CASA0005 – Geographic Information Systems and Science

Assessing the effect of suspending free travel for 11 to 18-year-olds in London.

MSc Smart Cities and Urban Analytics

UCL Centre for Advanced Spatial Analysis

GitHub Repository: https://github.com/signesw/CASA0005_Coursework

Reproducible Analysis: https://signesw.github.io/CASA0005_Coursework/

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1. Introduction

Since 2008, free travel on London's buses and trams has been available for children under 18 with the Zip Oyster Card, giving over 1.85 million children easy access to the places they want to go (Greater London Authority, 2017).

In 2020 however, as the COVID-19 virus spread across the globe, people started working from home, schools closed, and travel became much less frequent. London's public transport network, Transport for London (TfL) saw a drop in passengers of almost 90% at the height of the pandemic (Staton, 2020). This has had a significant economic impact on TfL. The ongoing uncertainty on the spread of the virus and how this will impact travel patterns makes it difficult to forecast how, and if, the network will recover financially.

In order for TfL to stay operational, the government has provided financial support, but under certain conditions. One of those conditions was to suspend free travel for 11-to-18-year-olds. Sadiq Khan, the Mayor of London, was able to negotiate the removal of this condition from the final financial support plan, which will be in effect until March 2021 (*London City Hall,* 2020*)*. However, as the Coronavirus crisis continues to affect how people travel, it is likely that TfL will need continued government support next year (Staton, 2020) and the suspension of free travel cannot be ruled out.

The goal of this investigation is to answer the following questions:

What effect will the potential removal of free travel for 11-18-year-olds have on children living in different areas? Will the decision disproportionately affect already disadvantaged areas?

2. Literature Review

2.1. Dependence on Public Transport in London

While the removal of free travel will affect access to both education and extra-curricular opportunities, this investigation will focus on the ability to travel to and from school.

A large proportion of students in London are dependent on public transport in order to access their education. A survey conducted by Partnership for Young London (PYL) on more than 2000 young people in London found that more than 70% take the bus to school, and more than half stated that they take 2 or more modes of public transport to get to school (Partnership for Young London, 2020). Further, more than half said that if they lost free travel, they would not be able to afford to travel to all the places they want. Among

Black, Asian, and minority ethnic (BAME) respondents, this proportion was 76%. This suggests that the change would put a financial strain on London's young population who is highly dependent on TfL's services. This dependence on public transport is influenced by several factors such as travel distance, road safety, air quality and car access.

2.1.1. *Distance*

In choosing a mode of travel, distance is often listed as the most important factor. Previous studies have found that spatial and temporal constraints play a significant role in choosing a motorized mode of travel rather than walking or cycling (Ewing, Schroeder and Greene, 2004; He and Giuliano, 2017).

UK secondary schools often give priority admission to children living in proximity to the school. In London however, schools are becoming increasingly oversubscribed, and students are not always allocated to the school nearest to them (Mohdin, 2019). Further, the choice of school may depend on factors such as religious affiliation, subject specialisms, and facilities for special needs.

In the UK, students between 11-16 are entitled to free travel if their school is located more than 3 miles (5km) away from their home. This is defined as the statutory walking distance, the cut-off point beyond which students should not be expected to walk to school (Department for Education, 2014). However, studies have suggested that the real cut-off walking distance is smaller. One study in Britain found the threshold to be 1 km for children younger than 14, and 3 km for older children (Chillón *et al.*, 2015). A similar study in Ireland found that the majority of walkers lived within 2.5km and cyclists within 4km from their schools (Nelson *et al.*, 2008).

2.1.2. Safety

In the PYL survey**,** two-thirds of respondents stated that they were worried that getting to school is less safe without free travel. Further, fewer than 17% said that if they lost free travel, they would cycle instead to the places they want to go (Partnership for Young London, 2020). This suggests that road safety is an important factor in the dependence on public transport for young people. Pedestrians and cyclists are significantly more at risk of traffic accidents than users of public transport. Of all road casualties recorded in London in 2019, pedestrian and cyclists accounted for 34%, while travellers by bus accounted for 4%. Travelling by car is associated with most accidents, accounting for 38% of casualties (TfL, 2020). In terms of road safety, the use of public transport is the safest option, and students may be less inclined to walk or cycle in areas with high traffic levels and greater frequency of road accidents.

2.1.3. Air quality

A survey conducted by Living Streets found that 68% of parents in London are concerned about the impact of air pollution on their children's health when walking to school (Living Streets, 2019). A number of studies in London have found that pedestrians and cyclists are more at risk of the negative health effects of particulate matter than bus and car passengers (Briggs *et al.*, 2008; Kumar *et al.*, 2018). A study carried out among London schoolchildren found that walking along main roads has the highest exposure to air pollution (Varaden, Leidland and Barratt, 2019), suggesting that students may be more likely to choose public transportation over walking along roads with heavy traffic.

2.1.4. Car ownership

An English study by Mackett *et al.* (2002) found that children in households that have more than one car are highly likely to be taken to school by car and are less likely to travel to extracurricular activities by public transport. This suggests that car ownership plays a role in the dependency on public transport. It is important to consider however, that travel by car may also be influenced by socioeconomic factors such as parents' schedules and location-based factors such as traffic levels (He and Giuliano, 2017) .

3. Methodology

All data processing and subsequent analysis has been carried out using the R programming language.

3.1. Study Area

This study was set in the Greater London administrative area in the United Kingdom. To be eligible for a Zip Oyster Card one must be attending a school in one of London's Boroughs. Data was studied at the Lower Super Output Area (LSOA) level, a statistical geographic boundary containing around 1500 people each. The 2011 Census boundaries were used. In the Greater London area there are a total of 4835 LSOAs. The boundaries are shown in Fig. 1.

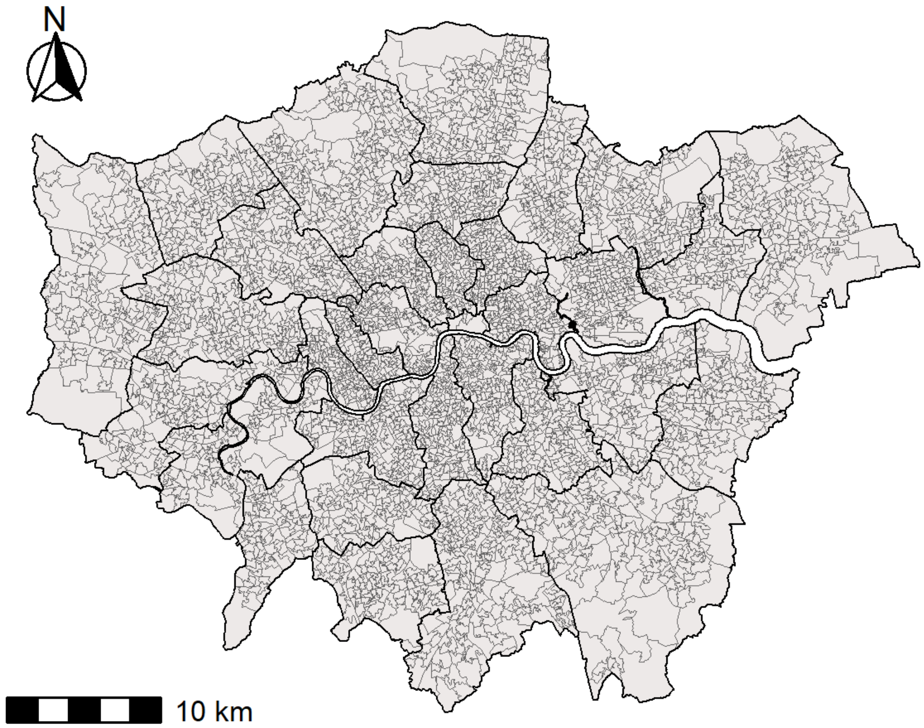

Figure 1*: Study Area used for Analysis: The LSOA boundaries are denoted by the thinner gray lines. The thicker, darker lines denote the London Boroughs*

3.2. Index of Public Transport Dependence

An index for the dependence on public transport (IPTD) to commute to school at LSOA level in London was created for the analysis by aggregating four indicators; school to home distance, road safety, air quality, and car ownership. The data and procedures used to assess the components of public transport dependence are summarised in Table 1. The analytical process is summarised in Fig. 2. Figures 3 and 4 show the straight line and network routes used to calculate travel distances, respectively.

Table 1. *Data sources and procedures used for computing the Index of Dependency on Public Transport*

Variable	Data Used	Data Source (Year Published)	GIS Procedure
School Distance	*School locations* Dataset including all operational schools in the UK as of 2020. Longitude and latitude data included.	Department for Education (2020)	Origin-destination lines created for each school and LSOA flow using the centroid of each LSOA. From these origin-destination pairs, shortest distance routes were generated based on the existing road network. Travel distance for each school-LSOA link was computed both in terms of the straight-line distance, and network distance. Network distance was used for subsequent analysis as it is more representational of actual travel patterns. Average distance for each LSOA was computed from total distance and pupil count.
	Secondary school flow data This dataset breaks down children living in an LSOA by where they go to school, providing an aggregated pupil flow count per LSOA for each school in London.	Greater London Authority 2016	
Road Safety	*Underlying indicators of the 2019 Indices of Multiple Deprivation* The published data contains information on reported road traffic casualties among pedestrians and cyclists. The indicator uses data for 2015 to 2017 published by the Department for Transport and is expressed as a rate per 1000 people of the LSOA population, as well as the non-resident workplace population from the 2011 Census.	Ministry of Housing, Communities & Local Government (2019)	Data on road casualties per 1000 people was linked to each LSOA.
Air Quality	*Underlying indicators of the 2019 Indices of Multiple Deprivation* Concentration values for NO_2, Benzene, SO_2 and particulate matter were based on 2016 air quality data published by the UK Air Information Resource, which produces air quality data for 1km grid squares across the UK. This data was then modelled to LSOA level. For each pollutant, the concentration was divided by the safe national standard as set out by the UK's National Air Quality Strategy. The final values were summed to produce a combined measure, where a greater score indicates worse air quality.	Ministry of Housing, Communities & Local Government (2019)	Data on air quality was linked to each LSOA.
Car ownership	*London LSOA Atlas* Information on car ownership at LSOA level was taken from the 2011 Census. This information was summarized in the London LSOA Atlas, a spreadsheet containing data in a variety of sectors at LSOA levels. The number of households with no car or van availability was used for the index, expressed as a percentage	Greater London Authority (2014)	Percentage of households with no car was linked to each LSOA.

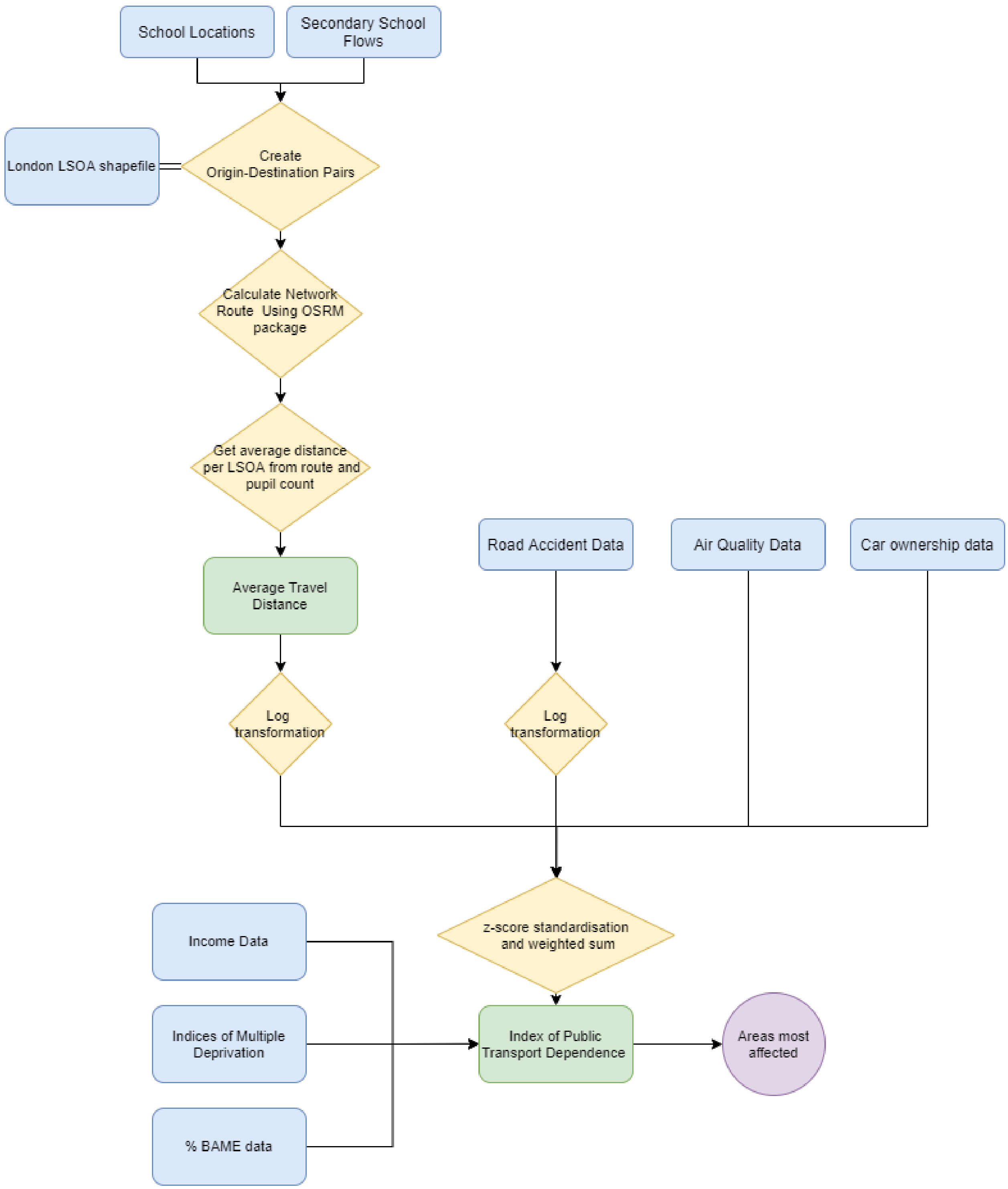

Figure 2: *Workflow used in analysis*

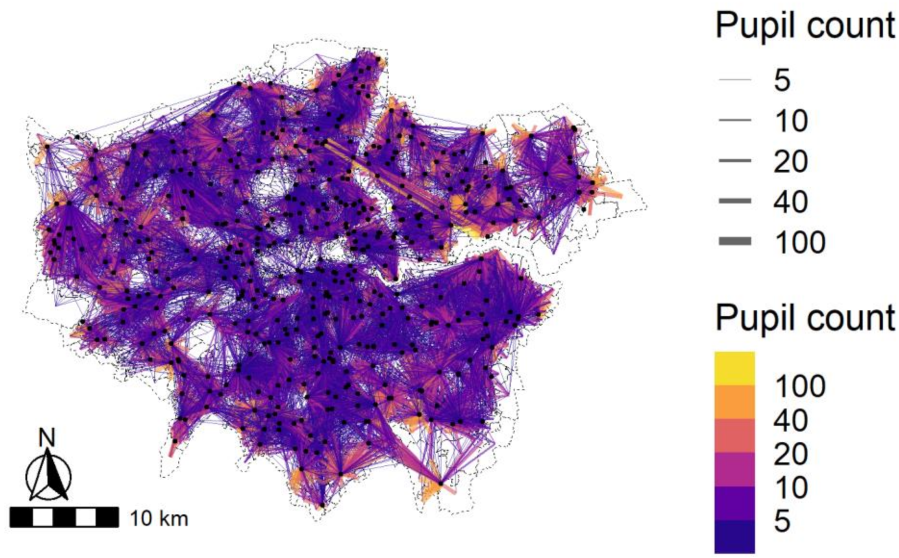

Figure 3: *Straight line routes from LSOA centroid to London Secondary Schools (Black points). The colour and width of the lines reflect the number of pupils in that particular origin-destination flow.*

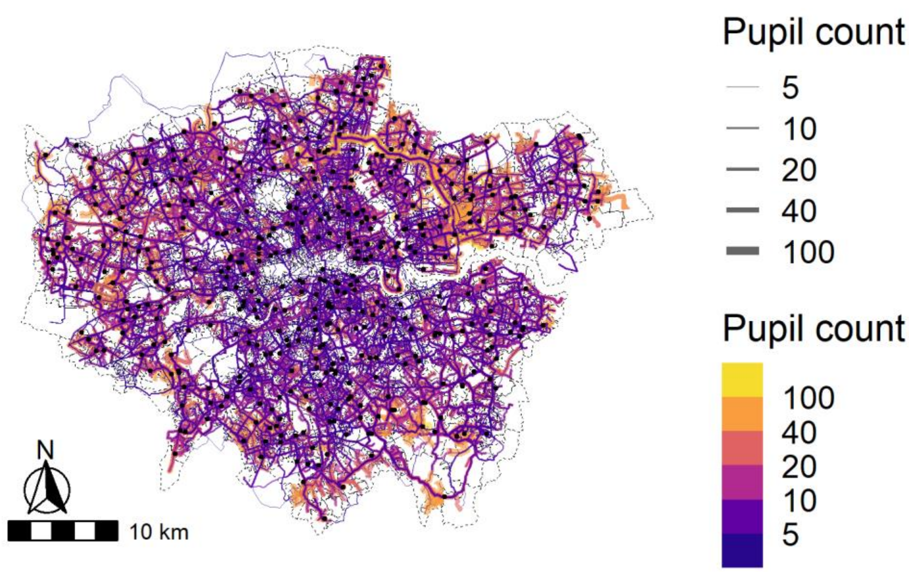

Figure 4: *Network routes from LSOA centroid to London Secondary Schools (Black points). The colour and width of the lines reflect the number of pupils in that particular origin-destination flow.*

Each of the variables described in Table 1 was standardized, and the dependency on public transport index was calculated by summing the z-scores of the four variables. The variables which followed a log-normal distribution were first log-transformed before the z-score standardisation. Weights summarised in Table 2 were applied to each of the z-scores, based on an interpretation of the existing literature.

***Table 2**. Weights applied to variables*

Variable	Weight applied
Network distance to school (km)	45%
Road traffic accidents indicator (per 1000 people)	10%
Air quality indicator	20%
Households with no car (%)	25%

3.1. Deprivation, ethnicity and dependence on public transport

To understand whether the removal of free travel would disproportionately affect students in deprived areas and/or students with BAME backgrounds, the calculated IPTD for LSOAs was divided into quintiles. LSOA's in the 5th quintile, representing the 20% of LSOAs most dependent were analysed.

Information on deprivation was obtained from the 2019 Indices of Multiple Deprivation (IMD) (Ministry of Housing, Communities & Local Government, 2019). IMD Deciles for each LSOA was used.

Data on ethnicity was obtained from the London LSOA Atlas, based on the 2011 Census. The calculated percentage of BAME people in each LSOA was used.

3.2. Identifying LSOAs most affected

Household income was obtained from ONS income estimates for MSOA's for the year 2018 (ONS, 2020). Net annual income after housing costs was used.

LSOAs were classified into three groups (high/medium/low) for IPTD and income. The combination of the groups was plotted to form a bivariate map in order to identify the areas which combine high public transport dependence and low household income.

3.3. Data Limitations

There are some limitations to the data. For some data, the most recent available statistics are more than 2 years old and the latest Census is from 2011. The flows dataset doesn't include independently funded schools and 16-18 Colleges. These limitations will affect the true IPTD value but are unlikely to influence the general distribution of the findings.

4. Results

4.1. Dependence on Public Transportation Index

4.1.2. Travel Distance

Average straight line and network distance by LSOA are summarised in Fig. 5 and Table 3.

Table 3. *Comparing Average Straight Line Distance & Network Distance*

Average Distance (km)	Mean	St. Dev.	Median	Max	Min	Variance
Straight-line distance	1.90	0.92	1.75	11.95	0.07	0.84
Network distance	2.85	1.31	2.65	18.58	0.06	1.72

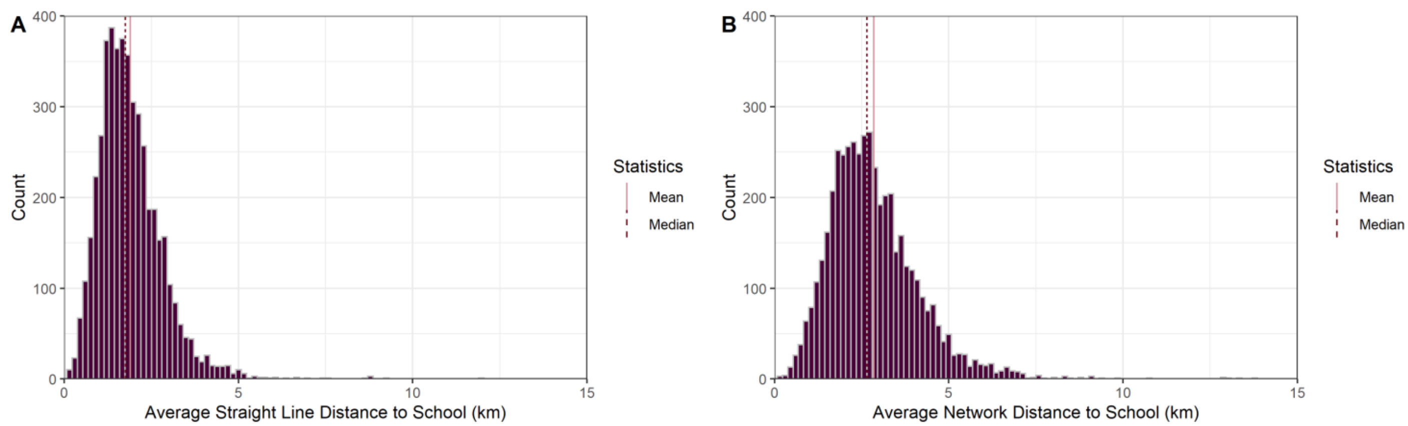

Figure 5: *Histogram of A.) Average Straight Line Distance , and B.) Average Network Route Distance*

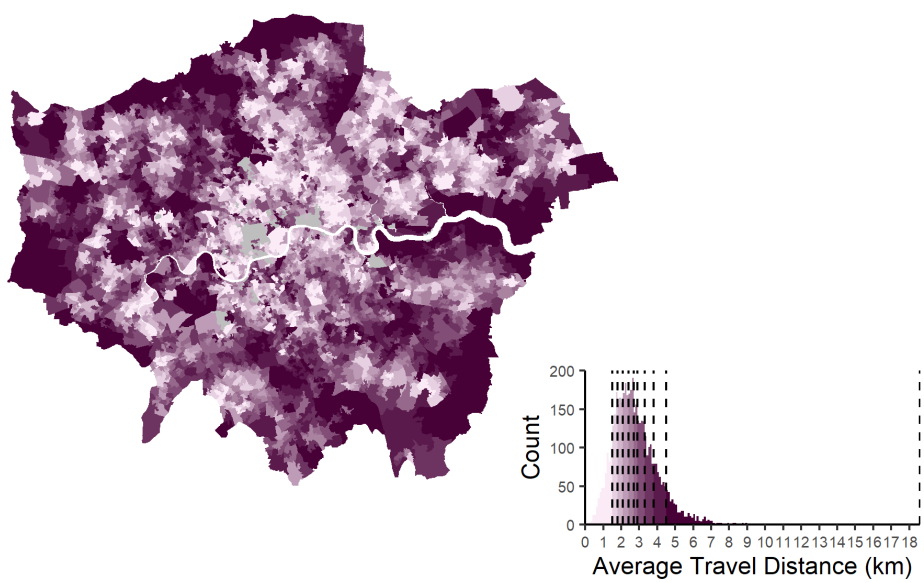

Figure 6: *London LSOAs by Average Network Travel Distance. Colour is grouped by deciles.*

4.1.3. Dependence on Public Transport Index

Summary statistics for the four variables used in developing the IPTD are summarised in Table 4. The histogram plots are shown in Fig. 7. The z-scores after normalisation of each variable used in creating the index are mapped in Fig. 8. The final index is shown in Fig. 9.

Table 4. *Variables used in constructing the Index of Dependence on Public Transport (IDPT)*

Variable	Mean	St. Dev.	Median	Max	Min	Variance
Network distance to school (km)	2.85	1.31	2.65	18.58	0.06	1.72
Road traffic accidents indicator (per 1000 people)	1.03	1.06	0.88	44.29	0.15	1.13
Air quality indicator	1.31	0.18	1.31	1.90	0.73	0.03
Households with no car (%)	40.03	18.52	38.70	86.30	2.70	342.93

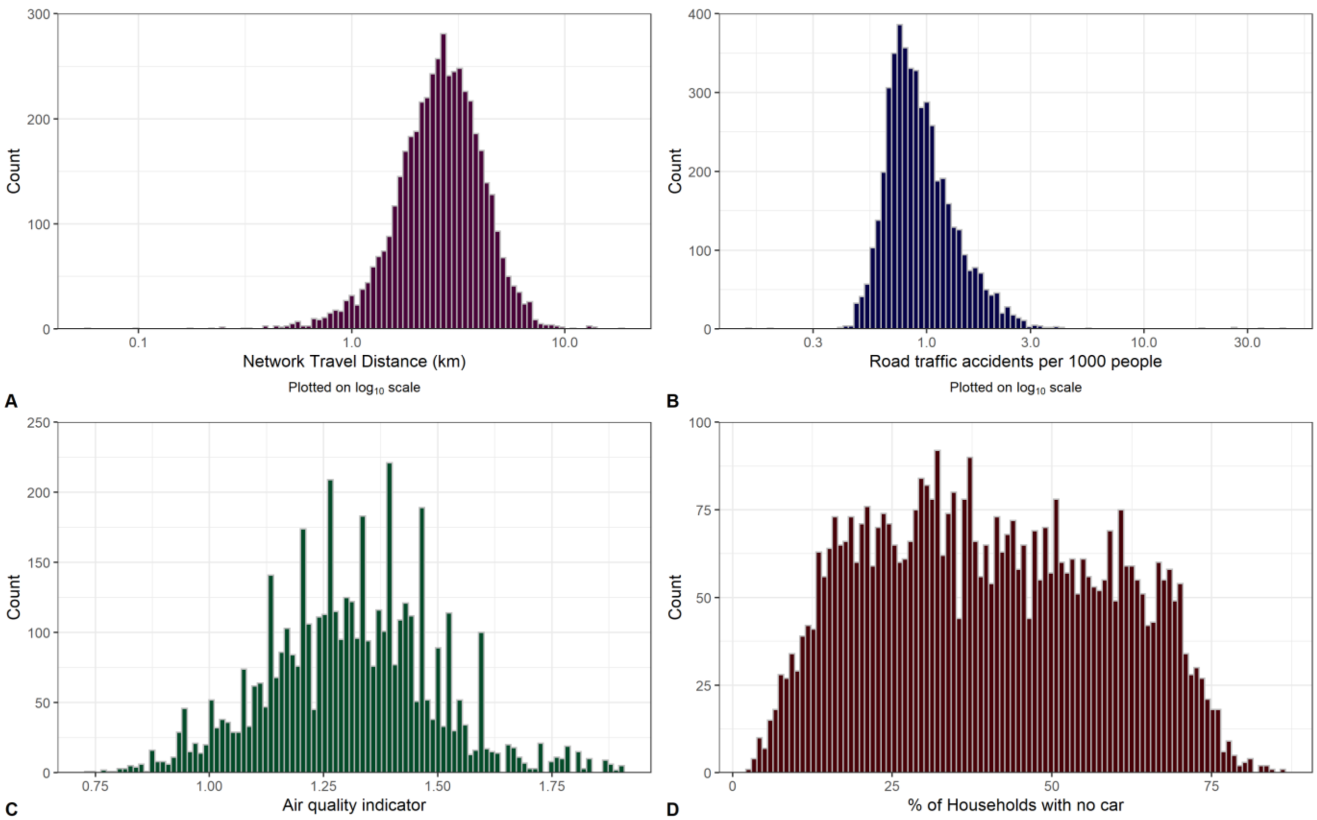

Figure 7: *Histogram of A.) Network Travel Distance to School, B.) Road traffic accidents per 1000 people, C.) Air quality indicator, and D.) Percentage of households with no cars. Note: Distance and Traffic accidents are plotted on a log_{10} scale and were transformed before z-score normalization was carried out*

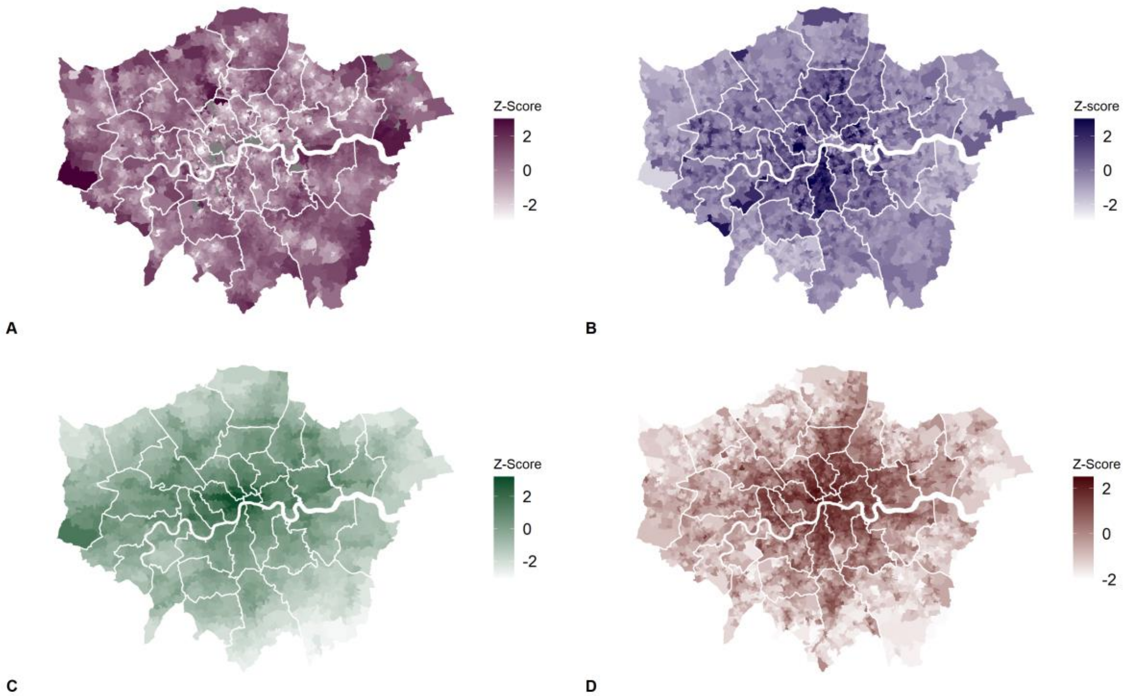

Figure 8: *Z-scores by LSOA of A.) Network Travel Distance to School, B.)Road traffic accidents per 1000 people, C.) Air quality indicator, and D.) Percentage of households with no cars.*

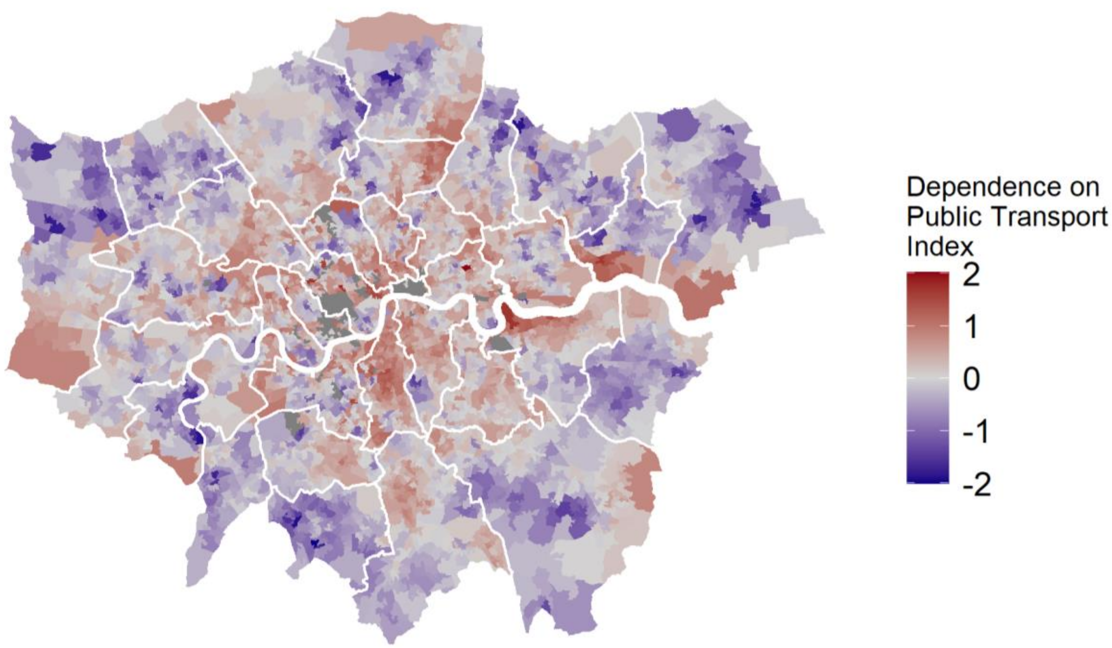

Figure 9: *The Dependence on Public Transport Index mapped. Children living in LSOAs with a greater index value are more dependent on public transport.*

4.2. Deprivation, ethnicity and dependence on public transport

Figure 10 shows IPTD in each LSOA, grouped by quintiles. The LSOAs in the 5th quintile, representing the 20% most dependent on public transportation, are shown in Figs. 11 and 12 along with Index of Multiple Deprivation and proportion of BAME.

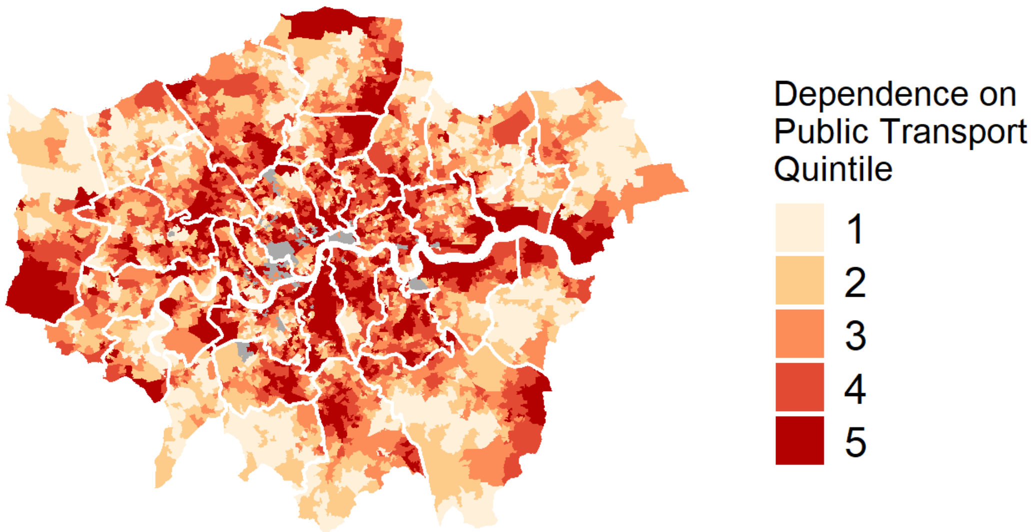

Figure 10: *Index of Dependence on Public Transport, grouped by quintiles*

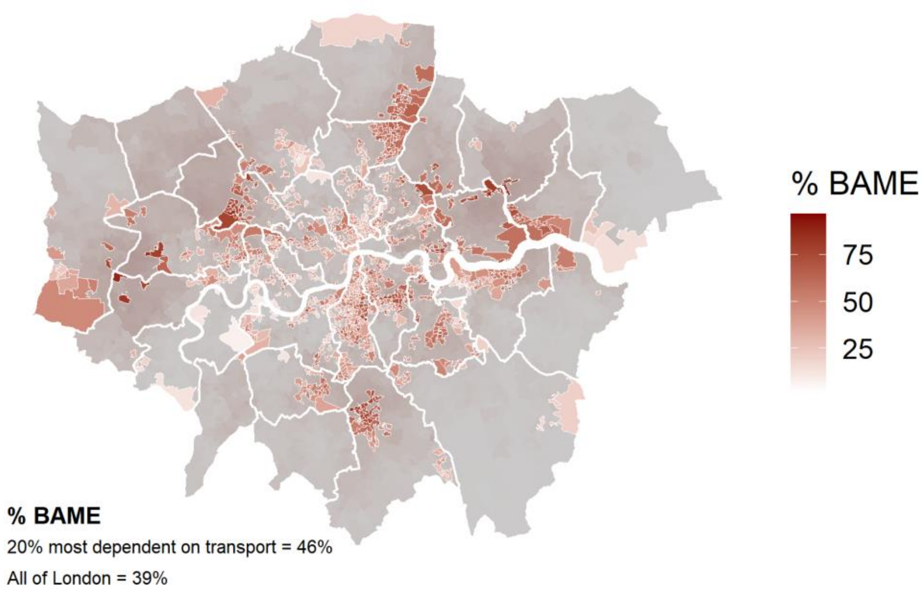

Figure 11: *Chloropleth Map showing the LSOAs in the 5th quintile of IDPT with proportion of BAME inhabitants*

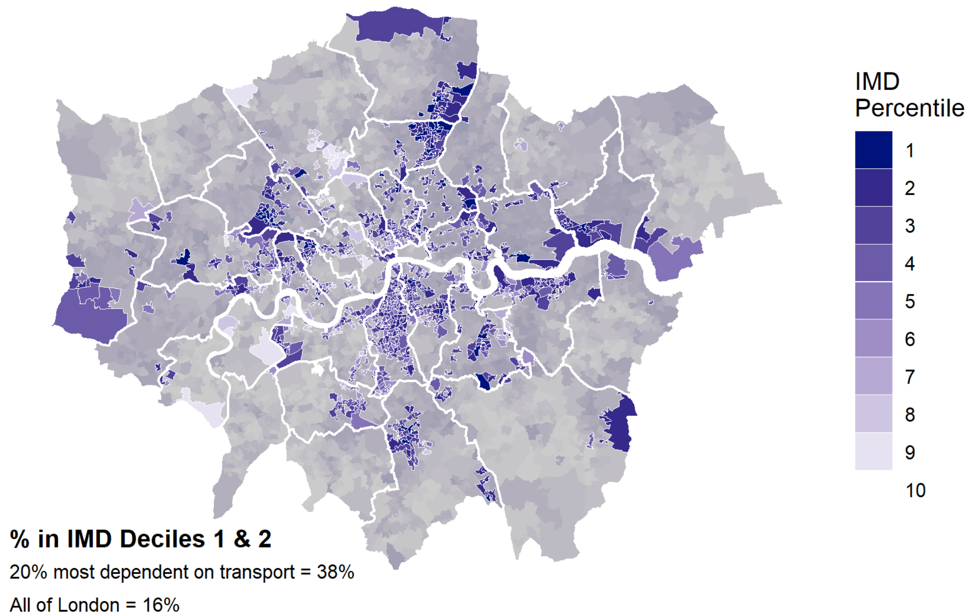

Figure 12: *Chloropleth Map showing the LSOAs in the 5th quintile of IDPT with IMD Deciles*

Table 5. *Comparing Average Straight Line Distance & Network Distance*

Variable	5^{th} IPTD Quintile	Greater London
% of LSOAs in IMD deciles 1 and 2	38%	16%
% BAME in LSOAs	46%	39%

Table 6: *Comparing Central London with Greater London*

	Central London	**Greater London**	**Percentage (%)**
Number of LSOAs	74	4761	16%
Number of LSOAs in 5th IPTD Quintile	364	952	38%
Percentage (%)	49%	20%	

4.3. Dependence on Public Transport and Income

The bivariate plot combining household income with dependence on public transport is shown in Fig. 13.

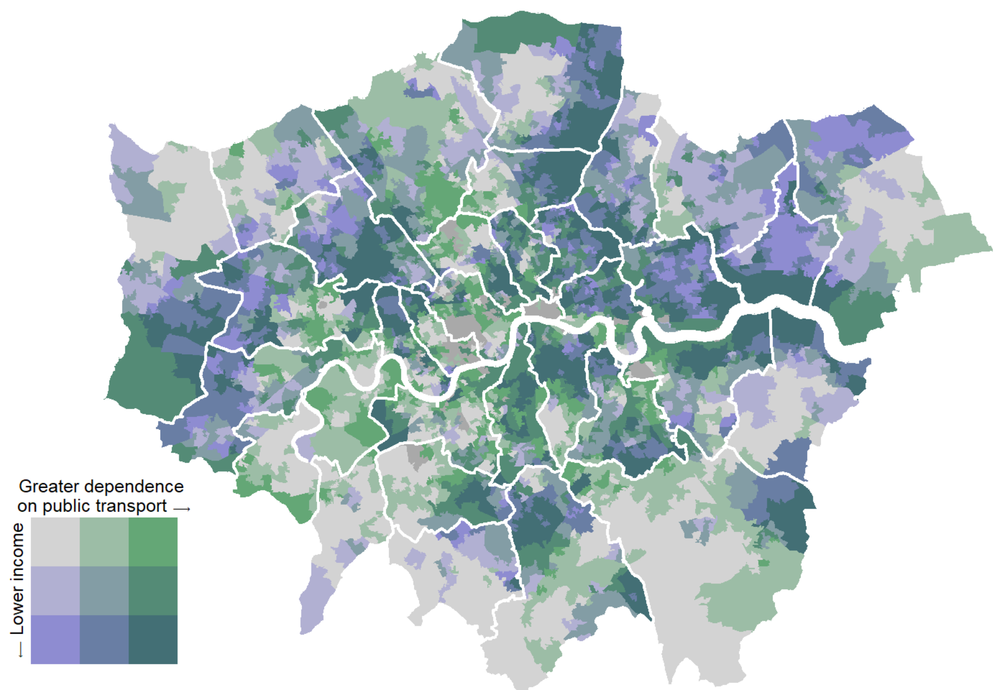

Figure 13: *Bivariate map showing dependence on public transport against household income. Shades of darker green indicate high dependence with low income levels.*

5. Discussion

5.1. Dependence on Public Transport

The histogram in Fig. 5 shows the average walking distance per LSOA. Half of London's LSOAs have an average network walking distance of more than 2.5km. Assuming an average walking speed of 5 km an hour, this would suggest that more than half of London's secondary school pupils would spend at least an hour walking if no other transport option to school is available.

Figure 6 shows that pupils in outer London neighborhoods travel greater distances to school. This is likely as outer London is less densely populated and consequently has greater LSOA areas, resulting in higher average travel distances.

The other three factors in Fig. 8 seem to follow an opposite trend, with larger values being concentrated towards the centre of the city. This is likely because traffic accidents, air quality, and car ownership all correlate to population density. While students in these areas have shorter distances to travel to school, these other factors are influencing their dependence on public transport.

Consequently, from Figs. 9 and 10 and Table 6, the majority of LSOAs most dependent on public transport are located in central London. The 7 Central London boroughs (Camden, Kensington, City of London, Islington, Lambeth, Southwark and Westminster) contain 38% of LSOAs with the top 20% IDPT, while only containing 16% of all London's LSOAs. This suggests that the removal of free travel will disproportionately affect young people living in central London.

5.2. Deprivation and BAME

Fig. 11 and 12 shows the distribution of IMD and BAME inhabitants in the LSOAs most dependent on public transport.

The 20% areas with the highest dependence on public transport also have a greater proportion (47%) of Black, Asian and Minority ethnic inhabitants than the whole of London (36%), suggesting that BAME populations will be disproportionately affected by the removal. The PYL survey found that Black and Asian students had the lowest rates of walking and cycling to school, further highlighting this inequality (Partnership for Young London, 2020) .

Of the 952 LSOAs in the top 20%, 38% have an IMD Index in the top 20% (top 2 deciles) most deprived in the UK. For the whole of London, this proportion is 16%. This result is expected, as two of the variables used in the index, traffic accidents and air quality, are also used as underlying indicators for IMD.

5.3. Income and Dependence

Fig. 13 combines the dependence on public transport with household income to identify the areas where the removal of public transport will have the greatest impact. From the map, the East of London appears to have more areas with high dependence and low income. From Fig. 14 it can be seen that the worst performing borough is Southwark, with 39% of its LSOAs having a high dependence on public transport with low income. Haringey and Hackney follow closely. These three boroughs all have greater than average proportions of BAME inhabitants, confirming that the change would strongly impact young people in minority groups.

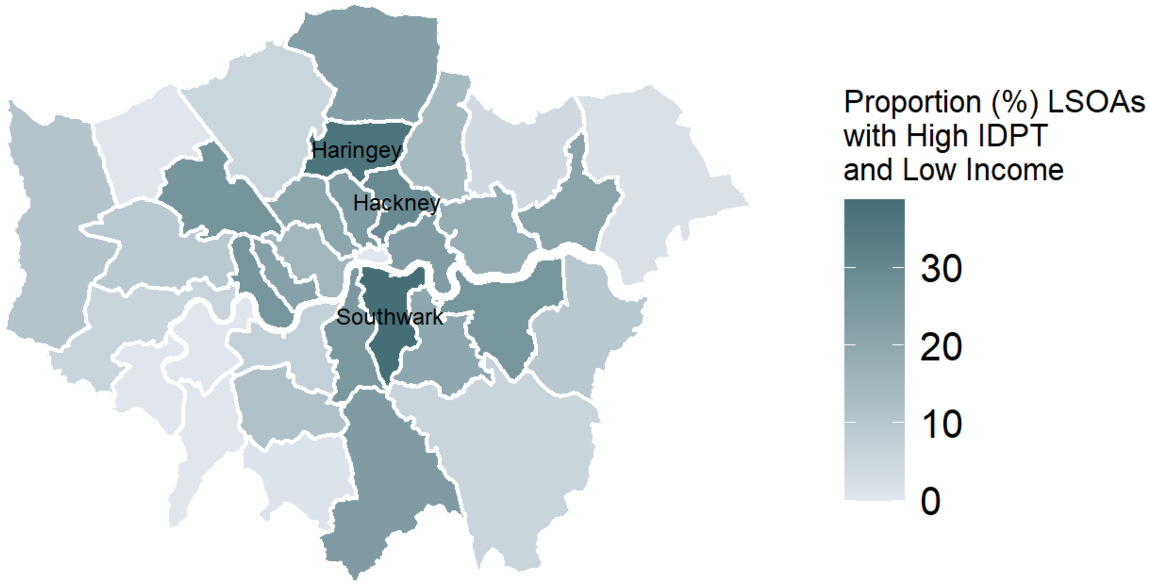

Figure 14*: Proportion of LSOAs with High IDPT and Low Income, by Borough*

5.4. Limitations

This investigation has a number of limitations. The weights applied to the z-scores were based on interpretations of existing literature, but they may not reflect entirely the real drivers for the transport choices of young people in London. A survey on what factors influence dependency on public transport may make the weights more representational. It is also important to consider that this index is a simplification of the dependence on public transport. In reality this dependence is influenced by a variety of factors, many interrelated and nuanced, thus difficult to quantify.

This study does not include a detailed analysis on the spatial distribution of affected areas. Future analyses could benefit from analysing whether more dependent areas are subject to spatial autocorrelation and clustering, and comment on the implications of this.

6. Conclusion

This work has investigated the possible consequences of removing free travel for 11-to-18 year olds in London. The analysis has found that over 50% of young people living in London have a travel distance to school in excess of 2.5 km. In central London young people are more reliant on public transport than outer areas, and consequently would be more affected by the possible removal of free travel. The correlation between areas with a high dependence on public transport, and areas with lower average household income and/or a higher proportion of BAME inhabitants implies that a possible suspension of the ZIP Oyster Card scheme would disproportionately affect young people from minority ethnic backgrounds living in already deprived areas.

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8. Declaration of Authorship

I, Signe Swarttouw, confirm that the work presented in this assessment is my own. Where information has been derived from other sources, I confirm that this has been indicated in the work.

Signe Swarttouw

Date of signature: 10th of January 2021
Assessment due date: 11th of January 2021