MITIGATING EXPOSURE TO TRAFFIC POLLUTION IN AND AROUND SCHOOLS

Guidance for Children, Schools and Local Communities

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GLOSSARY

Active control: Control systems that directly reduce air pollution emissions at the source (e.g. particulate filters inside vehicle tailpipes).

Carpool club: An activity that can be managed by the school community to reduce the number of cars during drop-off/pick-up hours.

Carbon dioxide: Although fossil fuel use composes the main source of anthropogenic carbon dioxide, it is also exhaled by humans as part of the respiration process, and when measured can be used to assess the adequacy of ventilation in enclosed environments. High levels of carbon dioxide indicate a lack of proper ventilation and are associated with negative cognitive effects including a reduced ability to concentrate.

Citizen science: Scientific research undertaken by members of the public. To enhance public understanding of air pollution, citizen science should incorporate inclusion (e.g. community involvement in planning the research), collaboration (e.g. between the school, community, and researchers), and reciprocation (e.g. presentation of results by schools to communities for their feedback).

Coarse particles: Particulate matter with a diameter of between 2.5 and 10 micrometres; also known as $PM_{2.5\text{-}10}$. Coarse particles in the air are predominantly generated by non-exhaust sources, such as resuspension of road dust.

Co-creation: A design process throughout which all stakeholders (e.g. researchers, schools, children) are equally involved and free to contribute.

Community: Parents, children, local residents and the general public.

Dispersion: The transportation and dilution of air pollution from the source (e.g. a vehicle exhaust) by the wind.

Fine particles: Particulate matter less than 2.5 micrometres in diameter; also known as $PM_{2.5}$. Fine particles are one of the most harmful classes of air pollutants because their small size means that they can travel deep into the respiratory system, contributing to heart and lung disease. They are predominantly generated by combustion and emitted via road vehicle exhausts.

Indoor air quality: The quality of air within enclosed buildings and structures, such as schools, which influences the health, comfort and well-being of building occupants. Poor air quality may include harmful particles and other pollutants such as nitrogen dioxide, formaldehyde and volatile organic compounds. UK and international bodies offer guidance for air filtration and ventilation.

In-pram babies: Babies in different types of single/double 3 or 4-wheeler prams, pushchairs, buggies, strollers.

Main road: A commonly used public road with through access (i.e. not including cul-de-sacs). Traffic congestion along main roads typically peaks in the morning and late afternoon hours (e.g. during child drop-off and collection/pick-up).

Particle number concentration: The total number of particles per unit volume of air, which is usually represented as # cm^{-3}.

Passive control: An intervention that indirectly reduces air pollution exposure, such as green barriers between roads and pedestrians.

Pollution hotspot: Places where emissions from specific sources, such as cars, may expose local populations to elevated health risks. Pollution hotspots typically include traffic intersections and bus stops.

Young children: Babies, toddlers and infants. In terms of air pollution exposure, young children are among the most sensitive and vulnerable groups due to their higher breathing rates and lower breathing heights than that of adults and older children (e.g. teenagers).

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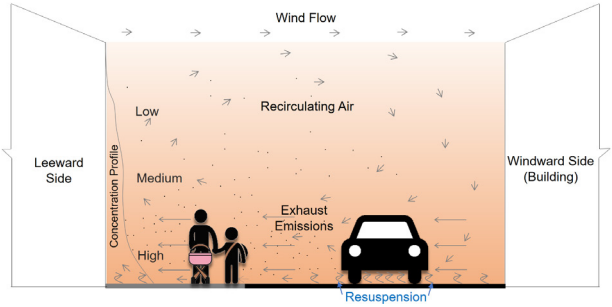
INTRODUCTION

The exposure of children to air pollution is associated with a lack of alertness and concentration, as well as bronchitis, stunted lung development, and an increased risk of long-term conditions including asthma[1] and other respiratory diseases[2].

Children are more vulnerable to exposure than adults due to their incomplete lung development, low breathing height and high physical activity and breathing rates[3]. However, for accessibility, many schools are located near main roads, vehicular emissions from which readily infiltrate school premises, including classrooms. In the UK, more than 2,000 schools and nurseries are near roads with high levels of air pollution[4], including toxic pollutants such as particulate matter less than 2.5 micrometre in diameter ($PM_{2.5}$). The UK also has a higher prevalence of childhood asthma than any other European country[4].

The use of cars to take and collect children to and from school intensifies pollution hotspots in and around school premises. In England, car use for school journeys has doubled over the past two decades, and as many as 1 in 4 cars on the road at morning peak times are taking children to school[5]. Child exposure may be unnecessarily increased by engine idling (stationary vehicles with engines running) and vehicle acceleration-deceleration, both in and near school premises, during drop-off/pick-up hours.



The above figure demonstrates the low breathing height of children and in-pram babies, who are at a height where vehicular emissions are highly concentrated (adopted from Sharma and Kumar[3]). The breathing height of young children is between 0.55m and 0.85m above ground level and vehicle exhaust pipes usually sit within 1m from road level. This increases their vulnerability to air pollution exposure.

While an active control system (e.g. reducing exhaust emissions at the source) is invariably the most effective solution, other evidence-based strategies can be adopted to reduce pollution concentrations and mitigate exposure in and around schools. However, a holistic approach is required from those directly contributing to and/or affected by pollution to make a real difference at grass-roots level[6]. A successful exposure mitigation strategy requires multifaceted actions that target school children, schools and the local community.

The aim of this guidance document is to translate complex science into simple action points that enable schools, children and communities to make informed decisions and help reduce the exposure of school children to air pollution.

This document summarises the best practice regarding air pollution exposure mitigation in and around schools. Recommendations are based on contemporary scientific evidence and may, therefore, be subject to modification as the evidence base evolves. The uniqueness of this document lies in its co-created and co-designed practical approach, targeting the key receptor groups (children, school, and community) equally. It utilises major relevant research[7-10] and review studies[3,11-13] and builds upon our Guildford Living Lab (GLL)[14] activities and extensive experience in providing public and practitioner guidance (e.g. pioneering guidance on green infrastructure implementation[15], general recommendations for plant species selection and management[16], and numerous policy briefs[17]). This present document also supplements previous work on, for example, air quality guidance for school and college staff[18], outdoor air quality and health[19], future land-use planning and development control[20], clean air toolkits[21-25], health effects of indoor air quality[26], and anti-idling[27].

Most of the recommendations in this guidance document concern the mitigation of fine particles, a class of air pollutants with the most severe impact on human health[28]. However, the general messages may apply to other harmful pollutants, such as nitrogen oxides. This guidance focuses on the particular issue of drop-off/pick-up points and traffic congestion around schools. Detailed descriptions or recommendations regarding indoor (e.g. classroom) air quality and related health effects are beyond its scope. The document offers 10 generic and 10 specific recommendations for three target audiences (children, schools, and local communities). We recognise that some schools, such as urban schools with smaller premises, will face challenges in implementing some of the recommendations, but implementing as many as possible will be beneficial. It may also serve as an educational guide, adapted to be age appropriate where necessary, helping schools to improve the knowledge of children and their parents/carers and thus reduce their contribution and exposure to air pollution.

Our general and targeted recommendations are not prioritised or ordered according to significance or impact. This is partly due to a lack of evidence regarding the comparative impact of each action, and partly because a holistic approach is needed to tackle the problem (see general recommendation #1). As a rule of thumb, active control systems (e.g. anti-idling policies and incentives to reduce vehicle use) are the most effective strategies and should constitute the first line of defence.

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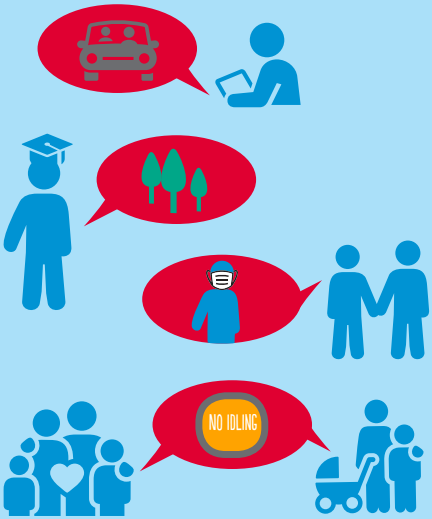
GENERAL RECOMMENDATIONS



1. INVOLVE EVERYBODY AND WORK TOGETHER

Measures to limit exposure to air pollution include active and/or passive control systems at the source (e.g. limiting exhaust emissions), receptor (e.g. masks), and between source and receptor (e.g. green barriers). Exposure can also be mitigated by appropriate behavioural changes and informed decision-making, such as the selection of routes to avoid pollution hotspots. A holistic approach, with communication and participation between schools, children, parents, communities, and governmental bodies, is therefore key to overall change and effective exposure reduction.

2. CREATE A CLEAN AIR ZONE AROUND SCHOOLS

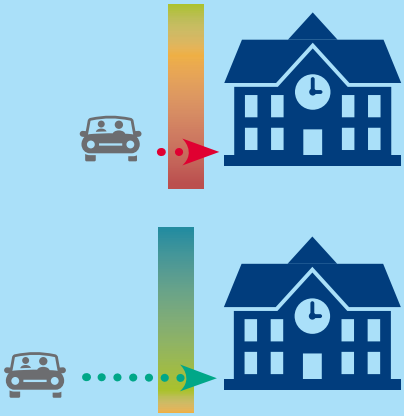
Creating a clean air zone around schools by implementing 'active' solutions (anti-idling approaches to control vehicle emissions, relocating drop-off/pick-up points away from school entrances, etc) can minimise pollution levels in and around school premises.

3. UTILISE 'PASSIVE' CONTROL SYSTEMS

'Passive' control systems, such as green barriers (e.g. hedges) along the boundary between school premises and adjacent roads, can minimise the daily exposure of school children to traffic emissions. Careful plant selection, considering the physical context and environmental conditions of the site, can minimise trade-offs (e.g. pollen emissions) and maximise the potential for other ecosystem services (e.g. noise pollution reduction or biodiversity support).

4. CONSIDER CLASSROOM AIR QUALITY

Restricting the opening of doors/windows that face the drop-off/pick-up point can reduce the infiltration of traffic-emitted particles but increase carbon dioxide build-up in nearby classrooms. Use of adequate mechanical ventilation and air filtration, perhaps including self-standing units, can further reduce the build-up of harmful particles and other pollutants including carbon dioxide.

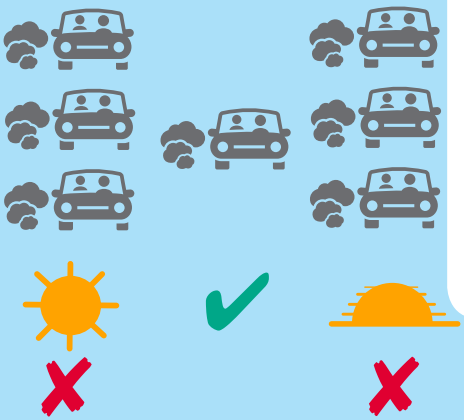


5. PLAN NEW SCHOOL BUILDINGS CAREFULLY

The majority of schools are close to busy roads, where air pollution is typically highest. Pollution concentrations tend to decay exponentially with distance from the road. Consequently, new school buildings should be strategically located away from main roads, where possible, but with safe walking passages between the school premises and main connecting roads. They should also be within walking distances of communities, to encourage walking and cycling and to minimise impacts of car emissions by parents/carers during school runs.

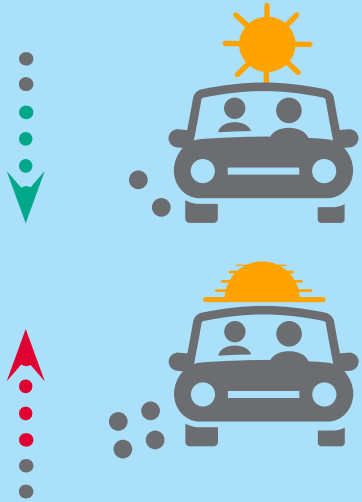
6. WALK TO SCHOOL

Walking to/from school should be encouraged for the benefit of mental and physical wellbeing and to support independence, social skills and road safety skills for children, as well as to reduce traffic volume/congestion and air pollution. Regular walking to/from school can also strengthen children's sense of community and understanding of their local area.



7. AVOID NON-ESSENTIAL VEHICLE USE

Concentrations of fine particles are generally highest during morning drop-off hours (07:00-09:00) due to higher traffic volumes and less favourable dispersion conditions when compared with afternoon pick-up hours (15:00-17:00). However, avoiding non-essential travel during both morning and afternoon peak hours can have a direct, positive impact by reducing traffic volume, congestion and journey times and consequently reducing the pollution exposure of children and their parents/carers during school runs.



8. CONSIDER ROAD SURFACE DUST

Despite less traffic and better atmospheric dispersion conditions during afternoon pick-up hours than during morning drop-off hours, concentrations of coarse particles can still be higher due to drier road surfaces in the afternoon, assisting the resuspension of road surface dust by road traffic. Overnight dew usually suppresses roadside resuspension during morning hours, and wetting road surfaces during dry periods in the daytime could effectively reduce resuspension of road dust.

9. SET UP CITIZEN SCIENCE PROJECTS

Direct collaboration via citizen science can improve awareness of air pollution and mitigation measures among children, parents, schools and communities. Citizen science and participatory research can also enable individuals to share their experiences and/or concerns (e.g. regarding road safety) with researchers and policymakers for all-round action to address significant issues.

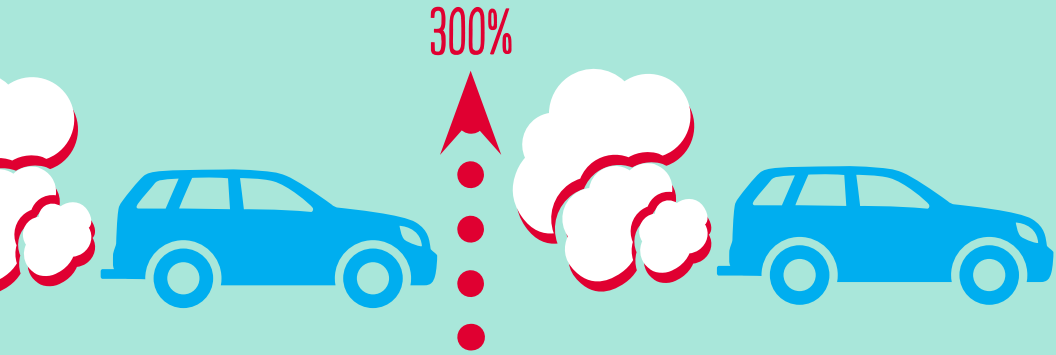
10. EMBED AIR POLLUTION ISSUES IN EDUCATION

Air pollution and mitigation strategies could be integrated into the national curriculum. For example, fundamental scientific, social and road safety skills are reinforced as part of practices recommended in this guidance document, all of which help children to meet curriculum objectives. Moreover, the increasing availability of affordable pollution sensors could support relevant hands-on exercises and pupil-led experiments in curriculum subjects or before-/after-school clubs.

TARGETED RECOMMENDATIONS

FACT #1

CARS QUEUING/IDLING DURING DROP-OFF HOURS CAN GENERATE UP TO A 300% INCREASE IN CONCENTRATIONS OF FINE PARTICLES IN THE SCHOOL PREMISES.



Avoiding vehicle use during drop-off hours could result in a threefold reduction in school children's exposure to harmful vehicular pollutants.

CHILDREN

- Stay away from a car or a queue of cars when their engines are on.

SCHOOL

- Schools should support more children to walk, e.g. through accreditation and behaviour change schemes.
- Vehicle use inside or very close to school premises should be discouraged by relocating drop-off/pick-up points away from the school entrance.
- Staggered drop-off times and/or carpool clubs may be encouraged.
- Reinforce that any no-stop areas(e.g. double yellow lines) around the school should be respected.

COMMUNITY

- Switch off the engine while you wait, even if it's only briefly.
- Avoid vehicle use during drop-off (as well as pick-up) hours, or park cars away from the school entrance.
- Parents and children should, where feasible, walk or cycle to/from school, to reduce their negative impact on air quality, increase their physical activity, and practice road safety and navigation skills.

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FACT #2

CONCENTRATIONS OF FINE PARTICLES DURING PICK-UP HOURS ARE UP TO THREE TIMES LOWER THAN AT DROP-OFF HOURS DUE TO DISTRIBUTED PICK-UP TIMES AND BETTER DISPERSION CONDITIONS IN THE AFTERNOON.

Staggered collection times during pick-up hours due to after-school activities substantially reduces traffic congestion and, subsequently, traffic emissions.

CHILDREN

- Keep your distance from idling cars as much as possible.

SCHOOL

- Organise and schedule before- and after-school activities to stagger child drop-off and pick-up times or a carpool club to reduce the number of cars.
- Support access to bicycles for all, e.g. via a bike pool scheme.

COMMUNITY

- Avoid vehicle use for school runs, where possible, or park cars away from school entrances.
- Encourage local authorities to create controlled parking zones and to prohibit parking on streets around schools to improve the flow of cars during drop-off/ pick-up hours.

FACT #3

FINE PARTICLE CONCENTRATIONS IN THE PLAYGROUND NEXT TO A BUSY ROAD CAN BE COMPARABLE TO THOSE ON THE MAIN ROAD DURING DROP-OFF HOURS.

Nature-based solutions, such as a dense hedge around the school perimeter, can help to improve air quality in the school environment.

Any activities in the playground should be limited during drop-off hours until adequate mitigation measures are implemented by the school and/or community.

CHILDREN

- If your playground is near a road, try not to play near that road in the mornings.

SCHOOL

- Any outdoor classes in morning hours should, where possible, be rescheduled for later in the school day (i.e. afternoon).
- Schools can plant or improve low-allergy, non-poisonous green barriers (e.g. hedges) between school premises and nearby roads to further reduce traffic impacts on school environments.
- Consider implementing an additional entry close to the main road, with a safe footpath surrounded by green barriers inside the school premises.
- Schools should prevent children from playing near any fence bordering a busy road.

COMMUNITY

- Local community members can support the school in planting green barriers around the school and/or implementing other suitable control measures.
- Local community should collaborate with local authorities to adopt a planning approach in all existing and new developments that prioritises safe and enjoyable streets, in order to encourage parents and children to walk.

FACT #4

FINE PARTICLE CONCENTRATIONS IN A ROAD-FACING CLASSROOM CAN DOUBLE DURING DROP-OFF HOURS.

Reduce traffic emissions adjacent to the school by restricting vehicle entry and relocating drop-off points away from the school entrance.

CHILDREN

- Avoid opening doors or windows in classrooms next to drop-off points.

SCHOOL

- Drop-off/pick-up points should be away from classroom entrances.
- Children should be directed to relevant classrooms via interior doors/routes, to restrict exposure to traffic emissions from drop-off/pick-up points.
- Access to classrooms via doors that face towards/close to traffic congestion should be restricted to reduce the impact of traffic-emitted particles on indoor air quality.

COMMUNITY

- Avoid vehicle use during drop-off/pick-up hours wherever possible, and try to park cars away from school entrances.
- Encourage parents and children to walk or cycle to/from schools.

FACT #5

CLOSING CLASSROOM DOORS/WINDOWS CAN RESTRICT THE INGRESS OF TRAFFIC-RELATED EMISSIONS. HOWEVER, DOING SO CAUSES A CARBON DIOXIDE CONCENTRATION BUILD-UP IN THE CLASSROOM.

To minimise traffic-related air pollution in classrooms, keep any traffic-facing doors/windows closed during peak hours and open internal doors/windows instead.

CHILDREN

- If you can see the school entrance from your classroom window, try to keep the window closed during your first lesson to protect yourself from morning pollution. If your teacher says so, you can open windows later in the day or if you feel hot or tired.

SCHOOL

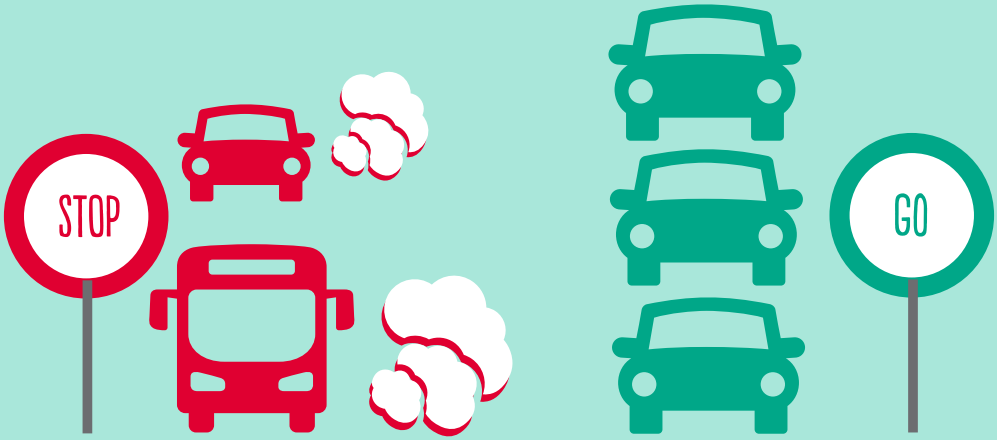
- Consider installing carbon dioxide monitors in classrooms.
- Draw fresh air into the classroom if teachers notice/are made aware of symptoms among children of high carbon dioxide levels (e.g. tiredness, inability to think clearly, headaches, dizziness).
- Doors/windows that immediately face a road should be utilised for air exchange only during off-peak hours.
- Clean air purifiers/filters regularly or consider setting up proper air filtration and ventilation systems to mitigate indoor air pollution and minimise infiltration of outdoor pollutants.

COMMUNITY

- Residents should work with local authorities to ensure that new schools are strategically located in areas away from main roads, with safe walking/cycling passages to link the school premises with main connecting roads as well as housing/communities.

FACT #6

PARTICLE NUMBER CONCENTRATIONS AT POLLUTION HOTSPOTS, SUCH AS TRAFFIC INTERSECTIONS AND BUS STOPS, CAN BE NEARLY TWO-THIRDS HIGHER THAN AT SECTIONS OF THE ROUTE WITH FREE-FLOW TRAFFIC.



Stop-start and acceleration-deceleration conditions usually lead to elevated pollutant concentrations at places such as traffic intersections and bus stops, and minimising time spent at them will reduce your exposure to pollution.

CHILDREN

- Try to stand away from the curb, traffic intersections and bus stops to reduce your exposure to harmful vehicular pollutants.

SCHOOL

- Schools should notify parents/carers that commuting to/from school via main roads presents a risk of high exposure to vehicular emissions.
- Alternative routes with no/less traffic should be suggested.

COMMUNITY

- With support from schools, communities should encourage local authorities to move traffic intersections and bus stops away from school premises where feasible.

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FACT #7

IN-PRAM BABIES AND YOUNG CHILDREN MAY BREATHE UP TO 60% MORE POLLUTED AIR THAN ADULTS DURING SCHOOL RUNS BECAUSE THEIR BREATHING ZONES ARE CLOSER TO VEHICLE EXHAUST HEIGHTS, WHERE CONCENTRATIONS ARE HIGHEST.

Pollutant concentrations are generally highest in the first metre from ground-level and decrease with distance (including height) from the road. Where feasible, increasing the breathing height and keeping as far away as possible from vehicle exhausts will reduce exposure.

CHILDREN

- Try to keep away from the edge of the road when walking to or from school.

SCHOOL

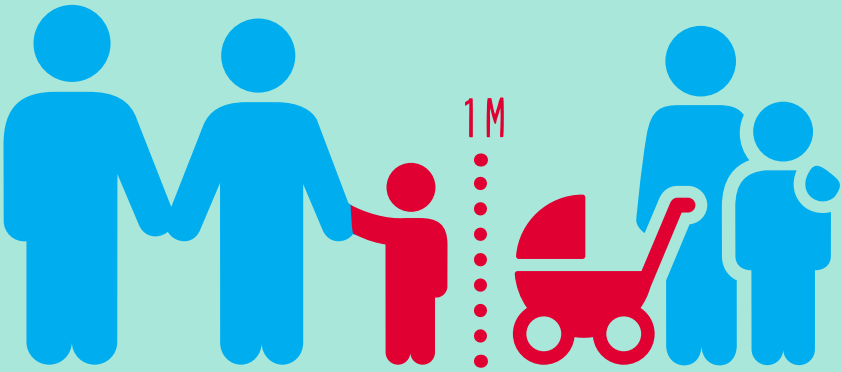
- Schools should stress the significance of high concentrations at lower heights to parents/children and suggest alternative, cleaner routes (e.g. passing through parks).

COMMUNITY

- Where feasible, using high-riding prams rather than low-riding pushchairs can raise the breathing height of the child and reduce their exposure.
- Carrying babies or young children (e.g. in a baby carrier backpack) at and around pollution hotspots, where it is safe to do so, may also increase the height of their breathing zone and provide an opportunity to face them away from the source to consequently reduce exposure.
- Community members may consider leaving space for green barriers (e.g. hedges) between main roads and buildings, walkways, cycleways, etc when planning any development on private land.

FACT #8

THE TYPE OF PRAM OR PUSHCHAIR CAN MAKE AN APPRECIABLE DIFFERENCE TO RIDERS' EXPOSURE DURING TYPICAL SCHOOL RUNS. FOR EXAMPLE, PARTICLE NUMBER CONCENTRATIONS CAN BE UP TO 72% HIGHER AT THE BOTTOM SEAT OF A DOUBLE PRAM THAN AT THE TOP SEAT.



The first metre above the road level, where vehicle exhaust emissions meet the ambient air, coincides with the breathing height of young children or pushchair riders and is thus a high-risk zone for air pollution exposure.

CHILDREN

- Remember to walk on the far side of the pavement, away from the edge of the road, to stay away from pollution.

SCHOOL

- Dedicated waiting areas could be provided for parents with pushchairs, which should be away and at elevated heights from vehicle parking spaces.

COMMUNITY

- Where possible, parents should avoid bringing prams or pushchairs close to busy roads and/or queuing traffic, and may opt for parent-facing prams if they can do so.
- Active control at the source (e.g. reducing vehicle use) is always more effective than any single passive strategy to protect the recipient. However, any parents considering a new pram or pushchair may consider the in-pram breathing height.

FACT #9

IMPLEMENTING APPROVED/SAFETY-TESTED PRAM OR PUSHCHAIR COVERS, ESPECIALLY AROUND POLLUTION HOTSPOTS SUCH AS TRAFFIC INTERSECTIONS OR BUS STOPS, COULD REDUCE YOUNG CHILDREN'S EXPOSURE TO FINE PARTICLES BY MORE THAN ONE-THIRD DURING SCHOOL RUNS.

Ideally, pram or pushchair covers should be used near busy roads or at pollution hotspots.

CHILDREN

- If your pushchair has a cover, you can use it to protect you from pollution near the road.

SCHOOL

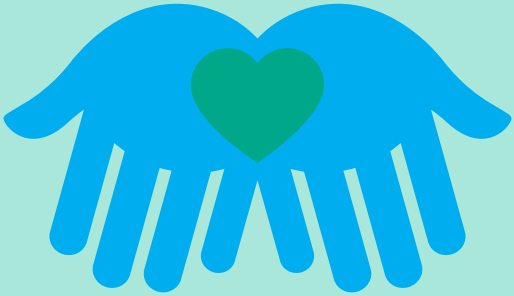
- Schools can promote mitigation measures to parents/carers, such as choosing alternative and low-traffic routes, minimising time spent at pollution hotpots, and using pram covers where applicable. Schools should also clearly signpost any available waiting areas in school premises for parents with pushchairs.

COMMUNITY

- Waterproof/solid pram covers may be utilised for short periods in cold weather conditions at pollution hotspots (e.g. traffic intersections and bus stops) as physical barriers between vehicle exhaust emissions and in-pram breathing zones. There is no readily available scientific evidence to say whether or not breathable covers (e.g. for sun protection) are similarly effective.
- Pram cover use is not recommended for extended periods, in order to avoid the accumulation of carbon dioxide, nor in hot weather conditions.

FACT #10

COMMUNITY INVOLVEMENT IN CO-DESIGNING AND CO-CREATING SCIENTIFIC AIR QUALITY INITIATIVES HAS SHOWN TO IMPROVE UNDERSTANDING OF HOW AIR POLLUTION AFFECTS HUMAN HEALTH AND HELP INDIVIDUALS TO MAKE INFORMED DECISIONS FOR EVERYDAY EXPOSURE MITIGATION.



Schools and local residents should not merely be participants in citizen science studies but should be active partners with researchers, following a three-pronged approach of: (i) inclusion (e.g. introducing seminars and workshops to involve people from diverse socio-demographics); (ii) collaboration (i.e. continuous interaction between researchers, communities and policymakers); and (iii) reciprocation (e.g. debate between citizen scientists regarding their research findings).

CHILDREN

- Children can participate in data collection activities for hands-on experience.
- They can share their experiences with their friends and families to organise their thinking and reinforce good practices.

SCHOOL

- Schools can participate in the design of studies, such as by co-developing research objectives and co-identifying sampling locations.
- Schools should support data collection, share findings with parents/guardians and children, and adopt good practice (both in terms of scientific rigour and any identified exposure control measures) to lead by example.

COMMUNITY

- Communities can participate by co-creating and co-implementing studies, thereby ensuring that these studies and their findings have a broad public impact.
- They can facilitate access to local schools, venues, and other environments for workshops, data collection, etc, and can take part as individuals.

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