Updated Analysis of Air Pollution Exposure in London

Report to Greater London Authority

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Aether

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Executive Summary

This research is to provide an update to similar analysis undertaken in 2013, published recently by the GLA[1]. Air quality in London has improved in recent years as a result of policies to reduce emissions, primarily from road transport. However, recently updated maps of pollution concentrations for 2013 still show significant areas of exceedances of the annual mean NO_2 EU Limit Values. Improvements are planned to address these, as recently announced in the Mayor's package of air quality measures. The research described in this report considers pollution exposure in London in 2013 and considers how exposure varies by indicators of relative deprivation and ethnic groups in London.

Through the research described in this report, the GLA is seeking to understand inequalities in access to clean air in London and to consider how this will be improved by planned air pollution controls. The previous Analysing Air Pollution Exposure in London report found that populations living in the most deprived areas were on average more exposed to poor air quality than those in less deprived areas. Exposure to air pollution at schools was also assessed. It was found that in 2010, there were 1777 primary schools in London of which 433 were in locations where average concentrations exceed the NO_2 EU limit value. Of these 433 primary schools, 82% were deprived schools. By contrast, of the 1344 primary schools that were not exposed to above EU limit values of NO_2, 39% were deprived.

Annual average air quality concentrations of NO_2, PM_{10} and $PM_{2.5}$ across London in 2013 have been modelled at a 20 m resolution by the Environment Research Group (ERG) at Kings College London using recently updated data for the London Atmospheric Emissions Inventory (LAEI). These concentration maps were summarised by Transport for London, calculating average air pollution concentrations within small geographical areas (Output Areas, OAs and Lower Super Output Areas, LSOAs). These estimates of concentrations were then combined with Census data on resident population (totals, ethnic group and by age group), Index of Multiple Deprivation scores for each LSOA and the ethnic profile of each LSOA. Air pollution levels at the locations of schools have also been considered, by calculating the average concentration within 150m of the school. Pollution concentrations in 2020, 2025 and 2030 have also been considered.

This study has found that in 2013 there was still significant exposure of the London population to levels of NO_2 above the EU limit value and that this exposure is predicted to decline significantly (96%) by 2020. However, current modelling results show that in 2020 there will still be more than 72,000 people living in locations with average NO_2 above the EU limit value. In contrast, average concentrations of particles (PM_{10} and $PM_{2.5}$) were, by 2013, already within EU Limit Values for the annual average concentrations. These estimates of future exposure are preliminary. This is due to pending updates expected this year to account for methodology developments such as new COPERT emission factors which take closer account of "real world driving" emissions from road vehicles. However, the geographic distribution of predicted air pollution is not expected to change significantly following the update so the patterns described in this report will remain valid.

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[1] Analysing Air Pollution Exposure in London, Aether, produced 19/09/2013

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1   Introduction

The aim of the work described in this report was to build on the findings in the previous Analysing Air Pollution Exposure in London report[1] produced in 2013, which was based on data on 2010 air pollution concentrations. This report provides analysis based on 2013 air pollution concentrations, specifically for London, using the latest version of the London Atmospheric Emissions Inventory[2].

The data presented here provides the GLA with an evidence base of quantified exposure to air pollution across the whole population and the level of inequalities that exist within this pattern of exposure. Understanding in detail the spatial nature of such inequalities is important in the development of policies to reduce inequalities and in the wider context of sustainable development. This report includes new analysis which considers the air pollution exposure of different ethnic groups within London for the first time. It also presents results from the consideration of exposure in the context of age distribution to assess whether the elderly and young populations are disproportionately exposed to high levels of air pollution. The young are particularly susceptible to air pollution, and this study also considers exposure at school locations. This report provides baseline data for future analysis of likely impacts of planned improvements.

Air quality in London has improved in recent years as a result of policies to reduce emissions, primarily from road transport. However, recently updated maps of pollution concentrations for 2013 show exceedances of the annual mean NO_2 EU Limit Values (**Figure 1**).

Figure 1 Annual mean NO_2 concentrations in 2013 in Greater London[3]
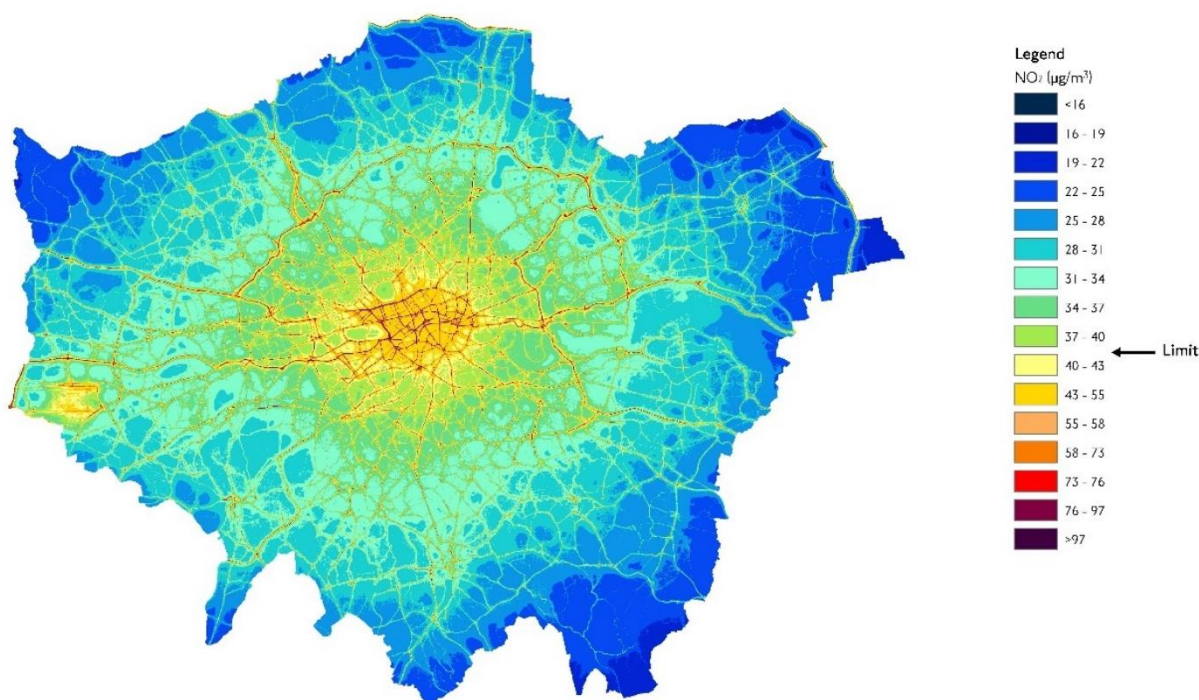
don Atmospheric Emissions Inventory (2013)

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[1] Analysing Air Pollution Exposure in London, Aether, produced 19/09/2013
[2] LAEI https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory-2013
[3] Available from the London Datastore: https://data.london.gov.uk/dataset/llaqm-bespoke-borough-by-borough-air-quality-modelling-and-data/resource/e770d524-dd30-46db-bc2e-e8c4da8902a4

Air pollution poses a risk to health, and this is particularly significant for susceptible groups such as those who are already experiencing health problems which can be exacerbated by poor air quality. Age is an important factor in susceptibility to health effects of air pollution, key impacts being asthma in children and chronic obstructive pulmonary disease and coronary heart disease in older adults. However, whole life exposure may be important in the development of such conditions in later life. EU limit values (see **Table 1**) have been set in order to minimise the impact of air pollution on public health.

Table 1 Air pollution EU Air Quality Directive Limit Values and health impacts of NO$_2$, PM$_{10}$ and PM$_{2.5}$

Pollutant	Concentration measured as	EU Limit Value	Health Impacts
Nitrogen Dioxide (NO$_2$)	Annual mean 24 hour mean	40 µg/m^3 200 µg/m^3 not to be exceeded more than 18 times a year	NO$_2$ irritates the airways of the lungs, increasing the symptoms of those suffering from lung diseases. There is increasing evidence linking chronic exposure to elevated levels of NO$_2$ to premature mortality[4].
PM$_{10}$	Annual mean 24 hour mean	40 µg/m^3 50 µg/m^3 not to be exceeded more than 35 times a year	Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of heart and lung diseases. There is emerging evidence suggesting a role in other, systemic inflammatory responses. There is strong evidence linking chronic exposure to fine particles with premature mortality.
PM$_{2.5}$	Annual mean	25 µg/m^3	

The impacts of the following committed measures are included in the new predicted air quality maps for 2015:
- Retrofit of 900 Euro III buses with Selective Catalyst Reduction (SCR) to reduce NO$_x$ and NO$_2$ emissions;
- 1,150 Hybrid buses by 2016;
- A 15-year age limit for Taxis; and
- Further phases of the Low Emission Zone introduced in 2012 to cover larger vans and tighten standards for heavy vehicles.

For 2020 the LAEI baseline includes:
- The introduction of ULEZ in central London for all vehicles in 2020;
- A requirement for all newly licenced taxis to meet zero emission capable (ZEC) standards from 2018, with 9,000 taxis on streets in 2020;
- All double decker buses (c.3000) in central London meeting Euro VI hybrid standards and all single decker buses (c.300) in London being electric or hydrogen; and
- An additional 400 Euro V buses outside central London retrofitted to meet Euro VI standards.

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[4] Royal College of Physicians, 2016, https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution

Further plans have recently been announced by the Major of London to improve air quality in London, focusing actions on the most polluted vehicles. These measures have not been included in the air quality maps. These measures included:

- Implementing a £10 Emissions Surcharge on the most polluting vehicles entering central London during congestion charging hours from October 2017. The charge would apply to all vehicles with pre-Euro IV emission standards and will cost an extra £10 per day on top of the existing Congestion Charge.
- Bringing forward the introduction of the central London Ultra-Low Emission Zone (ULEZ) zone to 2019.
- Extending the ULEZ beyond central London[5]: for motorcycles, cars and vans, to the North and South Circular; and for lorries, buses and coaches London-wide.
- Developing a detailed proposal for a national diesel scrappage scheme for Government to implement.
- Bringing forward the requirement for all double–deck buses to be ULEZ-compliant (Euro VI hybrid) in central London from 2020 to 2019 as well as other measures to transform emissions from the London bus fleet.
- Implementing clean bus corridors – tackling the worst pollution hotspots by delivering cleaner buses on the dirtiest routes.

Air quality and access to green spaces were identified as a one of the significant factors in health inequalities by the Marmot review[6] alongside other factors in addition to deprivation such as housing, fuel poverty, transport and diet. Deprivation and health inequalities are closely linked but this current study seeks to consider if exposure to poor air quality also varies across the social gradient within London, and therefore whether there is likely to be a compound effect on the health of these groups. The relationship between exposure and social gradient has been investigated before, but this study provides a more up-to-date evidence base for London. In addition, for the first time this report considers the inequalities linked between ethnic groups and exposure to poor air quality.

The analysis described in this report follows similar work undertaken at the national scale in 2006, funded by Defra[7], and follows on from the first Analysis of Air Pollution in London report published in 2013[8].

1.1 Main findings

- 1.9 million people in London in 2013 were exposed to annual average NO_2 concentrations above the EU limit value of 40 $\mu g/m^3$. In contrast, average concentrations of particles (PM_{10} and $PM_{2.5}$) were, by 2013, already within EU Limit Values for the annual average concentrations.
- There are still considerable differences in average levels of exposure in 2013 between more deprived and less deprived communities, with more deprived communities experiencing higher NO_2 and PM_{10} concentrations than less deprived communities.

[5] At the time of writing this report, the extension of the ULEZ was under consultation: https://consultations.tfl.gov.uk/environment/air-quality-consultation-phase-2/?intcmp=42947
[6] http://www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review
[7] Air Quality and Social Deprivation in the UK: an environmental inequalities analysis. Report to Defra, June 2006. http://uk-air.defra.gov.uk/reports/cat09/0701110944_AQinequalitiesFNL_AEAT_0506.pdf
[8] Analysing Air Pollution Exposure in London. Report to the GLA, September 2013. Prepared by Aether Ltd.

- The pattern is less pronounced when considering variations in exposure between different ethnic groups, because of the very mixed ethnic geography of London. However, people living in places with high proportions of Black, Mixed or "Other" ethnic groups (defined in **Table 2**) are more likely to be exposed to above EU NO_2 limit value concentrations than those in areas with a high proportion of white people. This effect is not seen for areas with a high proportion of Asian groups.
- In 2013, 802 schools in London were in locations with NO_2 concentrations above the EU limit value.

1.2   Report outline

This report presents estimates of current and future population exposure to poor air quality and how this exposure varies across the social gradient of deprivation, varying proportions of ethnic groups as well as by age. **Section 2** describes the data and methods of analysis that have been used. **Section 3** presents estimates of total population exposure. **Section 4** presents data on levels of exposure compared to levels of deprivation and how this varies across different areas of London. **Section 5** presents data on how air pollution concentrations vary with the proportion of different ethnic groups. **Section 6** briefly considers the levels of air pollution exposure of young and older people. **Section 7** analyses changes in pollution levels predicted between 2013 and 2030 to consider if the inequality in exposure will change with time and what are the significant components of change causing these reductions. **Section 8** presents conclusions of this study.

2   Data and Methods

2.1   Air quality pollutant concentrations

Annual average air quality concentrations of NO_2, PM_{10} and $PM_{2.5}$ across London in 2013 at a 20m resolution were obtained from the Environment Research Group (ERG) at Kings College London[9]. These concentration data are in the form of recently updated maps based on the latest 2013 LAEI emissions estimates[10] and were aggregated to Output Areas (OAs) and Lower Super Output Areas (LSOAs). A range of improvements[11] have been implemented in the latest LAEI emission estimates, these include: significant improvements in road transport emissions estimates, updating the methodology for estimating non-road mobile machinery, rail and shipping emissions, more complete estimates for electric trains, deriving London specific emission factors for domestic heating.

Maps of predicted pollution concentrations for 2020, 2025 and 2030 were also obtained from ERG. These are based on estimated future emissions levels using data in the latest LAEI and have been used to make estimates of future exposure. It should be noted that there are significant uncertainties associated with future emission estimates, primarily due to the sensitivity of the concentration estimates to changes in base year meteorology and the uncertainty in COPERT road transport emission factors, which have since been updated. The future year emissions modelling will be updated this year to take these changes into account and to consider the impact of planned policies.

In order to combine the pollution concentration data with population statistics, the pollution maps were aggregated to OAs and LSOAs by calculating an average air pollution concentration within each OA and LSOA based on the 20m grid squares that it covers. This analysis was undertaken by the Air Quality team at TfL. The inclusion of OA averages has been included in order to take into account concentration peaks at roadside locations. This data has been used to determine the air pollution exposure of the total population (see **Section 3**). However, average concentrations for LSOA have been used to compare air quality concentrations with the selected inequality indicators (see **Sections 2.2 – 2.5**) as some of indicators were only available at an LSOA level. To remain consistent, all inequality indicators have been compared against LSOA air quality concentrations. In addition, air pollution exposure of the total population was also considered at LSOA level. At the LSOA level, it was found that a greater number of exceedances are reported in 2013, but fewer exceedances were reported in future years compared to the OA results. Further information is provided in **Annex I**.

In common with the previous report, the approach undertaken here considered pollutant concentrations within groups of LSOAs defined as deciles i.e. a ranked list of LSOAs divided into ten groups containing an equal number of LSOAs. Average concentration data for LSOAs within deciles have been summarised as "box and whisker" plots, which are graphs that show the 2.5th, 25th, 75th and 97.5th percentiles and the maximum values within the distribution of values in each decile. This provides a very useful visual representation of the variation in pollution levels across the population variable (see **Figure 5**). Statistical analysis, specifically Principal Factor Analysis (PFA) has been implemented for initial data exploration. This type of analysis assumes the existence of underlying factors, or non-observed variables, that explain the structure in data (correlation among observed variables). However, based on the preliminary results it has been decided that there is no added benefit on conducting statistical analysis on the data.

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[9] ERG air pollution maps http://www.londonair.org.uk/london/asp/annualmaps.asp

[10] https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory-2013

[11] TfL personal communications

2.2   Index of Multiple Deprivation

The Office of National Statistics (ONS) has developed an established measure of deprivation known as the Index of Multiple Deprivation (IMD). IMD data across London for 2015 were obtained, 2015 data being available at LSOA scale[12]. The IMD is made up of 7 domains of deprivation, each of which is compiled from a number of indicators. These indicators and domains are then given a weighting according to their perceived contribution to overall deprivation. These include:

- Income deprivation
- Employment deprivation
- Health deprivation
- Disability, education, skills and training deprivation
- Barriers to housing and services
- Crime and living environment deprivation.

The living environment includes air quality, houses without central heating and road traffic accidents involving pedestrians and cyclists. Air quality is included in the IMD, but it only makes up 1.5% of the total index and therefore it is not enough to bias the results. The overall scores for each domain are combined using the weightings to provide an overall IMD score.

For our analysis the LSOAs were ranked by IMD score and the rankings have been used to divide the LSOAs into decile (10%) ranges within which average pollution exposure and exceedances of the NO_2 limit value have been considered using the air concentration maps. In addition, analysis of income has been completed separately.

2.3   Population data and projections

Population data was obtained from the London Datastore[13] for the population within each OA and LSOA in 2013, 2016, 2020, 2025 and 2030. Data from the 2011 Census at LSOA[14] have be used to calculate the percentage of children and young people (under 19) and percentage of elderly people (over 65) within each LSOA. LSOAs were ranked twice and split into deciles according to the percentage of the population in these two groups. This approach provided two separate indicators of concentration of the age groups within the population of the LSOA, giving a metric similar to that available from the IMD and therefore allows the analysis techniques to be consistent.

2.4   Ethnicity Data

Data from the 2011 Census at OA[15] has been used to calculate the total population of the following ethnic groups within each LSOA: White, Asian/ Asian British, Black/ African/ Caribbean/ Black British, Mixed/ Multiple, and Other ethnic groups as defined in **Table 2**.

LSOAs were assigned a rank for each ethnic group and split into deciles according to the percentage of the population in these five groups in each LSOA. This approach provided five separate indicators

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[12] http://data.london.gov.uk/datastore/package/indices-deprivation-2010

[13] 2014 Round of Demographic Projections SHLAA-based ethnic group projections, Capped Household Size, short-term migration scenario. Available from: https://files.datapress.com/london/dataset/gla-population-projections-custom-age-tables/2015-12-01T13:10:48/2014-round-shlaa-capped-egpp-custom-age-range-creator.xls

[14] Table PP04 2011 Census: Usual resident population by five year age group, Middle Layer Super Output Areas (MSOAs) and Lower Layer Super Output Areas (LSOAs) in England and Wales

[15] Table LC2101EW Census: Ethnic group by sex by age, Output Areas (OAs) in London.

of proportion of the population of each ethnic group within the LSOA, giving a metric similar to that available from the IMD and therefore allows the analysis techniques to be consistent.

Table 2 The ethnic groups used and their corresponding sup-groups, taken from the 2011 census

Ethnic Group	Sub-groups
White	White: English/Welsh/Scottish/Northern Irish/British White: Irish White: Gypsy or Irish Traveller White: Other White
Asian/Asian British	Asian/Asian British: Indian Asian/Asian British: Pakistani Asian/Asian British: Bangladeshi Asian/Asian British: Chinese Asian/Asian British: Other Asian
Black/African/Caribbean/Black British	Black/African/Caribbean/Black British: African Black/African/Caribbean/Black British: Caribbean Black/African/Caribbean/Black British: Other Black
Mixed/multiple	Mixed/multiple ethnic group: White and Black Caribbean Mixed/multiple ethnic group: White and Black African Mixed/multiple ethnic group: White and Asian Mixed/multiple ethnic group: Other Mixed
Other ethnic groups	Other ethnic group: Arab Other ethnic group: Any other ethnic group

2.5 Schools

The Air Quality team at Transport for London have updated the analysis of pollution concentrations within 150 m of schools using the 2013 air pollution maps. The average NO_2 concentrations within a 150 m buffer around each school was used to assess air pollution exposure. This analysis now includes all schools in London.

Access to free school meals was considered in the previous Analysing Air Pollution in London as a proxy measure of deprivation. This analysis has not been repeated for this report.

3   Air Pollution Exposure of Total Population

The updated pollution maps for 2013 and projected pollution maps for 2020, 2025 and 2030 have been used to calculate new estimates of the population exposed to levels of pollution that exceed the EU Air Quality Directive limit value of 40 $\mu g/m^3$ for NO_2. **Figure 2** shows that in 2013 approximately 1.9 million people in London, the majority of whom are in inner London, were living in areas with average NO_2 concentrations above the EU limit value. The graph shows that exposure is expected to significantly decline after 2013 and it is predicted that no exceedances of the NO_2 limit value will occur by 2030.

Figure 2 Estimate of population exposed to NO_2 concentrations in exceedance of the EU Air Quality Objective (40 $\mu g/m^3$) for 2013, 2025, 2025 and 2030

Year	Population Exposed to Exceedances			Percentage of Total London Population
	Inner London	Outer London	London Total	
2013	1,562,000	369,000	1,931,000	23.2%
2020	53,000	19,000	72,000	0.8%
2025	2,000	300	3,000	0.0%
2030	0	0	0	0.0%
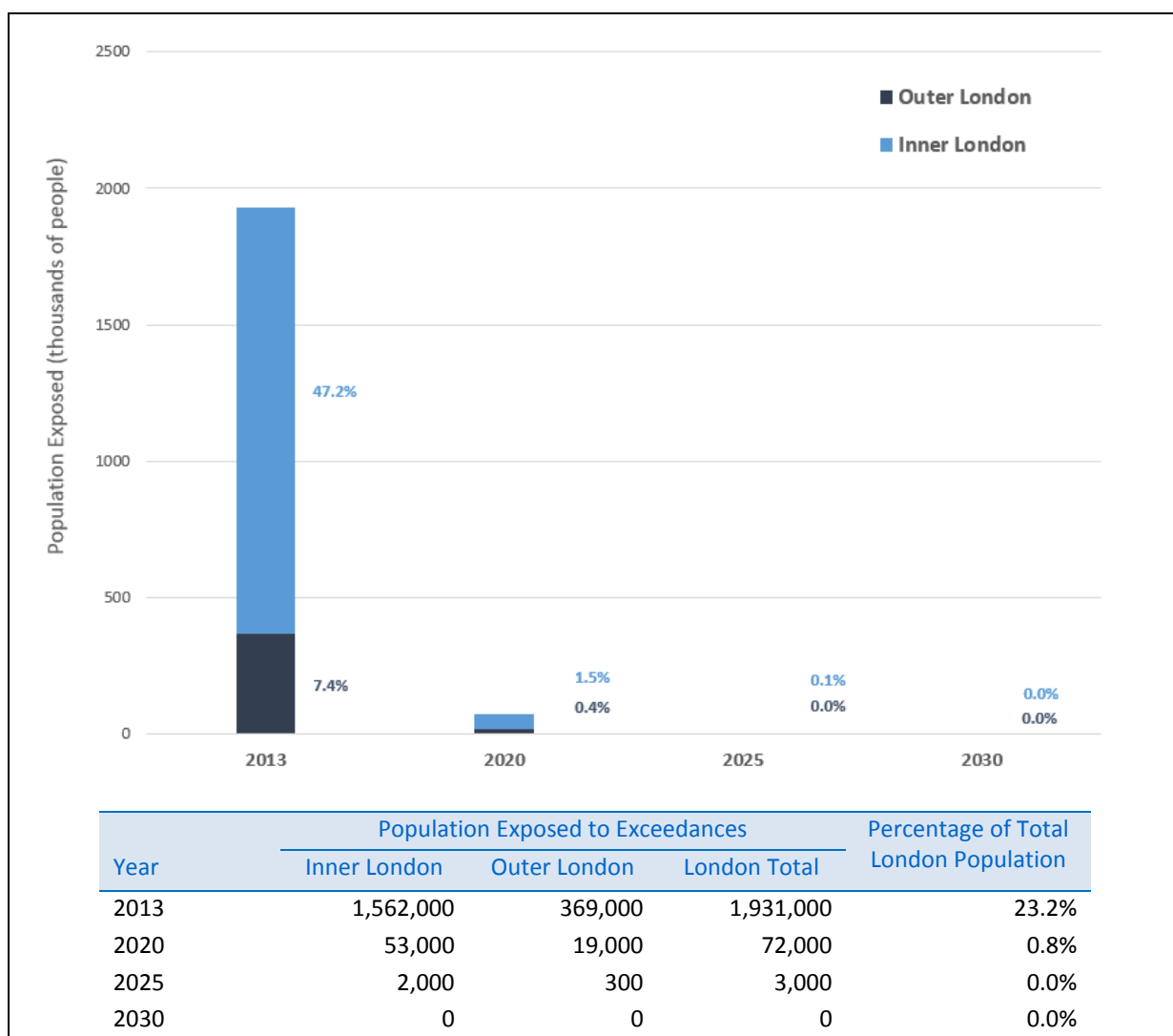
The estimates presented above are calculated by summing the populations within OAs that have an average concentration above the EU limit value (average across the 20m resolution modelled locations within the OA). There is geographical variability in the pollution level within each OA and therefore not all dwellings will be directly exposed to concentrations above the limit value. However, these OAs are small areas (with a population of around 325) and within people's daily activities it is assumed that they will be in close proximity to concentrations above the limit value if the average exceeds it.

Reductions in emissions of particles over recent years have resulted in annual average concentrations of PM_{10} in London now complying with EU PM_{10} limit values. This is shown in **Figure 3** below. Slight further reductions in annual average PM_{10} concentrations are expected between 2013 and 2030, with slightly higher concentrations occurring in Inner compared to Outer London. Whilst there are no exceedances of the PM_{10} limit value in London, the World Health Organisation (WHO) sets an Air Quality Guideline concentration of 20 $\mu g/m^3$ as an annual mean. As shown in **Figure 3**, all OAs in London are predicted to still be in exceedance of the WHO guidance by 2030.

Currently, there is no limit value objective in England for $PM_{2.5}$. **Figure 4** compares the $PM_{2,5}$ concentrations in London in 2013 to 2030 to the current WHO Air Quality Guideline value (10 $\mu g/m^3$). In 2030, $PM_{2.5}$ concentrations are predicted to remain above the WHO guideline value.

Figure 3 Pollution concentrations of PM_{10} in 2013, 2020, 2025 and 2030 in Inner and Outer London
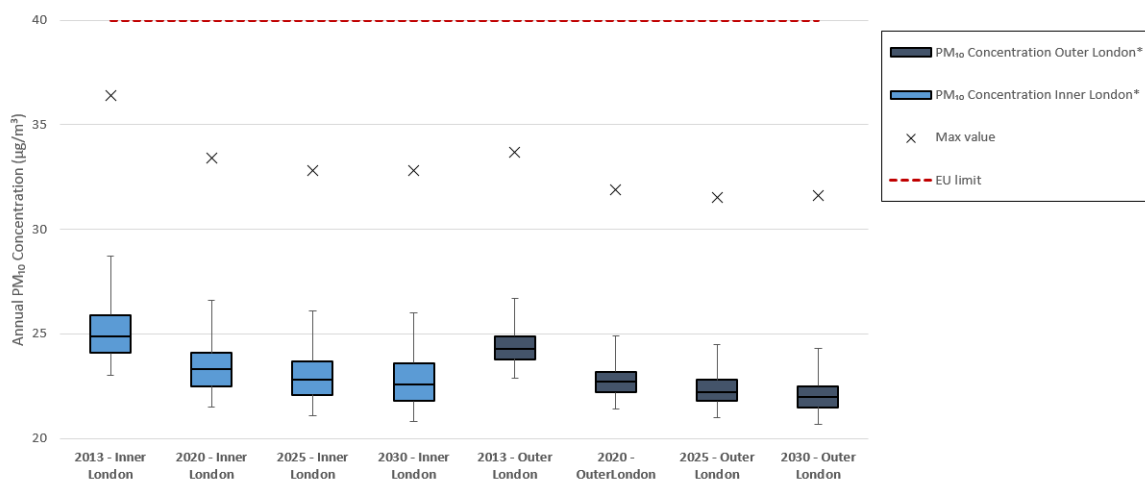
* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

Figure 4 Pollution concentrations of $PM_{2.5}$ in London in 2013, 2020, 2025 and 2030 compared to the WHO guideline value
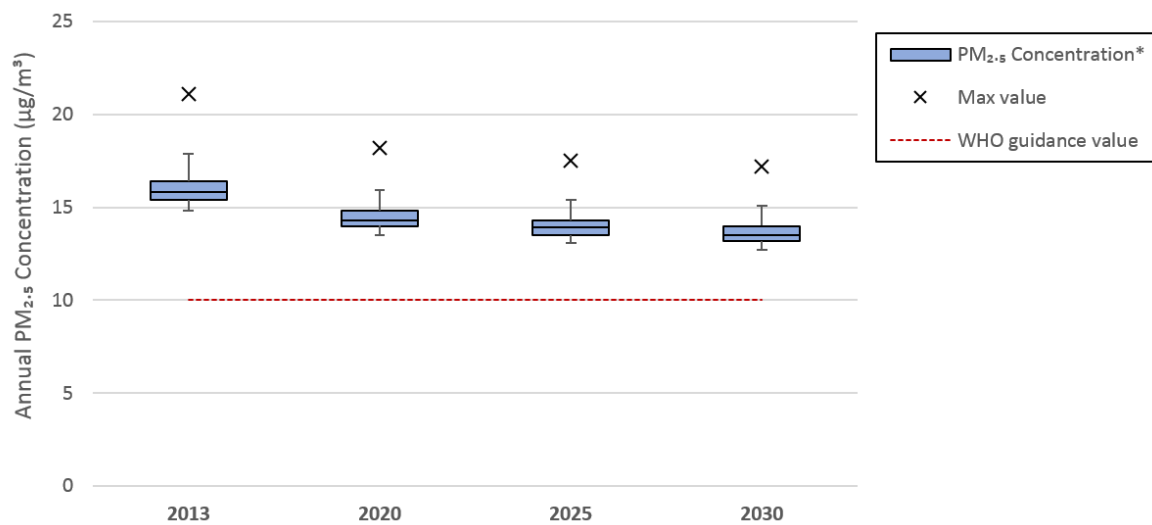
* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

Other metrics for particulate matter are available, such as the Exposure Concentration Obligation and exposure reduction target set in the EU Clean Air Directive. However, these are not suitable for this form of analysis, for example, the target is based on averaged concentrations across Member States using a three-year average and so is not useful for analysis of differences between small areas.

One of the features of the analysis used in this research is the need to show and analyse differences in exposure. It is clear from the discussion above that exceedances on the NO_2 Limit Value, and potentially other thresholds, is a suitable metric, given that some areas are in exceedance and some are not. However, the available PM metrics are not suitable for threshold type analysis, as there is either almost total compliance, or total exceedance. Moreover, the relatively small change in concentration between areas, while present, follows the same pattern as for NO_2, although less pronounced. Thus, while evidence shows that the health effects of exposure to PM are more severe, annual average NO_2 concentrations provide a better metric for the assessment of differences in exposure to air pollution.

4   Air Pollution Exposure in Areas of Deprivation

Each LSOA in London has been allocated to a deprivation decile, defined as 10 percent groups of LSOAs ranked by their Index of Multiple Deprivation (IMD) scores. Each decile contains an average of 483 LSOAs (4829 LSOAs in total) within which the air pollution concentration has been calculated by averaging air pollution in each modelled 20 m grid square. Air pollution data for each deprivation decile has been summarised to show the trend in pollution across the social gradient of deprivation. These are shown in **Figure 5**. In addition, air pollution concentrations within each deprivation decile where the NO_2 limit value is exceeded are shown in **Figure 6.**

Figure 5 LSOA pollution concentrations by deprivation decile groups in London 2013 (a) NO_2, (b) PM_{10}, (c) $PM_{2.5}$. Note the differing y axis scales used for each figure.
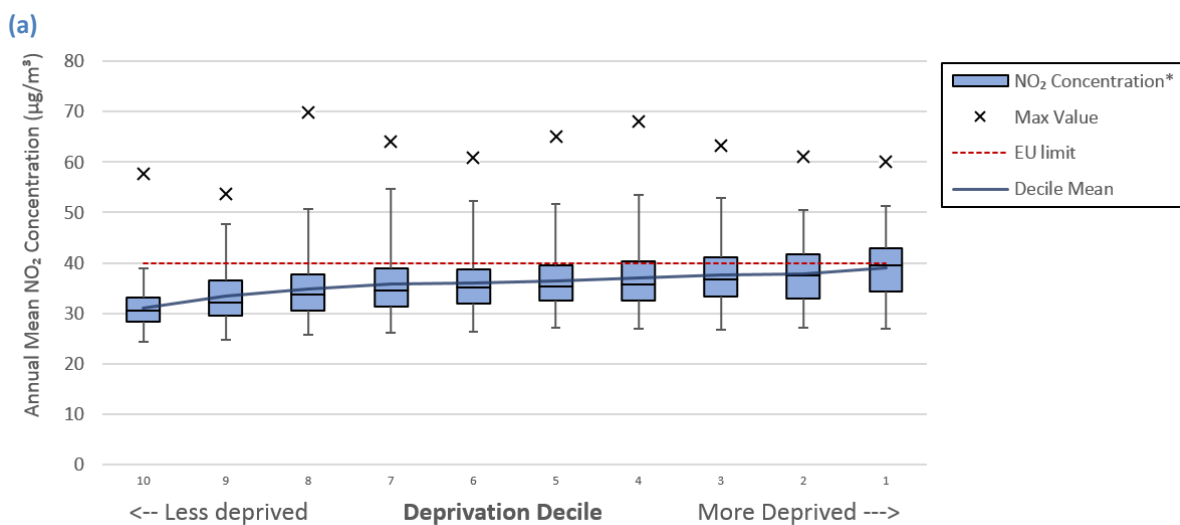
(a)

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(b)
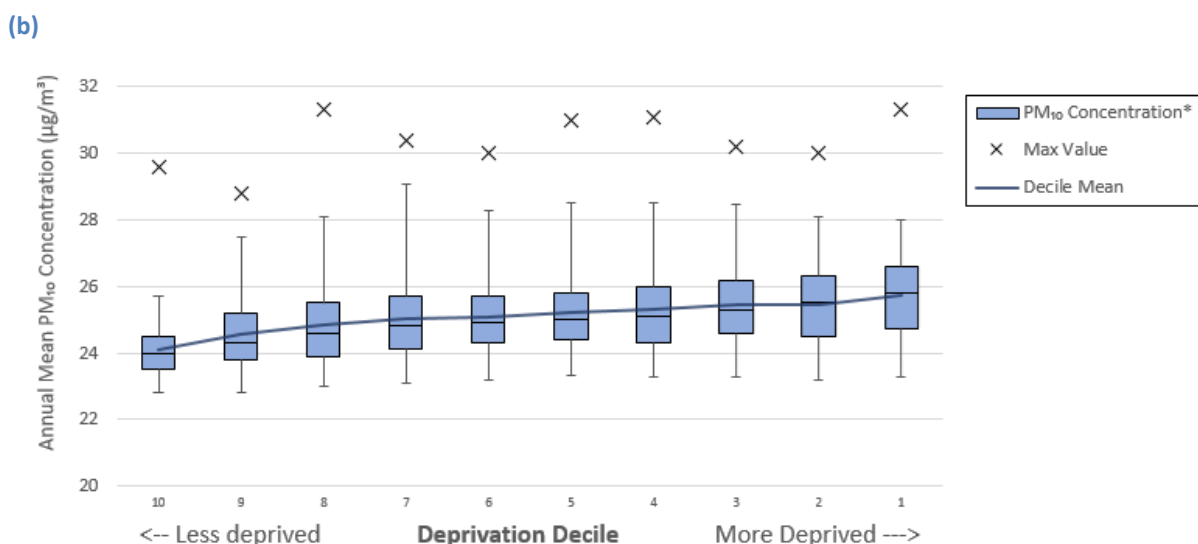
* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(c)

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile
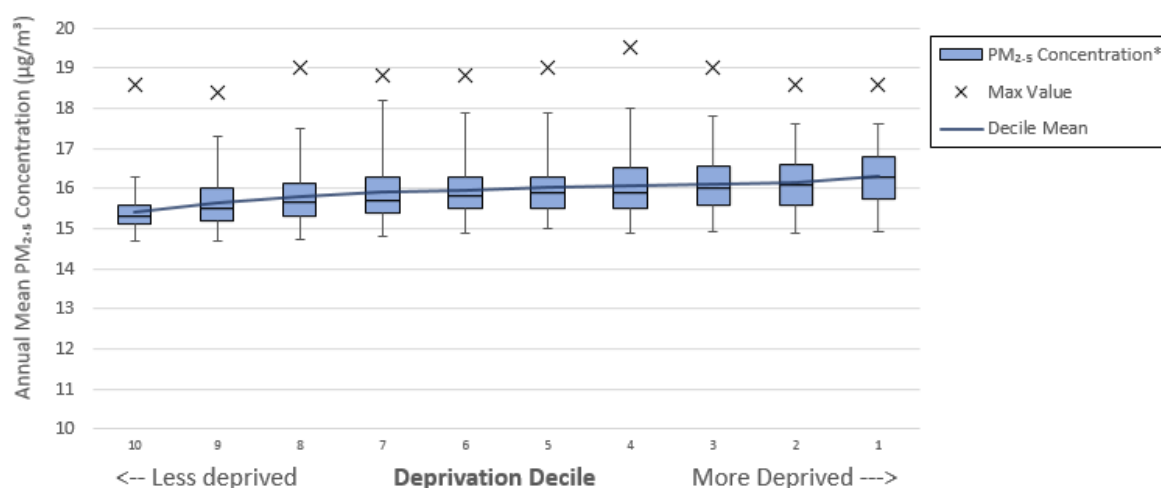
Figure 5 illustrates both the trend of average NO_2 concentration levels across the deprivation deciles whilst also showing the variability that exists within each deprivation decile. Average concentration levels of NO_2 (i.e. the decile average line) are highest in decile 1, the most deprived, with an average NO_2 concentration level of 39.0 µg/m³, which is just within the EU limit value. 46% of LSOAs within decile 1 have average concentrations above the EU limit value, and the highest average concentration is 60.0 µg/m³. As the level of deprivation declines so does the average level of NO_2 concentration and the lowest average concentration level of NO_2 (31.1 µg/m³) occurs in decile 10, the least deprived. 2% of LSOAs in decile 10 have an average concentration above the EU limit value. In areas poor air quality, where the annual mean NO_2 limit value is exceeded, 32% of people are from the most deprived groups, whereas only 7% are from the least deprived.

The variability in average NO_2 concentration levels in the LSOAs is lowest in the least deprived deciles (i.e. the area of the blue box in **Figure 5**), and the whisker plots (showing the range of 2.5 to 97.5 percentiles), however there is no discernible trend in variability across deciles. There is no trend in the maximum average values with deprivation levels because there are peak concentrations occurring in locations across the social gradient. A possible explanation for the general trend may be the link between lower house prices, and hence poorer households, and proximity to main roads such as the M4, inner ring roads and radial roads (see the maps in **Figure 7**). Roads are a significant source of NO_2 emissions in London. It is clear from **Figure 6** that whilst exceedances of the NO_2 limit value occurred in every deprivation decile in 2013, the number of people exposed increases with deprivation.

Figure 5 also shows that average concentrations of both PM_{10} and $PM_{2.5}$ vary considerably less than for NO_2 concentrations across the deprivation deciles in London because there is generally less variation in particle concentrations across the city. Furthermore, there is less variation within the deprivation deciles for both PM_{10} and $PM_{2.5}$ and neither exceed the EU limit value for the annual average.

Figure 6 NO₂ concentrations by deprivation decile groups in London 2013 where the limit value (> 40μg/m³ annual average) is exceeded.
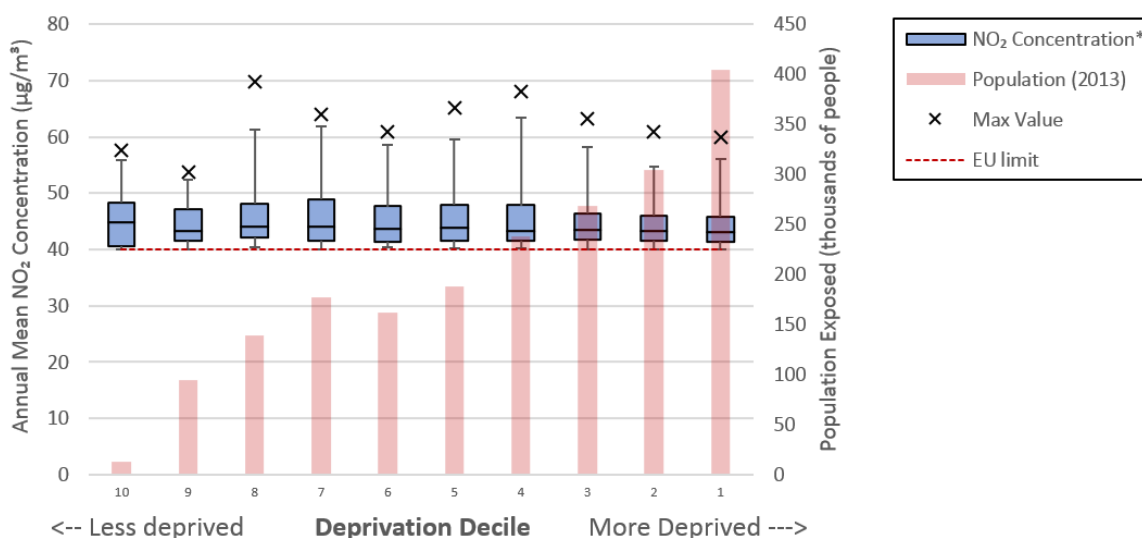
* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

London's worst air quality areas can be identified as the top 30% of LSOAs in terms of average NO₂ concentration. **Table 3** shows the number of people living in these areas of worst air quality and their distribution across the deprivation deciles. It can be seen that in general there are more people in these poor air quality areas in the most deprived deciles than the least deprived deciles, and this is clearer in Inner London than Outer London.

Table 4 shows the distribution of the population of these worst air quality areas across the deprivation deciles by Local Authority. Barking and Dagenham, Croydon, Newham, Tower Hamlets and Hackney have the highest proportions of most deprived populations (top 30% deprived) in London's worst air quality areas. Tower Hamlets, Southwark, Hackney, Islington and Lambeth have the highest total numbers of people living in London's worst air quality areas. **Figure 7** shows the locations of the most deprived LSOAs across London overlaid on maps of NO₂ concentrations in 2013.

Figure 7 Locations of the 30% most deprived LSOAs in 2013 compared to the locations of exceedances to NO$_2$ limit value
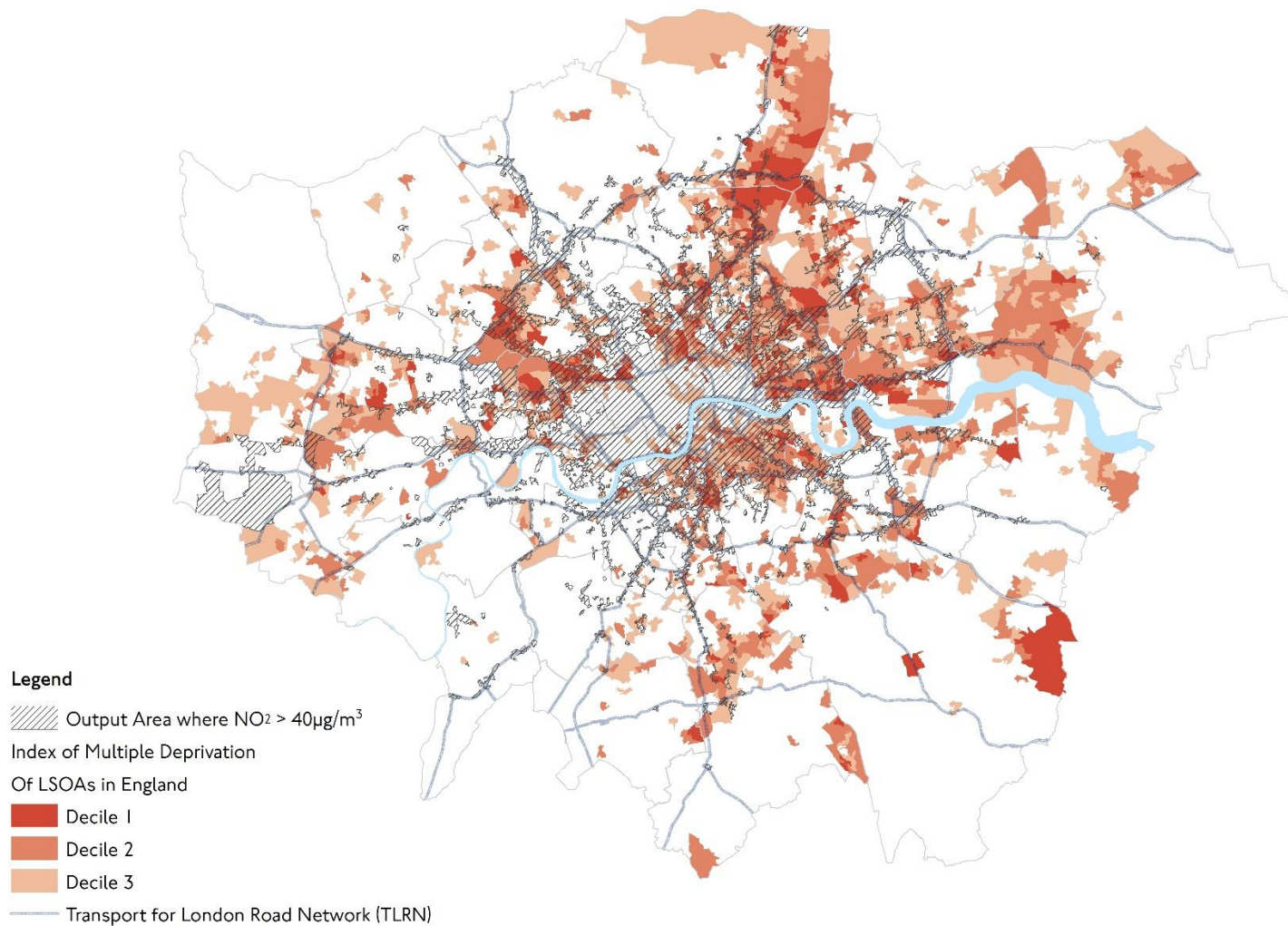

Legend

Output Area where NO$_2$ > 40µg/m^3

Index of Multiple Deprivation
Of LSOAs in England

Decile 1

Decile 2

Decile 3

Transport for London Road Network (TLRN)

Table 3 Populations by deprivation decile in the 30% most polluted (NO$_2$) LSOAs in 2013

| Deprivation Decile	Population Inner	Outer	Total
Decile 1 - most deprived	422,737	72,717	495,454
Decile 2	341,736	44,784	386,520
Decile 3	276,124	75,289	351,413
Decile 4	249,849	50,413	300,262
Decile 5	205,206	47,540	252,745
Decile 6	165,791	51,585	217,376
Decile 7	172,990	48,782	221,772
Decile 8	131,770	43,513	175,283
Decile 9	105,809	27,836	133,645
Decile 10 - least deprived	17,074	4,184	21,258

Table 4 Percent of population in the 30% most polluted (NO$_2$) LSOAs by deprivation deciles in 2013 by Borough

Borough	Deprivation Decile (% of population) ← Less Deprived 10	9	8	7	6	5	More Deprived → 4	3	2	1	Population in deciles 1 to 3
Inner London	1	5	6	8	8	10	12	13	16	20	
Camden	3	8	10	12	10	10	10	12	15	12	78,665
City of London	39		32		18	11					0
Hackney				3	8	4	17	17	24	27	112,896
Hammersmith and Fulham	1	8	9	14	11	12	11	10	10	13	53,939
Haringey			6	4		8	11	13	20	38	54,280
Islington			2	4	7	13	15	16	22	22	111,773
Kensington and Chelsea	1	19	19	9	8	9	10	4	8	13	40,270
Lambeth			1	7	12	17	12	15	20	16	103,481
Lewisham				3	12	15	21	13	13	23	31,139
Newham					2	6	6	25	20	41	59,011
Southwark	1	4	2	4	5	8	14	20	29	14	139,338
Tower Hamlets	1	2	3	4	5	6	6	15	14	43	159,259
Wandsworth	1	17	16	20	10	10	14	3	5	3	15,862
Westminster		5	11	17	8	9	11	11	9	17	80,684
Outer London	1	6	9	10	11	10	11	16	10	15	
Barking and Dagenham								19	44	36	12,305
Barnet		6	21	25	17	10	3	14		3	8,811
Bexley			44	56							0
Brent				3	3	7	18	15	16	37	69,283
Croydon								58	42		9,744
Ealing		2	5	12	15	19	15	17	3	12	22,163
Enfield					13		36	6	6	39	12,357
Greenwich		2	9	15	18	14		13	24	6	26,182
Hillingdon					100						0
Hounslow	3	17	15	17	10	7	12	16		4	11,395
Kingston upon Thames		17	56			27					0
Merton	22	27				25		26			1,726
Redbridge		23	29	14	6	9		10	9		4,420
Richmond upon Thames	14	57	28								0
Waltham Forest					6	12	23	34	7	18	18,325

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4.1   Air Pollution Exposure by Income

In addition to considering the air pollution exposure of LSOAs based on their IMD scores. Each LSOA in London has been allocated to an income decile, defined as 10 percent groups of LSOAs ranked by their Income scores which form one component of the IMD. Air pollution data (NO_2) for each income decile has been summarised and is shown in **Figure 8**. Whilst there is a slight trend in NO_2 concentrations increasing as income decreases, the difference between the highest and lowest decile is only 3.6 $\mu g/m^3$ compared to 8.0 $\mu g/m^3$ for the Deprivation deciles. In addition, there is a greater number of people exposed to exceedances of the NO_2 EU limit value in decile 1 (highest income) compared to decile 10 (lowest income). This is linked to a large proportion of people with the highest incomes living within central areas of London, such as the City of Westminster, which suffer from poor air quality.

Figure 8 LSOA NO_2 concentrations by income decile groups in London 2013
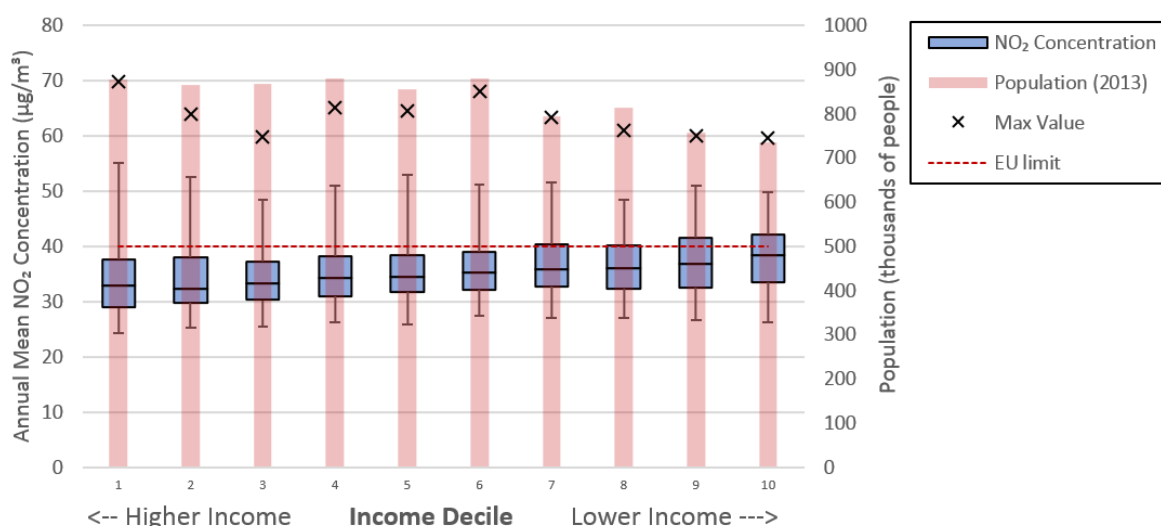
* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

4.2   Summary

It has been shown that pollution levels are on average higher in locations of highest deprivation compared with locations of lowest deprivation, and this is shown most clearly for NO_2. 46% of LSOAs within the most deprived decile have concentrations above the NO_2 EU limit value compared with 2% in decile 10 (least deprived). However, there is a wide variation in pollution concentration values across the social gradient, with all deciles showing a large range between minimum and maximum values. The pattern for PM_{10} and $PM_{2.5}$ is less pronounced showing less variation across the social gradient because of a flatter concentration pattern across London.
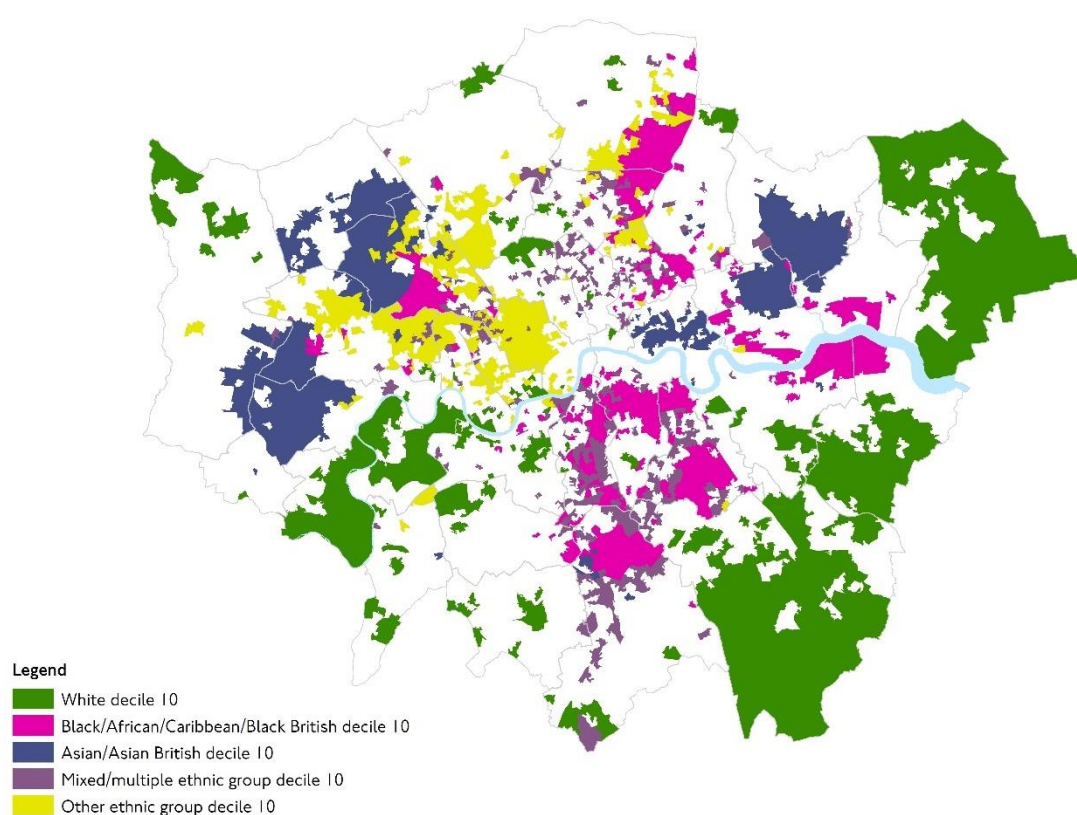
The correlation between air pollution exposure and income is complex, with no clear trend apparent. More people who have the highest income were exposed to exceedances of the NO_2 EU limit value in 2013 compared to those with the lowest income.
It is important that future measures to improve air quality are targeted to ensure that this inequality is reduced by improving the air quality in the most deprived areas. This is considered in **Section 7** of this report where the predicted changes in exposure are analysed.

5   Air Pollution Exposure of Ethnic Groups

Each LSOA in London has been allocated to an ethnicity decile for each of the five ethnic groups (see **Table 2**), defined as 10 percent groups of LSOAs ranked by percentage population of the relevant ethnic group. Decile 1 represents the LSOAs with the lowest percentage population of the relevant ethnic group, and decile 10 the LSOAs with the highest percentage population. The deciles have been based on percentage populations rather than actual population to prevent a skewing effect on LSOAs with larger populations. Each LSOA has been allocated an ethnicity decile per ethnic group within which the air pollution concentration has been calculated by averaging air pollution in each modelled 20m grid square. The locations of LSOAs in decile 10 for each ethnic group are shown in **Figure 9**.

Figure 9 Locations of areas with the highest proportions of each ethnic grouping

Legend
- White decile 10
- Black/African/Caribbean/Black British decile 10
- Asian/Asian British decile 10
- Mixed/multiple ethnic group decile 10
- Other ethnic group decile 10

Air pollution data for each ethnicity decile has been summarised to show the trend in pollution with an increasing proportion of each ethnic group.   These are shown in **Figure 10**. Only the results for NO$_2$ are presented here. Similar, but slightly less pronounced trends are found for particulates, whose results are provided in **Annex II**.

In 2013, high NO$_2$ concentrations occurred across all ethnicity deciles for each ethnic group. This is highlighted by the occurrence of exceedances of the NO$_2$ EU limit. However, **Figure 10a** shows that mean NO$_2$ concentrations are on average lowest where the proportion of the White population is highest, with concentrations increasing by 5 µg/m^3 in LSOAs with the lowest proportion of the White population. In contrast, for the remaining four ethnic groups, NO$_2$ concentrations are lowest in decile 1. The greatest difference between deciles is seen for the Other ethnic group (**Figure 10e**), where the mean annual NO$_2$ concentrations exceed the EU limit value in the highest Ethnicity Decile.

The distribution of each ethnicity decile to exceedances of the annual mean NO_2 limit value is also shown in **Figure 10.** For White and Asian/Asian British communities there is a relatively normal distribution across ethnicity deciles. The ethnicity deciles with the lowest number of exceedances is decile 10 for White and decile 1 for Mixed and Other ethnic groups. This suggests that in 2013 the areas with the worst air quality corresponds to the areas where the relative proportion of White ethnic groups is lowest and where the proportion of Mixed and Other ethnic groups is highest. This is supported by the greatest number of exceedances (over 450,000 people) being recorded in areas where the proportion of Other ethnic groups is highest **Figure 10e**. In addition, for Black/ African/ Caribbean/ Black British, Mixed/ Multiple and Other ethnic groups the total number of people exposed to exceedances is shown to increase as the proportion of these ethnic groups increases.
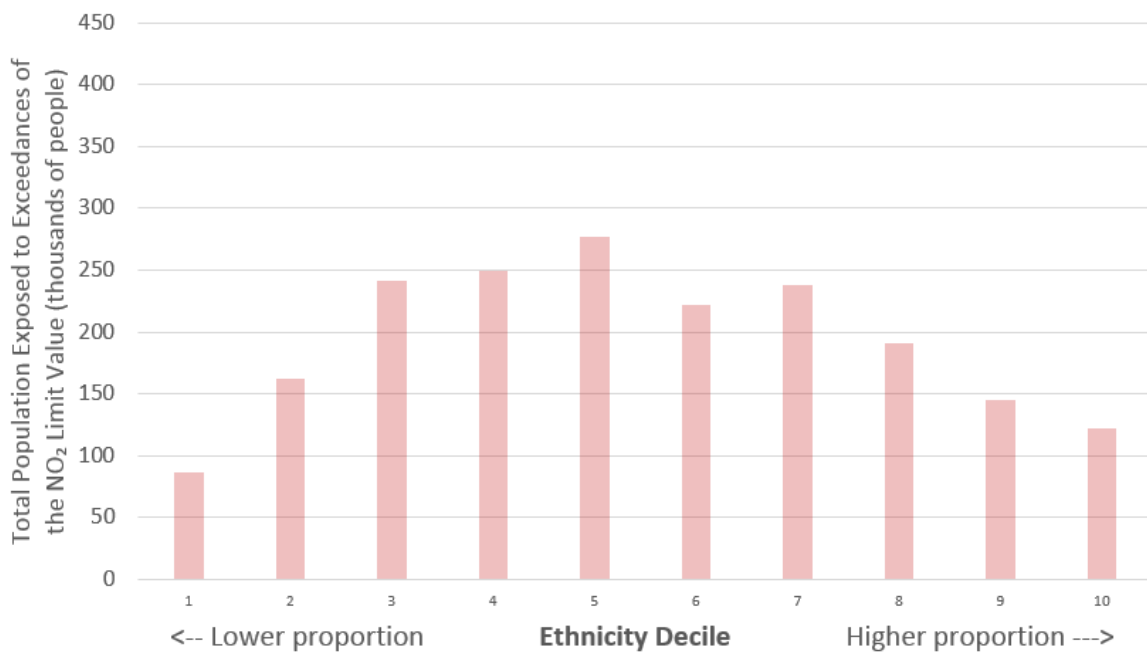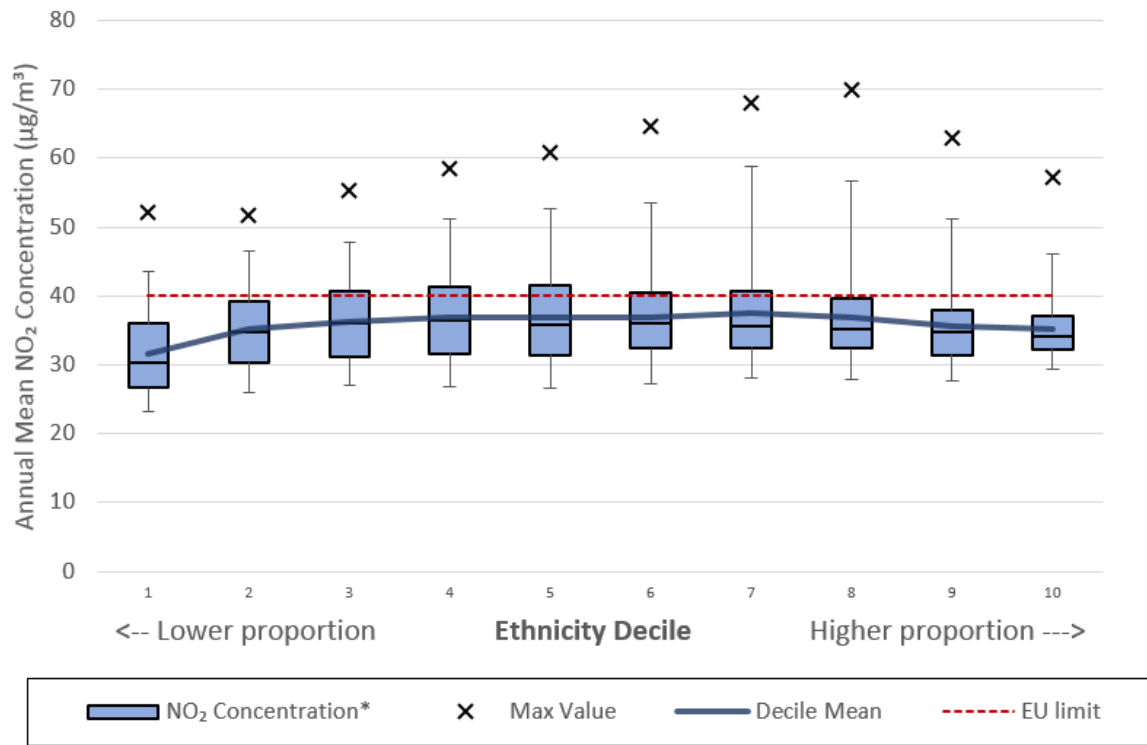
Figure 10 NO₂ concentrations and the population exposed to exceedances of the NO₂ limit value by ethnic decile groups in London 2013 (a) White (b) Asian/ Asian British, (c) Black/ African/ Caribbean/ Black British, (d) Mixed/ Multiple and (e) Other ethnic groups.
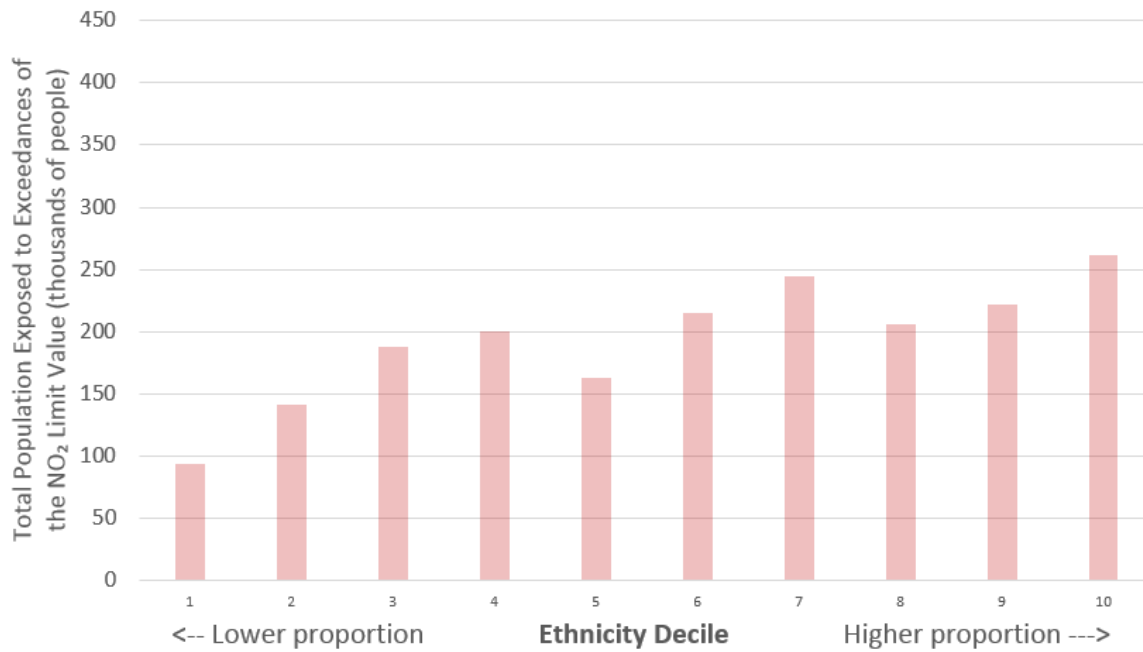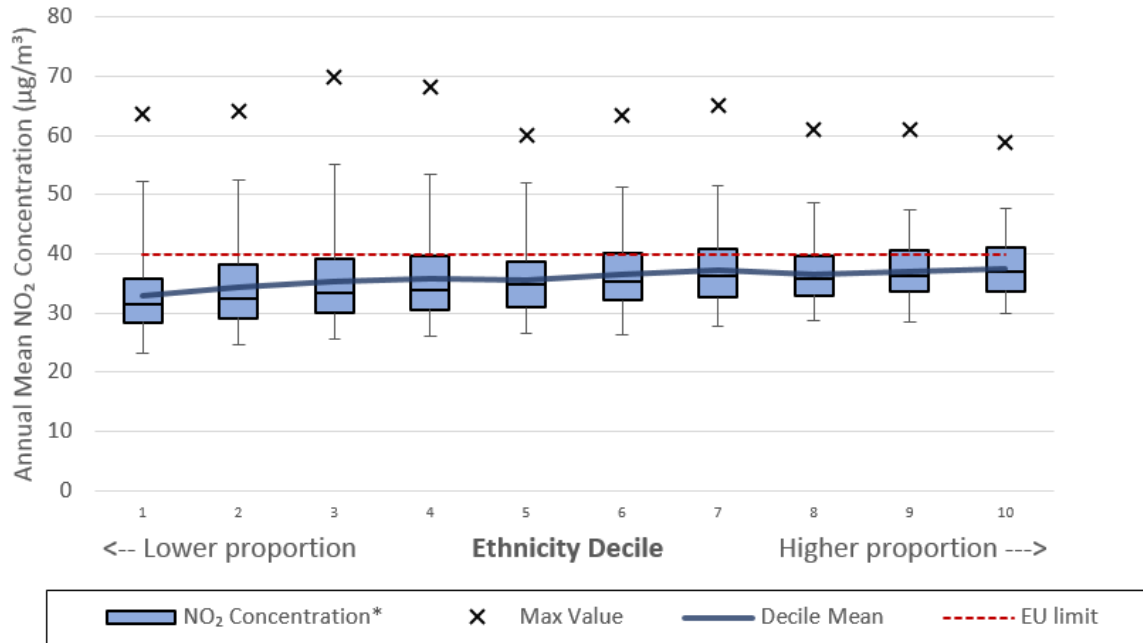
(a) White
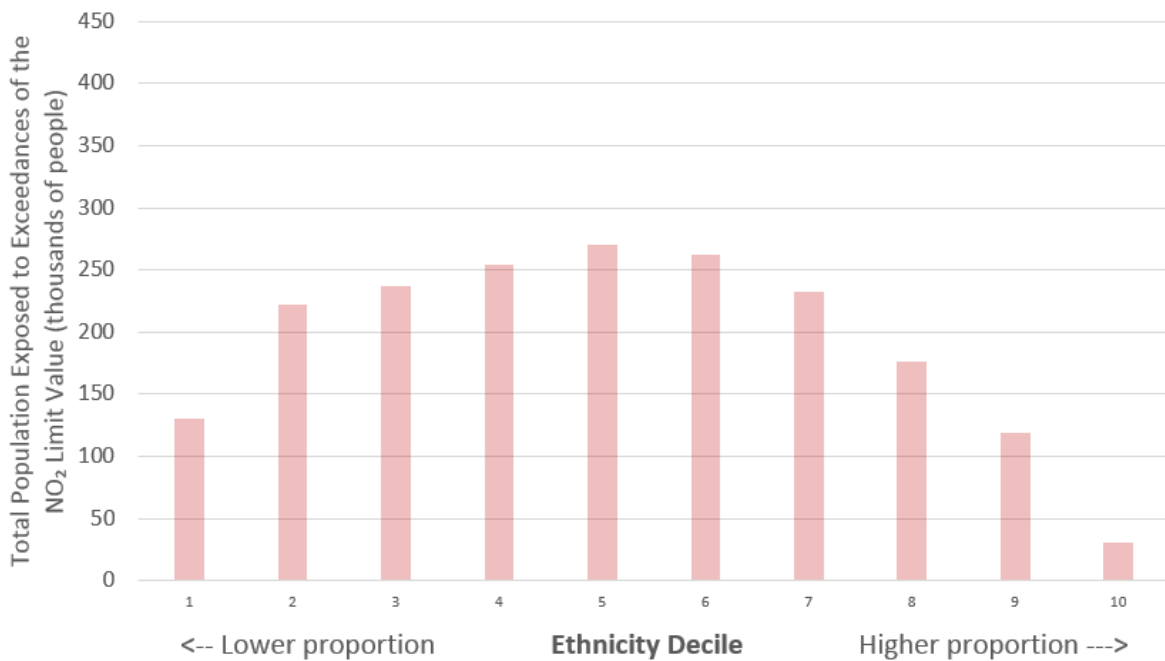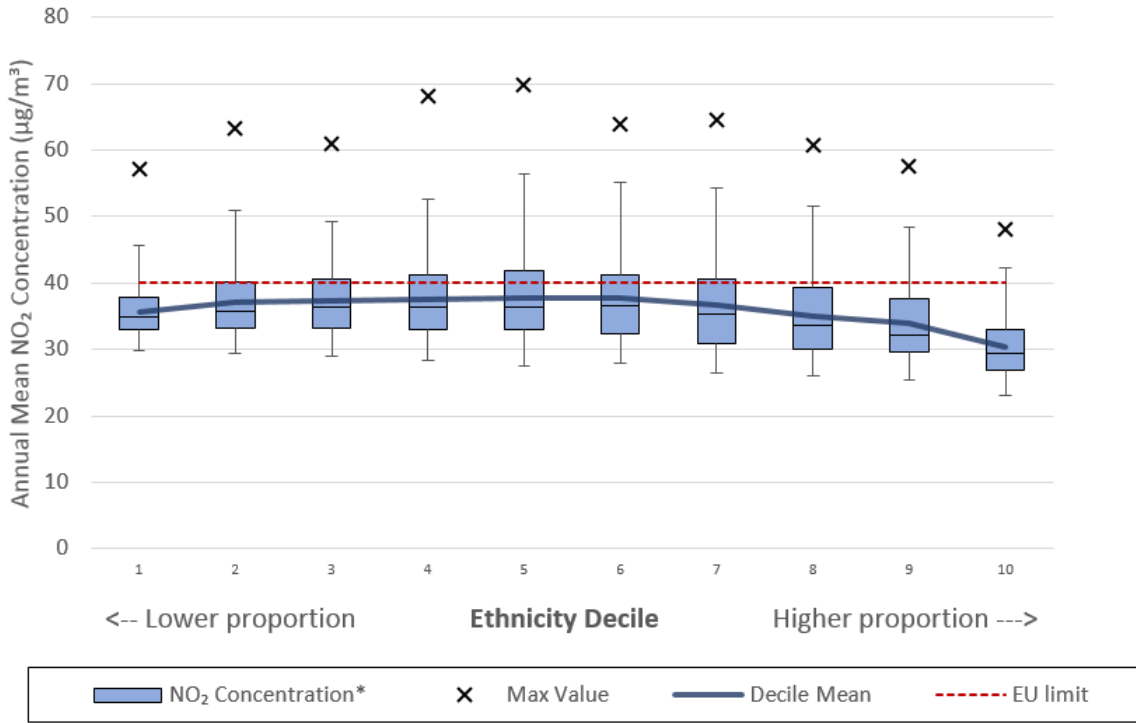
* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

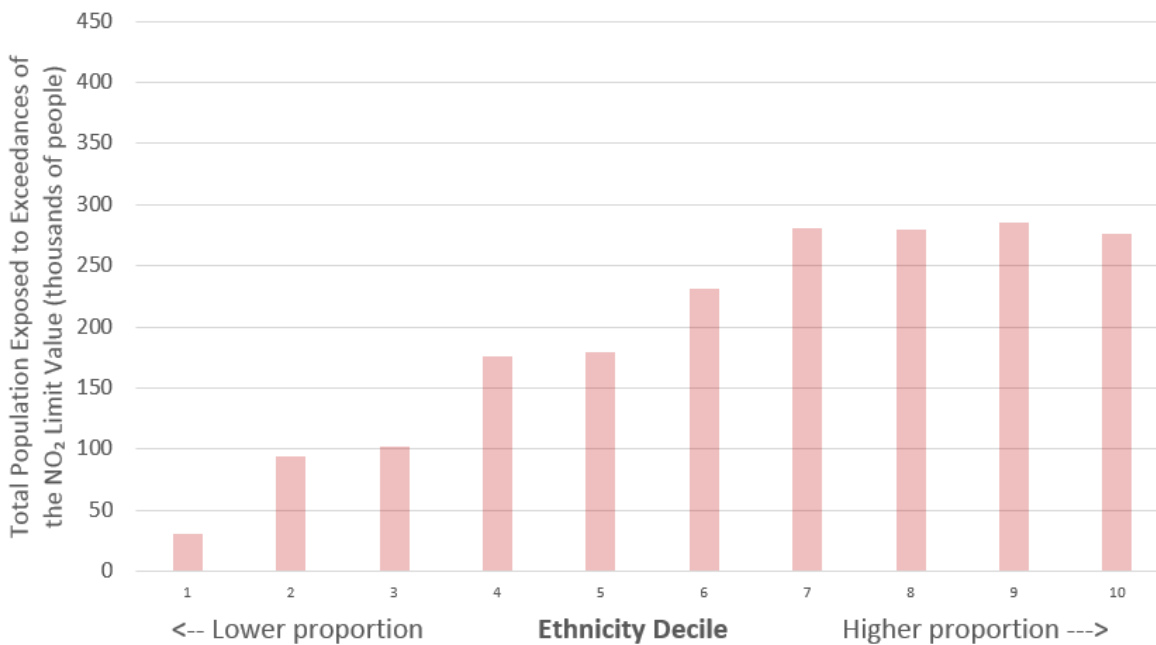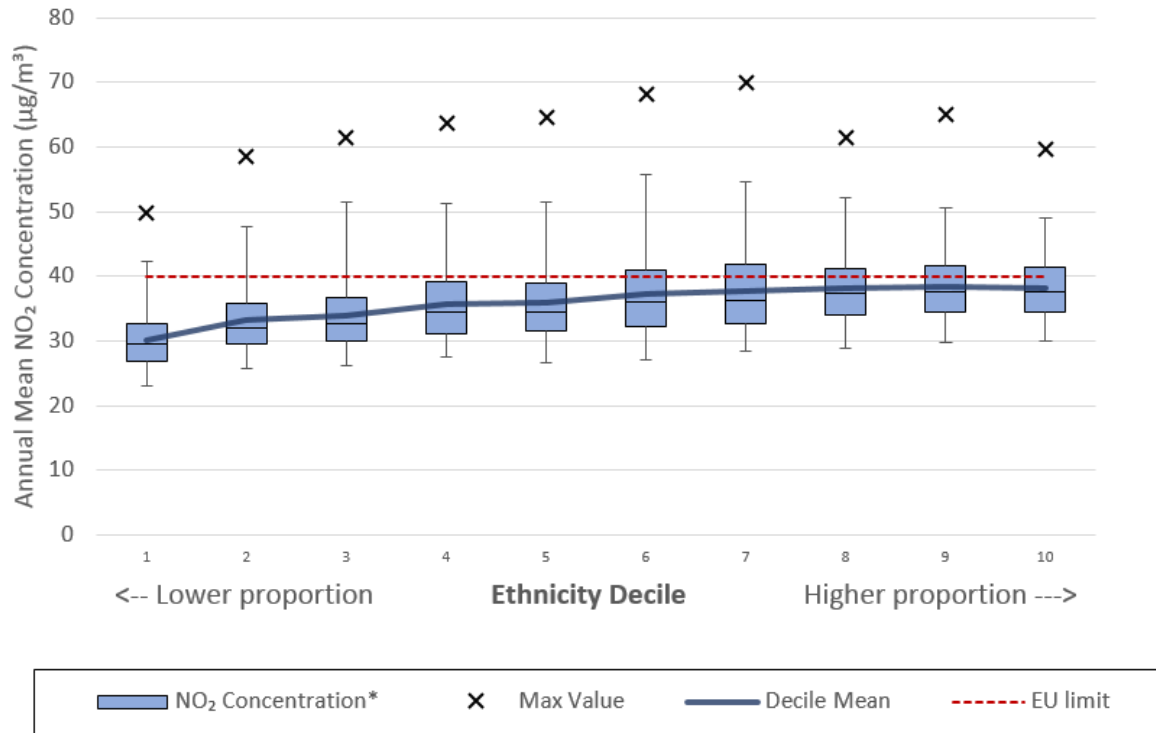![Aether logo]   19

(b) Asian/ Asian British

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

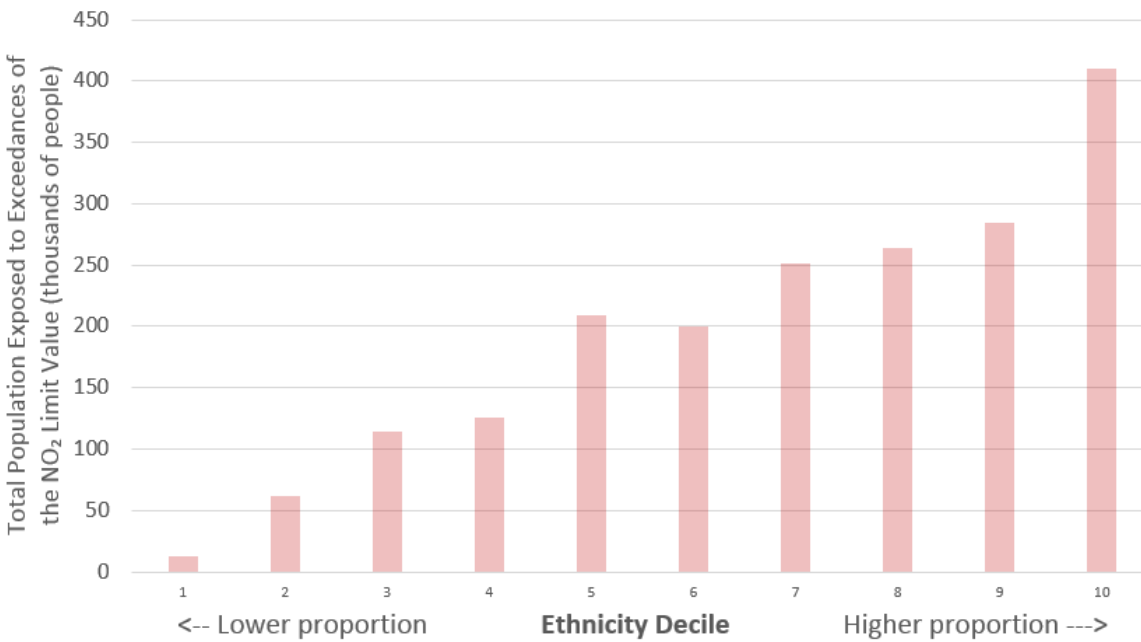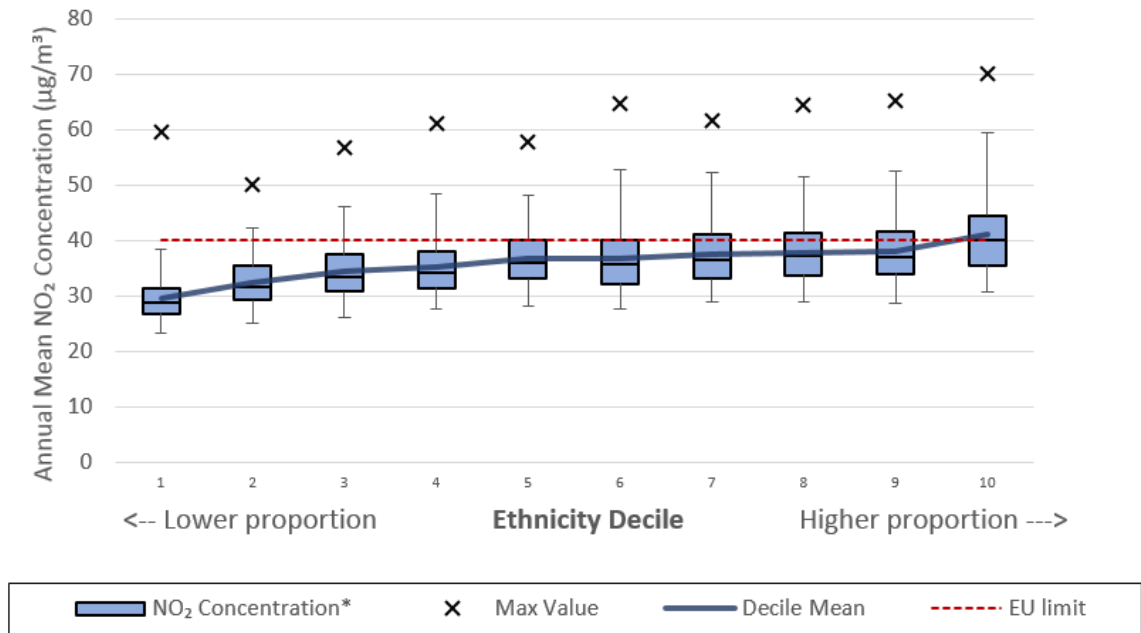## (c) Black/ African/ Caribbean/ Black British

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(d) Mixed/ Multiple ethnic groups

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(e) Other ethnic groups

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

Figure 11 shows populations in each ethnic group as a proportion of the total London population and compares this to proportions of ethnic group populations exposed to exceedances of the NO_2 EU limit as a proportion of the total number of people exposed to exceedances of the NO_2 EU limit. The total population numbers are also shown. White and Asian/ Asian British are the only ethnic groups whose proportion of the total population is greater than the proportion of people exposed to exceedances of the NO_2 EU limit. This suggests that people in the remaining ethnic groups are more likely to be exposed to higher levels of NO_2, although this effect is not strong.

Figure 11 The proportion of each ethnic group exposed to exceedances of the NO_2 EU limit (red) and the proportion of each ethnic group of the total population (blue) in 2013. The total population numbers are shown in bold.
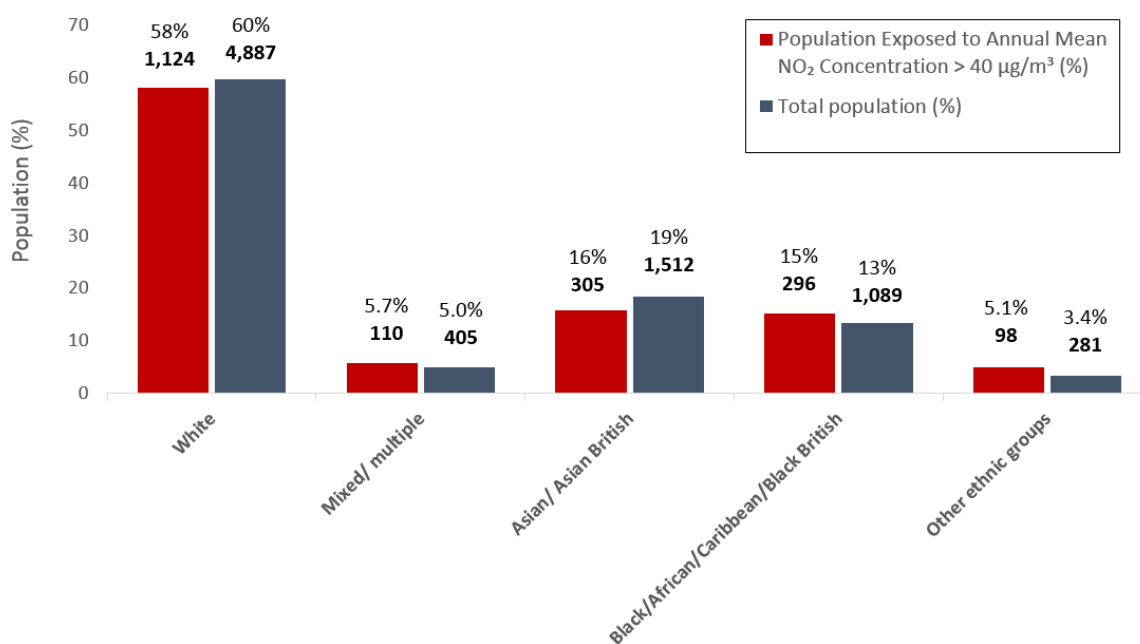

In addition, the difference between the air pollution exposure for each ethnic group and correspondence with locations of deprivation are shown in **Figure 12**. The areas with the highest levels of deprivation (deciles 8 – 10) and also the highest proportion of each ethnic group are highlighted in purple. The OAs which exceed the annual mean NO_2 limit value are also shown. These maps show the location of the areas of highest NO_2 concentrations and the varying areas with high populations of different ethnic groups where deprivation is high.

Figure 12a shows that there are relatively few LSOAs where both the proportion of the white population and deprivation are high. These areas are generally located on outskirts of Outer London where the air quality objectives are not exceeded. In contrast, for all other ethnic groups considered here, there is a higher concentration of highlighted LSOAs located within areas where the NO_2 concentrations exceeded the limit value in 2013. This correlates most strongly to the Black/ African/ Caribbean/ Black British, Mixed/ Multiple and Other ethnic groups.

Figure 12 Annual average NO$_2$ concentrations in 2013 showing the Output Areas where NO$_2$ > 40 µg/m^3 and the most deprived areas based on IMD (a) locations of 30% most deprived LSOAs (Deciles 1-3) and highest proportion of ethnic group: White

Legend

- Output Area where NO2 > 40µg/m^3
- 30% most deprived and White decile 10
- 30% most deprived and White decile >7
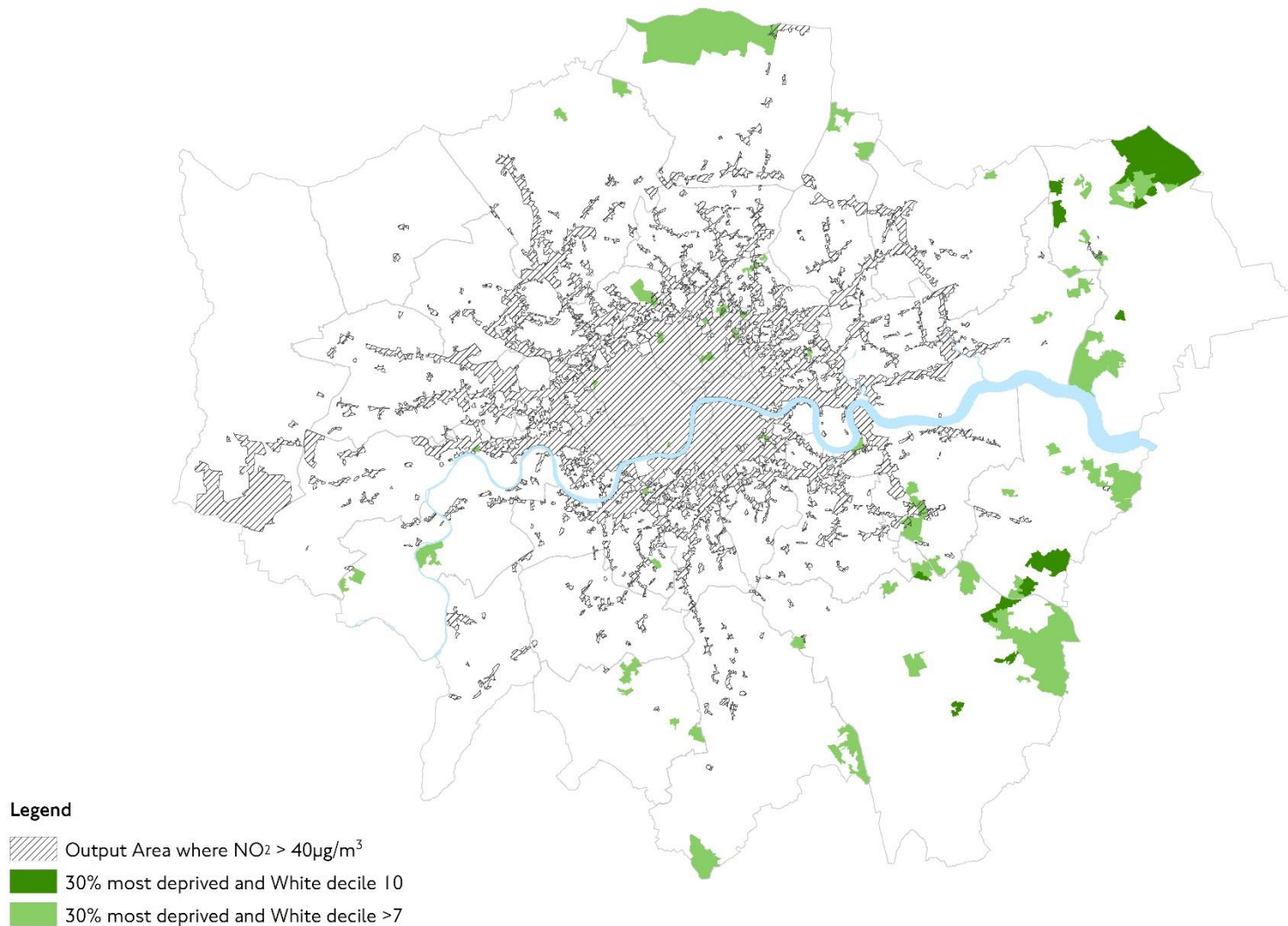
(b) locations of 30% most deprived LSOAs (Deciles 1-3) and highest proportion of ethnic group: Asian/Asian British

Legend

▨ Output Area where NO$_2$ > 40µg/m^3

▨ 30% most deprived and Asian/Asian British decile 10

▨ 30% most deprived and Asian/Asian British decile >7
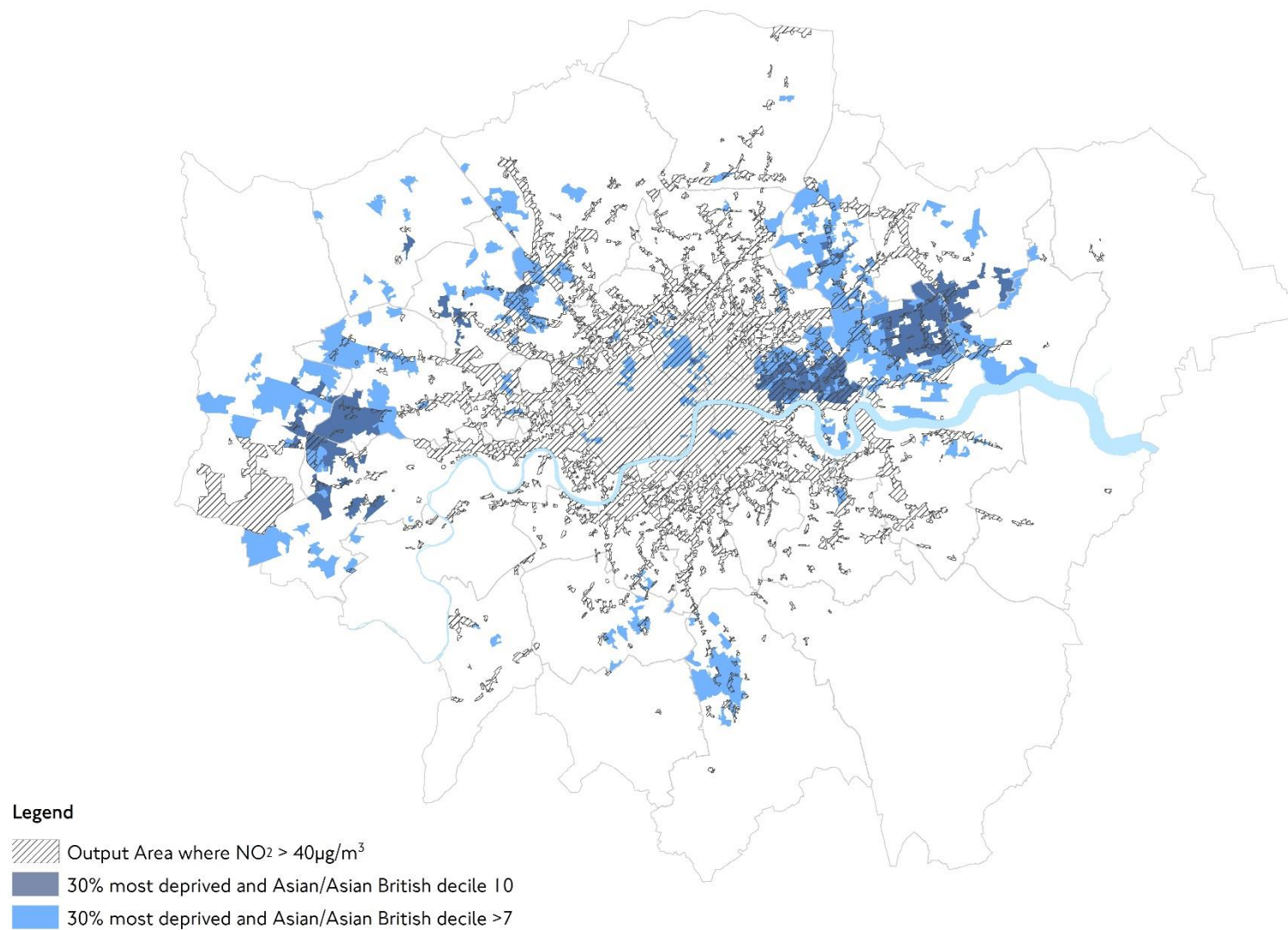
(c) locations of 30% most deprived LSOAs (Deciles 1-3) and highest proportion of ethnic group: Black/African/Caribbean/Black British

Legend

///// Output Area where NO$_2$ > 40µg/m^3

■ 30% most deprived and Black/African/Caribbean/Black British decile 10

■ 30% most deprived and Black/African/Caribbean/Black British decile >7
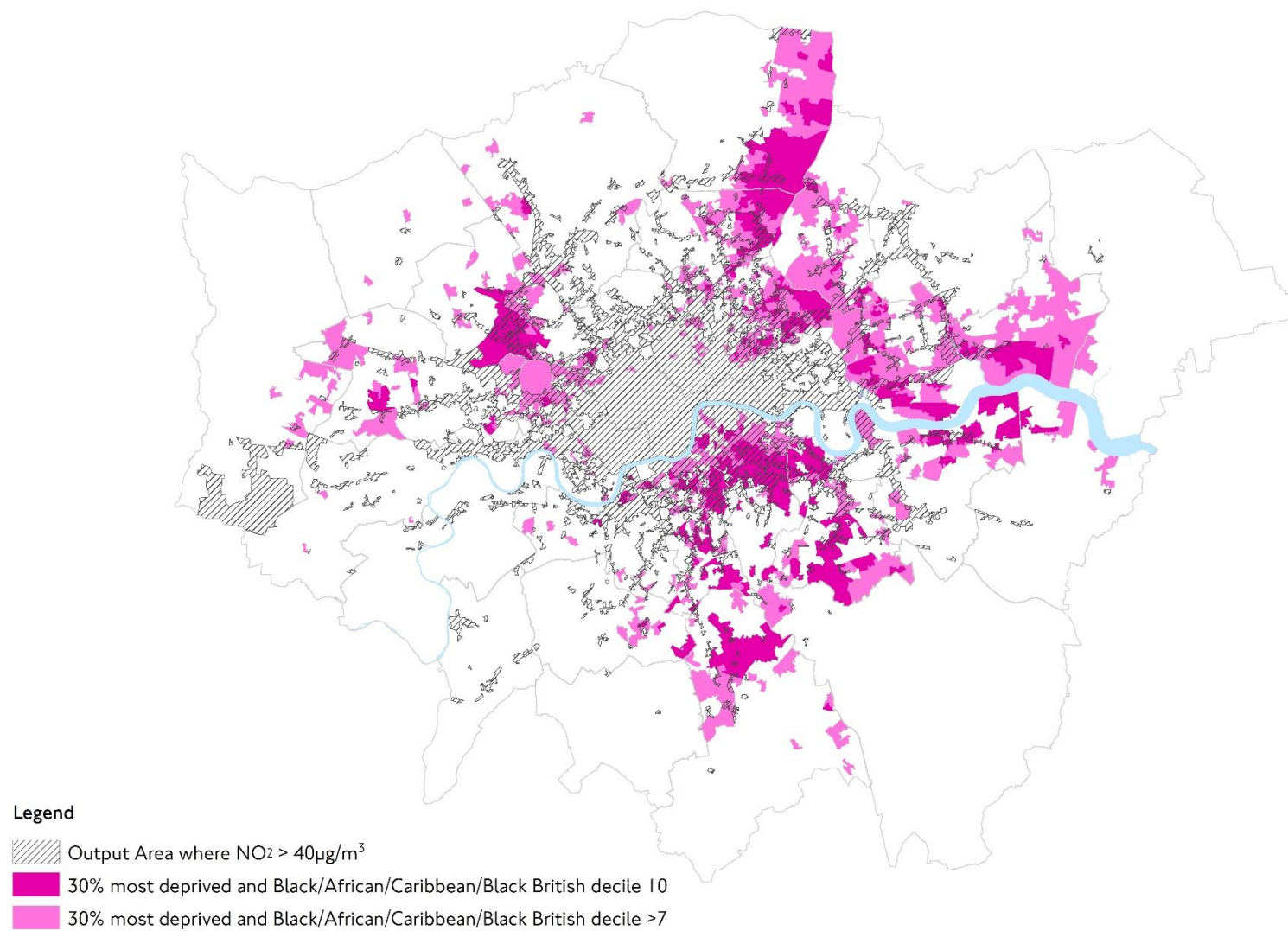
(d) locations of 30% most deprived LSOAs (Deciles 1-3) and highest proportion of ethnic group: Mixed/Multiple ethnic groups

Legend

▨ Output Area where NO$_2$ > 40µg/m^3

■ 30% most deprived and Mixed/multiple ethnic group decile 10

■ 30% most deprived and Mixed/multiple ethnic group decile >7
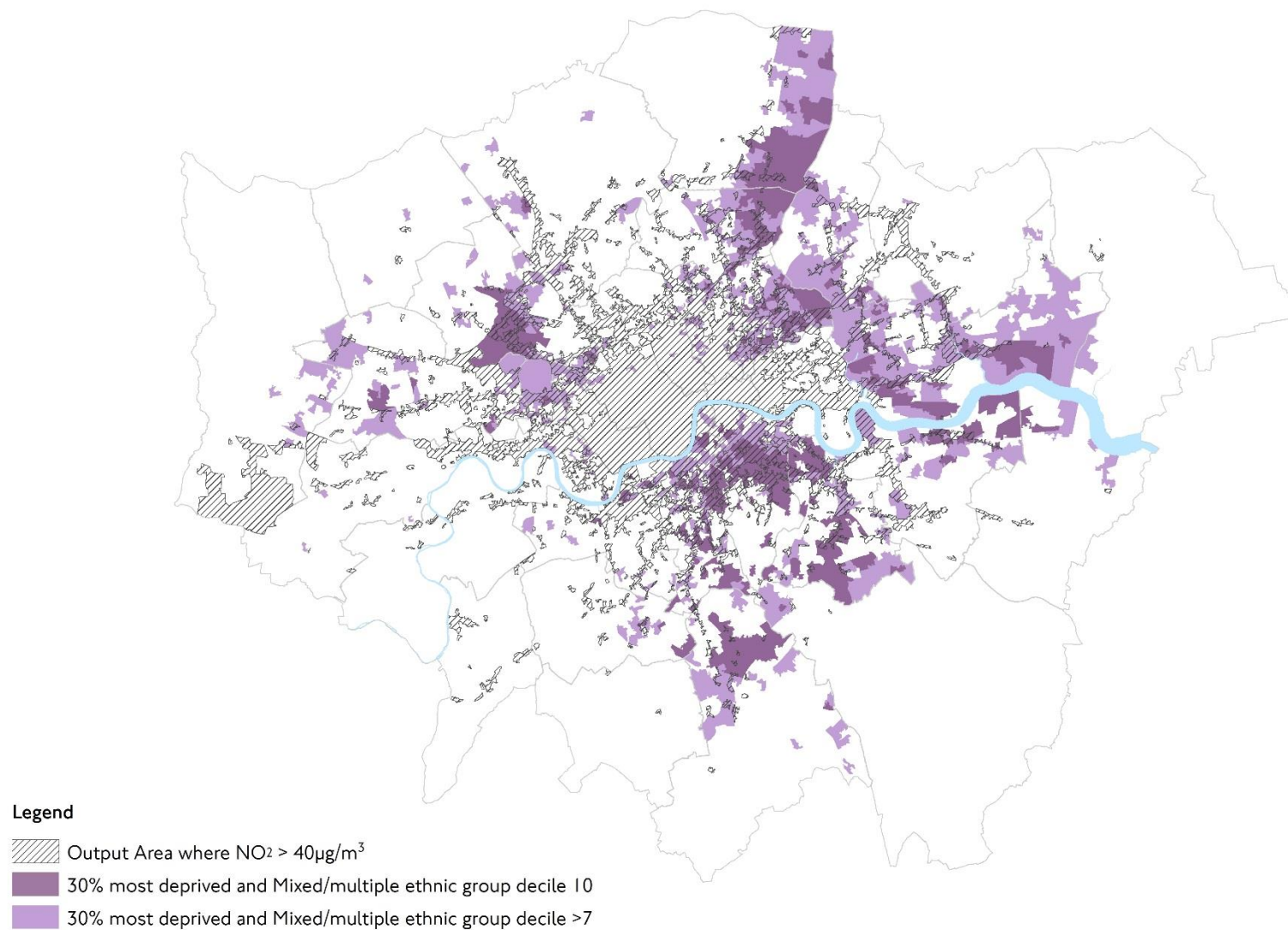
(e) locations of 30% most deprived LSOAs (Deciles 1-3) and highest proportion of ethnic group: Other ethnic groups

Legend

▨ Output Area where NO2 > 40µg/m³

▨ 30% most deprived and Other ethnic group decile 10

▨ 30% most deprived and Other ethnic group decile >7
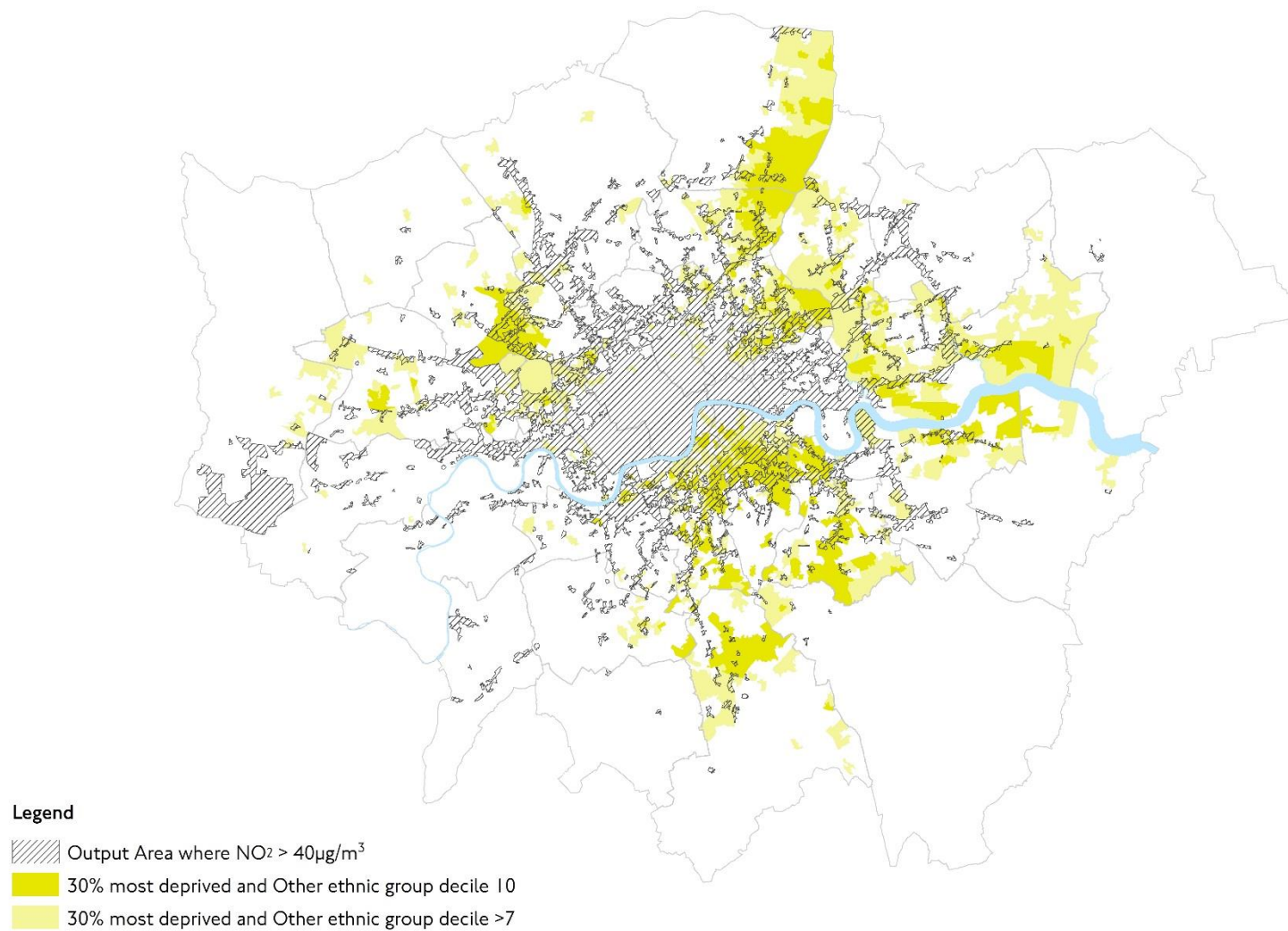
5.1 Summary

Air quality, as represented by NO_2 concentration, has been compared to the prevalence of five ethnic groups: White, Asian/ Asian British, Black/ African/ Caribbean/ Black British, Mixed/ Multiple, and Other ethnic groups (see **Table 2**). White and Asian/ Asian British are the only ethnic groups whose proportion of the total population is greater than the proportion of people exposed to exceedances of the NO_2 EU limit. This suggests that people in the remaining ethnic groups are proportionately more likely to be exposed to higher levels of NO_2, although this effect is not strong.

Analysis of air pollution exposure of the most deprived communities (deprivation deciles 1 – 3) has been combined with the deciles representing the highest proportions of each ethnic groups (**Figure 12**). For all other ethnic groups except for White, there is a relatively higher concentration of highlighted LSOAs located within areas where the NO_2 concentrations exceeded the limit value in 2013. This correlates most strongly to the Black/ African/ Caribbean/ Black British, Mixed/ Multiple and Other ethnic groups (**Figure 12**).

6   Pollution Exposure of the Most Vulnerable Age Groups

This study has also specifically focused on the young and older population in London because these age groups are particularly at risk given their greater susceptibility to the health impacts of air pollution. The total number of this age group exposed to pollution above EU limit values has been calculated for 2013. Similar results to those presented in the previous Analysing Air Pollution Exposure in London report[1] have been found in this study, the results of which are briefly discussed in this section. In addition, this report considers the air pollution and a wider range of schools than previously considered.

6.1   Air pollution level at Schools

The Air Quality team at Transport for London have updated the analysis of pollution concentrations within 150m of schools using the 2013 air pollution maps. This analysis now includes all schools in London. The updated results are briefly presented here, showing the total numbers of different types of schools that are exposed to above and below the NO_2 EU limit value (**Table 5)**, and a map showing the locations of the primary and secondary schools exposed to the highest air pollution concentrations (**Figure 13**). 25% of all schools within London have been identified as being in areas with exceed the annual mean NO_2 EU limit value. The full dataset is available as a download on the London Datastore[16].

Table 5 Schools within London which are exposed to NO_2 concentrations within and above the EU limit (40 μg/m³ annual average) by school type

Type of school	Number of schools with average NO_2 concentration > 40 μg/m³	Number of schools with average NO_2 concentration <= 40 μg/m³	Total number of schools
Nursery	27	53	80
Primary	360	1460	1820
Secondary	78	355	433
16 plus	30	32	62
Community Special School	27	80	107
Higher Education Institutions	28	12	40
Other Independent School	201	305	506
Other Independent Special School	18	32	50
Pupil Referral Unit	10	33	43
Other	23	97	120
All	802	2459	3261

Figure 13 The top 100 Primary and Secondary schools within London in relation to NO₂ exposure
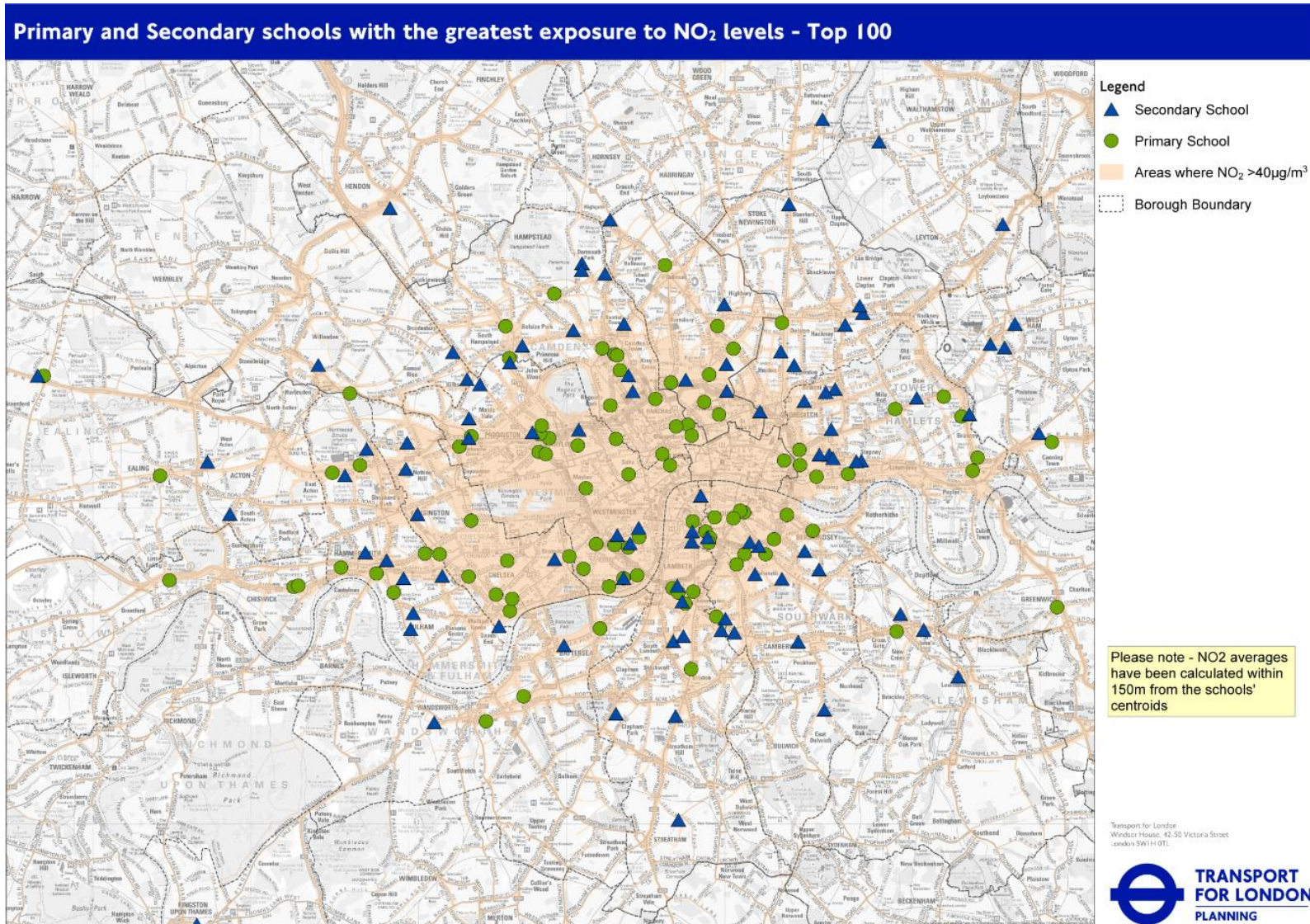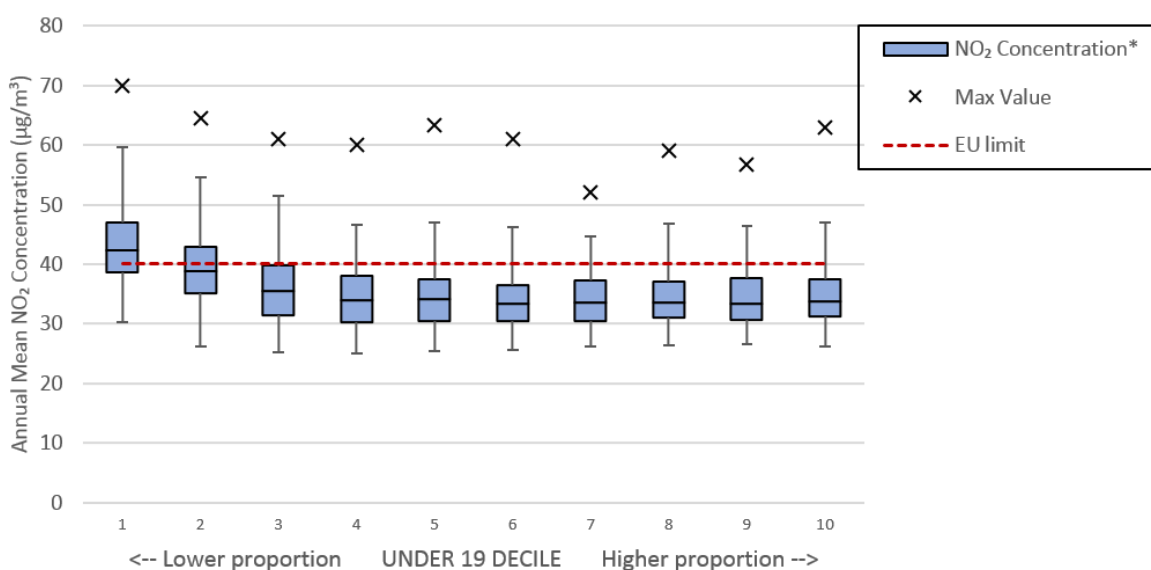
6.2   Under 19 age group

The study has estimated that in London 388,000 people under 19 are currently living in OAs that exceed the EU limit value of 40 µg/m³ (**Table 6**). The majority of these young people are living in Inner London. **Figure 14** illustrates the trend in the average of NO_2 concentration levels across the groups of LSOAs classified by their percentage of population under 19 (henceforth called the 'under 19' deciles).   The graphs also show the variability in concentrations that exists within each under 19 decile. **Figure 14** shows that under 19 decile 10 (LSOAs containing the highest proportion of under 19 year olds) is exposed to the lowest average level of NO_2 concentration. Average concentration levels of NO_2 are highest (average of 43.2 µg/m³) in the decile with the lowest percentage of under 19 year olds. The variability in average NO_2 concentration levels in the LSOAs increases as the proportion of under 19s in LSOAs decreases, but there is again no trend in maximum values compared with percentage of under 19 in the population. Only the results for NO_2 are presented here, the results for PM_{10} are provided in **Annex III**.

Table 6 Total Exposure of the Under 19 population to NO_2 Concentrations in exceedance of the EU Air Quality Objective

Year	Inner London	Outer London	London Total
2013	304,000	83,000	388,000

Figure 14 NO_2 concentrations by decile groups of LSOAs categorised by % population under 19 in 2013

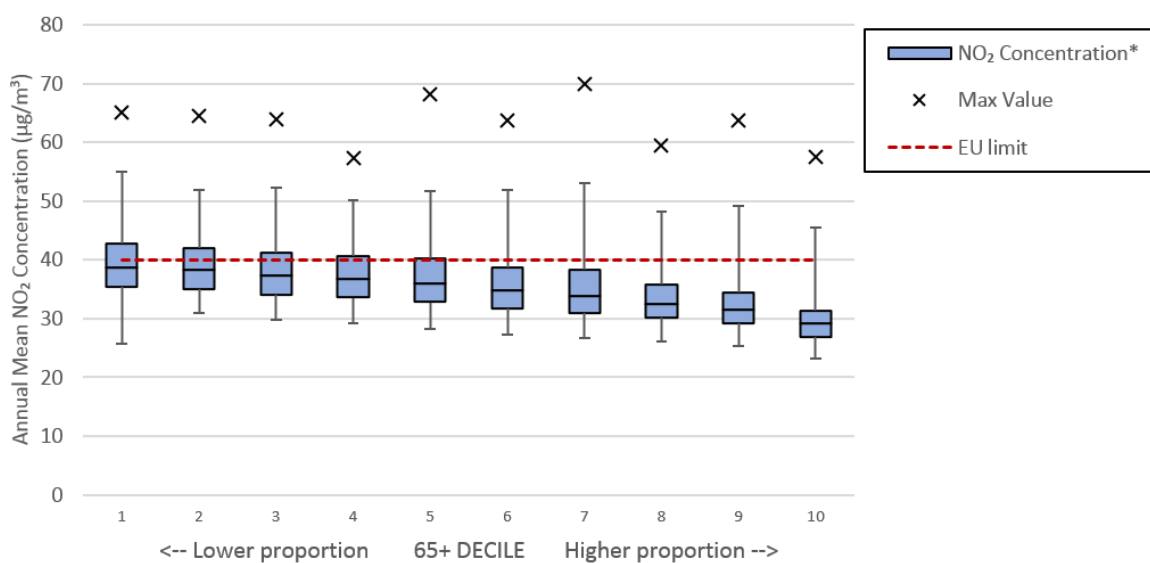* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

6.3   Over 65 Age Group

It has been estimated that in London 161,000 people over 65 are currently living in OAs that exceed the annual NO_2 EU limit value of 40 µg/m³ (**Table 7**). The majority of these older people are located in inner London. **Figure 15** illustrates the trend in the average of NO_2 concentration levels across the groups of LSOAs classified by their percentage of population over 65 (henceforth called the 'over 65' deciles). **Figure 15** shows that over 65 decile 10 (LSOAs containing the highest proportion of over 65 year olds) is exposed to the lowest average level of NO_2 concentration. Average concentration levels of NO_2 are highest (average of 39.6 µg/m³) in the decile with the lowest percentage of over 65 year olds and lowest in the decile with highest proportion of over 65s. The variability in average NO_2 concentration levels in the LSOAs increases as the proportion of over 65 in LSOAs decreases, but there is again no trend in maximum values compared with percentage of under 19 in the population.

Table 7   Total Exposure of the Over 65 population to NO_2 Concentrations in exceedance of the EU Air Quality Objective

Year	Inner London	Outer London	London Total
2013	128,000	33,000	161,000

Figure 15 NO_2 concentrations by decile groups of LSOAs categorised by % population over 65 in 2013

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

6.4   Summary

In summary, the data shows that the more vulnerable under 19 andover 65 age groups are not disproportionately exposed to high levels of air pollution concentrations. In fact the general trend shows that exposure to high concentration levels of NO_2, PM_{10} and $PM_{2.5}$ decreases as the number of under 19 and over 65 year olds living in an LSOA increases.

7   Predicted changes in exposure by 2030

7.1   Changes in exposure

Estimates have been presented earlier (**Figure 1**) of the change between 2013 and 2030 in population exposure to concentrations of NO_2 above the EU limit value. The number of people exposed is predicted to decrease by 96 % in this time period. By 2020 over 72,000 people are predicted to still live in locations with average concentrations above the EU limit value. Between 2020 and 2025 the number of people exposed is predicted to decrease again by 96%, falling to no exceedances predicted in 2030. It should be noted that these estimates of future exposure are preliminary.   This is due to pending updates expected this year to account for methodology developments such as new COPERT emission factors which take closer account of "real world driving" emissions from road vehicles. However, the geographic distribution of predicted air pollution is not expected to change significantly following the update so the patterns described in this report will remain valid.

Figure 16 shows the predicted exposure to NO_2 across the social gradient in London based on modelled 2020 concentrations compared with the 2015 IMD dataset. In contrast to the average NO_2 concentrations by decile in 2013 (the purple dotted line, and which was also presented in **Figure 5a**), decile average values for 2020 (solid blue line) are expected to decline across all the deprivation deciles. However, this average hides large ranges of concentrations across each decile, shown by the 2.5 to 97.5 percentiles and maximum values plotted in **Figure 16**. The reduction in the decile average concentration between 2013 and 2020 is biggest in decile 1 (most deprived locations) and therefore the amount of inequality across the social gradient is expected to reduce with time resulting in a flatter average across the deciles.

Figure 16   Pollution concentrations of NO_2 in 2020 by Deprivation decile groups of LSOAs in London compared to the mean 2013 NO_2 concentrations
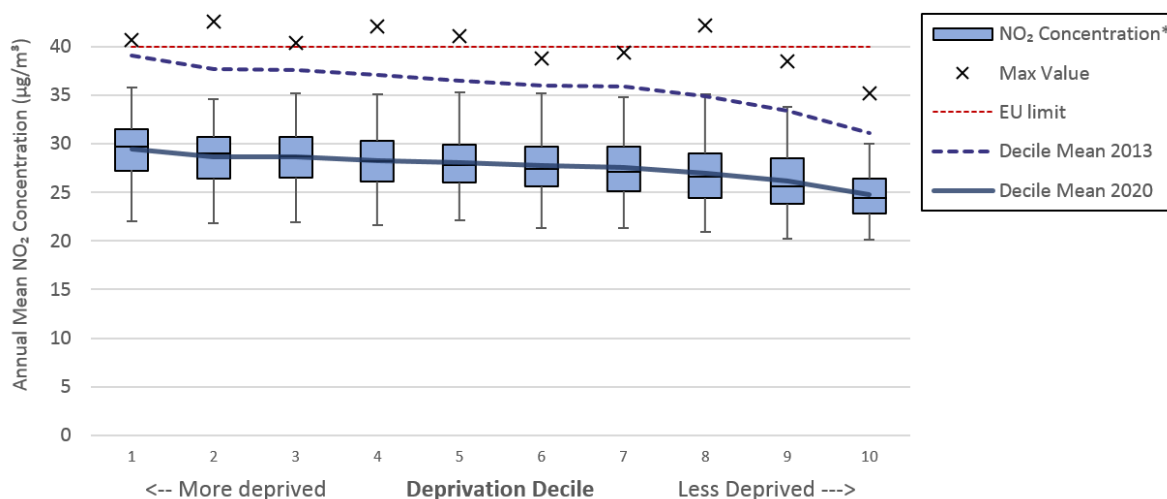
* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

7.2   Locations of areas exceeding EU Limit value

Pollution concentrations are expected to be significantly lower in most areas by 2020, reducing the number of people exposed to poor air quality compared with the present. However, there are still expected to be 72,000 people exposed to exceedances of the EU limit value for NO_2 predicted in 2020 based on the modelling which includes planned measures. Almost 60% of the remaining exceedances of the NO_2 limit value occur in the following four London Boroughs:

1. Westminster (17% of exceedances, 12,122 people exposed)
2. Tower Hamlets (15%, 10,917)
3. Kensington and Chelsea (14%, 9,882)
4. Hammersmith and Fulham (14%, 9,745)

By 2025, it is predicted that exceedances of the air quality objectives will only occur in these four boroughs. Targeted further measures are required to bring NO_2 concentrations in these locations down to within the EU limit value. The recently announced Mayor's package of air quality plans and measures are expected to improve the air quality in these areas but the likely impact on exposure of these measures has not yet been quantified.

8   Conclusions

This study has found that there was significant exposure of the London population to levels of NO_2 above the EU limit value in 2013 and that this exposure is predicted to decline significantly (96%) by 2020. Current modelling results show that in 2020 there will still be more than 72,000 people living in locations with average NO_2 above the EU limit value. In contrast, average concentrations of particles (PM_{10} and $PM_{2.5}$) were, by 2013, already within EU Limit Values for the annual average concentrations, although above the WHO Air Quality Guidelines which are significantly lower.

Populations living in the most deprived areas are on average currently more exposed to poor air quality than those in less deprived areas. 46% of the LSOAs within the most deprived 10% of London have concentrations above the NO_2 EU limit value. This is in contrast to 2% above the NO_2 EU limit value in the 10% least deprived areas. However, there is a wide variation in pollution concentration values across the social gradient, with all deciles showing a large range between minimum and maximum values. Inequalities are predicted to reduce by 2020 as a result of new policies predominantly resulting from reductions in road transport emissions. Further measures and plans announced recently (and not included in the modelling) are expected to improve this picture.

Barking and Dagenham, Croydon, Newham, Tower Hamlets and Hackney are the Boroughs that have the highest proportion of most deprived populations (top 30% deprived) in London's areas of worst air quality. Tower Hamlets, Southwark, Hackney, Islington and Lambeth are the Boroughs that have the highest numbers of people living in London's worst air quality areas. These Boroughs in particular need targeted action to reduce inequalities in access to clean air.

Air quality, as represented by NO_2 concentration, has been compared to the prevalence of five ethnic groups. Slight correlations between the proportion of each ethnic group with annual mean NO_2 concentration have been identified. In addition, proportionally more people have been found to be exposed to exceedances of the NO_2 EU limit value in areas with a high proportion of Black/ African/ Caribbean/ Black British, Mixed/ Multiple and Other ethnic groups. Analysis of air pollution exposure of the most deprived communities (deprivation deciles 1 – 3) has been combined with the deciles representing the highest proportions of each ethnic group. For all ethnic groups except for White, there is a relatively higher concentration of highlighted LSOAs located within areas where the NO_2 concentrations exceeded the limit value in 2013. This correlates most strongly to the Black/ African/ Caribbean/ Black British, Mixed/ Multiple and Other ethnic groups.

The maps of predicted air quality used in this analysis included planned measures to reduce air pollution emissions but did not include the impacts of further additional measures and plans recently announced by the Mayor of London. These are expected to further improve the air quality by 2020 beyond that quantified here.

Annex I Comparing air pollution exposure of the total population at OA and LSOA level

The exposure of the total population to exceedances of the annual mean NO_2 limit value was considered at both the Output Area (OA) level and the Lower Super Output Area (LSOA) level to consider the impact of geographic resolution on the results.

Table A8 compares the total number of people exposed to exceedances of the annual mean NO_2 limit value at OA and LSOA level in 2013 within each London Borough. Overall, more people are found to be exposed to exceedances in 2013 when aggregating to LSOA compared to OA in 2013. It was found that the converse is true in 2020 and other future years. However, the data for 2020 are not presented below because they are uncertain and the estimates for future concentrations are due to be updated later this year (see section 2.1 for an explanation).

The difference in pattern between 2013 and future years is thought to be due to the higher peak pollutant concentrations in 2013 resulting in higher average concentrations and hence exposure estimates. Whilst in future years the concentration gradients are lower and averaging of NO_2 concentrations over a larger area (LSOA) results in less impact of the peak pollution concentrations and therefore result in lower estimates of population exposure. The use of OAs for determining the overall population exposure to NO_2 pollution was considered more appropriate to prevent an underestimation of the number of people exposed to exceedances in future years.

Table A8 Population exposed to exceedances of the NO_2 EU limit Value (40 µg/m³) at OA and LSOA level in 2013 by Borough

London Borough	Exceedances of the NO_2 EU Limit Value in 2013	
	OA	LSOA
Barking and Dagenham	7,456	2,322
Barnet	42,226	36,055
Bexley	2,306	1,386
Brent	66,058	74,414
Bromley	1,389	0
Camden	154,454	169,908
City of London	7,612	5,078
Croydon	14,057	0
Ealing	55,734	44,193
Enfield	19,057	13,227
Greenwich	34,019	29,102
Hackney	117,594	139,979
Hammersmith and Fulham	93,834	115,753
Haringey	48,651	41,956
Harrow	1,244	0
Havering	735	0
Hillingdon	5,190	1,876
Hounslow	35,058	32,170
Islington	138,420	151,730
Kensington and Chelsea	144,470	153,148
Kingston upon Thames	9,487	2,670

| London Borough | Exceedances of the NO_2 EU Limit Value in 2013 | |
	OA	LSOA
Lambeth	147,930	168,689
Lewisham	45,970	33,890
Merton	12,095	1,726
Newham	47,887	42,786
Redbridge	21,615	17,642
Richmond upon Thames	12,178	1,156
Southwark	163,502	188,498
Sutton	561	0
Tower Hamlets	150,779	178,268
Waltham Forest	28,808	24,509
Wandsworth	102,298	103,296
Westminster	198,647	212,579
Total	1,931,319	1,988,001

Annex II Exposure of Ethnic Groups to Particulates

Air pollution data for each ethnicity decile has been summarised to show the trend in pollution with an increasing proportion of each ethnic group. The result for NO_2 are presented in **Figure 10** in the report. The results for PM_{10}, and $PM_{2.5}$ are presented here in **Figure A17** and **Figure 18**, respectively.

Figure A17 PM_{10} concentrations by ethnic decile groups in London 2013 (a) White (b) Asian/ Asian British, (c) Black/ African/ Caribbean/ Black British, (d) Mixed/ Multiple and (e) Other ethnic groups. The population exposed is provided on the secondary axis. Note the differing scales on the secondary axis used for each figure.

(a) White

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(b) Asian/ Asian British

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(c) Black/ African/ Caribbean/ Black British

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(d) Mixed/ Multiple ethnic groups

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(e) Other ethnic groups

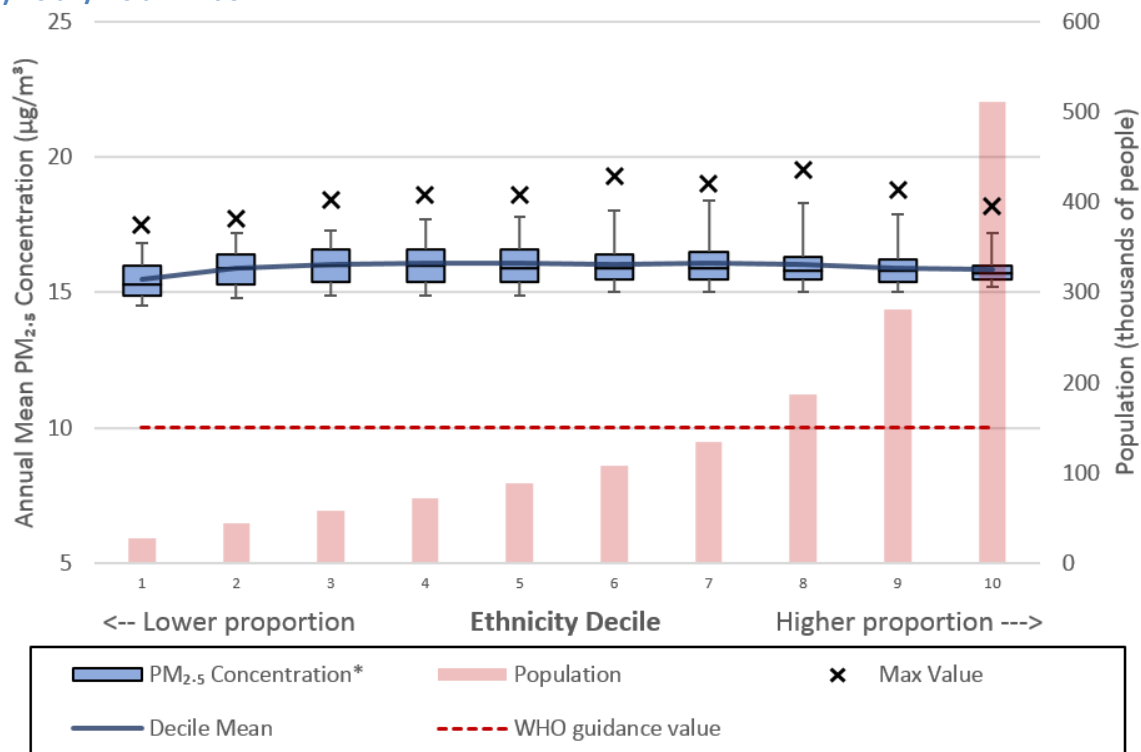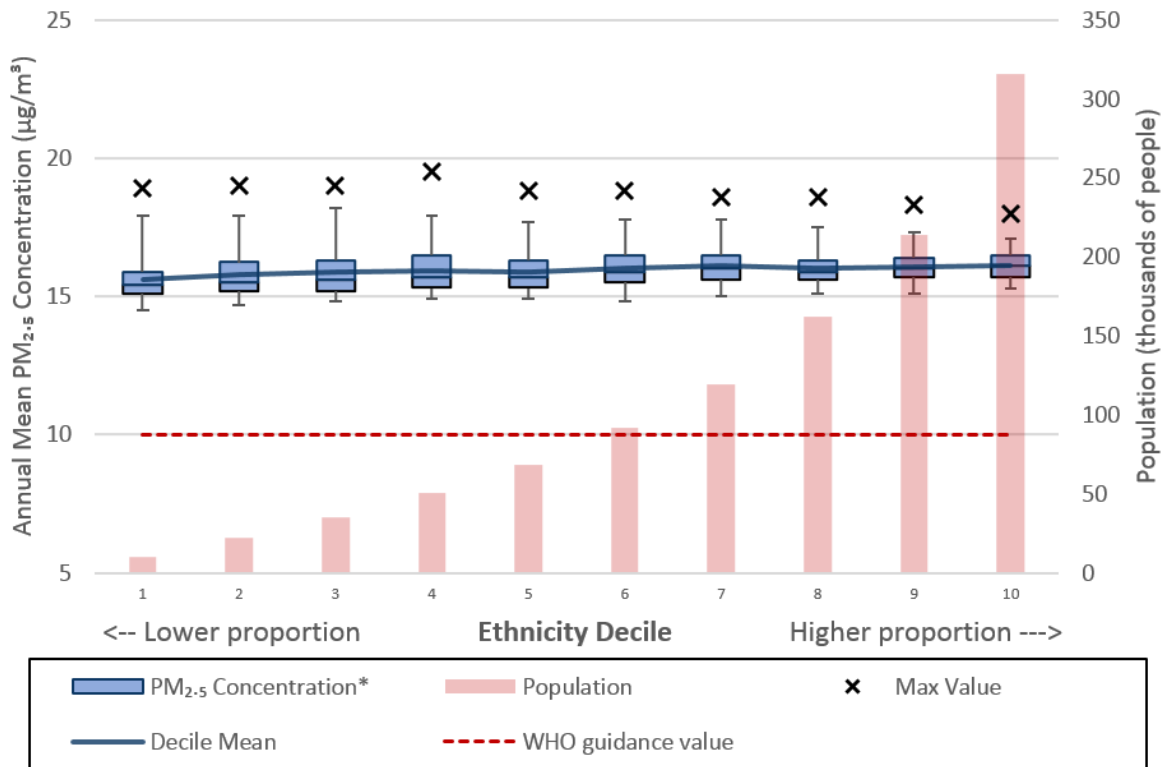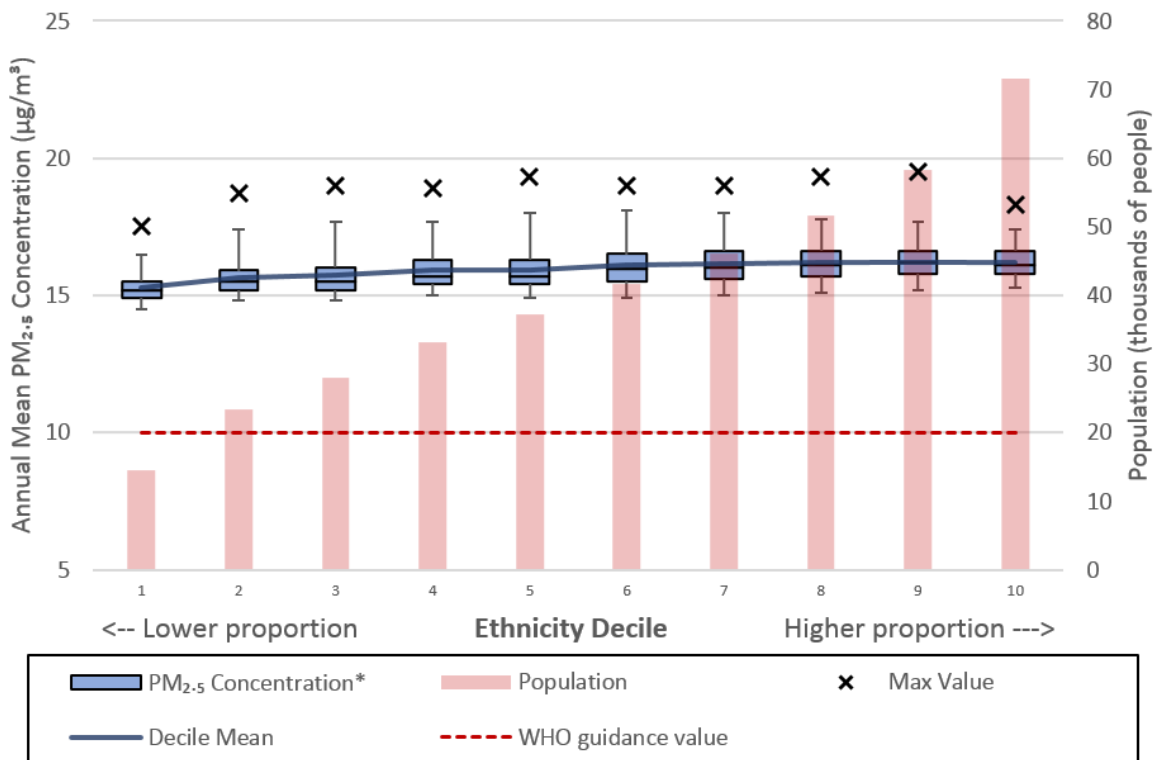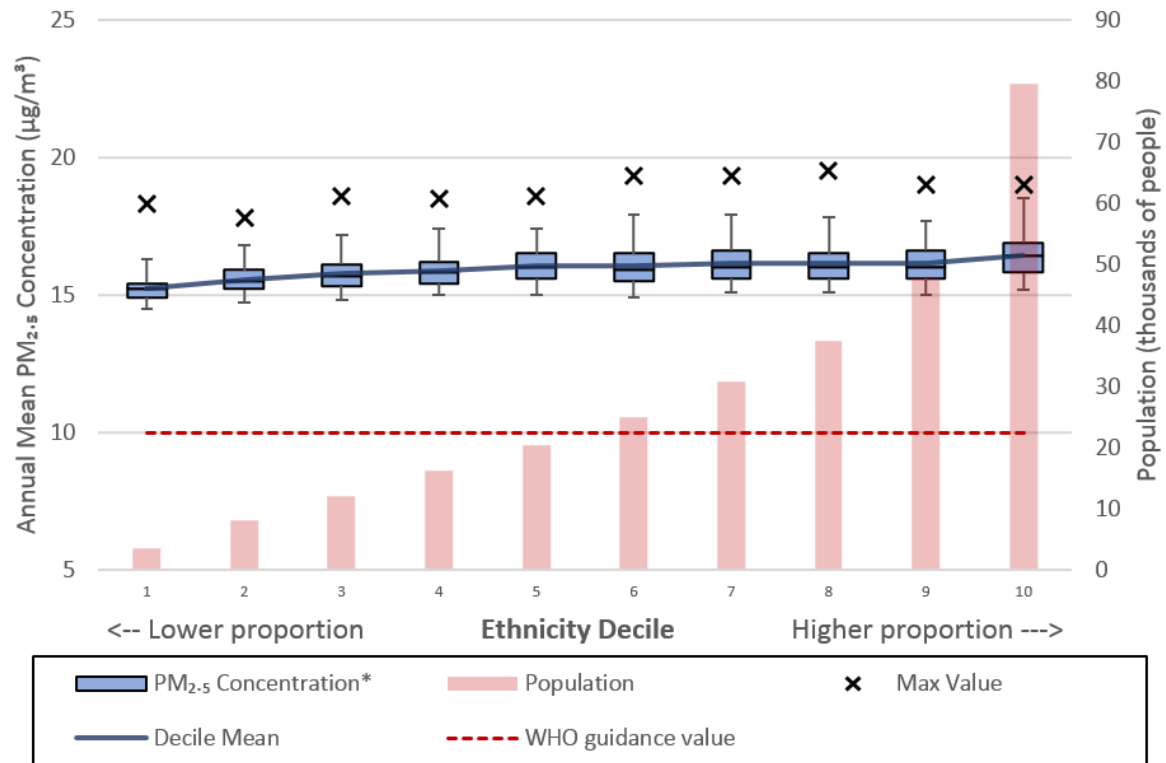* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

Figure 18 PM₂.₅ concentrations by ethnic decile groups in London 2013 (a) White (b) Asian/ Asian British, (c) Black/ African/ Caribbean/ Black British, (d) Mixed/ Multiple and (e) Other ethnic groups. The population exposed is provided on the secondary axis. Note the differing scales on the secondary axis used for each figure.

(a) White

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(b) Asian/ Asian British

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(c) Black/ African/ Caribbean/ Black British

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(d) Mixed/ Multiple ethnic groups

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(e) Other ethnic groups

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

Annex III Exposure of Vulnerable Age Groups to Particulates

The exposure of people in the under 19 and over 65 age groups were considered in the main report in **Sections 6.2 and 6.3** with regards to NO_2. The results for PM_{10} and $PM_{2.5}$ are presented here in **Figure 193** and **Figure 20**, respectively.
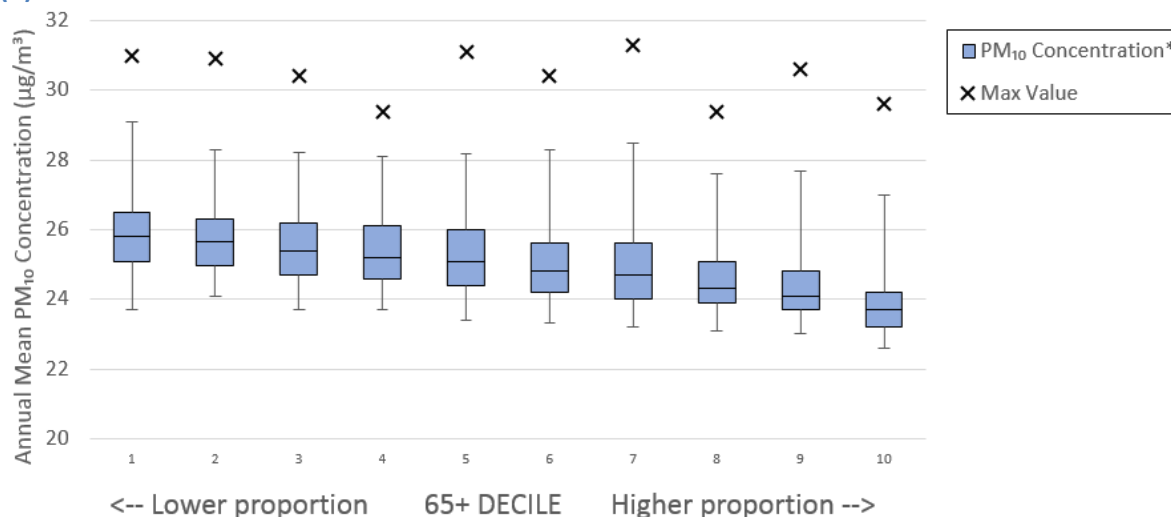
Figure 193 PM_{10} concentrations in 2013 by decile groups of LSOAs categorised by % population (a) under 19 and (b) over 65
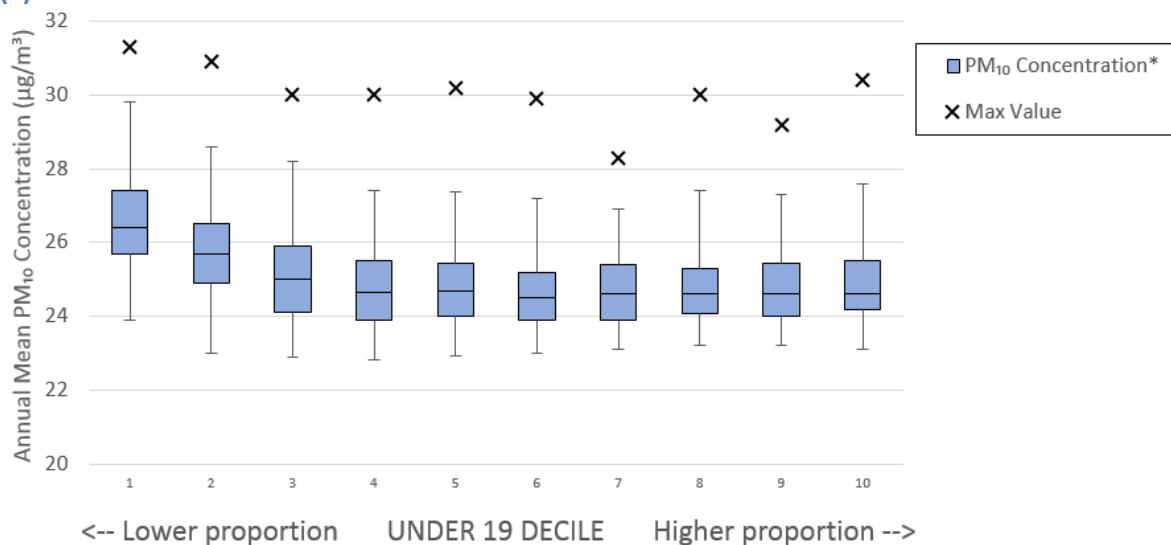
(a) Under 19

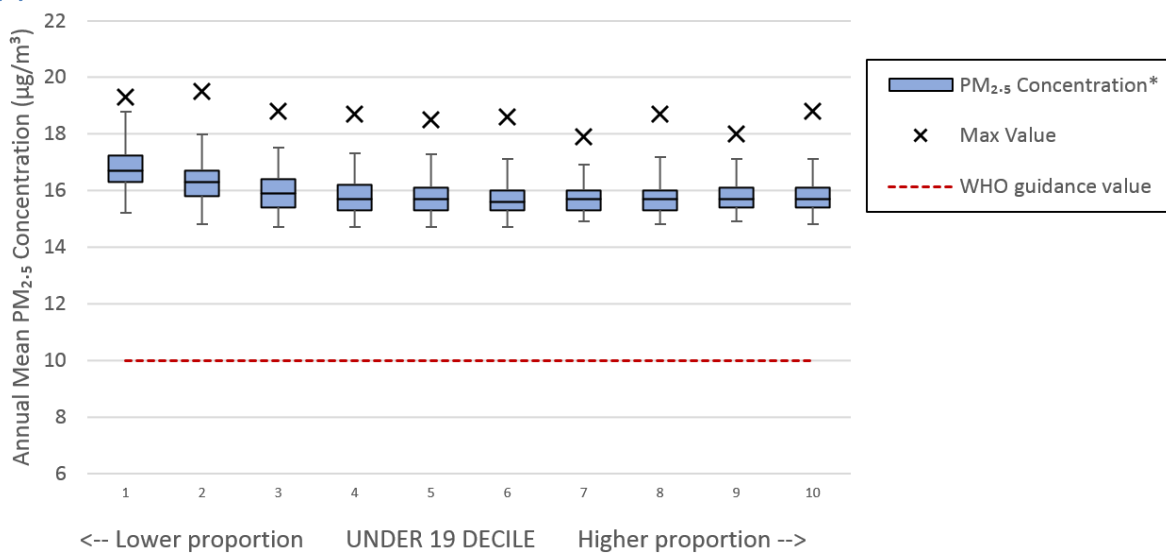* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(b) Over 65

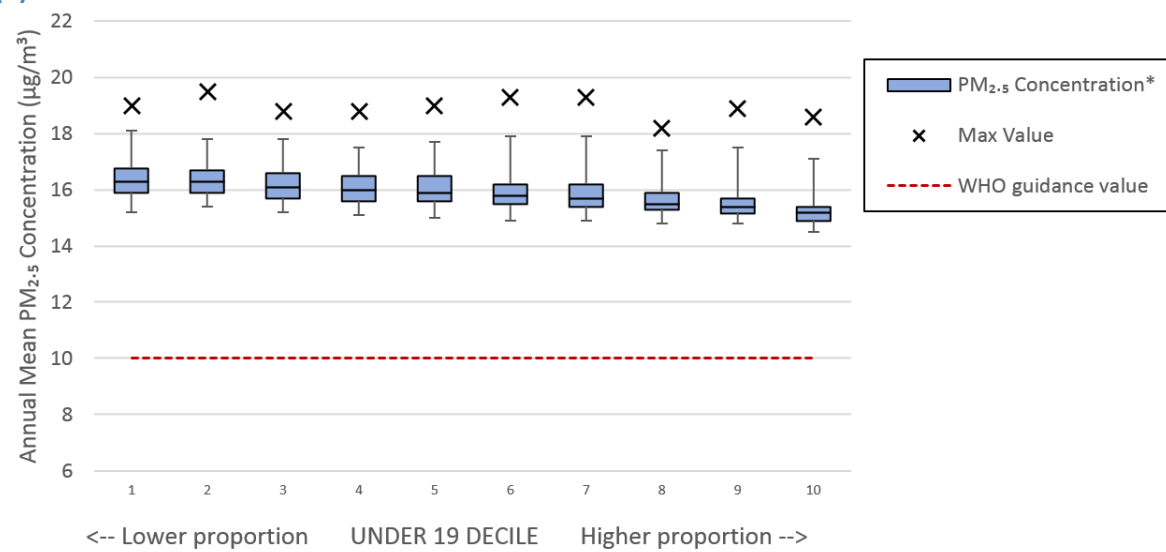* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

Figure 20 PM₁₀ concentrations in 2013 by decile groups of LSOAs categorised by % population (a) under 19 and (b) over 65

(a) Under 19

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile

(b) Over 65

* Boxes in the graphs represent 25-75%ile. Whiskers are 2.5 and 97. 5%ile