Supplemental Information 2: Methods used to process parking permit records and calculate mean past-year driving

The Parking team of Lambeth Council supplied us with data on all active parking permits as of 1st March 2018, 1st March 2020, and 1st March 2023. The fields provided were numberplate (also known as 'vehicle registration mark'), home postcode, permit start date, and permit type. Our analysis focused on 'residents' permits and 'disabled' permits, which are centred on a person's home.[1] We did not include 'estate' permits here (i.e., parking permits for residents on housing estates) as this permit type was only available in the 2023 dataset. We also did not look at permits centred on places of work ('business', 'teachers' and 'doctors' permits) as these represent under 2% of all parking permits issued by Lambeth, and so an analysis of these would not be meaningfully powered.

Numberplates are unique but can be switched between vehicles. The first step in processing these data was to use the permit numberplate plus permit start date to identify the current (as of March 2023) numberplate of a given vehicle. This was done using the numberplate lookup services of UK Vehicle Data (https://ukvehicledata.co.uk). The second step in processing these data was to use the current numberplate to look up 1) vehicle data including keepership history (via UK Vehicle Data) and 2) MOT history (via the Driver and Vehicle Standards Agency's MOT history API https://findtransportdata.dft.gov.uk/dataset/mot-history-api). These processing steps were done in March 2023.

We focussed our analysis on cars and vans, using the 'SMMT market sector' and 'doorplan' fields of the vehicle data to exclude the 1% of vehicles of other types (e.g., caravans, motorcycles, and taxis).

In the UK, all cars and vans that are three or more years old must undergo an 'MOT test' every 12 months. This MOT test includes recording the mileage on the odometer (i.e. the dashboard gauge showing distance travelled). Among cars/vans with an active permit as of 1st March 2020, we sought to compare odometer readings between two successive annual MOTs in the window 1st March 2018 to 1st March 2020 ('pre-LTN'). Similarly, among cars/vans with an active permit as of 1st March 2023, we sought to compare odometer readings between two successive annual MOTs in the window 1st March 2021 to 1st March 2023 ('post-LTN').

Finally, among cars/vans with an active permit as of 1st March 2018, we sought to compare odometer readings between two successive annual MOTs in the window 1st March 2016 to 1st March 2018. We did this in order to examine whether any pre/post changes observed between 2020 and 2023 permit holders might be a continuation of longer-term trends. In particular, if there were already a downward trend in driving levels inside the LTNs prior to 2020, then this would reduce confidence that any subsequent further decrease could be attributed to the LTN schemes.

To select the two successive MOT tests of interest, we started by identifying the most recent MOT in the window as the second selected MOT. We then identified the MOT-before-that as the first selected MOT (ignoring any MOTs within the past week, because vehicles often initially fail an MOT and then pass it within a day or two after having remedial work). For example, imagine a vehicle had MOT tests on the following dates, and with the following passed/failed test results: 5th March 2021 (PASSED), 2nd March 2022 (FAILED), 3rd March 2022 (PASSED), 25th February 2023 (FAILED), 28th February 2023 (PASSED). The test on 28th February 2023 would be chosen as the second selected

[1] Unfortunately, we did not have sufficient power to compare impacts across these two permit types, as only around 1% of these permits are 'disabled'.

MOT, as it is the most recent. The test on 25th February 2023 would be ignored, as it is less than a week earlier. The MOT on 3rd March 2022 would therefore be chosen as the first selected MOT.

We used the two selected MOTs to generate mean past-year daily kilometres driven. This past-year mean was calculated as the total change in vehicle kilometres across the two selected successive MOT tests, divided by the number of days between the selected tests.

We excluded vehicles from our analysis for several reasons.

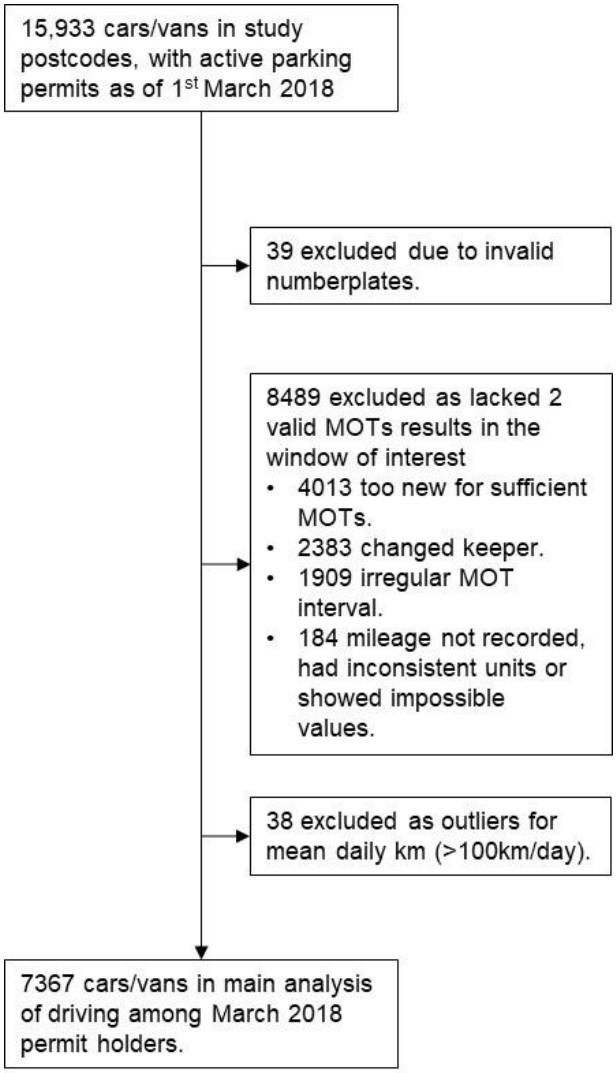
1. **Invalid numberplates**: A numberplate that could not be matched to a vehicle on the UK Vehicle Data database and/or MOT history database.
2. **Vehicle too new for sufficient MOT data**. This covered vehicles less than 4 years old, since vehicles are not required to have their first MOT until they are 3 years old and since we needed two successive MOTs. Across the UK, around 16% of cars/vans are ≤3 years old as of January 2023[2] – in our study this was 25% in 2020 and 21% in 2023 (see Figure 2 of the main text). It is a limitation of the study that information on the annual driving of newer cars/vans is not available. However, we see no clear reason to expect that the impact of LTNs will differ for newer versus older vehicles.
3. **Vehicle changed keeper**: If the vehicle changed keeper during our MOT window of interest, then we trimmed the start and/or dates of the window accordingly. For example, the standard window of '1st March 2021 to 1st March 2023' might shrink to '1st March 2021 to 5th June 2022' if there was a change of keepership on 5th June 2022. We would then still try to identify two successive annual MOTs within the remaining window of interest, but this was not always possible (e.g. because the remaining window was too short). It is a limitation of the study that we are less able to examine impacts on driving levels among cars/vans that change keepership. However, we see no clear reason why the impact of LTNs will differ for this type of vehicle.
4. **Irregular MOT interval**: For vehicles in personal use, the stipulated gap between MOT tests is 12 months. It is possible to get the MOT up to '1 month minus 1 day' early without bringing forward the date of the next required MOT. This means that for personal vehicle use, the expected gap between MOT tests is 11 to 13 months. We excluded vehicles with a longer or shorter gap than this between their successive MOTs, as this may indicate non-typical personal vehicle use. For example, a short MOT gap could indicate use as a private hire vehicle (where 6-month MOTs are required), or a change of driver for a leased vehicle (note that for a leased vehicle, a change of driver does not necessarily imply a change of keepership). Or a longer gap could indicate a vehicle that had been taken off the road for a period of time. In all these cases, the inclusion of such vehicles would be expected to add noise to the analysis, and reduce power to detect effects. A further advantage of requiring a full year between successive MOT tests is that our results are not affected by any seasonality in levels of driving. Our findings were similar in a sensitivity analysis that included vehicles where the interval between MOTs was 7 to 19 months.

[2] European Automobile Manufacturers' Association (ACEA). 2023. Vehicles in use in Europe, 2023. Accessed 14/04/2023 from https://www.acea.auto/files/ACEA-report-vehicles-in-use-europe-2023.pdf . Percentages calculated from Tables on pages 10 and 11. The higher proportion of newer cars in Lambeth may possibly reflect people buying newer cars in response to the expansion of London's Ultra Low Emission Zone across our study area. This Ultra Low Emission Zone charges older and more polluting cars a daily rate of £12.50 to drive within the Zone. The expansion was announced in June 2018 and happened in October 2021.

5. **Mileage not recorded, had inconsistent units, or showed impossible values**: 'Mileage not recorded' refers to vehicles where an odometer was marked during the MOT test as not present or as unreadable. 'Inconsistent units' refers to vehicles where the units assigned to the odometer varied between miles and kilometres across different MOT tests, suggesting some of these tests had inputting errors and meaning one could not calculate mean daily past-year kilometres with confidence. 'Impossible values' referred to vehicles in which the mileages recorded in the selected MOT tests yielded past-year daily kilometres with a mean below zero or above 500km/day. Such impossible values are likely to reflect inputting errors when recording the odometer value.
6. **Outliers**: In our main analysis, we excluded as outliers vehicles with a past-year mean of over 100km/day. This represented around the top 0.5% of mean past-year daily kilometres, and we thought it likely that many of these extremely high values reflected inputting errors (just as we assumed such errors explained 'impossible' mean values of over 500km/day). Our findings were similar in sensitivity analyses that a) used a lower threshold to identify outliers, excluding vehicles with a past-year mean of over 50km/day (the top 5% of all vehicles), or b) did not exclude any vehicles as outliers, but instead reduced their influence by using log-transformed daily kilometres as the outcome. Note that we prefer to present untransformed values as our main analysis due to the greater ease of interpretation.

The flow diagram in the main text shows the number of vehicles excluded for each reason in the 2020 ('pre') and 2023 ('post') samples. An equivalent flowchart is shown below for the exclusion of vehicles with parking permits as of 1st March 2018.

Figure A2.1: Flow chart of cars and vans included in our study sample for analysis of mean past-year driving among cars with an active 'resident' or 'disabled' parking permit on 1st March 2018



Our primary analysis included all cars/vans in the 'pre' (2020) and 'post' (2023) samples. A secondary analysis restricted the sample to vehicles from households present at the same address both 'pre' and 'post'. We identified these households as ones where the same numberplate was present at the same postcode in both the 2020 'pre' and 2023 'post' records of parking permits. Note that not all the vehicles in stable households had useable data at both time points, for example some were too new to have had two MOTs in 2020 but did provide data in 2023.

A further secondary analysis stratified by small-area deprivation status. This was defined as the less deprived half relative to all of London versus the more deprived half relative to all of London.