UNIVERSITY OF WESTMINSTER

6DATA004W.2
Data Visualisation and Dashboarding

What is the true impact of the Ultra Low Emission Zone (ULEZ) in London on public health outcomes and healthcare costs?

Jesus Daniel Martin
W1834001

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Intro

As a resident of London for the past nine years, my daily cycling routine has brought me face to face with the city's traffic and its associated pollution. This personal experience has made me acutely aware of how pollution can impact our health, with some individuals suffering from severe respiratory illnesses. This personal connection drives me to raise awareness about the ULEZ and its potential to improve the health and longevity of Londoners.

The ULEZ, a zone where heavy pollutant cars are charged a fee upon entry, has been a remarkable journey since its inception in 2015. It started charging non-compliant vehicles in central London in April 2019, marking a significant step towards cleaner air. The zone then expanded its reach in October 2021, covering the inner London area inside the North and South Circular roads. And the journey continues, with ambitious plans to extend the ULEZ to cover all 32 boroughs of London by August 2023.

The most frequent measurements are the concentration of NO2 and PM2.5 to measure the pollution.

NO2, primarily from burning fossil fuels in vehicles, power plants, and industrial facilities, significantly contributes to ground-level ozone and particulate matter pollution. Exposure to NO2 can lead to respiratory issues, diminished lung function, and a heightened risk of respiratory infections, posing a significant threat to our health.

PM2.5 refers to fine particulate matter small enough to penetrate deep into the lungs and even enter the bloodstream. Sources of PM2.5 include natural causes like dust or forest fires and human sources like roadworks, breaks, and motor vehicles. PM2.5 is particularly dangerous because it can carry toxic organic compounds and heavy metals into the respiratory tract and other organs. Health effects can include respiratory and cardiovascular issues, exacerbation of asthma, and even premature death.

Data

The data is from a study published by Webber, Xu, and Graff in 2020, commissioned by Transport for London and the Greater London Authority. Using information on how the pollution level has changed over the years, the introduction of laws to reduce pollution, the increase in the population of London, the cost of hospitalisations, and the social cost of respiratory diseases, they created a model that shows the impact of different scenarios from 2016 until 2050.

Description

In the model, they consider four different scenarios:

Scenario 0: The baseline scenario assumes air pollution levels remain at 2016 levels until 2050.

Scenario 1: The ULEZ scenario includes modelled air quality improvements resulting from the introduction of the central ULEZ in 2019, the tightening of the restrictions of the Low Emission Zone (LEZ) in 2020, and the expansion of the ULEZ in 2021, as well as additional policy measures in the period 2016-2024.

Scenario 2: The London Environment Strategy (LES) scenario, which includes modelled air quality improvements because of the central ULEZ, LEZ tightening and ULEZ expansion, as well as those resulting from additional policies in the LES over the period 2025-2050.

Scenario 3: In the final scenario, reduced exposure to non-anthropogenic levels is used to calculate air pollution's impact on new diseases.

The dataset comprises 68 Excel files covering the 32 boroughs of London and the City of London; for each location, there are two files, one for each particle, NO2 and PM2.5. Also, there is a location for London with the sum of all boroughs. There are no missing values.

Each Excel sheet has different sheets, including the incidence, cases avoided, hospitalisations avoided, NHS cost avoided, and social cost avoided. Another sheet has cumulative values for any of these properties.

Data pre-processing

I used Python to merge all boroughs into one single Excel file. I used Google Collab with the libraries *os*, *openpyxl*, and *pandas* to merge the borough's files into a single file, making managing the dataset easier.

Data Analysis

London: Incidence (Shape Map)

Let's start with a preview feature of PowerBI, a shape map of London with the incidence; this is the occurrence of new cases of disease related to pollution from 2016 to this year:

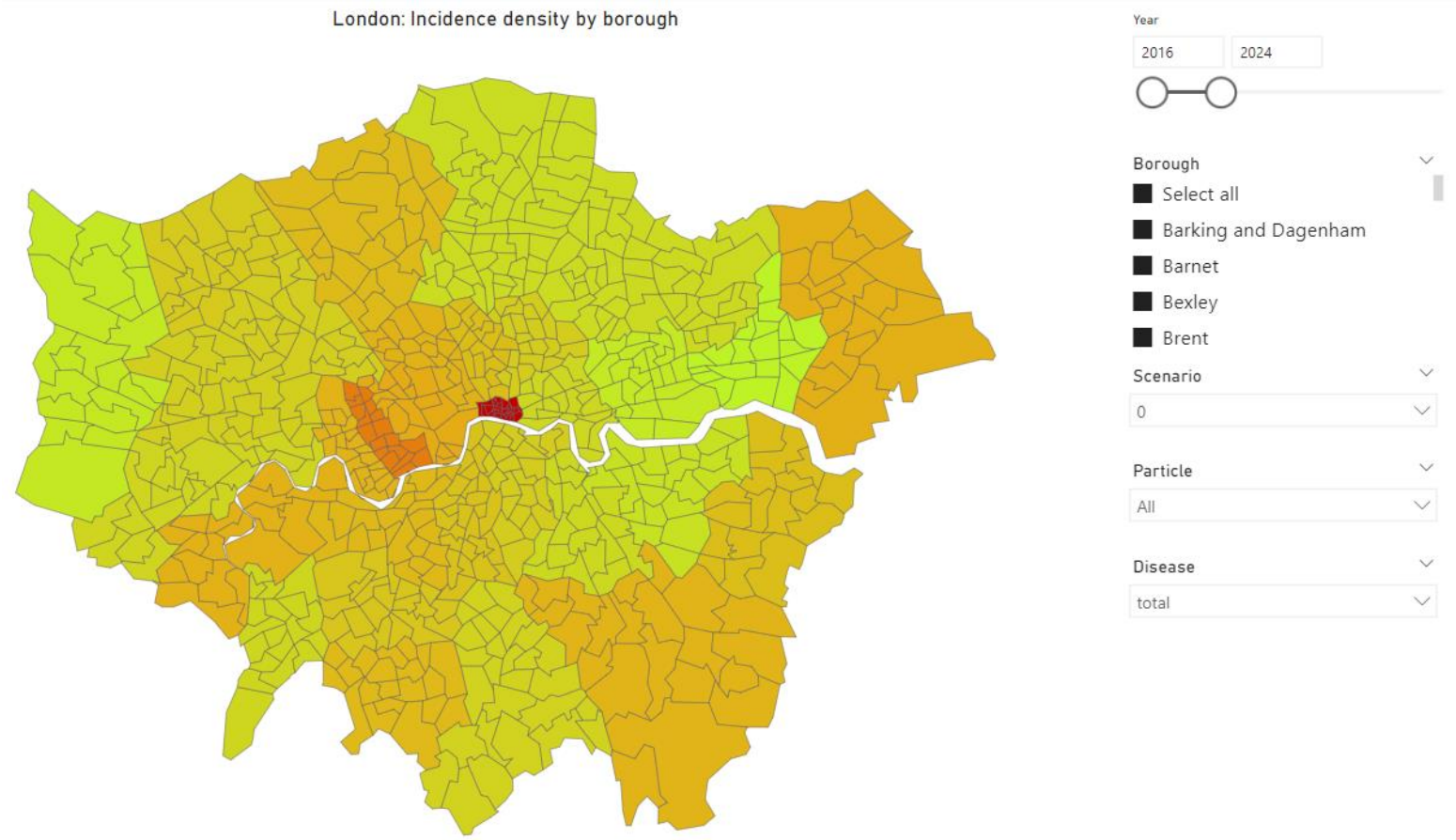

Figure 1 - London, Incidence density by Borough

We can observe that the borough most hit by pollution is the City of London, followed by Kensington and Chelsea. The City of London, as a significant financial district, has dense traffic and high building density, which can contribute to poor air quality. Kensington and Chelsea, a densely populated and affluent area, may also experience similar issues due to traffic and urban activities.

These two boroughs will be incredibly beneficial with a reduction in pollution density.

City of London: Diseases by PM 2.5 (Column Chart)

Let's look at the diseases correlated caused by the pollution of PM 2.5 particles in the City of London.

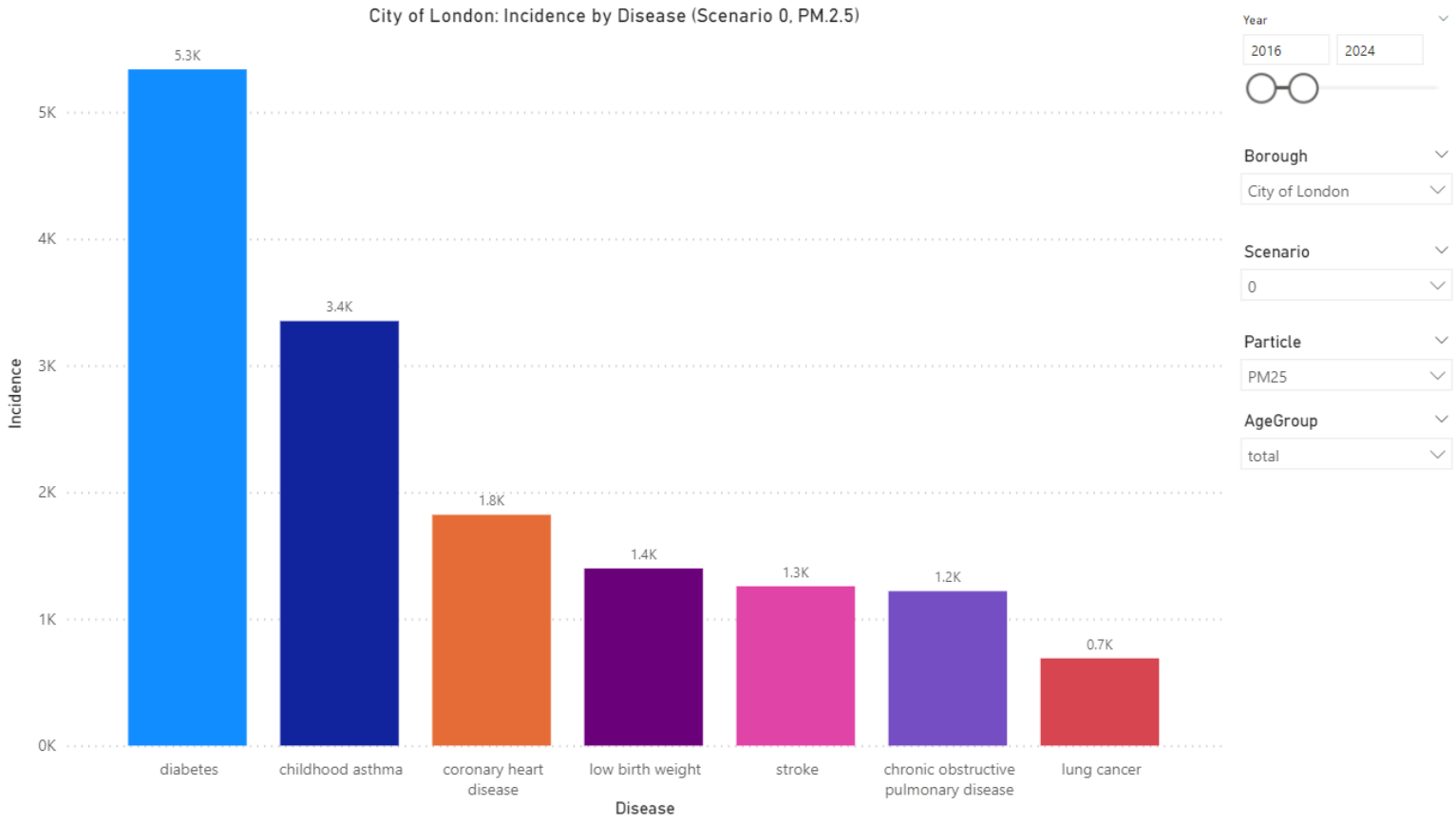

Figure 2 - City of London, Incidence by Disease

The column chart displays the incidence from 2016 to 2024 of various diseases related to the pollution of PM2.5 particles. Here are some highlights:

- Diabetes is the most common condition, with 5.3K (5,338).
- Childhood asthma follows with 3.4K (3,351).

Analysing only the first most common diseases raises some questions, such as whether the numbers for diabetes and asthma seem to be larger than the total population of the City of London; the sum for both is 8.7K, and according to the census of 2021, the population was 8,583, which is peculiar.

We had to consider the sum of incidences over eight years. If we expand this idea, 1.1 K people develop symptoms of diabetes or childhood asthma every year in the City of London.

The model might consider the people employed there; according to the last survey, 2018, there were more than 500,000 workers.

Or it could be that the urban environment contributes to these health issues with high pollution levels. After all, we are exploring scenario zero, which has the same pollution levels as 2016.

London: Incidence by age group (Stacked Column Chart)

Going back to London with all the boroughs, we can see the cases that can be avoided by implementing any of the different scenarios. This avoided incidence results from the difference between the baseline scenario and the measures implemented in scenarios one, two and three. That is why scenario zero is not in the chart.

Figure 3 - London, Avoided incidence by age group

The first insight that we can get from this stacked column chart is that the number of incidences avoided in scenario three is vast. The measure scenario three is the reduction of all pollution generated by humans. This sounds great on paper; it would be amazing to have a quieter and greener London, without cars, construction, roadworks, or trains; this will disrupt the way of living of millions of people while only improving the lives of 0.3 million. This is not a solution.

The second insight is the age distribution; from scenario one, in 2050, we get a cumulative incidence avoided of:

Age group	0 – 5:	1,200	(1.7%)
	06 – 17:	5,788	(8.2%)
	18 – 64:	38,984	(55.1%)
	65+:	24,779	(35.0%)

The distribution of the London population of age 65+ is 18.6% (from census 2021), and 35.0% of the avoided incidence is in 65+; this means that the introduction of measures like the ULEZ and the LES is having a more significant impact on the older population, increasing their life expectancy and improving quality of life.

Westminster: Hospitalisations (Line Chart)

As we are in New Cavendish St, in the borough of Westminster, with the University College Hospital close by, let's analyse the hospitalisations that can be avoided by implementing the ULEZ and LES policies.

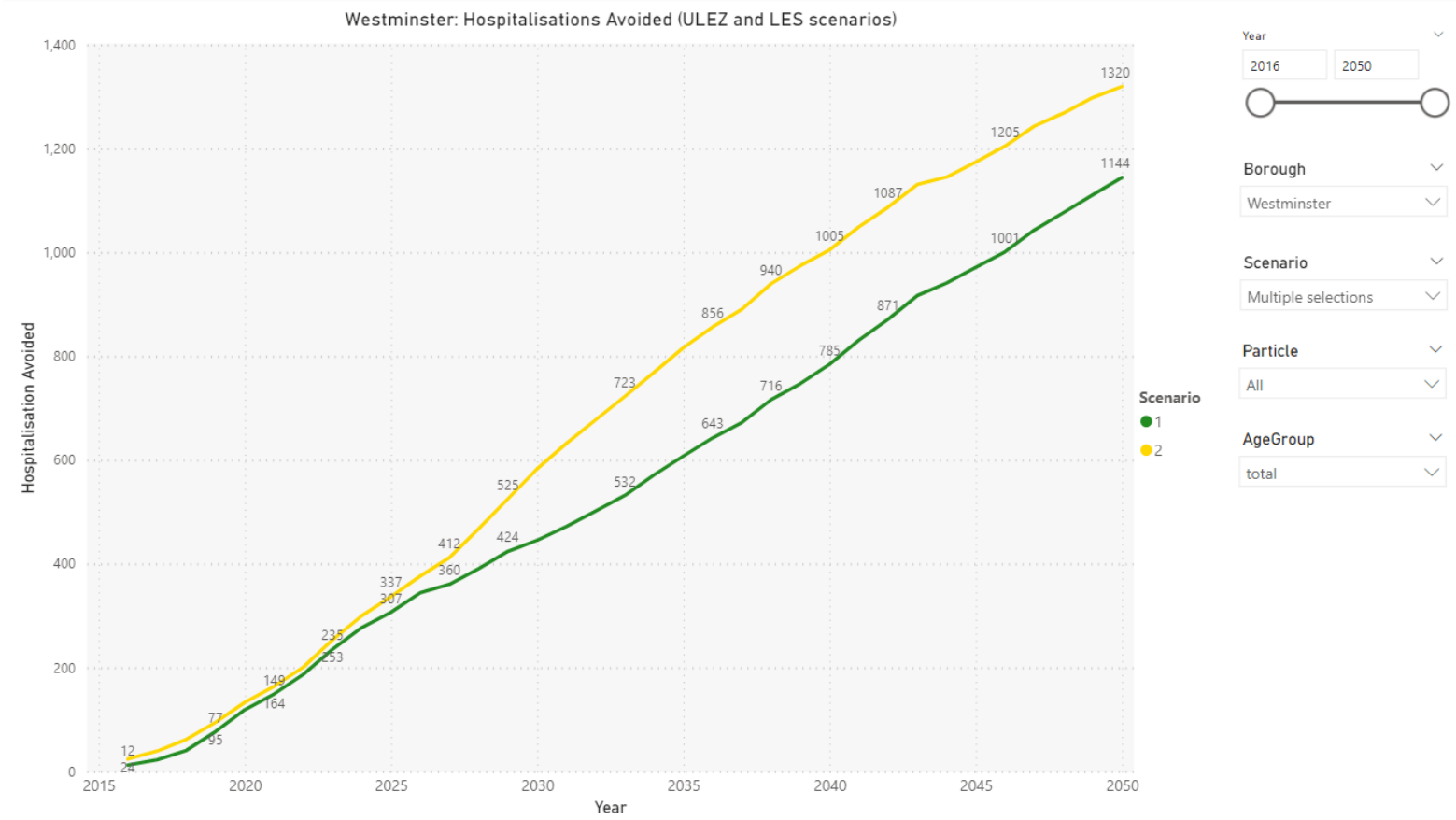

Figure 4 - Hospitalisations Avoided

These figures represent the number of hospitalisations avoided due to the decreased prevalence of diseases related to NO2 and PM2.5. I have selected scenarios one and two, ULEZ and LES, blue and green, respectively, because they are achievable. Scenario three has been disregarded because even if the number of hospitalisations avoided is more considerable, removing all pollution caused by humans is not realistic.

From the line chart, we observed that the lines were very close from 2016 until 2024, and from 2025, the gap between them started to widen. The cause of this separation is that from 2025, the London Environmental Strategy will have tighter and additional policies than the Ultra Low Emission Zone.

Implementing the ULEZ in Westminster is estimated to prevent 1,144 hospitalisations annually and associated costs by 2050.

London: NHS (Stacked Line Chart)

In the ULEZ scenario, the following stacked line chart represents the potential savings on cost avoided for the NHS.

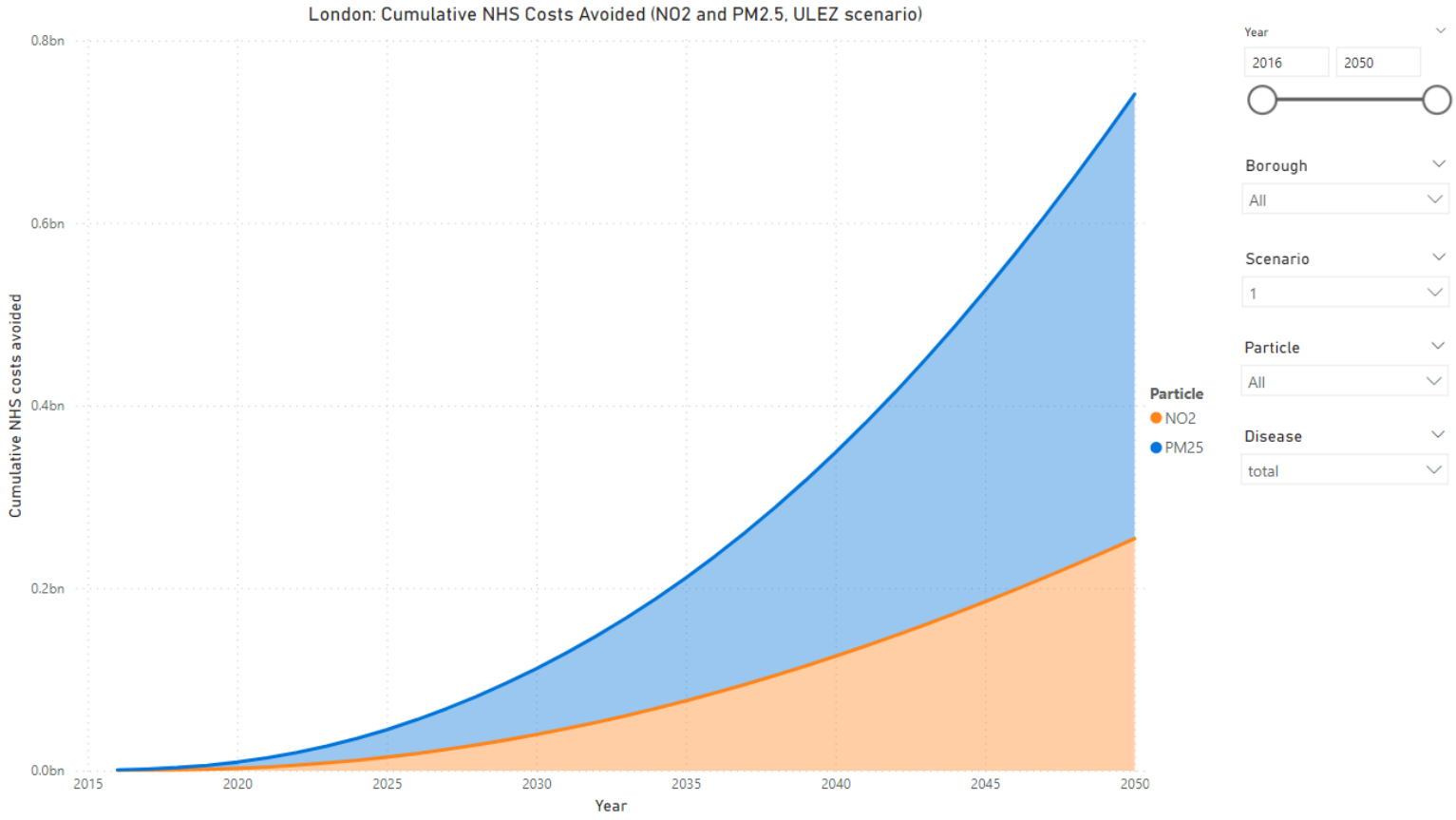

Figure 5 - NHS Cost Avoided

We can observe that the particle with a broader area is PM2.5. These particles are related to more diseases or diseases that are more expensive to treat than those associated with NO2.

If all measures from the ULEZ scenario are fulfilled, the potential savings for the NHS could be £0.2bn by 2035 and almost £0.8bn by 2050.

In perspective, the estimated final cost to deliver the expanded ULEZ ranges from £145 – 155m, as reported in November 2022. We also must consider that TfL estimates that the London-wide ULEZ could generate up to £200 million a year in net revenue for the first two years following expansion. However, this will decline sharply with no surplus by 2026/27 as compliance increases.

Saving costs in the NHS can benefit the community. It ensures essential services and treatments are available to those who need them most. It also facilitates investment in medical technologies and research and improves healthcare outcomes. Moreover, efficient financial management enhances patient care and contributes to the sustainability of the health system.

London: Social care (Stacked Line Chart)

It is similar to the previous chart but displays the social care costs avoided by implementing the ULEZ.

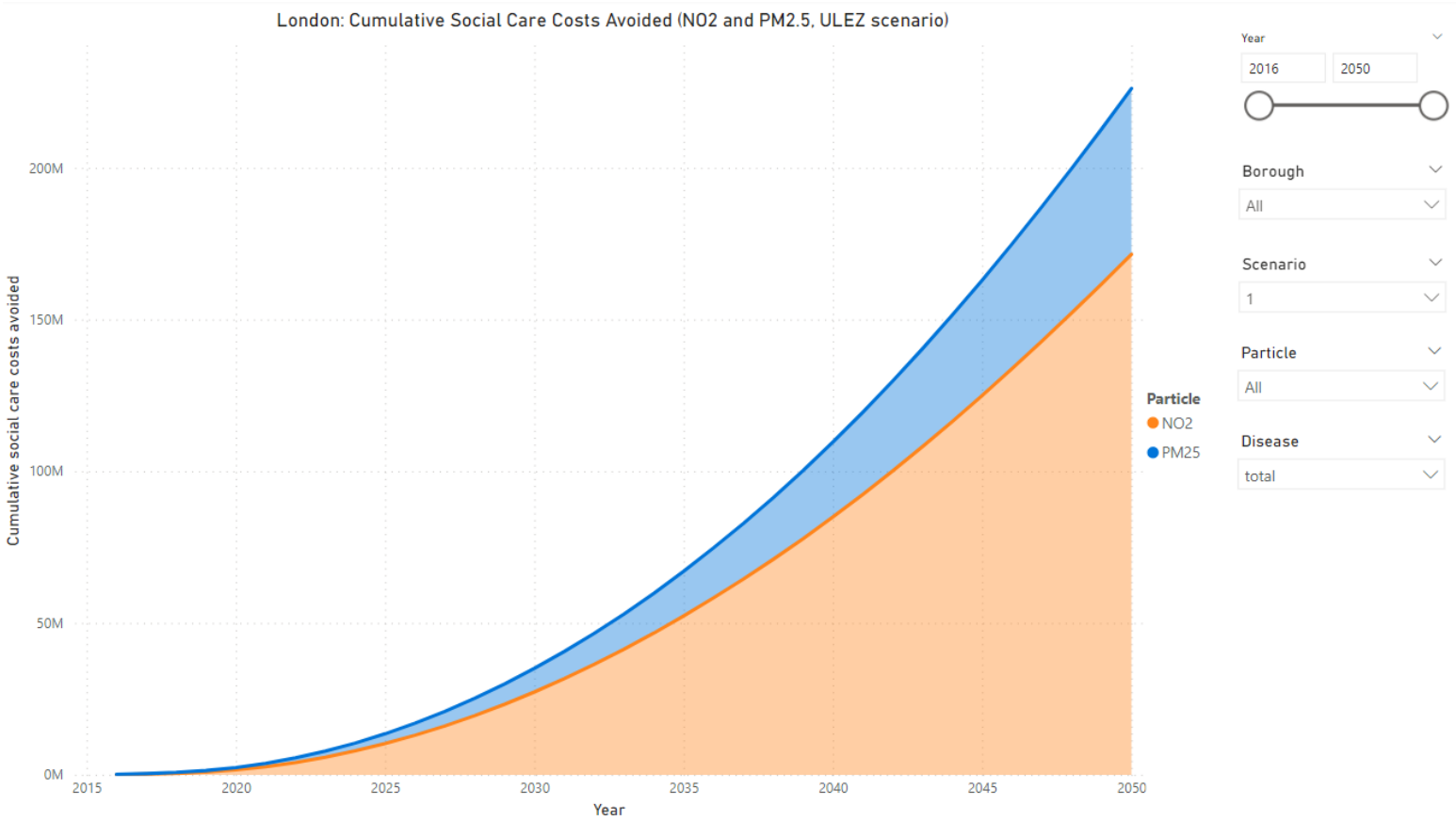

Figure 6 - Social Care Cost Avoided

PM2.5 particles significantly impact NHS costs, while NO2 affects social care costs more. The avoided social care cost in 2050 could be £225m, where £171m is related to the NO2 reduction levels and £54m is associated with the reduction of PM2.5.

Conclusion

As a Londoner who lives in Southwark, studies in Westminster, and works in Kensington and Chelsea, the map shows how implementing the ULEZ and some of the London Environmental Strategy has affected my daily health and improved the air I breathe.

The column chart taught me that pollution can cause chronic diseases that don't necessarily have to be respiratory. The disease more related to the pollution of PM 2.5 is diabetes. The City of London needs cleaner air.

In the stacked column chart, it is evident that people aged over 65 years would benefit the most from pollution reduction. While reducing pollution to natural levels would be great, achieving this target is still a far-off vision. However, we can accomplish the ULEZ and LES policies as a minimum necessary for green air. As a society, we should strive towards reaching this point.

Based on the line chart, stricter pollution regulations are associated with more avoidable hospitalisations. This is a positive sign for public health as it leads to cost savings for healthcare systems, frees up resources for critical areas of public health, and enhances patient care quality. The University College Hospital in Warren St would favour supporting the Ultra Low Emission Zone (ULEZ).

From the stacked line charts, we observe that the implementation and the initial payment of almost £155m for the ULEZ can have great returns, saving £0.8bn just in the NHS.

Adding the £200m of social care cost avoided, London could save up to a billion pounds by implementing policies regulating air quality.

ULEZ was extended to encompass all 32 boroughs just over a year ago. This and other initiatives have propelled the city towards a more sustainable and eco-friendly future. Fast-forward to 2024, the improved air quality is apparent city-wide, with all residents now able to breathe cleaner air thanks to initiatives like the ULEZ.

The reason behind visualisations

The colours on the graphs have high contrast and are suitable for people with colour blindness.

London, Shape map

It makes it easy to relate pollution to specific boroughs of London. Utilising colour or shading to depict diverse levels of pollution density is an effective method for facilitating the quick and easy comprehension of complex data.

City of London, Column chart

Column charts are an excellent tool for comparing multiple categories at once. When analysing the impact of pollution on various diseases, a column chart can help viewers quickly compare the incidence rates across different diseases. This visual comparison can help identify which health issues are most affected by pollution, providing a better understanding of the broader health implications.

Column charts are inherently quantitative, clearly indicating the magnitude and making them a robust visual communication tool.

London, Stacked column chart

A stacked column chart is an effective way to display pollution incidence by age group. It shows the total incidence and distribution across age groups within the same chart. Comparing the cumulative total and individual segments in one glance makes it easier to identify which age groups are most affected by pollution.

Adding small multiples with different scenarios to a stacked column chart allows a side-by-side comparison of how pollution affects various age groups.

Westminster, Line chart

A line chart that displays two scenarios is an excellent way to show the impact of pollution reduction on avoided hospitalisations. It allows for comparing outcomes over time between different scenarios, such as the ULEZ and the LES. This chart type is intuitive and easy to understand, making it accessible to a diverse audience.

London, Stacked line charts

A stacked line chart highlights the avoided costs of reducing NO2 and PM2.5 pollutants. The chart shows the individual contributions of each pollutant to the overall cost savings in the NHS and social care, as well as the cumulative effects of reducing both contaminants. By stacking the lines for NO2 and PM2.5, the chart clearly represents the total avoided costs when both pollutants are reduced.

Resources

Main report:

Webber, L., Xu, M. and Graff, H. (2020) 'Modelling the long-term health impacts of changing exposure to NO2 and PM2.5 in London', *Greater London Authority.* Available at: https://www.london.gov.uk/programmes-and-strategies/environment-and-climate-change/environment-publications/modelling-long-term-health-impacts-air-pollution-london (Accessed: 22 April 2024).

PDF:

https://www.london.gov.uk/sites/default/files/modelling_the_long-term_health_impacts_of_changing_exposure_to_no2_and_pm2.5_in_london_final_250220_-4.pdf (Accessed: 22 April 2024).

Original Datasets:

https://data.london.gov.uk/dataset/long-term-health-impacts-of-air-pollution (Accessed: 22 April 2024).

GitHub Code

https://github.com/KorvenDalas/w1834001_DataVisualisation_Y6/blob/main/Data_V.ipynb (Accessed: 22 April 2024).

Dataset after preprocessing:

https://drive.google.com/file/d/1FjCxqdbyU6qq2hKSDxwoCYam-b1vt2mV/view?usp=sharing (Accessed: 22 April 2024).

References

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Office for National Statistics (2023) ‘How life has changed in the City of London’, *Census 2021*. Available at: https://www.ons.gov.uk/visualisations/censusareachanges/E09000001 (Accessed: 22 April 2024).

Age UK (2023) ‘Facts and Figures’, *Census 2021*. Available at: https://www.ageuk.org.uk/london/about-us/media-centre/facts-and-figures/ (Accessed: 22 April 2024).

City of London (2018). ‘Economic Statistics’. Available at: https://web.archive.org/web/20190828214510/https:/www.cityoflondon.gov.uk/business/economic-research-and-information/Pages/economic-statistics.aspx (Accessed: 22 April 2024).

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