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LONDON'S POLLUTED SCHOOLS: THE SOCIAL CONTEXT

Aether

FIA FOUNDATION

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The FIA Foundation Research Paper series seeks to provide interesting insights into current issues, using rigorous data analysis to generate conclusions which are highly relevant to current global and local policy debates.

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Aether is a UK-based environmental consultancy, specialising in air quality and climate change emissions data analysis and policy development. **www.aether-uk.com**

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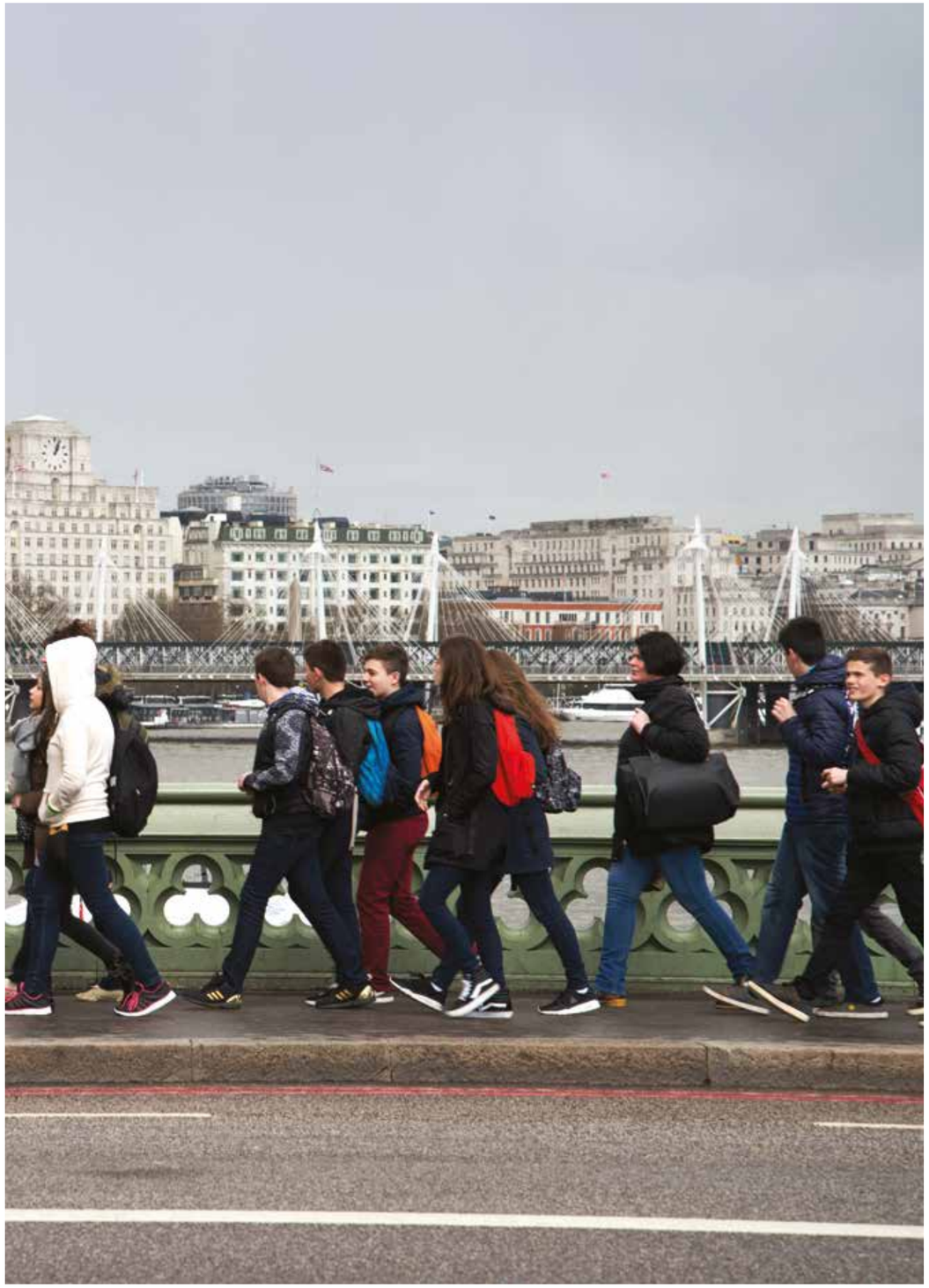


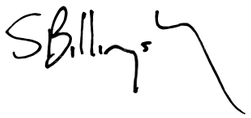
FOREWORD

Poor air quality is a serious issue that affects the health of millions of people in London, particularly vulnerable groups such as young children, the elderly, and those with existing respiratory conditions. The FIA Foundation, as part of the Child Health Initiative, is highlighting the importance of safe and healthy journeys to school globally. London is a city that is increasingly aware of the issues of air pollution and is putting in place a clear agenda for healthy streets.

Aether's previous work on children's' exposure to poor quality air in London has been ground-breaking in revealing the hundreds of schools that are located in areas with air quality below legal air quality standards. In this study Aether has extended this detailed analysis of air quality to explore the relationships with other indicators relating to these schools: social deprivation, childhood obesity, travel to school modes and physical activity levels.

The aim of the work is to seek to understand these connections better, and in particular how the social context in which these schools find themselves, might impact on the air quality solutions which are developed, whilst recognising the complexities of these issues.

In funding this research and raising awareness of these issues in London, the FIA Foundation hopes to catalyse action here and in other cities, to help tackle the 3.7 million premature deaths from outdoor air pollution globally each year.



Saul Billingsley
Executive Director, FIA Foundation

EXECUTIVE SUMMARY

Poor air quality in London has become a critical issue, with children identified as being particularly at risk. One in five of London's state primary and secondary schools were in areas of poor air quality in 2013. It is important, however, to place these schools in the context of other relevant societal and health challenges, and to understand the extent of the role of the school in terms of mitigation. This broader view enables relationships between the challenges to be better understood and for policy synergies to be identified.

The analysis undertaken in this report focuses on the subset of London's schools most affected by poor air quality. It presents data for these schools on the issues of deprivation, obesity and physical activity. The report then moves on to consider the potential contribution that the schools, through pupil travel, could make to local air pollution. Caveats to and limitations of the data are acknowledged, and improvements to data collection identified as a key action.

It is clear from the outcomes of this research that these schools face multi-level challenges, with higher than average levels of deprivation and obesity in their catchments. The importance of action in the short and longer term is thus emphasised. Over 85% of the schools which are most affected by poor air quality have pupils from catchments which are more deprived than the London average.

Of the schools most affected by air quality issues, over 75% had obesity levels which are greater than the London average. This challenge is compounded with London itself having the highest obesity rates amongst children in England.

Considering rates of physical activity, through active travel, the results were more positive. Levels of walking to school at the schools with poor air quality were higher than the London average. This was consistent across Inner and Outer London (where differences could be expected) and across primary and secondary schools. For example, for the primary schools most affected by poor air quality, historic data (2010) suggests that 67% of Inner and 74% of Outer London schools had levels of walking to school which were higher than the London average. Distances travelled are, however, generally short and use of cycling as a mode is low compared with the London average.

In terms of the contribution of travel to school to local air pollution, the schools most affected by air pollution had lower levels of travel to school by car compared with the London average. For example, for primary schools, 76% of Inner London and 82% of Outer London schools most affected by air quality pollution had lower levels of travel to school by car than by the respective Inner and Outer London primary school averages. In 2010, the results are consistent with broader data on car ownership in the catchment areas of the schools. The pupils' contribution to the air pollution to which they are exposed is therefore likely to be low. This raises issues of equity concerning the mismatch between causes and impacts of local air pollution. The importance of action to reduce traffic volumes in all vehicle types and for all journey types therefore needs to be emphasised.

The results of this study highlight the importance of an integrated approach whereby key health issues are considered when developing action on environmental inequality. It also highlights shortcomings in data availability, which needs to be addressed.

INTRODUCTION

In London, air pollution is estimated to be responsible for the equivalent of about 9,400 deaths per year, as well as over 3,400 hospital admissions . The related total economic cost is estimated to be £3.7 billion per annum[1].

Children are identified as being particularly vulnerable to air pollution. They breathe in more air per minute, in relation to their size. Their respiratory tracts are more vulnerable and their brains are still developing[2]. Furthermore, the effects of air pollution can have lifelong health implications. Air pollution can damage the development of a child's lungs[3] which carries through to adulthood[2]. Children who live in the most polluted areas are four times more likely to have reduced lung function as adults[4].

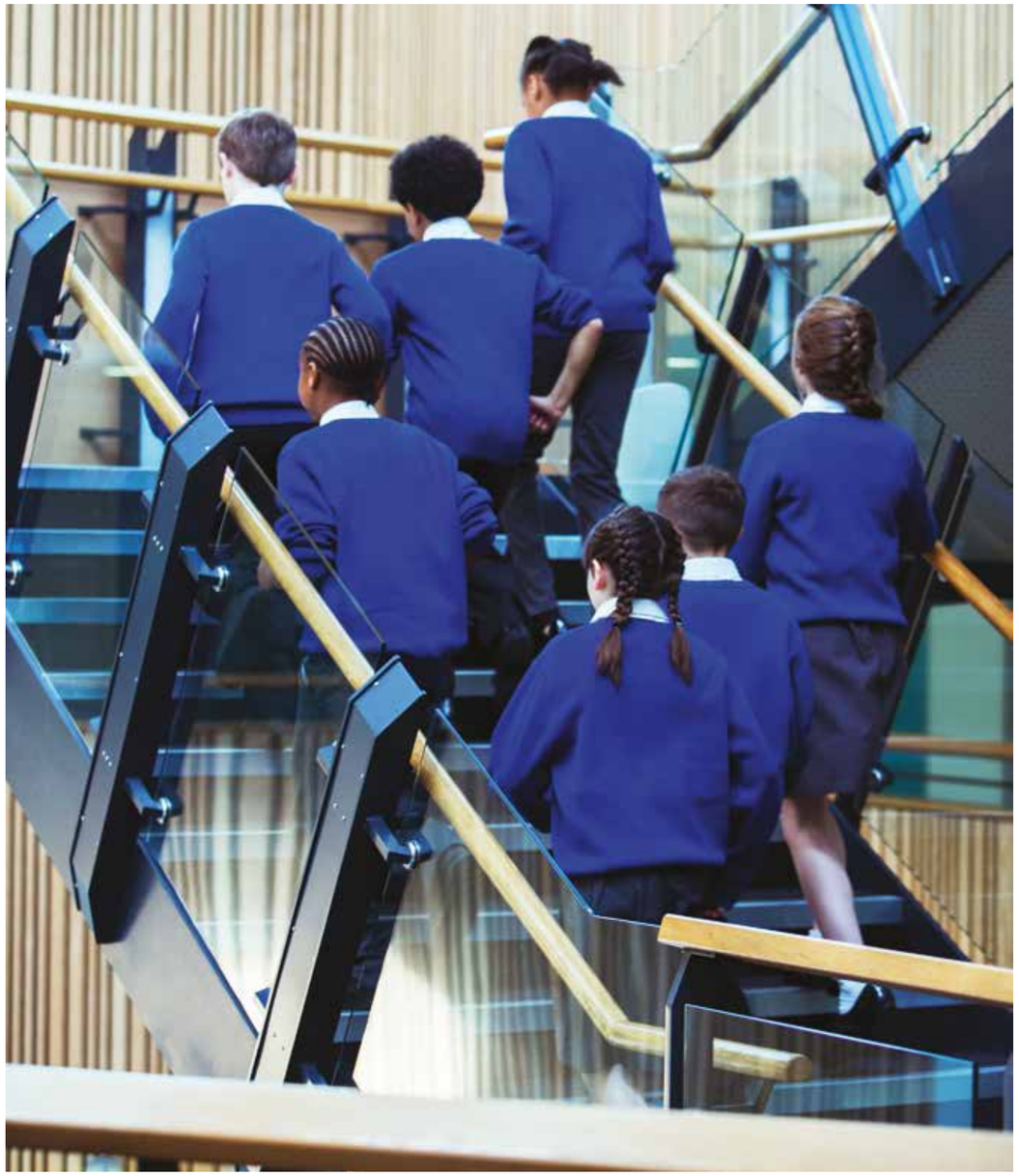
Research previously undertaken by Aether in 2013[5] considered air pollution exposure in London and how it varies with patterns of social deprivation, finding that populations living in the most deprived areas were on average more exposed to poor air quality than those in less deprived areas. It also identified 433 primary schools, approximately one in four, to be in locations of poor air quality - where average concentrations exceeded the NO_2 EU limit value. Of these schools, 82% were considered deprived. The analysis was updated in 2017, using the latest Transport for London data on annual average NO_2 concentrations. The second report considered all schools in London, with approximately a fifth of all London's state primary schools and state secondary schools found to be in areas of poor air quality[6].

The vulnerability of these schools from the perspective of air quality is a key area of media and public interest. However, in order to fully understand this vulnerability, it is important to consider the schools from a wider perspective. This perspective needs to consider:

- The relationship between air pollution and other societal and health challenges. For example, the extent of deprivation, obesity, and physical inactivity affecting the schools.
- The potential contribution that the schools, through pupil travel, make to local air pollution.
- What next steps are required to help improve the wellbeing of pupils at these vulnerable schools?

Multi-level challenges faced by schools have potentially combined impacts but also potentially synergistic solutions.

EXPLORING MULTI-LEVEL CHALLENGES



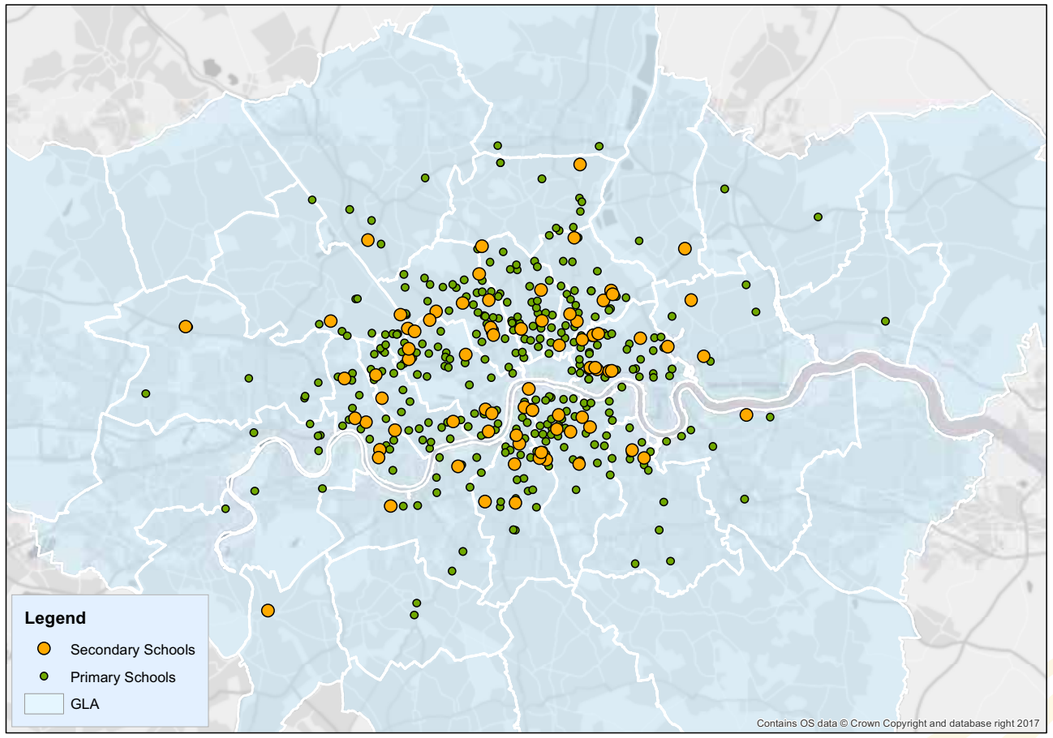
This section considers a selection of key issues relevant to children, schools and air quality in the London context. The issues considered are social deprivation, childhood obesity and levels of physical activity. While there are clearly further potential issues affecting the schools, the issues we have identified are interrelated in terms of impacts and solutions. For example, the links between physical activity (active travel) and obesity, and the potential links between air quality and obesity.

While climate change is not explicitly considered in the analysis, it is a key environmental issue. It is important to note that many, but not all, opportunities to reduce air quality pollution contribute to reductions in greenhouse gas emissions. The increased use of diesel cars to reduce CO_2 emissions is, however, one example where challenges between these goals can exist.

For each of the issues identified, context at the UK and London level is provided. Detailed analysis and insights are then offered in relation to the London state schools most affected by air quality issues. As with Aether's previous research, the analysis has focused on those schools where the annual average NO_2 concentration was in exceedance of limit values in 2013[7]. For each school, catchment data from the Greater London Authority has been used to determine the attributes of the catchment based on statistics for the area within which the pupils live (at Lower and Middle Layer Super Output Area). However, there was no catchment data available for 3 schools therefore the subset of schools with poor air quality identified in the previous research was reduced to for 76 (from 78) secondary schools and 359 (from 360) primary schools. The school locations are shown in Figure 1. The schools are mostly in Inner London because of the nature of the distribution of air pollution in London. Within this subset of schools, 86% of the primary schools and 88% of the secondary schools are in Inner London.

The datasets for the other variables – social deprivation, childhood obesity, levels of physical activity - were analysed at the most detailed spatial unit level available. Data from the same years was used, where possible. Further information on the analytical approach used is provided in Appendix A.

FIGURE 1 – PRIMARY AND SECONDARY SCHOOLS MOST AFFECTED BY AIR QUALITY ISSUES – THE FOCUS OF THIS ANALYSIS



Social Deprivation

CONTEXT

Social deprivation is multi-faceted and the English Indicator of Multiple Deprivation is organised around seven distinct domains of deprivation - income, employment, education, health, crime, barriers to housing and services and the living environment. London is the most unequal region in the UK[8]. Six London boroughs[9] rank among the most deprived 10 per cent of local authorities in England . While Tower Hamlets is amongst the three most deprived local authorities in England[10]. Child poverty in London has remained largely unchanged over the past decade[8].

Links between deprivation and other challenges are well recognised. Obesity levels in the 10% most deprived groups are approximately double those in the 10% least deprived[11]. While for air quality, on average as the level of deprivation declines so does the average level of NO_2 concentration. For example, in London, 46% of the 10% most deprived Lower super output (LSOAs) have average concentrations of NO_2 above the EU limit value and this falls to 2% of the 10% least deprived LSOAs[6].

ANALYSIS

An Index Multiple Deprivation (IMD) score for each school, was developed from the English Index of Multiple Deprivation[12]. The score was calculated as a weighted average of the IMD scores of the LSOAs in the school catchment area, based on the percentage of pupils at that school from each LSOA Area within their catchments.

The outcomes of the analysis are shown in Figures 2 and 3. For primary schools 86% of schools and for secondary schools 92% of schools have a deprivation score greater than the London average.

FIGURE 2 – PRIMARY SCHOOLS MOST AFFECTED BY AIR QUALITY POLLUTION IN THE CONTEXT OF DEPRIVATION

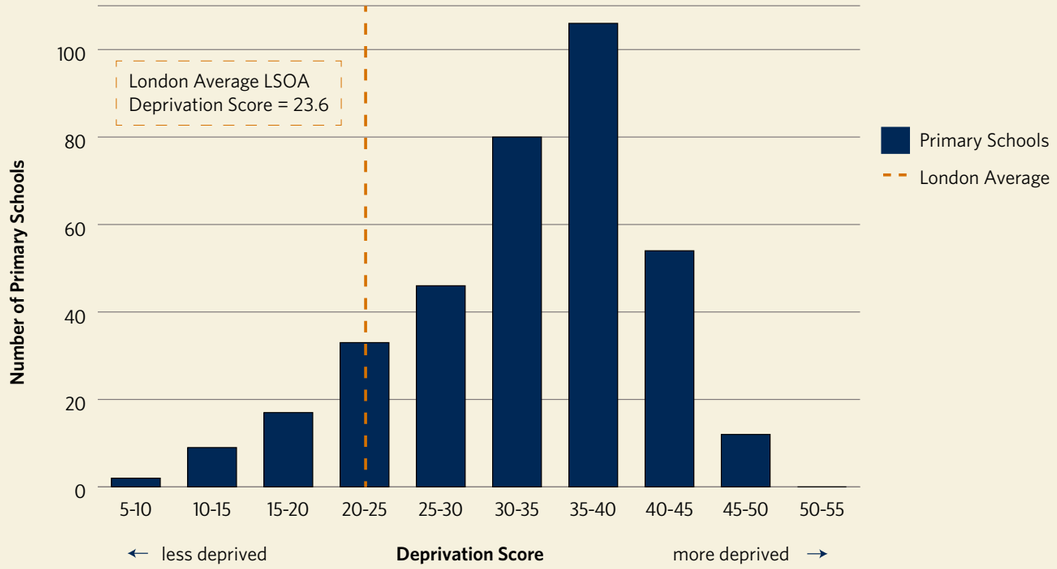
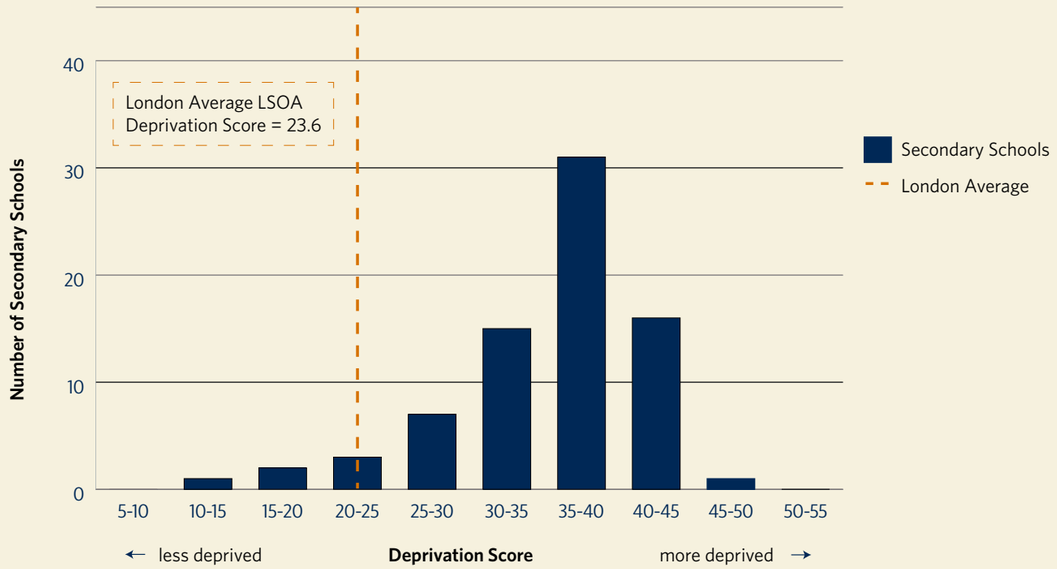


FIGURE 3 – SECONDARY SCHOOLS MOST AFFECTED BY AIR QUALITY POLLUTION IN THE CONTEXT OF DEPRIVATION



Childhood obesity

CONTEXT

In England, nearly a third of children aged between 2 and 15 are overweight or obese[13]. The associated health implications are significant. Obesity doubles the risk of dying prematurely and obese adults are seven times more likely to become a type 2 diabetic than adults of a healthy weight. London has the highest obesity rates amongst both reception (ages 4 to 5) and Year 6 children (ages 10 to 11) in England. There is the significant variation across London and neighbouring areas. For example, in Year 6 the range was from 11% in Richmond upon Thames, to 28.5 % in Barking and Dagenham[14].

Obesity is recognised as a complex problem with many drivers including environment, genetics, behaviour and culture[15]. Exposure to air pollution has also recently been identified as potentially contributing to childhood obesity[16,17] as has pre-natal exposure[18]. Potential mechanisms include the impact that pollution can have on the metabolism[16]. This contribution is identified as an area where further research is required[16]. Being obese can also exacerbate the health impacts of air pollution, for example cardio-vascular impacts[19]. Research also indicates that air pollution exposure can be linked to diabetes development[20,21].

Traffic - a key source of air pollution in cities - can also act as barrier to physical activity. Concerns over traffic danger can discourage children from taking up active travel[22] with traffic levels identified as a key risk factor in the development of obesity in children[23].

The links between deprivation and obesity are well established, with children in most deprived areas twice as likely to be obese than children in the least deprived areas[13].

ANALYSIS

Data was obtained from the National Child Measurement Programme for the 2013/14 to 2015/16 period. To produce as robust data as possible at the small area level, three years of data are combined. Data was for reception (ages 4 to 5) and Year 6 (ages 10 to 11).

In terms of metrics used for comparison two datasets were used. Firstly, the average obesity rate across all London schools, regardless to the extent of which they are affected by air quality limits, and secondly the Healthy Schools London Programme's target of less than 25% overweight and obese by 2025 for year 6 (ages 10 to 11)[24].

The data for children starting primary schools, using data for reception classes, shows that of the schools most affected by air quality issues, 75% had levels of obesity and 74% levels of excess weight which were greater than the London average - see Figure 4.

At the end of the primary school age range, using data from Year 6 (age 10 to 11) showed that for obesity 80% and for excess weight 81% (of the schools most affected by air quality issues) had levels which were greater than the London average. Data on excess weight is shown in Figure 5.

For secondary schools, data for year 6 children across the secondary catchments was used as a proxy. Here 88% of the schools most affected by air quality issues had levels of obesity and excess weight which were greater than the London average for all schools.

Achievement of the Healthy Schools London 25% target was very low, for the schools most affected by air quality limits. In fact it was achieved by only 0.8% of the primary schools and none of the secondary schools. This is perhaps to be expected given the 2025 timescale for the target, and is reflected in broader analysis – only 4.5% of all primary schools in London (i.e. including those not in exceedance of air quality limits) would currently meet the target.

The links between physical activity and obesity are complex. It is well established that physical activity combined with dietary change offer the greatest opportunities in terms of weight loss[25,26]. Walking, at low intensity, can, however, offer modest weight loss, and the level of activity needs to be in the region of 10,000 steps per day[25] (typically an hour to an hour and a half exercise).

In terms of **classification** children with a Body Mass Index (BMI) greater than or equal to the 95th centile of the British 1990 growth reference were classified as **obese**, while children with a BMI greater than or equal to the 85th centile of the British 1990 growth reference has been classified as **overweight**. Note that this also includes obese (**excess weight**).

FIGURE 4 – PRIMARY SCHOOLS MOST AFFECTED BY AIR QUALITY IN THE CONTEXT OF EXCESS WEIGHT (RECEPTION YEAR)

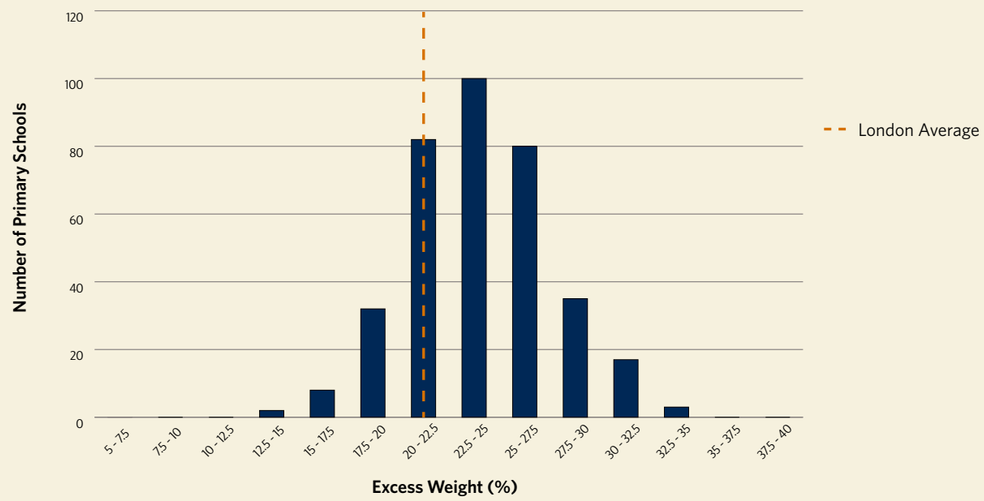
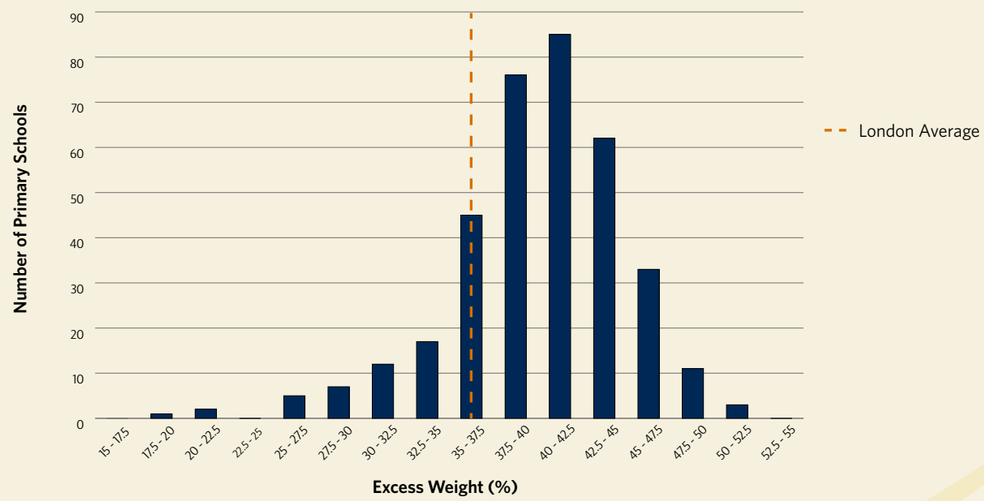


FIGURE 5 – PRIMARY SCHOOLS MOST AFFECTED BY AIR QUALITY IN THE CONTEXT OF EXCESS WEIGHT (YEAR 6)



Physical activity

CONTEXT

In England, only 21% of boys and 16% of girls aged between 5 and 15 currently meet guidelines of at least one hour of moderately intensive physical activity per day[26]. These are average figures across the age range, with figures decreasing as children get older. The number of boys meeting guidelines is 24% for those aged between 5 and 7, but 14% in those aged 13 to 15. For girls, the change is even greater from 23% at ages 5 to 7 to 8% in ages 13 to 15[27].

Geographically detailed data on childhood physical activity is comparatively limited and we discuss this further in the conclusions section. However, over 50% of the London population (all ages) are considered inactive with no participation in sport activities[28].

Physical activity through walking and cycling can have potential adverse side effects due to increased risks of road incidents or exposure to pollution faced by cyclists and walkers. Studies conclude, however, that the benefits of physical activity outweigh these risks[29,30,31,32]. However, studies are focused on adults rather than children, and collection of child equivalent data e.g. taking into account height differences should be a research priority.

It is useful to consider a hierarchy of benefits and impacts. Whilst optimum benefits of physical activity would be achieved in a clean environment, benefits but at lower levels would be achieved in more polluted environments.

ANALYSIS

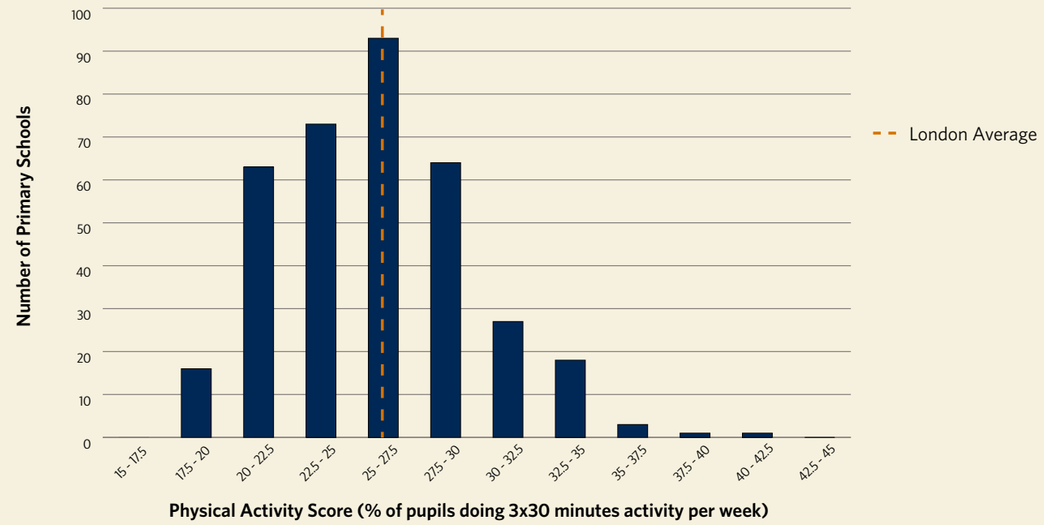
The analysis on physical activity is divided into two parts. The first considers data on active recreation in relation to the area of residence of the school pupils. The second considers the level of walk and cycle as a mode of travel to the schools. Data on active recreation was obtained from Sports England[33] and combines survey data from the Active People survey with additional data at the area level (e.g. health indicators and socio-economic status). Data on the level of walking and cycling at the schools was from the mode of travel to school section from the 2010 School Census[34]. It is important to note the limitations of both datasets. The data on active recreation is available for +16 and is not disaggregated by age, thus caution is required in its interpretation since the outcomes assume a correlation between broader activity at the Middle Super Output Area (MSOA) levels where pupils are resident, and the impacts at the school level. The data on walk and cycle to school is only available for 2010, when this information was last collected in the Department for Education's school census.

In terms of key messages, 54% of primary schools and 68% of the secondary schools studied had pupils from catchments which were below the London average for physical activity in terms of active recreation (% doing activity 3 x 30 minutes per week). Figure 6 shows data for primary schools.

In terms of walking and cycling activity at the schools, it was was important to take into account whether the schools were in Inner or Outer London.

For primary schools 67% of Inner London and 74% of the Outer London schools most affected by air pollution had levels of walking as a mode of travel to school which are higher than the London average (as shown in Figure 7). For secondary schools most affected by air pollution, 63% of schools in Inner London and 50% of schools in Outer London had levels of walking higher than the London average. However, for cycling less than 30% of primary and secondary schools most affected by air quality pollution had levels higher than the London average.

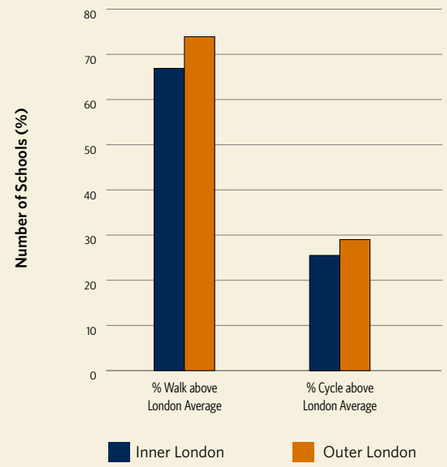
FIGURE 6 – PRIMARY SCHOOLS MOST AFFECTED BY AIR QUALITY IN THE CONTEXT OF ACTIVE RECREATION



This level of walking activity is positive in terms of physical benefits, however, it needs to be seen in the context of potential distance travelled. Distance travelled (one way), by all modes, was calculated for the purposes of this research. For primary schools the distance assumed was 0.8 km and for secondary schools 1.7 km, one way. Analysis taking into account return journeys and assuming child walking speeds suggests that commutes of this length could contribute approximately 50% of the guideline 60 mins of moderately intensive physical activity for primary children and ~ 80% for secondary school children.

The level of activity also raises concerns around the exposure of pupils to air pollution. While research studies[35] suggest there can be a higher air pollution exposure risk inside of cars compared to being a pedestrian or cyclist, on street levels can still be high and consideration needs to be given to inhalation rates and commute time. In terms of exposure a number of steps can be taken - eg. walking on the side of road opposite the traffic, especially during the commuting period[36] and optimisation of the phasing of lights to reduce pedestrian waiting time. Action to reduce traffic across the whole school route will also be key.

FIGURE 7 – PRIMARY SCHOOLS MOST AFFECTED BY AIR QUALITY IN THE CONTEXT OF ACTIVE TRAVEL TO SCHOOL

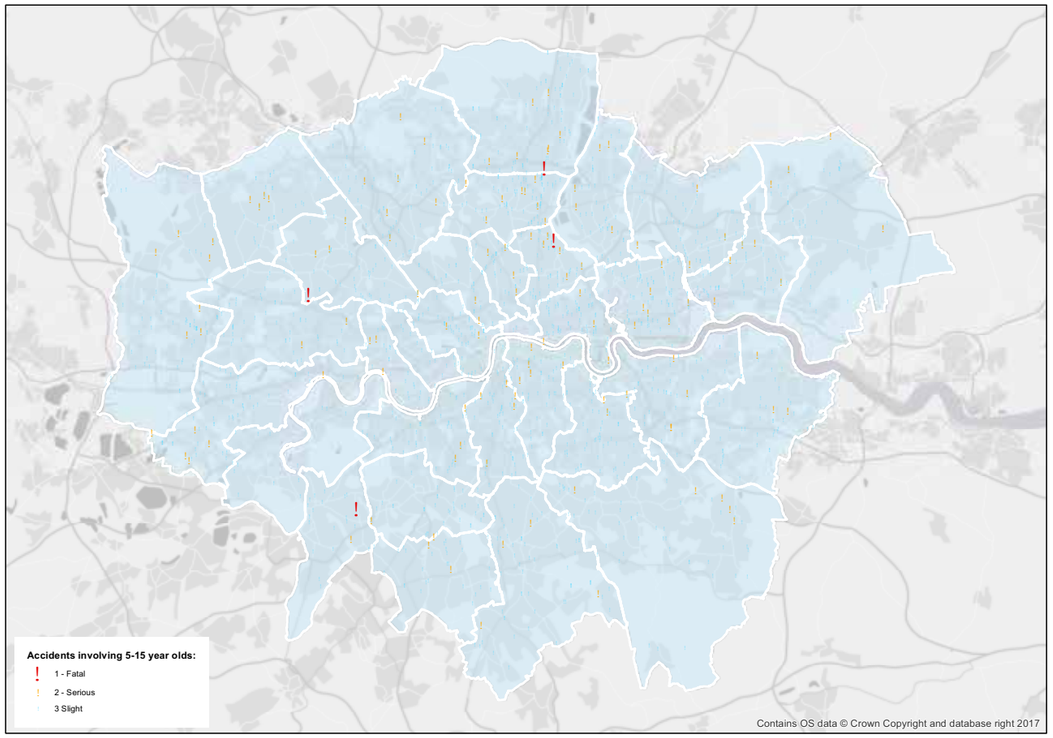


For schools, there are a number of barriers to cycling uptake which warrant further consideration. For example, potentially vulnerable groups can be put off cycling due to a lack of culturally accessible facilities or limited cycle parking opportunities[37]. There are socio-economic aspects to this – there are more than three time as many cyclists with an annual household income of over £52,000 than with an income of less than £15,559[36]. Any attempt to facilitate active travel by cycle need to take this into account.

Further barriers to cycling can include safety concerns, linked to crime and traffic levels[36]. For example, research suggests that two in five 11 to 17 year olds cite an absence of safe routes as being a barrier to cycling[38].

In London, in 2015, five children were killed (three pedestrians, one car passenger and one 'hover board' user), an increase from three in 2014[39]. Child serious casualties fell by 13% to 142[37]. However, slight casualties increased by 2% to 1,848. Overall child casualties increased by 1% in 2015 compared to 2014[37]. Data on child road safety incidents involving five to fifteen year olds is shown below in Figure 8. It is important to recognise that data such as this does not capture perceptions of safety and how these barriers to uptake in turn influence the statistics.

FIGURE 8 – CHILD ROAD SAFETY INCIDENTS (AGE 5 TO 15) IN LONDON IN 2015



SOURCE: GLA, 2015[40]

ISSUES OF EQUITY IN TRAVEL MODES AND POLLUTION EXPOSURE?

Road transport is a key source of air pollution. In the context of these most polluted schools, data on the number of pupils travelling to school by car improves our understanding of the school's potential contribution to local air quality emissions. Data on pupil travel by car from the School's 2010 census data was used. This was complemented by analysis on the adoption of the London STARS, (Sustainable Travel: Active, Responsible, Safe) programme by the schools. The STARS programme aims to promote increased walking, cycling and public transport use and reduced car use in schools in London. There are three levels of accreditation: bronze, silver and gold. Accreditation is awarded depending on the completion of different travel activities and the level of success in reducing car use and achieving sustainable travel[41].

- For the primary schools most affected by poor air quality, using data from School 2010 census, 76% of Inner London and 82% of Outer London schools had lower levels of travel to school by car than the respective Inner and Outer London primary school averages, irrespective of air quality.
- For secondary schools most affected by poor air quality, using data from the School 2010 census, 68% of Inner London and 100% of Outer London schools had lower levels of travel to school by car than the respective Inner and Outer London secondary school averages.

The results are consistent with broader data on car ownership in the catchment areas around the schools. For primary schools, 92%, and for secondary schools, 96%, of the schools affected by poor air quality had catchments with lower than the London average for car ownership.

In terms of STARS accreditation for primary schools most affected by poor air quality, 9% of the schools had achieved the Gold Star award, 9% Silver and 38% Bronze. For secondary schools, 4% of the schools had achieved Gold, 4% Silver and 17% Bronze. For London overall (all schools irrespective of air quality) the results are 11%, 9% and 26%, for Gold, Silver and Bronze respectively.

Overall key messages:

- The pupils most affected by air pollution have lower levels of travel to school by car compared with the London average. Their contribution to the local air pollution to which they are exposed is therefore likely to be low. The results correspond with lower levels of car ownership in the catchment areas surrounding the schools. Air pollution mitigation can therefore be considered a social justice issue.
- The attainment of STARS bronze, silver and gold awards by the schools is positive. There are opportunities to better understand barriers and opportunities to uptake of these awards.
- Schools affected by poor air quality are also impacted by higher levels of obesity and higher levels of deprivation than the London average.
- Emerging research suggests links between air pollution exposure and obesity and this warrants detailed consideration in the London context.
- In terms of physical activity, there are potentially positive messages about high levels of walking to school. GLA School Air Quality Audits could help ensure that lower pollution routes to school are identified where possible.
- Rates of active travel through cycling to school are lower in schools with poor air quality than the London average. This raises questions around longer term uptake of this mode; barriers to uptake need to be explored and addressed.
- For physical activity and active travel, data availability is identified as a key limitation in this analysis. Steps to improve data collection are required.
- Car travel for pupils going to schools with poor air quality is lower than the London average for all schools, as is car ownership in related catchment areas.
- Equity issues are therefore raised, with air pollution mitigation needing to be considered in the context of social justice.

CONCLUSIONS AND POLICY RECOMMENDATIONS

The research undertaken for this report has considered the London schools most affected by poor air quality in the context of a multi-level perspective. The outcomes indicate that while air pollution is a key issue and understandably a current focus of media and public attention, there are other societal and health impacts associated with these schools that must be considered in the context of policy on clean air.

London's complex geography and the varied nature of school catchment areas results in a focus on identifying linkages and patterns which is an important input for decision makers. Key points for consideration in research and policy development are therefore as follows.

First, pupils at the schools most affected by poor air quality are more likely than the London average to come from areas with higher than average levels of **obesity**, and there are two important points to consider here:

- Air pollution is linked to a number of health impacts, including: the worsening of asthma; increased risks of heart disease and in children, damage to the development of their lungs. There is increasing evidence of the links between air quality and diabetes. Obese children are at risk of the same conditions, in particular, diabetes and damage to lung development. Understanding the potential for overlap and even mutual reinforcement between these impacts is key.

- There is emerging evidence that exposure to air quality pollutants is linked to increased levels of obesity. Research to understand this in the London context is essential.

Second, in terms of **physical activity**, pupils at the schools most affected by poor air quality are more likely than the London average to walk to school. While some caution is required given the limitations of the data, this raises questions around pupils' exposure to air pollutants. In particular, it highlights the need to consider solutions which encompass the whole of the route to school.

How active travel to school sits within physical activity guidelines warrants further consideration, also in the context of the role that physical activity can play in achieving obesity reduction. The analysis for this report suggests that walking to school could make a contribution to achieving physical activity guidelines, but that the distances travelled are likely to mean that further activity will be required. How the local environment could facilitate this extra activity e.g. through access to green spaces needs to be explored.

Pupils at the schools with poor air quality are also less likely than average to cycle to school. Further understanding of the barriers to cycling in this context are required. In particular, the role of traffic. High traffic levels can act as a barrier to active travel and this highlights the importance of reducing traffic overall, not simply switching to less polluting vehicles. Cultural and socio-economic barriers to cycling adoption also need to be considered.

Third, in terms of **car travel to school**, the data suggests that pupils at the schools most affected by poor air quality are less likely to travel to school by this mode, and that pupils from these schools are more likely to come from areas where car ownership rates are lower. Equity issues around the causes of this local air pollution are thus raised. Measures which target pupil car travel including vehicle idling are less likely to have an impact at these schools. Action to reduce traffic for all trip purposes and from all road transport modes is therefore required.

Fourth, **deprivation**, can underpin the above impacts, by potentially further compounding air pollution and obesity health impacts, around physical activity and car travel. This highlights the importance of considering air pollution as a social justice issue with an integrated approach. Addressing air pollution exposure of school children will need to take into account issues at a much wider level than the school, which will take time. In the short to medium term, exposure reduction measures (ventilation changes, re-location of schools) may offer some benefits but over the longer term, targeting air quality policy more broadly towards areas of deprivation will be necessary.

Finally, for **policy appraisal** and **evaluation** to be robust, up to date data is required. Correspondingly, the importance of improvements to **data collection** and availability have been identified through this work, in particular, with regards to data on mode of travel to school and physical activity.

GLOSSARY OF TERMS

BMI	Body Mass Index, a measure of body fat based on height and weight
CO_2	Carbon dioxide
EU limit value	Legal limits for air quality established by the European Commission
IMD	Index of Multiple Deprivation
Inner London	The 12 Boroughs in central London and the City of London
LSOA	Lower Layer Super Output Area (The average population of a LSOA in London in 2010 was 1,722)
NO_2	Nitrogen dioxide
Outer London	20 Boroughs that form a ring around inner London
MSOA	Middle Super Output Area: (The average population of a MSOA in London in 2010 was 8,346)
STARS	A sustainable travel programme for schools funded by Transport for London (Sustainable Travel: Active, Responsible, Safe)

APPENDIX A

Data Processing Methods

The schools considered in this report were selected based on previous work to identify those that were in exceedance of NO_2 limit values in 2013 (based on London Atmospheric Emission Inventory 2013 maps). For the definition of the schools' catchment areas, data (for 2016) from the Greater London Authority was used. This allowed the allocation of pupils to their residential area, at the Lower Super Output Area level (LSOA).

For each of the variables studied, except the mode of travel to school, a weighted score for each school was calculated based on the rates of that variable within the LSOAs in the school catchment and the numbers of pupils from that school living in each LSOA. For example, for deprivation the results for each school were calculated from the score for the pupil's residential location (at the LSOA level) and the percentage of pupils in the different LSOAs.

For mode of travel to school, data was available at the level of the school and no further calculation was necessary. A key limitation of this data is its limited time series, with the latest year being 2010. As a result, there were gaps in the data reflecting changes at the schools. For primary schools, there was no mode of travel data for 14% of schools. This data was thus gap filled based on information on schools at the same LSOA or Middle Layer Super Output Area (MSOA) level. For secondary schools, there was no mode of travel data for 45% of schools and these schools were therefore excluded from the analysis. This, in part, reflects the introduction of new schools including Free schools and Academies in London. Gap filling the data suggests lower levels of walking and cycling than the London average this implies these are excluded from the analysis.

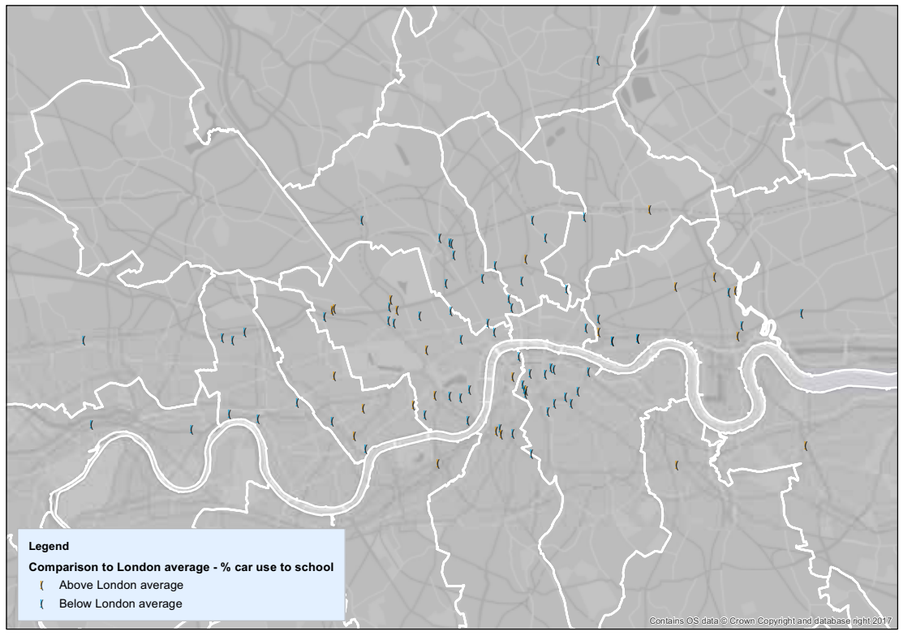
For obesity and excess weight, gap filling was required because some data had been suppressed due to confidentiality. Here, data from the borough level was used to gap fill these MSOAs. Sensitivity testing for schools with no gap filling showed similar outcomes.

APPENDIX B

Summary results: maps and tables

The following maps and summary table refer to the 100 State primary and State secondary schools which have highest levels of annual average NO_2 concentrations (2013). This is a subset of the schools covered in this report, which are the 435 schools with above EU limit value NO_2 concentrations. The aim of the maps is to show more details and local context of the study findings. This data is provided to encourage positive policy action for these schools.

FIGURE B1 – CAR TRAVEL TO SCHOOL RATES IN 2010 ABOVE AND BELOW THE INNER/OUTER LONDON AVERAGE AT THE LONDON SCHOOLS WITH HIGHEST ANNUAL AVERAGE NO_2 CONCENTATIONS IN 2013



It is important to note that is the travel to school data used in Figures B1-B3 reflects the position in 2010. For secondary schools, there was no mode of travel data for 45% of schools and these schools were therefore excluded from the analysis, this results in 92 rather than a 100 schools represented on the map. For primary schools, there was no mode of travel data for 14% of schools. This data was thus gap filled based on information on schools in the same local area.

Average data for Inner or Outer London was used for comparison as applicable.

FIGURE B2 - CYCLE TRAVEL TO SCHOOL RATES IN 2010 ABOVE AND BELOW THE INNER/OUTER LONDON AVERAGE AT THE LONDON SCHOOLS WITH HIGHEST ANNUAL AVERAGE NO_2 CONCENTATIONS IN 2013

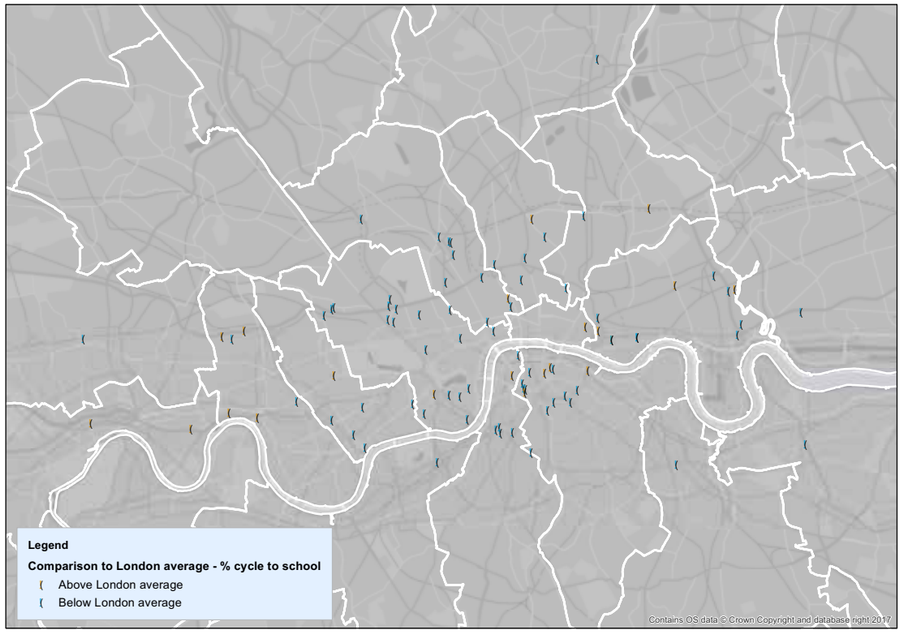


FIGURE B3 - WALKING TO SCHOOL RATES IN 2010 ABOVE AND BELOW THE INNER/OUTER LONDON AVERAGE AT THE LONDON SCHOOLS WITH HIGHEST ANNUAL AVERAGE NO_2 CONCENTATIONS IN 2013

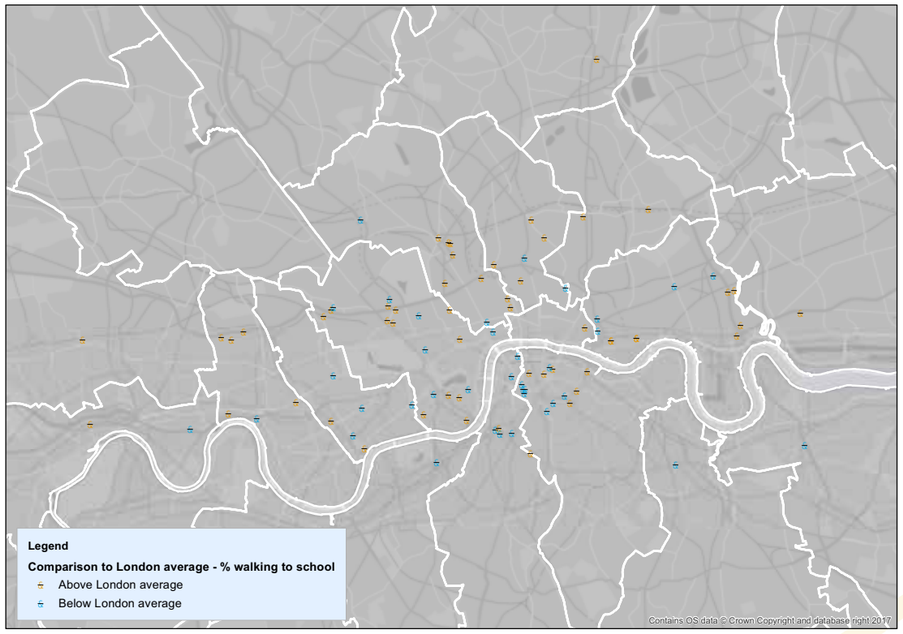
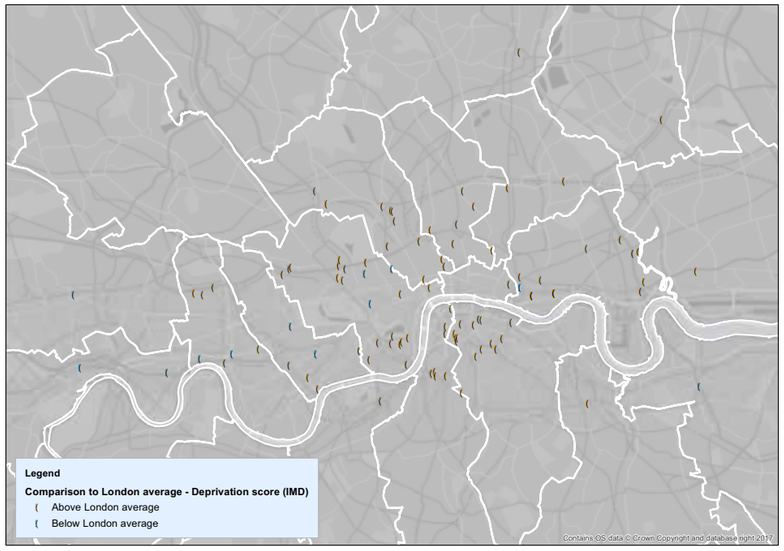
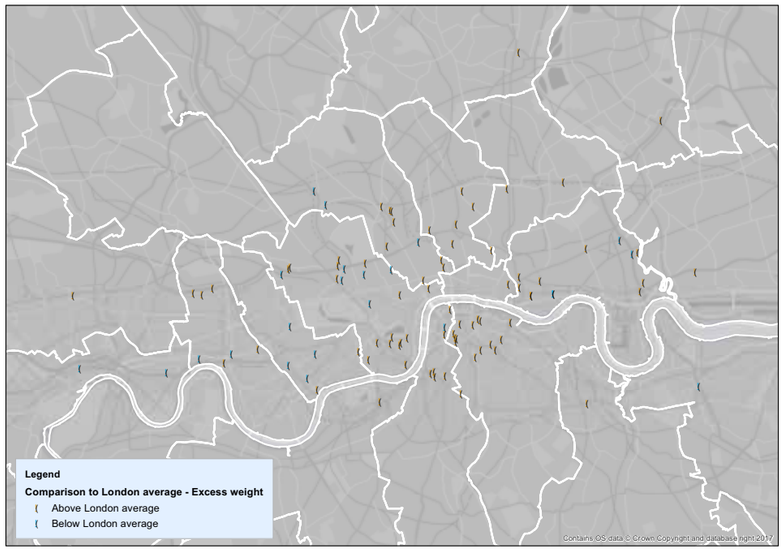


FIGURE B4 – SCHOOLS ABOVE AND BELOW THE LONDON DEPRIVATION AVERAGE FOR THE 100 LONDON SCHOOLS WITH HIGHEST ANNUAL AVERAGE NO_2 CONCENTATIONS IN 2013



The Index of Multiple Deprivation (IMD) score for each school was developed from the English Index of Multiple Deprivation[42]. The score was calculated as a weighted average of the IMD scores of the LSOAs in the school catchment area, based on the percentage of pupils at that school from each Lower Super Output Area within their catchments.

FIGURE B5 – SCHOOLS WITH ABOVE AND BELOW THE LONDON AVERAGE RATES OF EXCESS WEIGHT OF PUPILS, FOR THE LONDON SCHOOLS WITH HIGHEST ANNUAL AVERAGE NO_2 CONCENTATIONS IN 2013



In these maps data for primary schools relates to children age 5-6 ; data for secondary schools relates to children age 10-11 as a proxy.

FIGURE B6 – SCHOOLS WITH ABOVE AND BELOW THE LONDON AVERAGE RATES OF OBESITY IN PUPILS, FOR THE 100 LONDON SCHOOLS WITH HIGHEST ANNUAL AVERAGE NO_2 CONCENTATIONS IN 2013

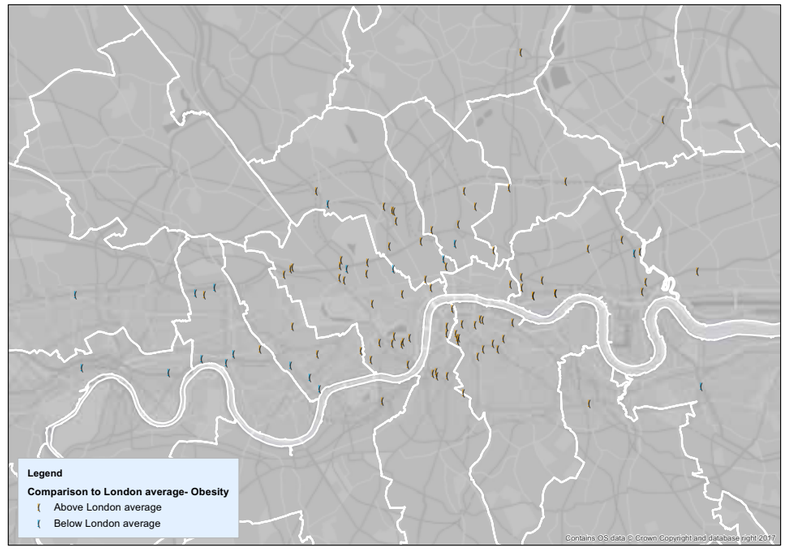
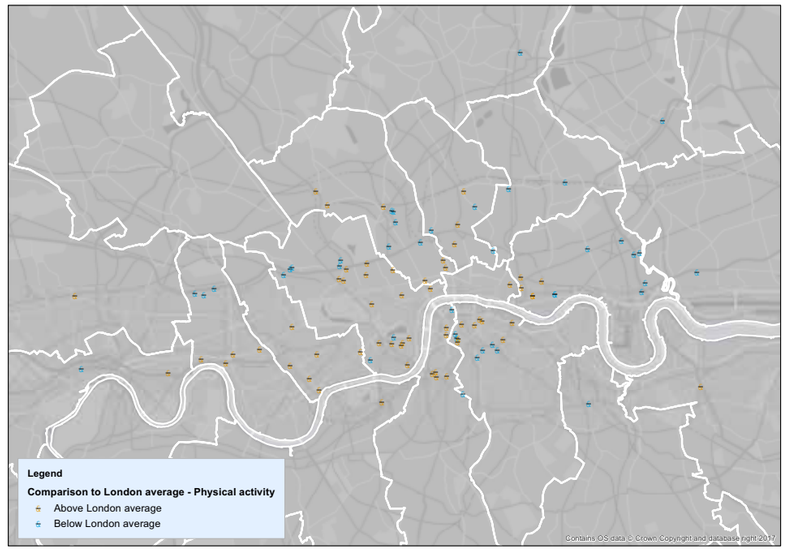


FIGURE B7 - SCHOOLS WITH ABOVE AND BELOW THE LONDON AVERAGE RATES OF PHYSICAL ACTIVITY BY ADULTS IN THEIR CATCHMENT, FOR THE LONDON SCHOOLS WITH HIGHEST ANNUAL AVERAGE NO_2 CONCENTATIONS IN 2013



The data for this map is based on active recreation for +16 ages and is not disaggregated by age. Therefore caution is required in its interpretation since this data does not relate directly to physical activity rates of children.

Data for the 100 most polluted schools covered by this study

Establishment Name	Borough	Phase of Education	NO_2 2013 mean	IMD Score	Mode of Travel: % Car	Mode of Travel: % Walk	Mode of Travel: % Cycle	Physical Activity Score	Obesity (%)	Excess Weight (%)
St Mary's Bryanston Square CofE School	Westminster	Primary	67.0	29.0	15.6	77.2	0	30.5	10.1	19.8
St Paul's CofE Primary School	Hammersmith and Fulham	Primary	65.2	31.4	10.0	66.9	3.8	27.6	10.0	22.8
St Clement Danes CofE Primary School	Westminster	Primary	65.0	26.5	9.6	53.8	0	29.4	12.9	23.1
The St Marylebone CofE School	Westminster	Secondary	64.8	29.6	NA	NA	NA	26.8	24.3	38.9
St George's Cathedral Catholic Primary School	Southwark	Primary	64.3	35.3	6.0	33.3	0	25.5	13.4	26.2
St Peter's Eaton Square CofE Primary School	Westminster	Primary	64.3	26.8	16.7	42.9	2.4	29.0	12.3	26.2
Christ Church Bentinck CofE Primary School	Westminster	Primary	64.1	44.6	5.4	91	0	22.5	11.9	24.5
The Minerva Academy	Westminster	Primary	63.7	35.4	9.2	74.8	0.3	28.7	12.0	25.5
Sir John Cass's Foundation Primary School	City of London	Primary	62.6	28.3	6.0	72.1	3.4	29.9	11.8	24.6
Woolmore Primary School	Tower Hamlets	Primary	61.8	38.8	16.4	83.2	0	24.9	13.0	23.7
Central Foundation Boys' School	Islington	Secondary	60.6	34.2	0.0	27.8	0	25.5	25.0	41.0
Sacred Heart High School	Hammersmith and Fulham	Secondary	59.8	22.7	NA	NA	NA	30.6	19.3	32.9
Oasis Academy South Bank	Lambeth	Secondary	59.4	30.8	NA	NA	NA	27.5	24.6	40.7
Hampden Gurney CofE Primary School	Westminster	Primary	58.9	25.9	3.9	76.4	0	32.4	10.2	20.3
Argyle Primary School	Camden	Primary	58.8	35.7	2.8	92.8	0	24.7	10.2	20.5
Christopher Hatton Primary School	Camden	Primary	58.4	29.1	1.3	90.3	4	26.5	10.0	22.5
St Josephs Primary School	Camden	Primary	58.1	27.9	1.9	72.8	0	27.7	12.3	23.4
St Anne's Catholic Primary School	Lambeth	Primary	57.7	33.1	18.0	59.2	0	27.0	12.0	23.5
Canon Barnett Primary School	Tower Hamlets	Primary	57.2	40.3	8.3	62.3	0	26.7	11.3	22.1
St Vincent de Paul RC Primary School	Westminster	Primary	56.9	25.7	8.5	81	0	30.7	12.7	26.0
Notre Dame Roman Catholic Girls' School	Southwark	Secondary	55.9	35.5	1.1	7.7	0	23.4	28.5	44.7
English Martyrs Roman Catholic Primary School	Tower Hamlets	Primary	55.9	23.5	27.9	54.5	3.6	31.2	11.1	22.5
St Jude's Church of England Primary School	Southwark	Primary	55.6	36.6	17.0	55.6	0	26.3	12.9	26.3
St Mary Abbots CofE Primary School	Kensington and Chelsea	Primary	55.2	20.0	36.8	39.7	3.8	31.7	11.6	21.2
Tower Bridge Primary School	Southwark	Primary	55.0	28.3	6.3	75.8	2.9	30.8	13.6	25.2
St Saviour's and St Olave's Church of England School	Southwark	Secondary	54.9	35.1	4.9	23.5	0	24.0	28.2	44.7
St John Evangelist RC Primary School	Islington	Primary	54.7	31.6	23.7	50.9	0	28.5	11.8	24.1
Westminster Cathedral RC Primary School	Westminster	Primary	54.5	30.9	4.3	74.5	0	28.3	13.0	28.3
Ark Conway Primary Academy	Hammersmith and Fulham	Primary	54.4	37.8	10.8	77.6	1.9	24.7	9.5	22.5
Holy Trinity CofE Primary School	Kensington and Chelsea	Primary	53.9	29.0	16.0	45.6	0	26.7	11.4	26.2
Westminster City School	Westminster	Secondary	53.5	36.1	NA	NA	NA	25.1	27.3	43.6
Ark Bentworth Primary Academy	Hammersmith and Fulham	Primary	53.3	43.7	10.8	77.6	1.9	19.1	9.4	22.2
Holy Trinity CofE Primary School, NW3	Camden	Primary	53.3	23.9	8.6	71.4	0	29.6	10.2	20.5
Saint Joseph's Catholic Primary School, the Borough	Southwark	Primary	53.2	30.4	0.0	92	0	26.8	12.6	24.9

Establishment Name	Borough	Phase of Education	NO_2 2013 mean	IMD Score	Mode of Travel: % Car	Mode of Travel: % Walk	Mode of Travel: % Cycle	Physical Activity Score	Obesity (%)	Excess Weight (%)
St Barnabas' CofE Primary School	Westminster	Primary	53.1	35.0	1.9	91	0	25.2	12.5	32.0
Soho Parish CofE Primary School	Westminster	Primary	52.9	30.1	0.0	91.7	0	27.1	11.1	23.3
St Cuthbert with St Matthias CofE Primary School	Kensington and Chelsea	Primary	52.2	31.3	9.2	78.3	0	32.5	9.7	21.3
Hawley Infant School	Camden	Primary	52.2	35.8	0.0	96.6	0	26.8	10.9	22.1
Culloden Primary - A Paradigm Academy	Tower Hamlets	Primary	52.1	48.1	14.3	75.7	0.6	19.3	12.4	24.2
Ashburnham Community School	Kensington and Chelsea	Primary	52.0	36.8	6.8	79.1	0	26.1	8.4	23.0
Servite RC Primary School	Kensington and Chelsea	Primary	51.8	29.1	22.2	37.6	0	29.9	9.0	20.4
Shapla Primary School	Tower Hamlets	Primary	51.6	38.4	9.7	81.6	3.4	30.1	14.4	30.0
St Paul's Whitechapel Church of England Primary School	Tower Hamlets	Primary	51.6	36.8	11.5	76.1	0	29.6	13.7	28.1
Bow School	Tower Hamlets	Secondary	51.5	42.9	6.1	52.9	1.8	21.0	24.3	39.2
The Cathedral School of St Saviour and St Mary Overy	Southwark	Primary	51.4	26.3	9.1	72.3	1.4	29.2	12.4	24.2
Westminster Academy	Westminster	Secondary	51.1	42.3	6.4	32.5	0	23.5	25.2	40.3
Charlotte Sharman Primary School	Southwark	Primary	51.1	35.2	12.4	62.1	2.5	26.6	13.3	26.1
Oasis Academy Johanna	Lambeth	Primary	51.0	28.8	14.8	71	1.3	27.1	11.5	20.2
Richard Cobden Primary School	Camden	Primary	50.9	36.8	8.1	80.2	0.7	23.2	12.8	23.4
The Grey Coat Hospital	Westminster	Secondary	50.7	28.9	NA	NA	NA	28.0	25.8	41.4
St Alban's Church of England Primary School	Camden	Primary	50.6	32.2	2.8	87	0	26.2	10.4	22.4
The UCL Academy	Camden	Secondary	50.4	25.3	NA	NA	NA	28.1	18.5	34.9
Lilian Baylis Technology School	Lambeth	Secondary	50.4	34.7	0.6	32.8	0	26.3	25.9	41.6
Henry Fawcett Primary School	Lambeth	Primary	50.4	32.4	4.1	69.4	0	27.5	11.5	22.2
Blue Gate Fields Infants' School	Tower Hamlets	Primary	50.3	41.8	8.4	85	0.9	24.7	11.9	21.7
Blue Gate Fields Junior School	Tower Hamlets	Primary	50.3	42.0	8.0	89	0	24.5	11.9	21.4
Townsend Primary School	Southwark	Primary	50.2	38.4	3.1	75.3	0	22.8	15.4	28.4
Hugh Myddelton Primary School	Islington	Primary	50.2	32.7	5.4	89.1	0.7	27.1	9.9	23.2
London Nautical School	Lambeth	Secondary	49.9	33.7	0.6	4.9	0	25.6	26.0	42.0
Grange Primary School	Southwark	Primary	49.9	31.3	5.9	87.2	0	26.9	12.4	24.3
St Matthew's School, Westminster	Westminster	Primary	49.8	33.2	7.2	62.3	0	30.5	12.9	25.3
St Mark's Church of England Primary School	Lambeth	Primary	49.8	31.1	15.1	69.3	0	27.8	11.9	23.1
Holy Trinity CofE Primary School	Haringey	Primary	49.7	45.1	18.3	70.4	0.6	20.1	13.9	26.5
De Beauvoir Primary School	Hackney	Primary	49.7	37.0	11.6	76.8	0	25.8	13.0	26.4
Victory School	Southwark	Primary	49.7	37.9	7.5	65.5	0	25.0	14.4	27.3
Our Lady of Victories RC Primary School	Kensington and Chelsea	Primary	49.5	21.3	38.4	25.3	0	34.4	11.2	21.8
Winton Primary School	Islington	Primary	49.4	35.9	8.5	87.1	0	23.8	13.1	26.0
St Peter's Primary School	Hammersmith and Fulham	Primary	49.2	23.0	9.0	79.1	7	33.3	7.5	18.3
St Mary's Catholic Primary School ,Chiswick	Hounslow	Primary	49.0	14.7	28.9	57.9	10.6	34.9	6.8	17.5
Charles Dickens Primary School	Southwark	Primary	49.0	26.6	8.7	80.4	1.9	29.3	12.0	24.5

Establishment Name	Borough	Phase of Education	NO_2 2013 mean	IMD Score	Mode of Travel: % Car	Mode of Travel: % Walk	Mode of Travel: % Cycle	Physical Activity Score	Obesity (%)	Excess Weight (%)
Marner Primary School	Tower Hamlets	Primary	48.9	44.4	12.3	80.2	0	19.5	9.1	19.5
St Mary's RC Voluntary Aided Primary School	Wandsworth	Primary	48.9	31.5	18.5	57.1	0	27.2	10.6	22.4
Netley Primary School	Camden	Primary	48.9	32.0	1.8	92.7	0	24.4	11.6	23.4
Christ the Saviour Church of England Primary School	Ealing	Primary	48.7	22.5	21.4	71.1	0.6	29.4	9.2	22.1
Wapping High School	Tower Hamlets	Secondary	48.6	36.2	NA	NA	NA	26.1	26.5	41.5
St Vincent's RC Primary School	Westminster	Primary	48.5	18.1	11.5	56.8	0	32.5	10.8	16.9
St Edward's Catholic Primary School	Westminster	Primary	48.5	40.4	19.7	66.7	0	24.6	11.9	23.2
The New North Academy	Islington	Primary	48.4	37.1	8.8	81.6	0.8	25.8	12.5	25.9
Keir Hardie Primary School	Newham	Primary	48.4	43.2	9.8	75.8	0	20.0	15.1	30.3
Floreat Brentford Primary School	Hounslow	Primary	48.2	22.9	22.8	68.5	2.3	24.5	9.1	19.0
Guardian Angels Roman Catholic Primary School	Tower Hamlets	Primary	48.1	36.6	32.8	32.8	2.5	22.8	11.3	22.0
St James's Hatcham Church of England Primary School	Lewisham	Primary	48.1	34.7	24.1	62.9	0	24.1	13.9	25.0
St Stephen's CofE Primary School	Westminster	Primary	48.0	43.1	9.2	74.8	0.3	25.5	10.2	21.4
All Souls CofE Primary School	Westminster	Primary	47.9	22.3	0.0	89.7	0	27.5	9.7	21.2
Friars Primary Foundation School	Southwark	Primary	47.8	29.5	8.0	81.3	0	28.1	13.3	26.0
Cardinal Pole Roman Catholic School	Hackney	Secondary	47.8	42.7	10.9	38.1	1.4	21.9	28.0	43.5
St Agnes RC Primary School	Tower Hamlets	Primary	47.8	38.7	21.0	67.9	0	21.7	10.6	21.5
St John's Walworth Church of England Primary School	Southwark	Primary	47.8	37.7	11.5	50.3	0	23.2	14.9	28.6
St Michael's Church of England Primary School	Camden	Primary	47.7	36.6	2.7	83.4	0	25.5	12.4	24.5
Our Lady of Dolours RC Primary School	Westminster	Primary	47.7	46.6	21.3	52.8	0	22.7	11.2	23.0
Avonmore Primary School	Hammersmith and Fulham	Primary	47.6	26.2	6.1	89.5	0	33.0	12.9	26.8
Connaught School for Girls	Waltham Forest	Secondary	47.6	30.5	NA	NA	NA	24.4	25.4	38.6
Burdett-Coutts and Townshend Foundation CofE Primary School	Westminster	Primary	47.6	28.2	4.0	80.1	0	28.6	12.8	26.7
Our Lady Roman Catholic Primary School	Camden	Primary	47.5	35.1	6.1	84.5	0	24.9	12.3	24.1
Oldfield Primary School	Ealing	Primary	47.5	20.0	22.0	69.9	0	22.3	9.2	19.6
St George's Hanover Square CofE Primary School	Westminster	Primary	47.4	21.8	18.0	22.2	0	32.4	10.3	18.6
Invicta Primary School	Greenwich	Primary	47.3	19.3	27.1	70.7	0	29.7	9.0	21.1
Phoenix High School	Hammersmith and Fulham	Secondary	47.3	37.5	1.1	65.4	0	23.4	24.3	38.2
St John the Divine Church of England Primary School	Southwark	Primary	47.2	35.5	4.4	93	0	23.8	15.0	30.3
Canonbury Primary School	Islington	Primary	47.2	29.4	9.7	81.4	2.5	28.8	10.4	22.3

Notes:

NO_2 concentration is for 2013
IMD = Index of Multiple Deprivation
IMD score is based on the IMD scores for the schools' catchments LSOAs
Physical activity score is calculated from the percentage of pupils doing activity 3 x 30 minutes per week based on the school LSOA data

For the purpose of this table obesity and excess weight refers to reception for Primary school and Year 6 for Secondary school
NA – Not Applicable – data not available from the 2010 School census

APPENDIX C

Endnotes

[1] Walton H. et al., (2015) Understanding the Health Impacts of Air Pollution in London King's College London.
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[8] London's Poverty Profile **http://www.londonspovertyprofile.org.uk/key-facts/changes-over-time/**
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