Planning of Technological Structures, 4th International Conference on Urban Regeneration and Sustainability (The Sustainable City)WIT Transactions on Ecology and the EnvironmentInternational Journal of Ecodynamics, 199-208	Conference abstract
Giannouli, M., Kalognomou, E. A., Mellios, G., Moussiopoulos, N., Samaras, Z., Fiala, J., Impact of European emission control strategies on urban and local air quality, Atmospheric Environment, 45, 4753-4762, 2011	No specific intervention
Givoni, Moshe, Re-assessing the Results of the London Congestion Charging Scheme, Urban Studies, 49, 1089-1105, 2012	No data reported for extraction
Glaeser, Edward L., Kahn, Matthew E., The Greenness of Cities: Carbon Dioxide Emissions and Urban Development, Journal of Urban Economics, 67, 404-18, 2010	No intervention
Glaister, Stephen, Graham, Daniel J., Pricing our roads: Vision and reality, 131, 2004	Modelling study
Gokhale, S., Traffic flow pattern and meteorology at two distinct urban junctions with impacts on air quality, Atmospheric Environment, 45, 1830-1840, 2011	Model validation
Gokhale, Sharad B., Rebours, Arnaud, Pavageau, Michel, The performance evaluation of WinOSPM model for urban street canyons of Nantes in France, Environmental Monitoring & Assessment, 100, 153-176, 2005	Model validation
Golzar, R., Optimum road pricing based on environmental capacity, 264P	Conference abstract
Gonçalves, María, Jiménez-Guerrero, Pedro, López, Eugeni, Baldasano, José M., Air quality models sensitivity to on-road traffic speed representation: Effects on air quality of 80kmhâˆ ’ 1 speed limit in the Barcelona Metropolitan area, Atmospheric Environment, 42, 8389-8402, 2008	Modelling study
Gouge, Brian, Dowlatabadi, Hadi, Ries, Francis J., Minimizing the health and climate impacts of emissions from heavy-duty public transportation bus fleets through operational optimization, Environmental Science & Technology, 47, 3734-42, 2013	Modelling
Grabow Maggie, L., Spak Scott, N., Holloway, Tracey, Stone, Brian, Mednick Adam, C., Patz	No relevant intervention

Jonathan, A., Air Quality and Exercise-Related Health Benefits from Reduced Car Travel in the Midwestern United States, Environmental health perspectives, 120, 68-76	
Greater London, Authority, Congestion charging: a first review, 2004	No measurement of particulates/health impact
Gromke, C., Buccolieri, R., Di Sabatino, S., Ruck, B., Dispersion study in a street canyon with tree planting by means of wind tunnel and numerical investigations - Evaluation of CFD data with experimental data, Atmospheric Environment, 42, 8640-8650, 2008	No data for extraction
Gromke, C., Ruck, B., Influence of trees on the dispersion of pollutants in an urban street canyon-Experimental investigation of the flow and concentration field, Atmospheric Environment, 41, 3287-3302, 2007	No data for extraction
Gromke, Christof, Blocken, Bert, Influence of avenue-trees on air quality at the urban neighborhood scale. Part II: traffic pollutant concentrations at pedestrian level, Environmental pollution (Barking, Essex : 1987), 196, 176-84, 2015	No data for extraction
Grundstrom, Maria, Pleijel, Hakan, Limited effect of urban tree vegetation on NO2 and O3 concentrations near a traffic route, Environmental pollution (Barking, Essex : 1987), 189, 73-6, 2014	No comparator
Gualtieri, G., A street canyon model intercomparison in Florence, Italy, Water, Air, and Soil Pollution, 212, 461-482, 2010	Model comparison
Guerrini, G. L., Beeldens, A., Crispino, M., D'Ambrosio, G., Vismara, S., International Society for Concrete Pavements, Oyster Bay Court Bridgeville Pennsylvania U. S. A., Environmental Benefits of Innovative Photocatalytic Cementitious Road Materials, 10th International Conference on Concrete PavementsInternational Society for Concrete PavementsHolcim (Canada)Transports Quebec, 912-923	Conference abstract
Gustafsson, Mats, Johansson, Christer, Trafikverket, Borlange Sweden, Road pavements and PM10: summary of the results of research funded by the Swedish Transport Administration on how the properties of road pavements influence emissions and the properties of wear particles, PUBLIKATION, 33	Not relevant intervention
Hagler, G. S. W., Tang, W., Freeman, M. J., Heist, D. K., Perry, S. G., Vette, A. F., Model evaluation of roadside barrier impact on near-road air pollution, Atmospheric Environment, 45, 2522-2530, 2011	Outcomes reported not relevant
Haller, Megan, Welch, Eric, Lin, Jie, Fulla, Shelley, Economic Costs and Environmental Impacts of Alternative Fuel Vehicle Fleets in Local Government: An Interim Assessment of a Voluntary Ten-Year Fleet Conversion Plan, Transportation Research: Part D: Transport and Environment, 12, 219-30, 2007	Outcomes not relevant
Hallmark, Shauna, Wang, Bo, Mudgal, Abhisek, Isebrands Hillary, N., Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., On-Road Evaluation of Emission Impacts of Roundabouts, Transportation Research Board 90th Annual MeetingTransportation Research Board, 17	Modelling
Hammadou, Hakim, Papaix, Claire, Policy Packages for Modal Shift and CO2 Reduction in Lille, France, Transportation Research: Part D: Transport and Environment, 38, 105-16, 2015	Outcomes measured not in protocol
Harvey, Joan, Thorpe, Neil, Fairchild, Richard, Attitudes towards and perceptions of eco-driving and the role of feedback systems, Ergonomics, 56, 507-21, 2013	No clear intervention

Hassan, Marwa, Okeil, Ayman, Louisiana State University, Baton Rouge Department of Civil, Environmental Engineering, Baton Rouge L. A. U. S. A. Gulf Coast Research Center for Evacuation, Transportation Resiliency, Louisiana State University Baton Rouge L. A. U. S. A. Research, Innovative Technology Administration, New Jersey Avenue S. E. Washington D. C. U. S. A., Field and Laboratory Investigation of Photocatalytic Pavements, This research was sponsored by the U.S. Department of Transportation	No data to extract
Hatzopoulou, M., Weichenthal, S., Barreau, G., Goldberg, M., Farrell, W., Crouse, D., Ross, N., A web-based route planning tool to reduce cyclists' exposures to traffic pollution: A case study in Montreal, Canada, Environmental Research, 123, 58-61, 2013	modelling study. May be relevant to 3a.
Henderson, D. K., Koenig, B. E., Mokhtarian, P. L., Using travel diary data to estimate the emissions impacts of transportation strategies: The Puget Sound Telecommuting Demonstration Project, Journal of the Air and Waste Management Association, 46, 47-57, 1996	No relevant intervention
Henriksson, Greger, Hagman, Olle, Andreasson, Hakan, Environmentally reformed travel habits during the 2006 congestion charge trial in Stockholm--a qualitative study, International Journal of Environmental Research and Public Health, 8, 3202-15, 2011	Outcomes not measured directly
Henry, Gary T., Gordon, Craig S., Driving Less for Better Air: Impacts of a Public Information Campaign, Journal of Policy Analysis and Management, 22, 45-63, 2003	Modelling study
Hertel, Ole, Hvidberg, Martin, Ketzel, Matthias, Storm, Lars, Stausgaard, Lizzi, A proper choice of route significantly reduces air pollution exposure--a study on bicycle and bus trips in urban streets, The Science of the total environment, 389, 58-70, 2008	Modelling study
Hickman, A. , Travel Awareness Campaigns: Travelwise in West Sussex; Managing demand for Car Travel, TRANSPORT POLICY AND ITS IMPLEMENTATION., p402, 12, 1996	Not an intervention study
Hixson, M., Mahmud, A., Hu, J., Bai, S., Niemeier, D. A., Handy, S. L., Gao, S., Lund, J. R., Sullivan, D. C., Kleeman, M. J., Influence of regional development policies and clean technology adoption on future air pollution exposure, Atmospheric Environment, 44, 552-562, 2010	No relevant intervention
Hodges, N., Intelligent Transport Systems and the Health Impact of Traffic in Leicester (UK), PROCEEDINGS OF THE ITS WORLD CONGRESS, HELD LONDON, 8-12 OCTOBER 2006, 12p	Conference abstract
Hodgkinson, M., Whitehouse, J., Grubb, E., Urban street activity in 20mph zones, TRAFFIC ENGINEERING AND CONTROL, 13-15, 2002	No outcomes measured
Hodgson, F., May, T., Tight, M., Corner, M, Evaluation of the MIST travel awareness campaign 2. The before-and-after study, Traffic Engineering & Control, 39, 103-112, 1998	No behaviour change measured
Holman, C., Harrison, R., Querol, X., Review of the efficacy of low emission zones to improve urban air quality in European cities, Atmospheric Environment, 111, 161-169, 2015	Not an intervention study - literature review
Hosking, Jamie, Macmillan, Alexandra, Connor, Jennie, Bullen, Chris, Ameratunga, Shanthi, Organisational travel plans for improving health, Cochrane Database of Systematic Reviews, 2010	Outcomes not relevant
Hutton Jessica, M., Bokenkroger Courtney, D., Meyer Melanie, M., Midwest Research Institute, Volker Boulevard Kansas City M. O. U. S. A. Missouri Department of Transportation Organizational Results Division P. O. Box Jefferson City M. O. U. S. A. Federal Highway	Modelling study

Administration New Jersey Avenue S. E. Washington D. C. U. S. A., Evaluation of an Adaptive Traffic Signal System: Route 291 in Lee's Summit, Missouri, 86	
Hyden, C., Varhelyi, A., The effects on safety, time consumption and environment of large scale use of roundabouts in an urban area: a case study, Accident; analysis and prevention, 32, 11-23, 2000	modelled emissions
Hyland, Jackie, Donnelly, Peter, Air Pollution and Health - The Views of Policy Makers, Planners, Public and Private Sector on Barriers and Incentives for Change, Journal of Transport & Health, 2, 120-126	No outcomes measured
Hymel, Kent M., Small, Kenneth A., Dender, Kurt Van, Induced Demand and Rebound Effects in Road Transport, Transportation Research: Part B: Methodological, 44, 1220-41, 2010	No relevant intervention
Institute for Public Policy, Research, Grayling, T., Foley, J., Sansom, N., In the fast lane: fair and effective road user charging in Britain, 32, 2004	Out of scope
Int Panis, L., Broekx, S., Liu, R., Modelling instantaneous traffic emission and the influence of traffic speed limits, Science of the total environment, 371, 270-285, 2006	Out of scope
Irving, P., Moncrieff, I., New Zealand traffic and local air quality, Science of the total environment, 334-335, 299-306, 2004	Outside of scope
Ishaque, Muhammad M., Noland, Robert B., Simulated Pedestrian Travel and Exposure to Vehicle Emissions, Transportation Research: Part D: Transport and Environment, 13, 27-46, 2008	Modelling
Issariyanukula, Apichai, Labi, Samuel, Nextrans, Purdue University Nextrans Center Kent Avenue West Lafayette I. N. U. S. A. Research, Innovative Technology Administration, New Jersey Avenue S. E. Washington D. C. U. S. A., Financial and Technical Feasibility of Dynamic Congestion Pricing as a Revenue Generation Source in Indiana - Exploiting the Availability of Real-Time Information and Dynamic Pricing Technologies, This document is disseminated under the sponsorship of the Department of Transportation	Modelling study / outcomes not relevant
Jackson, Eric, Holmen, Britt, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Modal Analysis of Vehicle Operation and Particulate Emissions from Connecticut Transit Buses, Transportation Research Board 88th Annual MeetingTransportation Research Board, 26	No measurement of specific particulates
Jacobs, L., Nawrot, T. S., De Geus, B., Meeusen, R., Degraeuwe, B., Bernard, A., Sughis, M., Nemery, B., Panis, L. I., Subclinical responses in healthy cyclists briefly exposed to traffic-related air pollution: An intervention study, Environmental Health: A Global Access Science Source, 9, 2010	No intervention
James, R., Application of environmental monitoring and forecasting systems in transport, TRANSIT NEW ZEALAND AND NEW ZEALAND INSTITUTE OF HIGHWAY TECHNOLOGY (NZIHT, 29P	Conference abstract
Janhall, S., Review on urban vegetation and particle air pollution - Deposition and dispersion, Atmospheric Environment, 105, 130-137, 2015	Not a primary study, not a systematic review
Janssen, S., Lefebvre, W., Mensink, C., Degraeuwe, B., The multi-scale character of air pollution: Impact of local measures in relation to European and regional policies - A case study in Antwerp, Belgium, International Journal of Environment and Pollution, 54, 203-212, 2014	No data for extraction

Jayaratne, E. R., Meyer, N. K., Ristovski, Z. D., Morawska, L., Miljevic, B., Critical analysis of high particle number emissions from accelerating compressed natural gas buses, Environmental Science & Technology, 44, 3724-31, 2010	Outside of scope
Jazcilevich, Aron, Mares Vazquez Jose, Maria, Ramirez Pablo, Lopez, Perez Irma, Rosas, Economic-environmental analysis of traffic-calming devices, Transportation Research Part D: Transport and Environment, 36, 86-95	Not a comparative study
Jeanjean, A. P. R., Hinchliffe, G., McMullan, W. A., Monks, P. S., Leigh, R. J., A CFD study on the effectiveness of trees to disperse road traffic emissions at a city scale, Atmospheric Environment, 120, 1-14, 2015	Modelling
Jensen Soren, Underlien, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Bicycle Tracks and Lanes: A Before-and-After Study, Transportation Research Board 87th Annual MeetingTransportation Research Board, 15	Outside of scope
Jensen, S. S., Larson, T., Deepti, K. C., Kaufman, J. D., Modeling traffic air pollution in street canyons in New York City for intra-urban exposure assessment in the US Multi-Ethnic Study of atherosclerosis and air pollution, Atmospheric Environment, 43, 4544-4556, 2009	Model evaluation
Johansson, C., Burman, L., Forsberg, B., The effects of congestions tax on air quality and health, Atmospheric Environment, 43, 4843-4854, 2009	Modelling study
Jones, P., Hervik, A., Edward Elgar Publishers, William Pratt House Dewey Court Northampton M. A. U. S. A., RESTRAINING CAR TRAFFIC IN EUROPEAN CITIES: AN EMERGING ROLE FOR ROAD PRICING. IN: THE AUTOMOBILE, Classics in Transport Analysis, 7, 609	Published prior to search dates (1992)
Jong-Tae, Lee, Ji-Young, Son, Yong-Sung, Cho, Benefits of Mitigated Ambient Air Quality Due to Transportation Control on Childhood Asthma Hospitalization during the 2002 Summer Asian Games in Busan, Korea, Journal of the Air & Waste Management Association (Air & Waste Management Association), 57, 968-973, 2007	Modelling study
Jullien, A., Moneron, P., Quaranta, G., Gaillard, D., Air emissions from pavement layers composed of varying rates of reclaimed asphalt, Resources, Conservation and Recycling, 47, 356-374, 2006	Outside of scope
Karanasiou, A., Moreno, T., Amato, F., Tobias, A., Boldo, E., Linares, C., Lumbreras, J., Borge, R., Alastuey, A., Querol, X., Variation of PM2.5 concentrations in relation to street washing activities, Atmospheric Environment, 54, 465-469, 2012	Modelling study
Karanasiou, Angeliki, Moreno, Teresa, Amato, Fulvio, Lumbreras, Julio, Narros, Adolfo, Borge, Rafael, Tobías, Aurelio, Boldo, Elena, Linares, Cristina, Pey, Jorge, Reche, Cristina, Alastuey, Andrés, Querol, Xavier, Road dust contribution to PM levels â□“ Evaluation of the effectiveness of street washing activities by means of Positive Matrix Factorization, Atmospheric Environment, 45, 2193-2201, 2011	Outside of scope
Kaur, S., Nieuwenhuijsen, M. J., Colvile, R. N., Pedestrian exposure to air pollution along a major road in Central London, UK, Atmospheric Environment, 39, 7307-7320, 2005	Outside of scope
Kaur, S., Nieuwenhuijsen, M., Colvile, R., Personal exposure of street canyon intersection users to PM2.5, ultrafine particle counts and carbon monoxide in Central London, UK, Atmospheric Environment, 39, 3629-3641, 2005	No intervention
Kelly, F. J., Fuller, G. W., Walton, H. A., Fussell, J. C., Monitoring air pollution: Use of early	Not an intervention study, not a systematic review

warning systems for public health, Respirology, 17, 7-19, 2012	
Kelly, Frank, Anderson, H. Ross, Armstrong, Ben, Atkinson, Richard, Barratt, Ben, Beevers, Sean, Derwent, Dick, Green, David, Mudway, Ian, Wilkinson, Paul, H. E. I. Health Review Committee, The impact of the congestion charging scheme on air quality in London. Part 2. Analysis of the oxidative potential of particulate matter, Research report (Health Effects Institute), 73-144, 2011	Outside of scope
Kelly, Frank, Armstrong, Ben, Atkinson, Richard, Anderson, H. Ross, Barratt, Ben, Beevers, Sean, Cook, Derek, Green, Dave, Derwent, Dick, Mudway, Ian, Wilkinson, Paul, H. E. I. Health Review Committee, The London low emission zone baseline study, Research report (Health Effects Institute), 3-79, 2011	Modelling study
Keuken, M. P., Jonkers, S., Verhagen, H. L. M., Perez, L., Trueb, S., Okkerse, W. J., Liu, J., Pan, X. C., Zheng, L., Wang, H., Xu, R., Sabel, C. E., Impact on air quality of measures to reduce CO2 emissions from road traffic in Basel, Rotterdam, Xi'an and Suzhou, Atmospheric Environment, 98, 434-441, 2014	No clear intervention
Keuken, M. P., Jonkers, S., Zandveld, P., Voogt, M., Elshout van den, S., Elemental carbon as an indicator for evaluating the impact of traffic measures on air quality and health, Atmospheric Environment, 61, 1-8, 2012	Modelling study
King, E. A., Murphy, E., McNabola, A., Reducing Pedestrian Exposure to Environmental Pollutants: A Combined Noise Exposure and Air Quality Analysis Approach, Transportation Research: Part D: Transport and Environment, 14, 309-16, 2009	Modelling study
Kings College London, Environmental Research Group, Air Pollution Alert Services Evidence Development Strategy - Prediction of Possible Effectiveness and Assessment of Intervention Study Feasibility, 1-83, 2014	Modelling
Kovacs, Kent F., Haight, Robert G., Jung, Suhyun, Locke, Dexter H., O'Neil-Dunne, Jarlath, The Marginal Cost of Carbon Abatement from Planting Street Trees in New York City, Ecological Economics, 95, 1-10, 2013	Outcomes not relevant - looks at the cost effectiveness of street-tree planting on carbon abatement
Ksiazek, A., Brebbia C A, Miralles i Garcia J. L., Wit Press, Ashurst Lodge Ashurst Southampton S. O. A. A. United Kingdom, Approach to Simulation Assessment of Area-wide Traffic Calming in the Context of Sustainable Development, 21st International Conference on Urban Transport and the Environment, 13	Review, not comparative study
Kuhns, H., Etyemezian, V., Green, M., Hendrickson, K., McGown, M., Barton, K., Pitchford, M., Vehicle-based road dust emission measurement - Part II: Effect of precipitation, wintertime road sanding, and street sweepers on inferred PM 10 emission potentials from paved and unpaved roads, Atmospheric Environment, 37, 4573-4582, 2003	Measured potential of particulates
Lai, Frank, Carsten, Oliver, Tate, Fergus, How much benefit does Intelligent Speed Adaptation deliver: an analysis of its potential contribution to safety and environment, Accident; analysis and prevention, 48, 63-72, 2012	No relevant intervention
Lai, Wen-Tai, The Effects of Eco-driving Motivation, Knowledge and Reward Intervention on Fuel Efficiency, Transportation Research: Part D: Transport and Environment, 34, 155-60, 2015	Outside of scope
Larsson, Hanna, Ericsson, Eva, The Effects of an Acceleration Advisory Tool in Vehicles for Reduced Fuel Consumption and Emissions, Transportation Research: Part D: Transport and	Outside of scope

Environment, 14, 141-46, 2009	
Lee, Gunwoo, Joo, Shinhye, Oh, Cheol, Choi, Keechoo, An evaluation framework for traffic calming measures in residential areas, Transportation Research Part D: Transport and Environment, 25, 68-76	Modelling study
Lefebvre, W., Fierens, F., Trimpeneers, E., Janssen, S., Van de Vel, K., Deutsch, F., Viaene, P., Vankerkom, J., Dumont, G., Vanpoucke, C., Mensink, C., Peelaerts, W., Vliegen, J., Modeling the effects of a speed limit reduction on traffic-related elemental carbon (EC) concentrations and population exposure to EC, Atmospheric Environment, 45, 197-207, 2011	Modelling study
Li, Zhi-Chun, Wang, Ya-Dong, Lam, William H. K., Sumalee, Agachai, Choi, Keechoo, Design of Sustainable Cordon Toll Pricing Schemes in a Monocentric City, Networks and Spatial Economics, 14, 133-58, 2014	Modelling study
Lilley, William, Cope, Martin, Marquez, Leorey, Smith Nariida, C., Its America, Virginia Avenue S. W. Suite Washington D. C. U. S. A., Demonstrating the Value of ITS for Reducing Near Road Pollution, 12th World Congress on Intelligent Transport SystemsITS AmericaITS JapanERTICO, 9	Modelling study
Lin, J., Yu, D., Traffic-related air quality assessment for open road tolling highway facility, Journal of Environmental Management, 88, 962-969, 2008	Modelling
Lindsay, Graeme, Macmillan, Alexandra, Woodward, Alistair, Moving urban trips from cars to bicycles: impact on health and emissions, Australian and New Zealand Journal of Public Health, 35, 54-60, 2011	Modelling study
Lurmann, Fred, Avol, Ed, Gilliland, Frank, Emissions reduction policies and recent trends in Southern California's ambient air quality, Journal of the Air & Waste Management Association (1995), 65, 324-35, 2015	No intervention
Macmillan, A. K., Hosking, J., Connor, J. L., Bullen, C., Ameratunga, S., A Cochrane systematic review of the effectiveness of organisational travel plans: Improving the evidence base for transport decisions, Transport Policy, 29, 249-256	Not primary research
Macmillan, A., Connor, J., Witten, K., Kearns, R., Rees, D., Woodward, A., The societal costs and benefits of commuter bicycling: Simulating the effects of specific policies using system dynamics modeling, Environmental health perspectives, 122, 335-344, 2014	No relevant outcomes
MacNeill, S. J., Goddard, F., Pitman, R., Tharme, S., Cullinan, P., Childhood peak flow and the Oxford Transport Strategy, Thorax, 64, 651-6, 2009	Modelling study
Madireddy, Madhava, et al.,, Assessment of the Impact of Speed Limit Reduction and Traffic Signal Coordination on Vehicle Emissions Using an Integrated Approach, Transportation Research: Part D: Transport and Environment, 16, 504-08, 2011	Modelling study
Malina, Christiane, Scheffler, Frauke, The Impact of Low Emission Zones on Particulate Matter Concentration and Public Health, Transportation Research: Part A: Policy and Practice, 77, 372-85, 2015	Modelling study
Mandavilli, S., Rys, M. J., Russell, E. R., Environmental impact of modern roundabouts, International Journal of Industrial Ergonomics, 38, 135-142, 2008	Modelling
Mansfield Theodore, J., Rodriguez Daniel, A., Huegy, Joseph, Gibson Jacqueline, MacDonald, The Effects of Urban Form on Ambient Air Pollution and Public Health Risk: A Case Study in	No relevant intervention

Raleigh, North Carolina, Risk Analysis, 35, 901-918	
Masiol, M., Agostinelli, C., Formenton, G., Tarabotti, E., Pavoni, B., Thirteen years of air pollution hourly monitoring in a large city: Potential sources, trends, cycles and effects of car-free days, Science of the total environment, 494, 84-96, 2014	No data for extraction
Massiani, Jerome, Stated preference surveys for electric and alternative fuel vehicles: are we doing the right thing?, Transportation Letters, 6, 152-160	Out of scope
McCrae, I. S., Green, J. M., Hickman, A. J., Hitchcock, G., Parker, T., Ayland, N., Traffic management during high pollution episodes: a review, TRL REPORT 459, 54p	Not a comparative study. not a systematic review
McNabola, A., Broderick, B. M., Gill, L. W., Reduced exposure to air pollution on the boardwalk in Dublin, Ireland. Measurement and prediction, Environment International, 34, 86-93, 2008	No relevant data to extract
McNabola, A., Broderick, B. M., Gill, L. W., A numerical investigation of the impact of low boundary walls on pedestrian exposure to air pollutants in urban street canyons, Science of the total environment, 407, 760-769, 2009	Outcomes reported not in protocol
Meinardi, S., Nissenson, P., Barletta, B., Dabdub, D., Sherwood Rowland, F., Blake, D. R., Influence of the public transportation system on the air quality of a major urban center. A case study: Milan, Italy, Atmospheric Environment, 42, 7915-7923, 2008	Outside of scope
Meurs, Henk, Haaijer, Rinus, Geurs, Karst T., Modeling the Effects of Environmentally Differentiated Distance-Based Car-Use Charges in the Netherlands, Transportation Research: Part D: Transport and Environment, 22, 1-9, 2013	Out of scope
Meyer Michael, D., Chu Hsing, Chung, Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Approach to Measure CO2 Emissions of Truck-Only Lanes, Transportation Research Board 88th Annual MeetingTransportation Research Board	Conference abstract
Meyer, Michael D., Demand Management as an Element of Transportation Policy: Using Carrots and Sticks to Influence Travel Behavior, Transportation Research: Part A: Policy and Practice, 33, 575-99, 1999	No outcomes measured
Mitchell, G., Namdeo, A., Milne, D., The air quality impact of cordon and distance based road user charging: An empirical study of Leeds, UK, Atmospheric Environment, 39, 6231-6242, 2005	Modelling study
Mitchell, Gordon, Hargreaves, Anthony, Namdeo, Anil, Echenique, Marcial, Land Use, Transport, and Carbon Futures: The Impact of Spatial Form Strategies in Three UK Urban Regions, Environment and Planning A, 43, 2143-63, 2011	Outcome measured not in protocol
Miyoshi, Chikage, Rietveld, Piet, Measuring the Equity Effects of a Carbon Charge on Car Commuters: A Case Study of Manchester Airport, Transportation Research: Part D: Transport and Environment, 35, 23-39, 2015	Outcomes measured not in protocol
Moore, Adam, Kendrick Christine, M., Bigazzi Alexander, York, Haire Ashley, Raye, George, Linda, Figliozzi, Miguel, Monsere Christopher, M., Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., Assessing Bicyclist and Pedestrian Exposure to Ultrafine Particles: Passive Shielding with Noise Barriers, Transportation Research Board 90th Annual MeetingTransportation Research Board, 13	Outcomes measured not in protocol
Mullen, M. A., Wilson, J. H., Gottsman, L., Noland, R. B., Schroeer, W. L., Transportation Research Board, Fifth Street N. W. Washington D. C. U. S. A., EMISSIONS IMPACT OF	Modelling / not a comparative study / looks at impact of imbcreasing speed limits on air pollution levels

ELIMINATING NATIONAL SPEED LIMITS: ONE YEAR LATER, Transportation Research Record, 120	
Namdeo, Anil, Mitchell, Gordon, An empirical study of estimating vehicle emissions under cordon and distance based road user charging in Leeds, UK, Environmental Monitoring and Assessment, 136, 45-51, 2008	Modelling
Nasir, Mostofa Kamal, Md Noor, Rafidah, Kalam, M. A., Masum, B. M., Reduction of fuel consumption and exhaust pollutant using intelligent transport systems, TheScientificWorldJournal, 2014, 836375, 2014	Outside of scope / modelling
Ng, W. Y., Chau, C. K., Evaluating the role of vegetation on the ventilation performance in isolated deep street canyons, International Journal of Environment and Pollution, 50, 98-110, 2012	Outcomes measured not in protocol
Norman, M., Johansson, C., Studies of some measures to reduce road dust emissions from paved roads in Scandinavia, Atmospheric Environment, 40, 6154-6164, 2006	Intervention not relevant
Oduyemi, K. O. K., Davidson, B., The impacts of road traffic management on urban air quality, Science of the total environment, 218, 59-66, 1998	no specific intervention
Ogilvie, D., Bull, F., Cooper, A., Rutter, H., Adams, E., Brand, C., Ghali, K., Jones, T., Mutrie, N., Powell, J., Preston, J., Sahlqvist, S., Song, Y., Evaluating the travel, physical activity and carbon impacts of a 'natural experiment' in the provision of new walking and cycling infrastructure: Methods for the core module of the iConnect study, BMJ Open, 2, 2012	No outcomes measured
Orru, Hans, Lovenheim, Boel, Johansson, Christer, Forsberg, Bertil, Potential health impacts of changes in air pollution exposure associated with moving traffic into a road tunnel, Journal of Exposure Science & Environmental Epidemiology, 25, 524-31, 2015	Modelling study
Ragettli, M. S., Corradi, E., Braun-Fahrlander, C., Schindler, C., de Nazelle, A., Jerrett, M., Ducret-Stich, R. E., Kunzli, N., Phuleria, H. C., Commuter exposure to ultrafine particles in different urban locations, transportation modes and routes, Atmospheric Environment, 77, 376-384, 2013	Outcomes measured not in protocol
RICARDO_AEA, Farnham Traffic Management and Low Emission Strategy, 1, 2014	No details on modelling used
Roby, Helen, Understanding the Development of Business Travel Policies: Reducing Business Travel, Motivations and Barriers, Transportation Research: Part A: Policy and Practice, 69, 20-35, 2014	Outcomes/ interventions not relevant
Rojas-Rueda, D., de Nazelle, A., Teixido, O., Nieuwenhuijsen, M. J., Replacing car trips by increasing bike and public transport in the greater Barcelona metropolitan area: A health impact assessment study, Environment International, 49, 100-109, 2012	No relevant intervention
Saelensminde, Kjartan, Cost-Benefit Analyses of Walking and Cycling Track Networks Taking into Account Insecurity, Health Effects and External Costs of Motorized Traffic, Transportation Research: Part A: Policy and Practice, 38, 593-606, 2004	Intervention not relevant - not about implementation of or changes to cycle routes or pedestrianised areas; or options for siting of routes
Saka Anthony, A., Agboh Dennis, K., Jamiat al-Imarat al-Arabiyah al-Muttahidah, Partners for Advanced Transit, Highways, University of California South th Street Building Richmond C. A. U. S. A. Partners for Advanced Transit, Highways, University of California Richmond C. A. U. S. A. University of Minnesota Twin Cities Department of Civil Engineering Pillsbury Drive S. E. Minneapolis M. N. U. S. A. University of California Irvine Institute of Transportation Studies	No relevant intervention

Irvine C. A. U. S. A. Joint Transportation Research Program Insurance Institute for Highway Safety North Glebe Road Arlington V. A. U. S. A. Texas Transportation Institute Texas A., M University System, College Station T. X. U. S. A. Chicago Transit Authority Chicago I. L. U. S. A. University of Utah Salt Lake City Utah Traffic Laboratory S. Central Campus Drive Salt Lake City U. T. U. S. A. University of Toronto Intelligent Transportation Systems Centre University of Hawaii Manoa Department of Civil Engineering Dole Street Holmes Hall Honolulu H. I. U. S. A., ASSESSMENT OF THE IMPACT OF ELECTRONIC TOLL COLLECTION ON MOBILE EMISSIONS IN THE BALTIMORE METROPOLITAN AREA, National Research Council (U.S.). Transportation Research Board. Meeting (81st : 2002 : Washington, D.C.). Preprint CD-ROM, 21	
Santos, G., Rojey, L., Newbery, D., The Environmental Benefits from Road Pricing, 2000	Modelling study
Schram-Bijkerk, D., van Kempen, E., Knol, A. B., Kruize, H., Staatsen, B., van Kamp, I., Quantitative health impact assessment of transport policies: two simulations related to speed limit reduction and traffic re-allocation in the Netherlands, Occupational and environmental medicine, 66, 691-8, 2009	Modelling study
Schulte, N., Snyder, M., Isakov, V., Heist, D., Venkatram, A., Effects of solid barriers on dispersion of roadway emissions, Atmospheric Environment, 97, 286-295, 2014	Model comparison
Steffens, J. T., Wang, Y. J., Zhang, K. M., Exploration of effects of a vegetation barrier on particle size distributions in a near-road environment, Atmospheric Environment, 50, 120-128, 2012	Model evaluation
Stieb, David M., Evans, Gregory J., Sabaliauskas, Kelly, Chen, L. I., Campbell, Monica E., Wheeler, Amanda J., Brook, Jeffrey R., Guay, Mireille, A scripted activity study of the impact of protective advice on personal exposure to ultra-fine and fine particulate matter and volatile organic compounds, Journal of Exposure Science & Environmental Epidemiology, 18, 495-502, 2008	outcomes not relevant
Stromberg, Helena K., Karlsson, I. C. MariAnne, Comparative Effects of Eco-driving Initiatives Aimed at Urban Bus Drivers--Results from a Field Trial, Transportation Research: Part D: Transport and Environment, 22, 28-33, 2013	Results not presented by comparator group
Sunitiyoso, Yos, Waterson, Ben, McDonald, Mike, Its America, th Street N. W. Washington D. C. U. S. A., Toward Informed Travellers: Developing a Real-Time Route Planner with Consideration of Travellers' Exposure to Air Pollution, 16th ITS World Congress and Exhibition on Intelligent Transport Systems and ServicesITS AmericaERTICOITS Japan, 8	Conference abstract
Tate, J. E., Bell, M. C., Evaluation of a traffic demand management strategy to improve air quality in urban areas, PROCEEDINGS OF THE 10TH INTERNATIONAL CONFERENCE ON ROAD TRANSPORT INFORMA, 158-62	Conference abstract
Tonne, C., Beevers, S., Armstrong, B., Kelly, F., Wilkinson, P., Air pollution and mortality benefits of the London Congestion Charge: spatial and socioeconomic inequalities, Occupational & Environmental Medicine, 65, 620-627, 2008	Modelling study
Transport for London, Taxi & private hire eco/smarter driving, 82, 2009	Baseline study - evaluating views on eco-driving prior to a campaign
Tribby Calvin, P., Miller Harvey, J., Song, Ying, Smith Ken, R., Do air quality alerts reduce traffic? An analysis of traffic data from the Salt Lake City metropolitan area, Utah, USA, Transport Policy, 30, 173-185	Not a comparative study / Outcomes do not meet the protocol

Tscharaktschiew, Stefan, Hirte, Georg, The Drawbacks and Opportunities of Carbon Charges in Metropolitan Areas--A Spatial General Equilibrium Approach, Ecological Economics, 70, 339-57, 2010	Out of scope
Van Ristell, Jessica, Quddus, Mohammed, Enoch, Marcus, Wang, Chao, Hardy, Peter, Quantifying the Transport-Related Impacts of Parental School Choice in England, Transportation, 40, 69-90, 2013	No relevant intervention
Varhelyi, Andras, The Effects of Small Roundabouts on Emissions and Fuel Consumption: A Case Study, Transportation Research: Part D: Transport and Environment, 7, 65-71, 2002	Modelling
Weber, Frauke, Kowarik, Ingo, Säumel, Ina, Herbaceous plants as filters: Immobilization of particulates along urban street corridors, Environmental Pollution, 186, 234-240, 2014	Outcomes measured not in protocol
West, J. J., Osnaya, P., Laguna, I., Martinez, J., Fernandez, A., Co-control of urban air pollutants and greenhouse gases in Mexico City, Environmental Science and Technology, 38, 3474-3481, 2004	No clear intervention
Whitlow, Thomas H., Hall, Andrew, Zhang, K. Max, Anguita, Juan, Impact of local traffic exclusion on near-road air quality: findings from the New York City "Summer Streets" campaign, Environmental pollution (Barking, Essex : 1987), 159, 2016-27, 2011	No data to extract (only charts presented)
Wood, Helen E., Marlin, Nadine, Mudway, Ian S., Bremner, Stephen A., Cross, Louise, Dundas, Isobel, Grieve, Andrew, Grigg, Jonathan, Jamaludin, Jeenath B., Kelly, Frank J., Lee, Tak, Sheikh, Aziz, Walton, Robert, Griffiths, Christopher J., Effects of Air Pollution and the Introduction of the London Low Emission Zone on the Prevalence of Respiratory and Allergic Symptoms in Schoolchildren in East London: A Sequential Cross-Sectional Study, PloS one, 10, e0109121, 2015	Cross sectional survey - not a comparative study

Appendix 5 Quality Appraisal checklists

QA EPOC Checklist for RCTs, non-randomised controlled trials and controlled before-after studies: draft

Administrative details

Study name or author and year [Type study name, or author and year (include letter if more than 1 paper with the same author and year, e.g. 'Smith 2010a')]	**STAR ID** [Type STAR ID]
Citation [Include citation details – usually authors, title of study, journal details, year]	
Linked studies (study name or author, year, STAR ID) [Include study name or author, year and STAR ID of any related studies, or state 'None']	
Final study quality score [Click to choose the final quality score. See 'Calculation of final study quality score' below for details on how to complete this.]	
Date of QA [Click to choose the date the QA was completed]	**Reviewer(s) names** [Type name of the reviewer/reviewers completing the quality assessment]

Calculation of final study quality score (from box 6.1 on page 95 of the NICE Guidelines Manual)

++	All or most of the checklist criteria have been fulfilled, and where they have not been fulfilled the conclusions are very unlikely to alter.
+	Some of the checklist criteria have been fulfilled, and where they have not been fulfilled, or are not adequately described, the conclusions are unlikely to alter.
-	Few or no checklist criteria have been fulfilled and the conclusions are likely or very likely to alter.

Quality Assessment

For all questions:

++	'Yes'	The study full meets the criterion.
+	'Partly'	The study largely meets the criterion but differs in some important respect.
-	'No'	The study deviates substantially from the criterion.
	'Unclear'	Report provides insufficient information to judge whether the study complies with the criterion.
	'NA (not applicable'	The criterion is not relevant in this particular instance.

Item	Decision	Comments
1. Was the allocation sequence adequately generated?	[Click here to choose a decision. ++ if a random component in the sequence generation process is described (e.g. a random number table), - if a non-random method is used (e.g. date of admission) or if study is a non-randomised controlled trial or controlled before-after study]	[State how the allocation sequence was generated.]
2. Was the allocation adequately concealed?	[Click here to choose a decision. ++ if allocation by institution, team or professional and allocation performed on all units at start of the study, or if the unit of allocation was by patient or episode of care and there was a centralised randomisation scheme (on-site computer system or sealed opaque envelopes). – if controlled before-after study.]	[State how the allocation was concealed.]
3. Were baseline outcome measurements similar?	[Click here to choose a decision.++ if performance or patient outcomes were measured prior to intervention and no important differences present across study groups. In RCTs score ++ if imbalanced but appropriate adjusted analysis was performed (e.g. analysis of covariance). Score - if important differences were present and not adjusted for in analysis.]	[State whether the baseline outcome measurements were similar.]
4. Were baseline characteristics similar?	[Click here to choose a decision. ++ if baseline characteristics of the study and control providers are reported and similar. Score - if there is no report of characteristics or if there are differences between control and intervention providers.]	[State whether the baseline characteristics were similar.]
5. Were incomplete outcome data adequately addressed?	[Click here to choose a decision. ++ if missing outcome measures were unlikely to bias the results (e.g. the proportion of missing data was similar in the intervention and control groups	[State whether incomplete outcome data were adequately addressed.]

	or the proportion of missing data was less than the effect size i.e. unlikely to overturn the study result). Score - if missing outcome data was likely to bias the results.]	
6. Was knowledge of the allocated interventions adequately prevented during the study?	[Click here to choose a decision. ++ if the authors state explicitly that primary outcome variables were assessed blindly, or outcomes are objective, e.g. length of hospital stay. Score - if primary outcomes were not assessed blindly.]	[State whether knowledge of the allocated interventions was adequately prevented during the study.]
7. Was the study adequately protected against contamination?	[Click here to choose a decision. ++ if allocation by community, institution or practice and it is unlikely that the control group received the intervention. Score - if it is likely that the control group received the intervention (e.g. if patients rather than professionals were randomised). Score “unclear” if professionals were allocated within a clinic or practice and it is possible that communication between intervention and control professionals could have occurred (e.g. physicians within practices were allocated to intervention or control).]	[State whether the study was adequately protected against contamination.]
8. Was the study free from selective outcome reporting?	[Click here to choose a decision. ++ if there is no evidence that outcomes were selectively reported (e.g. all relevant outcomes in the methods section are reported in the results section). Score - if some important outcomes are subsequently omitted from the results.]	[State whether the study was free from selective outcome reporting.]
9. Was the study free from other risks of bias?	[Click here to choose a decision. Score ++ if there is no evidence of other risk of biases.]	[State whether the study was free from other risks of bias.]

QA EPHPP Checklist for uncontrolled before and after studies (EPHPP)

Administrative details

Study name or author and year [Type study name, or author and year (include letter if more than 1 paper with the same author and year, e.g. 'Smith 2010a')]	**STAR ID** [Type STAR ID]
Citation [Include citation details – usually authors, title of study, journal details, year]	
Linked studies (study name or author, year, STAR ID) [Include study name or author, year and STAR ID of any related studies, or state 'None']	
Final study quality score [Click to choose the final quality score. See 'Calculation of final study quality score' below for details on how to complete this.]	
Date of QA [Click to choose the date the QA was completed]	**Reviewer(s) names** [Type name of the reviewer/reviewers completing the quality assessment]

Calculation of final study quality score (from EPHPP tool http://www.ephpp.ca/PDF/Quality%20Assessment%20Tool_2010_2.pdf)

++	Strong. No weak ratings.
+	Moderate. One weak rating.
-	Weak. Two or more weak ratings.

Quality Assessment

Item	Component Rating	Section Rating	Comments
Selection bias			
1. Are the individuals selected to participate in the study likely to be representative of the target population?	[Click here to choose a rating. Score ‘very likely’ if randomly selected from a comprehensive list of individuals in target population, ‘somewhat likely’ if referred from a source (e.g. clinic) in a systematic manner, ‘not likely’ if self-referred.]	[Click here to choose a decision. ‘**Strong**’ if Q1 is ‘very likely’ **and** Q2 is 80 to 100%. ‘**Moderate**’ if Q1 is ‘very likely’ **or** ‘somewhat likely’ **and** Q2 is 60 or 79% or ‘can’t tell’. ‘**Weak**’ if Q1 is ‘not likely’ **or** ‘can’t tell’ **and** Q2 is ‘can’t tell’.]	[Add comments if necessary.]
2. What percentage of selected individuals agreed to participate?	[Click here to choose a rating.]		
Study design			
3. What is the study design?	[Click here to choose a rating.]	[Click here to choose a decision. ‘**Strong**’ if RCT or CCT, ‘**moderate**’ if cohort analytic study, case control study, a cohort design, or interrupted time series, ‘**weak**’ for any other method or did not state method used.]	[Add comments if necessary, including description of study design if ‘other’.]
4. Was the study described as randomised?	[Click here to choose a rating. If ‘no’, mark questions 5 and 6 as ‘not applicable’ and go straight to ‘Confounders’ section.]		
5. Was the method of randomisation described?	[Click here to choose a rating.]		
6. Was the method of randomisation appropriate?	[Click here to choose a rating.]		
Confounders			
7. Were there important differences between groups prior to the intervention?	[Click here to choose a rating. Example of confounders include race, sex, marital status/family, age, socioeconomic status, education, health status, pre-intervention score on outcome measure.]	[Click here to choose a decision. ‘**Strong**’ if Q7 is ‘no’ **or** Q2 is 80% or more. ‘**Moderate**’ if Q7 is ‘yes’ **and** Q8 is 60 to 79%. ‘**Weak**’ if Q7 is ‘yes’ **and** Q8 is less than 60%, **or** if Q7 is ‘cant’ tell’ **and** Q8 is ‘can’t tell’.]	[Add comments if necessary.]
8. If yes, what percentage of relevant confounders were controlled (either in the design [e.g. stratification, matching] or analysis)?	[Click here to choose a rating.]		
Blinding			
9. Was/were the outcome assessor/s aware of the intervention or exposure status of participants?	[Click here to choose a rating.]	[Click here to choose a decision. ‘**Strong**’ if Q9 is ‘no’ **and** Q10 is ‘no’. ‘**Moderate**’ if Q9 is ‘no’ **or** Q10 is ‘no’, **or** Q9 is ‘can’t tell’ **and** Q10 is ‘can’t tell’. ‘**Weak**’ if Q9 is ‘yes’	[Add comments if necessary.]

10. Were the study participants aware of the research question?	[Click here to choose a rating.]	**and** Q10 is 'yes'.]	
Data collection methods			
11. Were data collection tools shown to be valid?	[Click here to choose a rating.]	[Click here to choose a decision. '**Strong**' if Q11 is 'yes' **and** Q12 is 'yes'. '**Moderate**' if Q11 is 'yes' **and** Q12 is 'no' **or** Q12 is 'can't tell'. '**Weak**' if Q11 is 'no' **or** Q11 is 'can't tell' **and** Q12 is 'can't tell'.]	[Add comments if necessary.]
12. Were data collection tools shown to be reliable?	[Click here to choose a rating.]		
Withdrawals and drop-outs			
13. Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?	[Click here to choose a rating.]	[Click here to choose a decision. '**Strong**' if Q14 is 80% or more. '**Moderate**' if Q14 is 60 to 79% **or** 'not applicable'. '**Weak**' if Q14 is less than 60% **or** 'can't tell'.]	[Add comments if necessary.]
14. What percentage of participants completed the survey?	[Click here to choose a rating. If percentage differs by groups, record the lowest.]		
Intervention integrity			
15. What percentage of participants received the allocated intervention or exposure of interest?	[Click here to choose a rating. If percentage differs by groups, record the lowest.]	Section rating not required.	[Add comments if necessary.]
16. Was the consistency of the intervention measured?	[Click here to choose a rating.]		
17. Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?	[Click here to choose a rating.]		
Analyses			
18. What is the unit of allocation?	[Click here to choose a rating.]	Section rating not required.	[Add comments if necessary. Add details if 'other' selected for question 18 and/or 19.]
19. What is the unit of analysis?	[Click here to choose a rating.]		
20. Are the statistical methods appropriate for the study design?	[Click here to choose a rating.]		
21. Is the analysis performed by intervention allocation status (i.e.	[Click here to choose a rating.]		

intention to treat) rather than the actual intervention received?			

A.4 Methodology checklist: Qualitative studies

Study identification	
Guidance topic:	**Key research question/aim:**
Checklist completed by:	

Theoretical approach		
1. Is a qualitative approach appropriate? *For example,* • Does the research question seek to understand processes or structures, or illuminate subjective experiences or meanings? • Could a quantitative approach better have addressed the research question?	Choose an item.	Comments:
2. Is the study clear in what it seeks to do? *For example,* • Is the purpose of the study discussed – aims/objectives/research question/s? • Is there adequate/appropriate reference to the literature? • Are underpinning values/assumptions/theory discussed?	Choose an item.	Comments:
Study design		
3. How defensible/rigorous is the research design/methodology? *For example,* • Is the design appropriate to the research question? • Is a rationale given for using a qualitative approach? • Are there clear accounts of the rationale/justification for the sampling, data collection and data analysis techniques used? • Is the selection of cases/sampling strategy theoretically justified?	Choose an item.	Comments:
Data collection		

4. How well was the data collection carried out? *For example,* • Are the data collection methods clearly described? • Were the appropriate data collected to address the research question? • Was the data collection and record keeping systematic?	Choose an item.	Comments:
Trustworthiness		
5. Is the role of the researcher clearly described? *For example,* • Has the relationship between the researcher and the participants been adequately considered? • Does the paper describe how the research was explained and presented to the participants?	Choose an item.	Comments:
6. Is the context clearly described? *For example,* • Are the characteristics of the participants and settings clearly defined? • Were observations made in a sufficient variety of circumstances? • Was context bias considered?	Choose an item.	Comments:
7. Were the methods reliable? *For example,* • Was data collected by more than one method? • Is there justification for triangulation, or for not triangulating? • Do the methods investigate what they claim to?	Choose an item.	Comments:
Analysis		
8. Is the data analysis sufficiently rigorous? *For example,* • Is the procedure explicit – i.e. is it clear how the data was analysed to arrive at the results? • How systematic is the analysis, is the procedure reliable/dependable? • Is it clear how the themes and concepts were derived from the data?	Choose an item.	Comments:
9. Is the data 'rich'? *For example,* • How well are the contexts of the data described? • Has the diversity of perspective and content been explored? • How well has the detail and depth been demonstrated? • Are responses compared and contrasted across groups/sites?	Choose an item.	Comments:

10. Is the analysis reliable? *For example,* • Did more than one researcher theme and code transcripts/data? • If so, how were differences resolved? • Did participants feed back on the transcripts/data if possible and relevant? • Were negative/ discrepant results addressed or ignored?	Choose an item.	Comments:
11. Are the findings convincing? *For example,* • Are the findings clearly presented? • Are the findings internally coherent? • Are extracts from the original data included? • Is the data appropriately referenced? • Is the reporting clear and coherent?	Choose an item.	Comments:
12. Are the findings relevant to the aims of the study?	Choose an item.	Comments:
13. Conclusions *For example,* • How clear are the links between data, interpretation and conclusions? • Are the conclusions plausible and coherent? • Have alternative explanations been explored and discounted? • Does this enhance understanding of the research topic? • Are the implications of the research clearly defined? • Is there adequate discussion of any limitations encountered?	Choose an item.	Comments:
Ethics		
14. How clear and coherent is the reporting of ethics? *For example,* • Have ethical issues been taken into consideration? • Are they adequately discussed e.g. do they address consent and anonymity? • Have the consequences of the research been considered i.e. raising expectations, changing behaviour etc? • Was the study approved by an ethics committee?	Choose an item.	Comments:
Overall Assessment		

As far as can be ascertained from the paper, how well was the study conducted?	Choose an item.	Comments:

QA Checklist to Assess Relevance and Credibility of Modelling Studies: draft

Administrative details

Study name or author and year [Type study name, or author and year (include letter if more than 1 paper with the same author and year, e.g. 'Smith 2010a')]	**STAR ID** [Type STAR ID]
Citation [Include citation details – usually authors, title of study, journal details, year]	
Linked studies (study name or author, year, STAR ID) [Include study name or author, year and STAR ID of any related studies, or state 'None']	
Final study quality score [Click to choose the final quality score. See 'Calculation of final study quality score' below for details on how to complete this.]	
Date of QA [Click to choose the date the QA was completed]	**Reviewer(s) names** [Type name of the reviewer/reviewers completing the quality assessment]

Calculation of final study quality score (from box 6.1 on page 95 of the NICE Guidelines Manual)

++	All or most of the checklist criteria have been fulfilled, and where they have not been fulfilled the conclusions are very unlikely to alter.
+	Some of the checklist criteria have been fulfilled, and where they have not been fulfilled, or are not adequately described, the conclusions are unlikely to alter.
-	Few or no checklist criteria have been fulfilled and the conclusions are likely or very likely to alter.

Quality Assessment

Item	**Decision**	**Comments**
Relevance Relevance addresses the extent to which the results of the model apply to the setting of interest to the decision maker.		
1. Is the population relevant? • Are there similar demographics? • Are the risk factors similar? • Are behaviours similar?	[Click here to choose a decision.	
2. Are any critical interventions missing? • Does the intervention analysed in the model match the intervention you are interested in? • Have all relevant comparators been considered?	[Click here to choose a decision.	
3. Are any relevant outcomes missing? • Are the health outcomes relevant to you considered?	[Click here to choose a decision.	
4. Is the context (settings and circumstance) applicable? • Is the geographic location similar? • Is the system similar? • Is the time horizon applicable to your decision? • Is the analytic perspective appropriate to your decision problem?	[Click here to choose a decision.	
Overall decision	[Click here to choose a decision.	
Credibility Each credibility domain should be assessed as a strength, neutral, weakness or fatal flaw (serious credibility issues) and overall credibility assessed as sufficient or insufficient.		
Validation	[Click here to choose a decision.	
5. Is external validation of the model sufficient to make its results credible for your decision? • Has the model been shown to accurately reproduce what was observed in the data used to create the model? • Has the model been shown to accurately estimate what actually happened in one or more separate studies? • Has the model been shown to accurately	[Click here to choose a decision.	

forecast what eventually happens in reality?		
6. Is internal verification of the model sufficient to make its results credible for your decision? • Have the process of internal verification and its results been documented in detail? • Has the testing been performed systematically? • Does the testing indicate that all the equations are consistent with their data sources? • Does the testing indicate that the coding has been correctly implemented?	[Click here to choose a decision.	
7. Does the model have sufficient face validity to make its results credible for your decision? • Does the model contain all the aspects considered relevant to the decision? • Are all the relevant aspects represented and linked according to the best understanding of their characteristics? • Have the best available data sources been used to inform the various aspects? • Is the time horizon sufficiently long to account for all relevant aspects of the decision problem? • Are the results plausible? • If others have rated the face validity, did they have a stake in the results?	[Click here to choose a decision.	
Design	[Click here to choose a decision.	
8. Is the design of the model adequate for your decision problem? • Was there a clear, written statement of the decision problem, modelling objective, and scope of the model? • Was there a formal process for developing the model design (e.g. influence diagram, concept map? • Is the model concept and structure consistent with and adequate to address, the decision problem/objective and the policy context? • Have any assumptions implied by the design	[Click here to choose a decision.	

of the model been described and are they reasonable for your decision problem? - Is the choice of model type appropriate? - Were key uncertainties in model structure identified and their implications discussed?		
Data	[Click here to choose a decision.	
9. Are the data used in populating the model suitable for your decision problem? - All things considered, do you agree with the values used for the inputs? - Did the approaches to obtaining and processing the data inputs meet the criteria from their corresponding questionnaires?	[Click here to choose a decision.	
Analysis	[Click here to choose a decision.	
10. Were the analyses performed using the model adequate to inform your decision problem?	[Click here to choose a decision.	
11. Was there an adequate assessment of the effects of uncertainty?	[Click here to choose a decision.	
Reporting	[Click here to choose a decision.	
12. Was the reporting of the model adequate to inform your decision problem? - Did the report of the analyses provide the results needed for your decision problem? - Was adequate nontechnical documentation freely accessible to any interested reader? - Was technical documentation, in sufficient detail to allow (potentially) for replication, made available openly or under agreements that protect intellectual property?	[Click here to choose a decision.	
Interpretation	[Click here to choose a decision.	
13. Was the interpretation of results fair and balanced?	[Click here to choose a decision.	
Conflict of interest	[Click here to choose a decision.	
14. Were there any potential conflicts of interest?	[Click here to choose a decision.	
15. If there were potential conflicts of interest, were steps taken to address these?	[Click here to choose a decision.	
Overall decision	[Click here to choose a decision.	

QA Checklist for Economic evaluations

Administrative details

Study name or author and year [Type study name, or author and year (include letter if more than 1 paper with the same author and year, e.g. ‘Smith 2010a’)]	**STAR ID** [Type STAR ID]
Citation [Include citation details – usually authors, title of study, journal details, year]	
Linked studies (study name or author, year, STAR ID) [Include study name or author, year and STAR ID of any related studies, or state ‘None’]	
Final study quality score [Click to choose the final quality score. See ‘Calculation of final study quality score’ below for details on how to complete this.]	
Date of QA [Click to choose the date the QA was completed]	**Reviewer(s) names** [Type name of the reviewer/reviewers completing the quality assessment]

Calculation of final study quality score (from box 6.1 on page 95 of the NICE Guidelines Manual)

++	All or most of the checklist criteria have been fulfilled, and where they have not been fulfilled the conclusions are very unlikely to alter.
+	Some of the checklist criteria have been fulfilled, and where they have not been fulfilled, or are not adequately described, the conclusions are unlikely to alter.
-	Few or no checklist criteria have been fulfilled and the conclusions are likely or very likely to alter.

Quality Assessment

For all questions:

++	'Yes'	The study full meets the criterion.
+	'Partly'	The study largely meets the criterion but differs in some important respect.
-	'No'	The study deviates substantially from the criterion.
	'Unclear'	Report provides insufficient information to judge whether the study complies with the criterion.
	'NA (not applicable'	The criterion is not relevant in this particular instance.

For detailed notes on completing the checklist, please see p10-20 of Appendix H of the Manual.

Item	**Decision**	**Comments**
Section 1: Applicability (relevance to specific review questions and the NICE reference case as described in section 7.3 of the Manual) This checklist should be used first to filter out irrelevant studies.		
1.1 Is the study population appropriate for the review question?	[Click here to choose a decision.	
1.2 Are the interventions appropriate for the review question?	[Click here to choose a decision.	
1.3 Is the system in which the study was conducted sufficiently similar to the current UK context?	[Click here to choose a decision.	
1.4 Are the perspectives clearly stated and are they appropriate for the review question?	[Click here to choose a decision.	
1.5 Are all direct effects on individuals included, and are all other effects included where they are material?	[Click here to choose a decision.	
1.6 Are all future costs and outcomes discounted appropriately?	[Click here to choose a decision.	
1.7 Is QALY used as an outcome, and was it derived using NICE's preferred methods? If not, describe rationale and outcomes used in line with analytical perspectives taken (item 1.4 above).	[Click here to choose a decision.	
1.8 Are costs and outcomes from other sectors fully and appropriately measured and valued?	[Click here to choose a decision.	
1.9 **Overall judgement:** There is no need to use section 2 of the checklist if the study is considered 'not applicable'. • **Directly applicable** – the study meets all applicability criteria, or fails to meet 1 or more applicability criteria but this is unlikely to change the conclusions about cost effectiveness. • **Partially applicable** – the study fails to meet 1 or more of the applicability criteria, and this could change the conclusions about cost effectiveness.	[Click here to choose a decision. Score ++ for directly applicable, + for partially applicable and – for not applicable	

• **Not applicable** – the study fails to meet 1 or more of the applicability criteria, and this is likely to change the conclusions about cost effectiveness. Such studies would usually be excluded from further consideration and there is no need to continue with the rest of the checklist.		
Other comments:		
Section 2: Study limitations (the level of methodological quality) This checklist should be used once it has been decided that the study is sufficiently applicable to the context of the guideline		
2.1 Does the model structure adequately reflect the nature of the topic under evaluation?	[Click here to choose a decision.	
2.2 Is the time horizon sufficiently long to reflect all important differences in costs and outcomes?	[Click here to choose a decision.	
2.3 Are all important and relevant outcomes included?	[Click here to choose a decision.	
2.4 Are the estimates of baseline outcomes from the best available source?	[Click here to choose a decision.	
2.5 Are the estimates of relative intervention effects from the best available source?	[Click here to choose a decision.	
2.6 Are all important and relevant costs included?	[Click here to choose a decision.	
2.7 Are the estimates of resource use from the best available source?	[Click here to choose a decision.	
2.8 Are the unit costs of resources from the best available source?	[Click here to choose a decision.	
2.9 Is an appropriate incremental analysis presented or can it be calculated from the data?	[Click here to choose a decision.	
2.10 Are all important parameters whose values are uncertain subjected to appropriate sensitivity analysis?	[Click here to choose a decision.	
2.11 Is there any potential conflict of interest?	[Click here to choose a decision.	
2.12 **Overall assessment:** Minor limitations/potentially serious limitations/very serious limitations. • **Minor limitations** – the study meets all quality criteria, or fails to meet 1 or more quality criteria but this is unlikely to change the conclusions about cost effectiveness. • **Potentially serious limitations** – the study fails to meet 1 or more quality criteria, and this could change the conclusions about cost	[Click here to choose a decision. Score ++ for minor limitations, + for potentially serious limitations and – for very serious limitations	

effectiveness. - **Very serious limitations** – the study fails to meet 1 or more quality criteria, and this is highly likely to change the conclusions about cost effectiveness. Such studies should usually be excluded from further consideration.	
Other comments:	

Appendix 6 Review Protocols

T:\GUIDANCE PH\TRAP - Outdoor Air pollution\Evidence\Review Protocol\TRAP Review protocol Oct 2015 - amended.docx