CLIENT PROJECT REPORT CPR 2808

COVID-19 Response: London Bus Garage Temperature Testing Trial

C Ellis, S Chowdhury, R Ramnath, A Edwards, C Wallbank

Report details

<table>
<tr><td colspan="2">Report prepared for:</td><td colspan="2">TfL</td></tr>
<tr><td colspan="2">Project/customer reference:</td><td colspan="2">CPR 2808</td></tr>
<tr><td colspan="2">Copyright:</td><td colspan="2">© TRL Limited</td></tr>
<tr><td colspan="2">Report date:</td><td colspan="2">4th September 2020</td></tr>
<tr><td colspan="2">Report status/version:</td><td colspan="2">Final</td></tr>
<tr><td colspan="4">Quality approval:</td></tr>
<tr><td>Indi Gill
(Project Manager)</td><td></td><td>Caroline Wallbank
(Technical Reviewer)</td><td></td></tr>
</table>

Disclaimer

This report has been produced by TRL Limited (TRL) under a contract with TfL. Any views expressed in this report are not necessarily those of TfL.

The information contained herein is the property of TRL Limited and does not necessarily reflect the views or policies of the customer for whom this report was prepared. Whilst every effort has been made to ensure that the matter presented in this report is relevant, accurate and up-to-date, TRL Limited cannot accept any liability for any error or omission, or reliance on part or all of the content in another context.

Contents amendment record

This report has been amended and issued as follows:

Version	**Date**	**Description**	**Editor**	**Technical Reviewer**
1	18.08.20	Draft report	SC CE	CW
2	04.09.20	Final report	SC CE AE	CW

Document last saved on:	04/09/2020 18:59
Document last saved by:	Ciaran Ellis

Executive Summary

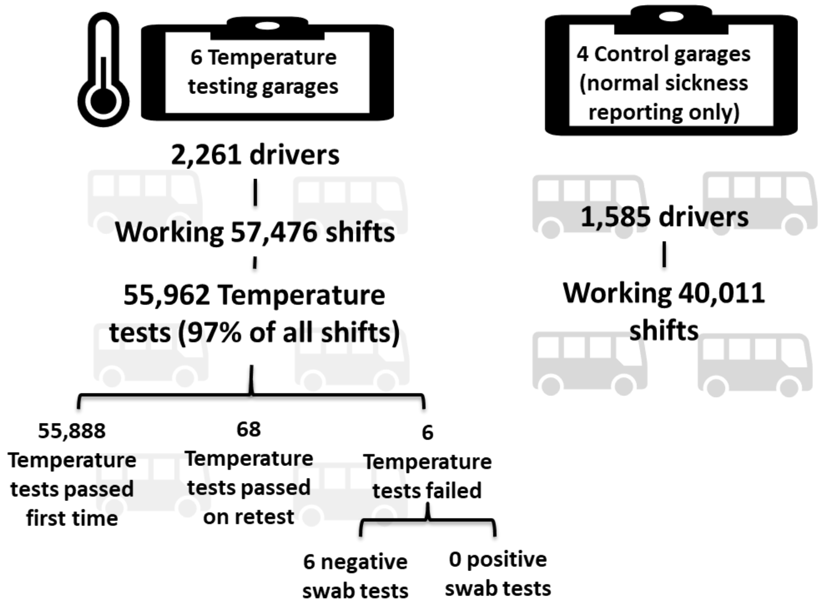
London Bus Garage Temperature Testing Trial

Bus drivers and other public transport workers in London have been seriously impacted by the COVID-19 epidemic. In response to staff concerns, bus operators in conjunction with TfL and following discussions with the bus drivers' union, Unite, put a series of measures in place to protect drivers and other staff. As part of these measures, on-site temperature testing of bus drivers was trialled in bus garages across London.

Trial set-up

Six bus garages carried out temperature testing and four garages followed normal reporting procedures to act as a control. Both sets of garages recorded numbers of drivers, numbers of tests and passes/fails (where applicable) and any drivers self-reporting COVID-19 symptoms. The analysis aimed to investigate whether rates of infection were the same across experimental and control garages and whether the accuracy of the test could be determined.

Data summary



Temperature testing participation and results

- Almost all tests conducted recorded a normal temperature range on the first attempt (55,888, 99.9% of the total).
- Participation in the trial was voluntary for both drivers and operators. Most drivers were happy to participate in the temperature testing, non-participation levels were steady at 1% throughout the trial and were 0% at some garages.

- Out of the total tests conducted 74 reported high temperatures. In 68 of the cases where a high temperature was recorded, the driver had a temperature within the acceptable range after retesting (following a 5-minute wait).
- In six instances the drivers’ temperature did not return to within the accepted range in the 5 minutes. In these cases, the drivers were asked to return home to self-isolate and arrange a swab test.
- These six drivers all returned to work following negative swab tests. The average time lost due to self-isolating and awaiting a swab test was 2.8 days.

Self-reported illness at the garages

- A further eleven drivers reported sick during the trial with COVID-19 symptoms. These drivers were asked to arrange a swab test: all swab tests adminstered came back negative. The number of drivers self-isolating was consistent between the experimental and control groups.

Logistics and Implementation

- Temperature testing was straightforward for operators to implement at the garages involved. Issues arising from garage layout could make implementation more difficult at other garages.
- The learnings from the implementation of the testing are captured in the report along with considerations of the use of two different equipment types: remote scanning and handheld devices.

Conclusions and Recommendations

The trial took place within the context of a low background infection rate and with other protection and prevention measures in place. No COVID-19 cases occurred at the garages involved in the trial during the six-week trial, either identified by temperature testing or via normal sickness report procedures. It was not possible to measure the accuracy of the test in detecting COVID-19, as no cases of COVID-19 were detected during the trial. Evidence was reviewed from other epidemics; mass-screening has not previously been found to be an accurate means of identifying cases of infectious disease and characteristics of SARS-CoV-2 (long incubation period and the possibility of asymptomatic spread) mean that temperature testing alone is unlikely to be effective in preventing the spread of COVID-19.

There isn’t currently evidence to support a large-scale roll-out of temperature testing. However additional behavioural research and a standardised approach to data collection and sharing across different industries could better inform the benefits and disbenefits.

Recommendation 1: Behavioural Research

There may be benefits to temperature testing that are difficult to quantify such as reassuring staff and encouraging team members to monitor symptoms. Additional behavioural research could help to understand the scale of these possible benefits and also identify potential disbenefits from any behaviour change. It is recommended that this additional qualitative insight is gathered from a sample of the experimental garages to gain a full understanding of the benefits and disbenefits of temperature testing in this context.

Recommendation 2: Standardised approach to data collection across industries

The methodology described here leads the way for other organisations who wish to take a scientific approach to temperature testing. Many businesses, large and small are now temperature testing employees; collecting data in a standardised way and combining datasets from multiple sources would advance knowledge of the effectiveness of temperature testing at detecting COVID-19 to the benefit of those working in public facing roles.

Recommendation 3: General advice to garages implementing temperature testing

Garages may choose to implement temperature testing for various reasons, including to reassure staff that symptomatic individuals are not entering the workplace. The report offers some general advice to those wishing to implement temperature testing, including the following:

- Location layout is of critical importance to the successful implementation of on-site temperature testing, some sites may find adapting their premises to temperature testing difficult and time should be allowed for this
- Remote-scanning systems were found to be more convenient than using handheld devices, though involved a larger initial investment
- Early communication with staff and a short familiarisation period with the equipment were important for staff to feel comfortable with the process

Table of Contents

2 Introduction

2.1 Background of trial

The COVID-19 epidemic has had a disproportionate impact on those in public-facing roles including bus drivers and other public transport workers (ONS, 2020). Bus drivers in London have been particularly affected and are understandably concerned about risk of infection during their time at work, including infection risk from colleagues in the workplace.

In response to COVID-19, bus operators and their respective garages have taken a series of measures to reduce risk since the start of the epidemic including enhanced cleaning regimes, adaptations to facilitate social distancing and hand sanitiser stations. Based on a collaborative project with UCL, TRL and TfL, the bus operators have also made modifications to help reduce risk of virus particles being passed to drivers, which include: covered speech holes, sealed gaps around the assault screens, turning off recirculating heating venting and air conditioning systems, and getting drivers to leave their cab window open as much as safely possible. As another part of these measures, the bus drivers trade union, Unite requested a trial of temperature testing and a means of detecting individuals with COVID-19 within the workforce.

The trial aimed to help TfL, Unite and the bus operators to make an informed decision on whether temperature testing should be rolled out in all London garages by answering the following research questions.

1) How accurate is the temperature test at detecting COVID-19 cases?
2) Is COVID-19 temperature testing more effective than normal sickness reporting procedures for ensuring that those with COVID-19 do not work?
3) What are the quantifiable benefits/disbenefits of temperature testing?
   a) How many additional cases of COVID-19 are detected due to temperature testing?
   b) How many drivers are sent home due to temperature testing who ultimately do not have COVID-19?

2.2 Background to temperature testing

In response to COVID-19, temperature testing for employees is now taking place within a range of different business types where working from home is impossible, from factories and airports to small businesses such as restaurants and cafes. Current[1] UK government guidance, however, suggests that temperature testing is not a reliable means of detecting if people have contracted COVID-19 (MRHA, 2020).

The basis of the government guidance comes both from past epidemics of other infectious diseases and from the characteristics of COVID-19. The results of large-scale research available from other epidemics such as H1N1 in 2009 (“Swine Flu”) and Ebola Virus Disease (EVD) in 2014, did not find evidence that temperature testing was an effective way to detect

[1] Up to date at time of writing 14th August 2020

infected individuals. In the case of H1N1, a study looked at data from over 9M passengers who were temperature checked at an international airport. Infrared scanning picked out 930 passengers with elevated temperatures, none of whom were subsequently confirmed to have H1N1 (Nishiura & Kamiya, 2011). The same study also looked at a small number of confirmed cases from stricter airport screening (passengers with a temperature or symptoms underwent diagnostic testing) and found only 2 out of the 9 individuals with confirmed H1N1 following testing had high temperatures at the time of screening. Similarly, temperature testing was not found to be effective for detecting EVD in over 165,000 people screened between 2014 and 2016 in Sierra Leone; none of the passengers denied travel for suspected EVD due to a high temperature subsequently tested positive for the virus, while active cases without high temperatures passed the screening and were allowed the travel (Wickramage, 2019). In both H1N1 and EVD epidemics, there were infected individuals who did not show high temperature as a symptom at the time of screening.

Though the data is only just emerging for COVID-19, a proportion of individuals with COVID-19 have no symptoms. While research indicates these individuals are less likely to spread the virus, asymptomatic transmission has been reported (Evidence for asymptomatic transmission has been reviewed in pre-print by (Byambasuren, 2020)). For those who do get symptoms, fever is not always present (Lechien, 2020; Grant, 2020) and may emerge late in the progress of the illness allowing spread of the disease before this symptom is present (Guan, et al., 2020).

Nonetheless, high temperature is a common symptom of COVID-19[2], and at the time of writing UK government guidance requests that those with a high temperature self-isolate for 10 days[3] (UK Government, 2020). Some workplaces may undertake temperature testing to assist staff in that self-isolation decision and to reassure other staff that symptomatic individuals are not attending work. Limited research has been undertaken on employee attitudes to testing, though a survey undertaken by communications consultancy Burson Cohn & Wolfe (BCW) indicates that the majority of employees are supportive of workplace measures including routine testing, temperature checks and PPE use (Webber, 2020). Besides reassuring staff, any staff member sent home as a result of temperature testing, who would otherwise have gone to work, will prevent potential spread of infection.

2.3 Potential benefits

Potential benefits from COVID-19 temperature testing include earlier detection of COVID-19 infected employees. The main benefit will be of detecting COVID-19 cases that would otherwise have gone undetected until symptoms worsened (if at all).

[2] Estimates for prevalence of high temperature vary – meta-analysis by (Grant, 2020) found that fever effected 78% of COVID-19 sufferers across 148 studies from 9 countries – though the author also notes that the research included is normally carried out in hospitals and therefore is skewed towards those with more severe symptoms. Estimates from an UK/EU observational study of those in hospital with mild to moderate symptoms put the percentage at around 45.4% (Lechien, 2020).

[3] Updated from 7 to 10 days on 30th July 2020

For many of these cases, at some point symptoms would have induced the driver to stay at home, but they will have been prevented from infecting others in the period between the temperature check and other symptoms developing. This period could be referred to as the “infectious days saved”. Collating this data would require detailed information on the progression of symptoms across the period that the driver is away from work. Given this will be difficult to obtain, it is proposed that “infectious days saved” is instead calculated as the period between failing the temperature test and testing positive for COVID-19.

Temperature testing may provide other benefits, it may act as a trigger for drivers to keep self-monitoring of symptoms at front of mind. It may also deter those with high temperatures from attending work, as they know they will be tested and sent home. This would have some benefit in reducing transmission not only of COVID-19, but also other coughs, colds, flu etc, with the benefit of improving the overall health of the driver workforce.

2.4 Potential disbenefits

There are also potential disbenefits of temperature testing. The main disadvantages stem from the fact that temperature is a crude indicator of COVID-19 infection – individuals with a high temperature could be suffering from other infections some of which would not pose a substantial risk to other drivers and passengers. For these individuals that are sent home unnecessarily, working days are lost and shifts must be covered.

Conversely, false negatives are possible. Not all COVID-19 infections result in a temperature. “Passing” a temperature test may instil false confidence and result in lower levels of compliance with COVID-19 prevention measures such as social distancing and workplace hygiene policies.

The study attempted to measure the quantifiable benefits and disbenefits e.g. “infectious days saved” and “working days lost”. The behavioural analysis necessary to measure the more intangible benefits and disbenefits is out of scope for this project.

3 Method

3.1 Overview

The trial took place for six weeks between 22nd June 2020 and 3rd August 2020.

Before the commencement of the trial a working group was set-up with membership from the following organisations:

- TRL – An independent research company commissioned by TfL to undertake the research
- Bus Operators – 6 bus operators took part in the trial
- Unite the Union – representatives from the bus drivers' union
- TfL – the Integrated Transport Authority for London

The working group met regularly throughout the project;

1) Before the trial started: to establish project goals and agree methods
2) Throughout the trial: to discuss any challenges and review data collected
3) After the trial ended: to discuss the draft report

The operators volunteered one or two garages for the trial to take place. Garages were split into experimental (temperature testing) or control garages (following normal sickness reporting).

3.1.1 Operators and garages

The bus operators and garages involved in the trial are listed in Table 1. Operators were asked to propose large garages for inclusion in the study so that the number of drivers studied over the period was maximised. Several locations were less suitable for temperature testing and so were chosen as control sites and asked to follow normal sickness reporting procedures throughout the trial.

Table 1: Operators and garages participating in the trial

Operator	Garage	Group	Equipment Used
Abellio	Southall	Control	N/A
Abellio	Twickenham	Experimental	Remote-sensing
Arriva	South Croydon	Experimental	Handheld
Arriva	Thornton Heath	Control	N/A
GoAhead	Bexleyheath	Control	N/A
GoAhead	Sutton	Experimental	Handheld
Metroline	Cricklewood	Control	NA
Metroline	Holloway	Experimental	Remote-sensing
RATP Dev London	Edgware	Experimental	Handheld
Stagecoach	Catford	Experimental	Handheld

The allocation of control and experimental sites was not random. Non-randomised trials can be used to determine effects of interventions if the trial is free of bias (that is, if there are no factors which both determine the allocation of the sites AND the likelihood of transmission). The main factor for determining the suitability of sites for temperature testing was site layout and ease of accommodating temperature testing equipment. This factor was deemed unlikely to be a cause of experimental bias as it was unlikely to increase or decrease the chance of COVID-19 transmission within the garages.

Other sources of bias were assessed: the age distribution of the drivers in the control and experimental populations were compared in case one group had a higher proportion of older individuals[4]. The locations of the control and experimental garages were also mapped and infection rates from the area for the 4 weeks leading up to the trial were calculated to ensure that background infection rates were broadly consistent across control and treatment groups. The results of these checks can be found in Appendix A.

3.2 Testing protocol

Drivers were temperature tested at each garage at the beginning of their shift. Drivers were able to continue to work if their temperature was recorded as below 37.8°C. This threshold is consistent with NHS definitions of fever, and in line with government guidance on COVID-19 symptoms.

Those with a temperature reading at or above 37.8°C were asked to sit in an area well away from other members of staff for a period of five minutes, before being retested. If on retest the temperature was recorded as below 37.8°C, the drivers could work.

If the second test confirmed a temperature at or above 37.8°C then the driver was asked to follow government guidelines and go home immediately and self-isolate. The drivers were

[4] Susceptibility to SARS-CoV-2 has been found to vary by age (Davies, 2020).

asked to undertake a swab test as soon as possible (by either requesting a home testing kit or attending a local testing centre) and return to work if the swab test returned negative.

3.2.1 Testing technology

Garages used either handheld devices or remote scanning as shown in Table 2. Two different handheld devices were used. Device specifications are shown below.

Table 2: Technical specifications of temperature testing devices

	Handheld Devices		**Remote sensing**
Device Make and Model	Beurer Non-Contact FT90	Microlife NC200	Temp Cam TIR TC320 Tablet
Clinical Status	Clinically tested	Clinically tested	No
Time to result	2s	3s	<1s
Distance of device from subject	2-3 cm away	5cm	1 - 2m
Reported accuracy	+/- 0.2 C	+/- 0.2	+/- 0.3 C

Operators undertook their own risk assessments. Those using handheld devices ensured that testers were in appropriate PPE and/or used the devices from behind a protective screen. Remote-sensing equipment did not require a tester to be present and so posed fewer risks, however at one site using remote-sensing equipment a keypad was used by drivers to input the data and so regular cleaning of the touch point was required.

3.3 Data collection

Experimental garages were asked to provide three sets of records on a weekly basis.

1) Daily summary of temperature tests (number of passes, retests and fails)

2) Further details on test failures and subsequent follow-up (i.e. swab test result, symptoms and period of time off work)

3) Records and follow-up for isolating drivers and those off-work with COVID-19 symptoms

Control garages were asked to provide two sets on records on a weekly basis.

1) Daily summary of driver numbers (numbers of drivers working)

2) Records and follow-up of drivers who were off-sick with COVID-19 symptoms or isolating

All data were anonymised through a pseudo-anonymisation process which replaced the driver ID with a non-descriptive key for the purposes of the trial.

3.4 Data analysis

The data described in Section 3.3 were analysed to answer the research questions:

1) How accurate is the temperature test at detecting COVID-19 cases?
2) Is COVID-19 temperature testing more effective than normal sickness reporting procedures for ensuring that those with COVID-19 do not work?
3) What are the quantifiable benefits/disbenefits of temperature testing?
   a) How many additional cases of COVID-19 are detected due to temperature testing?
   b) How many drivers are sent home due to temperature testing who ultimately do not have COVID-19?

3.4.1 How accurate is the temperature test at detecting COVID-19 cases?

The accuracy of temperature testing as a means of detecting COVID-19 cases can be calculated as the percentage of correctly classified instances (i.e. true positives and true negatives) over the total number of tests.

The following summary statistics were calculated and presented in a table format (known as a confusion matrix):

Table 3: Confusion matrix example

		Developed further symptoms / tested positive for COVID-19?	
		Yes	No
Failed the temperature test?	Yes	**True Positive (TP)** A correct identification of COVID-19. (driver fails a temperature test and is confirmed to have COVID-19)	**False Positive (FP)** A false identification of COVID-19 (drivers fails a temperature test but does not have COVID-19)
	No	**False Negative (FN)** A driver is incorrectly identified as COVID-19 free (driver passes the temperature but goes on to develop symptoms during the trial)	**True Negative** A driver correctly identified as COVID-19 free (driver passes the temperature test and does not develop symptoms during the trial)

Results from swab tests of any high temperature readings were used to confirm whether any failed tests were a true or false positive.

Drivers who recorded only normal temperatures throughout the trial, and did not develop COVID-19, were classified as True Negatives. However, drivers were not routinely swab tested unless they failed a temperature test or had symptoms, therefore it is difficult to confirm with certainty that no individuals with asymptomatic COVID-19 were not included in this number. A subset of drivers in this group were swab tested and the results are summarised in Section 4.1.4.

3.4.2 Is temperature testing more effective than normal sickness reporting at ensuring that infectious individuals do not work?

If temperature testing is more effective than normal sickness reporting at identifying infectious individuals, then we would expect a lower rate of infection at garages using temperature testing compared to garages using only normal sickness report.

3.4.3 What are the quantifiable benefits/disbenefits of temperature testing?

Quantifiable benefits/disbenefits identified were:

1) Benefit: infectious days saved
2) Disbenefit: working days lost

3.4.3.1 Calculating infectious days saved

Infectious days saved for each driver who failed the temperature test and tested positive for COVID-19 (true positives) was taken to be the time between failing the temperature test and testing positive for the virus. This value was then averaged across all drivers who failed the temperature testing using the using the formula below:

$$\frac{\sum_{i=1}^{N} \sum Date\ individual\ tested\ positive - Date\ individual\ failed\ temperature\ test}{N}$$

Where N is the total number of individuals who failed the temperature test.

3.4.3.2 Calculating working days lost

Working days lost for drivers who failed the temperature test but did not develop COVID-19 (false positives) is calculated as the time between failing the temperature test and the first day a driver could reasonably return to work (assumed to be the day following the negative swab test). The value was then averaged across all drivers who failed the temperature test but did not have COVID-19 using the formula below:

$$\frac{\sum_{i=1}^{N} (Date\ individual\ tested\ negative - Date\ individual\ failed\ temperature\ test + 1)}{N}$$

Where N is the total number of individuals who failed the temperature test.

4 Results

This section presents the results from the data collected throughout the trial period.

4.1 Summary of driver shifts, testing and self-reported illness during the trial

4.1.1 Driver shifts reported over the course of the trial

Figure 1 presents the number of driver shifts reported at the garages in the experimental group over the course of the trial.

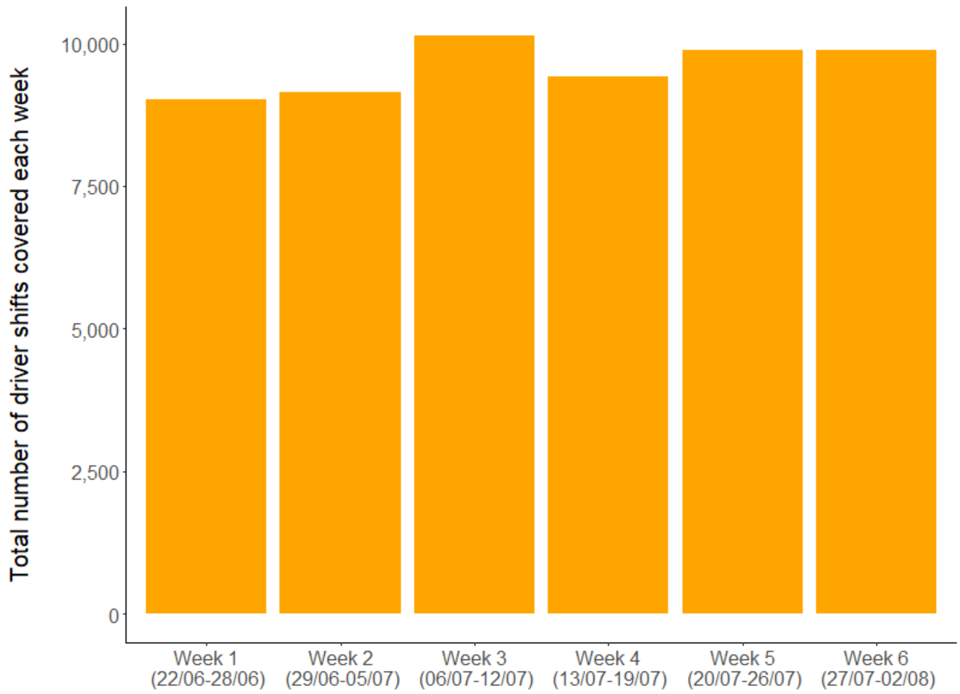


Figure 1: Number of driver shifts each week for experimental garages

The number of driver shifts reported each week were consistent, with an overall average of 9,580 shifts per week.

The equivalent figures for driver shifts at the control garages are presented in Figure 2.

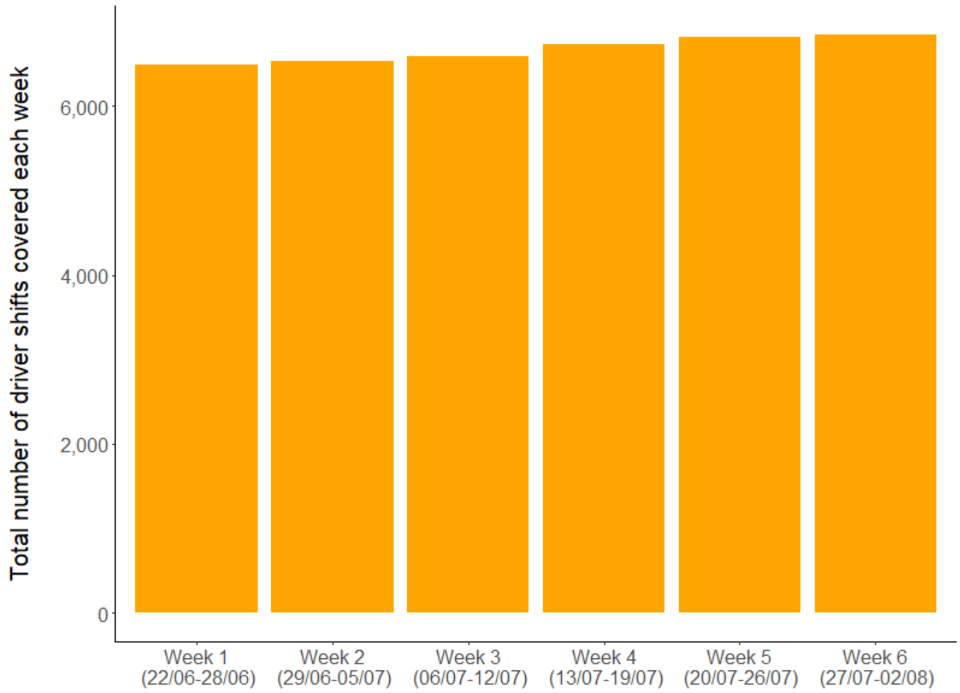


Figure 2: Number of driver shifts each week for control garages

The average number of driver shifts each week at the control garages was 6,669.

In total, 57,476 driver shifts took place in the experimental garages with 2,261 drivers taking part. 40,011 drivers shifts took place in the control garages over the course of the trial with 1,585 drivers.

4.1.2 Proportions of driver shifts with different temperature test outcomes

At each experimental garage, a temperature test was undertaken at the beginning of each driver shift. Overall, the majority (97%) of driver shifts at the experimental garages began with a temperature test.

Table 4: Summary of test results

Test Summary	Number of shifts
Number of drivers passed first time	55,888
Number of drivers passed on retesting	68
Missed tests	1,514
Failed tests	6
Total shifts	57,476

Figure 3 presents a split of the number of shifts by the various outcomes: tests passed on first attempt, tests passed on re-testing, tests failed, and tests missed due to various reasons.

About 554 (1%) tests were missed due to driver refusal and a further 960 (2%) were missed due to other reasons. Other reasons for missed tests include technical errors in logging the tests and drivers missing the test accidentally. Technical errors in logging the test only occurred at sites using remote-sensing devices: in these cases a temperature was often taken, but not recorded due to a temporary failure in wireless internet connection.

Of the 55,962 shifts that began with a temperature test (i.e. excluding missed tests), 55,888 (99.9%) recorded a temperature within the normal range on the first attempt. A total of 68 tests administered (less than 1%) were failed on the first attempt but passed on re-testing.

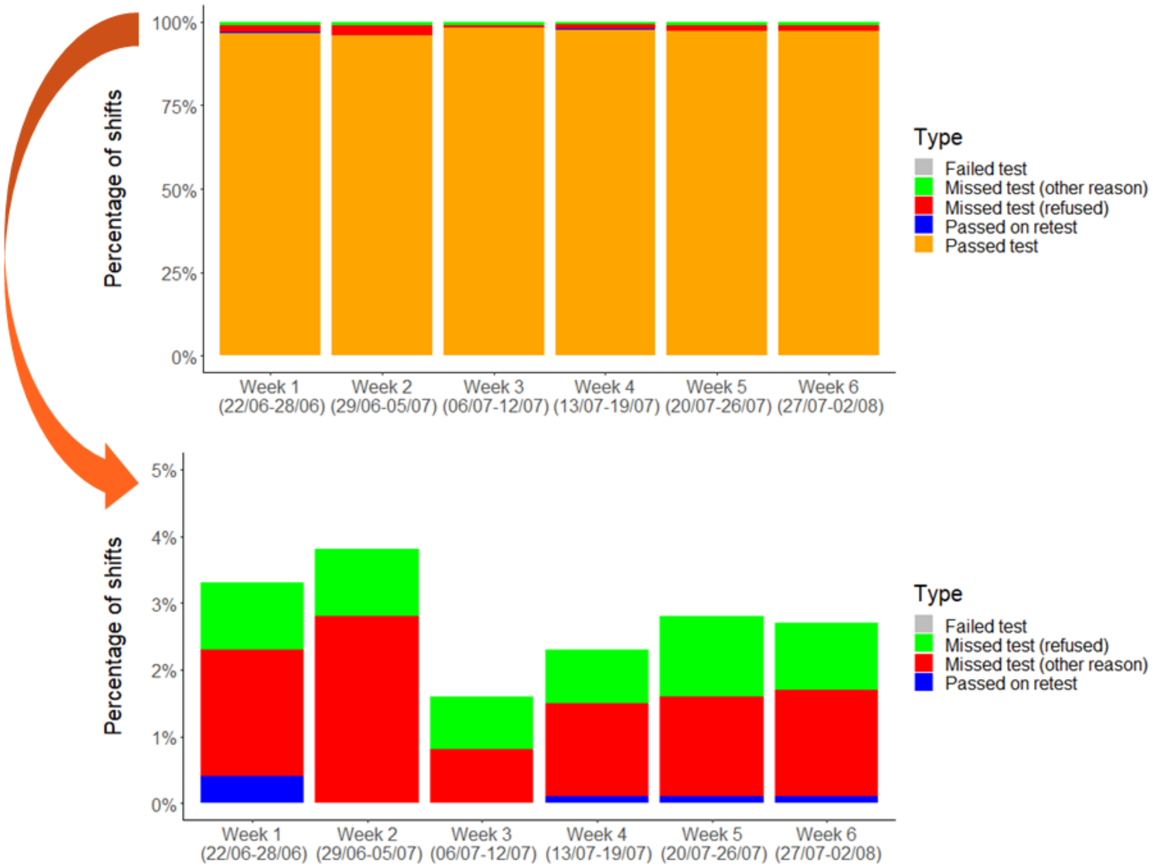


Figure 3: Test result summary

Six tests were failed on both attempts. The drivers involved in each instance were sent home to self-isolate and arrange a swab test. The small number of tests failed accounted for far less than 1% of the total tests conducted and therefore not visible in the figure above.

Of the six garages in the experimental group, four garages conducted their temperature testing using handheld devices and two garages used remote sensing devices. 1,363 (60%) bus drivers were tested using handheld devices and 898 (40%) using remote sensing devices.

The handheld temperature testing method was used for the six drivers who failed the temperature test. No test failures occurred at the garages using remote-scanning equipment.

Of the six drivers sent home to self-isolate, five drivers experienced a high temperature and one had normal temperature during their time off, but all of them showed no further symptoms. All six drivers tested negative for COVID-19 via the swab test.

4.1.3 Self-reported illness

Additional data on any self-reported illness was collected from both groups during the course of the trial. Bus drivers who called in sick with COVID-19 symptoms were asked to describe their symptoms and undertake a swab test.

This section compares the self-reported illness data from the experimental and control group. A summary is presented in Table 5.

Table 5: Self-reported illness by week and group

Group	Week						Total
	1	2	3	4	5	6	
Experimental	1	0	2	0	2	0	5
Control	0	1	1	1	0	3	6

Five (0.22%) bus drivers called in sick with symptoms in the experimental group and Six (0.38%) in the control group. A detailed comparison from the two groups is presented in Table 6.

Table 6: Comparison of self-reported illness

	Experimental	Control
Number of drivers reported off sick with COVID-19 symptoms	5	6
Indicative average duration of time off work for those with COVID-19 symptoms	16 days	5 days
Symptoms shown	Temperature (5 drivers)	Temperature and headache (5 drivers) Loss of smell/taste (1 driver)
Swab test results	All drivers tested negative for COVID-19	Three drivers tested negative for COVID-19. Three drivers did not get tested.

In the experimental group, all five drivers isolating due to symptoms tested negative for COVID-19 after undertaking a swab test. The indicative average time spent off work due to

COVID-19 related symptoms illness was 16 days. However, it must be noted that bus drivers worked different shifts, including weekends, and may not have been rostered to be working on consecutive days.

Of the six drivers who took time off to self-isolate with symptoms in the control group, five drivers reported a temperature and one reported loss of smell and taste. Three drivers undertook the swab test and were tested negative for COVID-19. Three drivers did not undertake any swab testing[5]. The indicative average time spent off work due to COVID-19 related symptoms was 5 days.

4.1.4 *Asymptomatic testing*

High temperature is a common symptom of COVID-19. However, there could be asymptomatic transmission of this illness where bus drivers showed no symptoms at all. A sample of drivers from four garages in the experimental group undertook asymptomatic tests during the last week of the trial, shown in Table 7.

Table 7: Asymptomatic test results

Garage	Total number of drivers	Drivers tested	Number of positive COVID-19 results
South Croydon	286	72 (25%)	0
Twickenham	326	71 (21%)	0
Catford	451	135 (30%)	0
Holloway	590	72 (12%)	0

A minimum of 12% of the total sample from each garage took the asymptomatic test during the last week of the trial. None of the drivers involved tested positive for COVID-19.

4.2 Answers to the research questions

This section presents the analysis of the temperature test data collected over the course of the trial and draws comparisons to the control group. All results are aggregated over six weeks and across garages.

[5] Reasons for not undertaking a swab test before returning to work included being assessed as well by a GP and not receiving a swab testing kit before the self-isolation period of 7 days was complete.

4.2.1 How accurate is the temperature test?

The accuracy of the temperature test was summarised using a confusion matrix (explained in Section 3.4). The results were aggregated across all six garages over six weeks and presented in Table 8.

Table 8: Confusion matrix of test accuracy

		Developed further symptoms / tested positive for COVID-19?	
Failed the temperature test?		Yes	No
	Yes	TP = 0	FP = 6
	No	FN = 0	TN = 2,255

None of the bus drivers tested failed the temperature test and also tested positive for COVID-19 via the swab test. This resulted in the total True Positive cases to be 0. Additionally, there were no drivers who did not fail the temperature test but test positive for COVID-19 via the swab test method (False Negatives).

Six drivers failed the temperature test; however, they did not test positive for COVID-19 using the swab test (these were therefore classified as False Positive). The majority (2,255) of the drivers passed the test and did not have any symptoms for COVID-19 (True Negative). The confidence in True Negative cases is further confirmed by the asymptomatic test results shown in Section 4.1.4.

Given the lack of COVID-19 positive cases, no firm conclusions can be drawn about the accuracy of the temperature testing method.

4.2.2 Comparing temperature testing to normal sickness protocols

This section compares the results from the bus drivers who failed the temperature test on both attempts in the experimental group and the drivers who reported unwell from the control group. A summary is provided in Table 9.

Table 9: Comparison of temperature testing to normal sickness protocols

Number of drivers...	**Experimental**	**Control**
Failed the temperature test	6	N/A
Self-reported illness with COVID-19 symptoms	5	6
Isolated who were confirmed COVID-19 cases	0	0
Typical symptoms shown	High temperature	Temperature, headache and loss of smell/taste

Indicative average duration of time off work following temperature test	6 days	N/A
Indicative average duration of time off work following self-reporting with COVID-19 symptoms	16 days	5 days
Total number of drivers	2,261	1,585

There were no confirmed COVID-19 cases identified from either the temperature testing or the normal sickness reporting procedures so no comment can be made on the relative effectiveness of either method.

Five drivers self-reported with COVID-19 symptoms in the experimental group and six in the control group. In both groups, high temperature was the main symptom exhibited during their time off work.

The average days off work due to self-reported illness was 16 days in the experimental group and 5 days in the control group. The average number of days of work due to test failure was 6 days. It must be noted that drivers worked different shift patterns, including weekends, which may have an impact on the average time off work.

4.2.3 Benefits and disbenefits of temperature testing

As explained in section 2.3, the benefits of the temperature testing method can be estimated by calculating the number of days an individual was prevented from working (and therefore potentially spreading the infection) from early detection of a high temperature to later developing COVID-19 symptoms. Infectious days saved were calculated from the day an individual failed the temperature test to the day the individual got tested positive for COVID-19 from the swab test. In the trial, since there were no positive COVID-19 tests the number of days was:

$$Infectious\ days\ saved\ due\ to\ True\ Positive: 0\ days$$

Conversely, the disbenefits of the temperature testing method can be measured by calculating the number of working days lost from false detections in individuals who did not develop COVID-19. Working days lost were calculated from the day the individual failed the temperature test to the day the individual tested negative for COVID-19 from the swab test. In this trial inclusive:

$$Average\ working\ days\ lost\ due\ to\ False\ Positive: 2.8\ days$$

Over the course of the trial, across all garages a total of 17 working days were lost to due false positives.

This total assumes that drivers who failed the temperature test but who did test positive for COVID-19 were not otherwise unwell enough to work on the days following the test.

4.3 Operator feedback

The operators on the working group gave feedback throughout the trial. For the most part the trial was straightforward to implement. Most drivers were comfortable with the testing and assessed risks could be minimised. The time taken to test temperature per driver was found to have a minimal impact on a driver's shift. There were however a small number of issues raised which are described below. These findings may be useful to those setting up temperature testing in a similar setting.

1) Logistical issues

An appropriate set-up for testing allows social distancing while temperature testing was carried out, and prevented bottlenecks forming around temperature testing equipment. Testing also required a space for individuals failing tests to wait for their re-test away from other drivers. Creating this set-up was not straightforward in all garages and may be near impossible in some.

For those garages using hand-held devices, at least one member of staff is required to carry out the testing, and at larger garages, two members of staff are required. This increases the overheads of the garage and there were challenges in manning the temperature testing throughout the night, as is required at some garages with night bus routes.

Some London bus garages have moved to allow garages to sign-on remotely from locations outside of the garages (i.e. at relief points). This would make it difficult to temperature test all drivers at the beginning of their shifts, potentially reducing any benefit of temperature testing.

The trial took place in summer and encompassed a spell of hot weather[6]. On these days it was necessary for several drivers to retake the temperature test after arriving at work with elevated temperatures. For garages wishing to undertake temperature testing in the summer months, providing a cool area for drivers awaiting retesting is advised.

2) Technology issues

The handheld devices were used without issue at the sites using them; however, there did appear to be discrepancies between the readings from two devices used at one site with one device reading slightly higher than the other. For both technologies, calibration and testing of the equipment is required on introduction, and a protocol of regular calibration is recommended to ensure continued efficacy of the equipment.

The feedback on the usability of the thermal cameras was also positive. However, the data upload link to send the camera data to the operator required WI-FI of high latency and signal strength so some data uploads were missed due to fluctuating WI-FI signals. This was fixed by the introduction of a SIM card to the devices.

The pros and cons of handheld devices versus remote scanning equipment are briefly summarised in Table 10.

[6] The trial period included 24th and 25th June 2020 where temperatures exceeded 30 degrees Celsius in London.

Table 10: Summary of temperature testing technology comparison

Features	Handheld Devices	Remote Scanning
Equipment cost (per device)	Low	High
Portability	Yes	No
Medical grade	Yes	No
Tester required	Yes	No
Automatic data link	No	Yes

The low equipment cost and high portability of handheld devices made these an appealing solution during the trial; operators could get set up with the necessary equipment cheaply and quickly. However, the requirement to have a member of staff acting as tester (or in some cases, multiple testers) meant that this was seen as a less practical solution for the longer term.

Remote sensing devices, on the other hand, required a comparatively large investment both in money and in time to set-up the devices and configure the data feeds. Once this was done however, data was conveniently matched to drivers via either a QR code scan or a numerical input pad at the beginning of each shift. This hands-off approach was seen as a more viable option for larger garages and for longer-term temperature testing. It should be noted however, that an initial period where drivers were assisted in using the technology was necessary before this option was able to run without assistance from an additional member of staff. The devices should also be calibrated at intervals determined by the manufacturer to ensure accuracy is maintained.

Handheld devices have slightly superior technical specifications: they are more accurate (though not by a large amount – see Table 2) and benefit from being covered by EC medical devices regulations. Remote scanners do not generally have this accreditation as they are often manufactured for other purposes such as site-security (MRHA, 2020). Any users of remote scanning equipment need to be conscious of the limitations of the equipment and the possibility of false negatives. In either case, temperature testing should only be used in conjunction with other COVID-19 protection measures and clear communication about risk of exposure.

3) Communication and Safety

The majority of drivers responded positively to the temperature testing. A subset of drivers did not wish to undertake temperature testing initially but did undertake the testing after discussions with either local Unite representatives or other garage staff around the purposes of the testing and the trial. This highlighted the need for clear and timely communications before rolling-out temperature testing and the benefit of an initial period of testing during which the equipment, set-up and protocols can be tested and so that staff can familiarise with the process.

A small proportion of drivers did not take part in temperature testing (1% overall) at any time throughout the trial. It is possible that longer-term temperature testing could lead to a higher refusal rate. For garages implementing temperature testing over the longer term, any new drivers would need to be introduced to the testing protocol and be given the opportunity to ask questions.

Risk assessments were undertaken before the trial and data privacy was considered by each operator individually. In a wider roll-out information could be shared across garages to simplify this process but time should also be allowed for any site-specific issues to be raised and resolved.

5 Conclusions and recommendations

The temperature testing trial took place in London between 22nd June and 3rd August and involved six operators, 10 bus garages and 3,846 bus drivers. 55,962 temperature tests were conducted, 99.9% of which detected temperatures within a normal range.

Six drivers failed the temperature test and were asked to self-isolate and get a swab test at their earliest convenience. On average, 2.8 working days were lost per driver to obtain a test and receive the result. No cases of COVID-19 were identified in the garages involved in the trials over the period of testing.

Drivers without symptoms were also offered COVID-19 swab tests as part of a Department of Health and Social Care (DHSC) asymptomatic testing trial which took place in the last week of this trial. No drivers involved in the trial tested positive during this additional testing.

A number of factors will have contributed to this result:

- The low background infection rate
- Control measures in place throughout the trial at all garages
- Modifications made to the buses to protect the drivers, including:
    - sealing speech holes in assault screens
    - sealing gaps around the assault screens
    - turning off recirculating Heating Ventilation and Air Conditioning (HVAC) systems
    - Encouraging drivers to leave their cab window open
- The behaviour of drivers (self-isolating)

During the trial, drivers followed normal sickness protocols and self-isolated if they were suffering from symptoms at both control (not temperature testing) and experimental (temperature testing) sites. There was no evidence that having temperature testing in place reduced self-reporting of symptoms.

It was not possible to measure the accuracy of the test in detecting COVID-19, as no cases of COVID-19 were detected during the trial. Research from other epidemics suggests that temperature testing is not an accurate means of detecting cases of infectious disease during outbreaks. Many companies across the UK are now routinely temperature testing staff, if data could be collected from all companies in a consistent way (such as the method used in this trial), firmer conclusions may be possible.

There may be benefits to temperature testing that are difficult to quantify such as reassuring staff, encouraging team members to monitor symptoms, not spreading other illnesses amongst staff that might cause more sick days. Additional behavioural research could help to understand the scale of these possible benefits and also identify potential disbenefits from any behaviour change. It is recommended that this additional qualitative insight is gathered from a sample of the experimental garages to gain a full understanding of the benefits and disbenefits of temperature testing in this context.

Temperature testing integrated well into garage working practices after some early logistical and technological challenges. Temperature testing did not impact driver shift times in any meaningful way. Drivers were generally comfortable with the testing and the level of refused tests remained low at 1% throughout the trial and was 0% for some garages, meaning every driver at that garage was temperature tested consistently throughout the trial. Remote scanning equipment was found to be on-balance, better suited to longer-term use, as handheld devices required additional staff overheads and also posed additional risks due to potential exposure of the staff member administering the tests to infected individual (or in some cases multiple staff members). While this risk could be managed by following appropriate protocols, PPE use and/or the use of Perspex screens, the management of these risks further increased overheads for this solution.

Operators highlighted some barriers to rolling-out temperature testing at some garages. For example, the layout of some garages makes providing the space required for temperature testing difficult, additional space is required to allow drivers requiring a retest to wait away from other staff and there are challenges associated with capturing all drivers, particularly in garages which operate twenty-four hours or those which employ remote sign-on points. These barriers will need to be addressed directly by any garage wishing to begin temperature testing. In particular, sufficient time is needed to set-up and adapt any space required.

6 Acknowledgements

The authors would like to thank all the members of the working group for their contributions to the study and comments on the report. We are also grateful to all the garage staff and drivers who participated in the study.

References

Byambasuren, O. e. (2020). Estimating the extent of asymptomatic COVID-19 and its potential for community transmission: systematic review and meta-analysis. *MedRXIV*, 20097543.

Davies, N. G. (2020). Age-dependent effects in the transmission and control of COVID-19 epidemics. *Nature Medicine*, 1205-1211.

GLA. (2020a, August 14). *Coronavirus (COVID-19) Cases*. Retrieved from London Datastore : https://data.london.gov.uk/dataset/coronavirus--covid-19--cases

GLA. (2020b, August 14). *Land Area and Population Density, Ward and Borough*. Retrieved from London Datastore: https://data.london.gov.uk/dataset/land-area-and-population-density-ward-and-borough

Grant, M. C. (2020). The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-CoV-2): A systematic review and meta-analysis of 148 studies from 9 countries. *Plos One*, 0234765.

Guan, W., Zheng-yi, N., Yu, H., Wen-hua, L., Chun-quan, O., Jian-xing, H., . . . Lan-juan, L. (2020). Clinical characteristics of Coronavirus Disease 2019 in China. *New England Journal of Medicine*, 382, 1708-1720.

Laycock, M. (2020, August 4). *York Press*. Retrieved from https://www.yorkpress.co.uk/news/18628340.nestle-staff-get-temperature-checked-anti-virus-move/

Lechien, J. R. (2020). Clinical and epidemiological characteristics of 1420 European patients with mild-to-moderate coronavirus disease 2019. *Journal of Internal Medicine*, Early View 13089.

MRHA. (2020, July 4). *UK Government News*. Retrieved from https://www.gov.uk/government/news/dont-rely-on-temperature-screening-products-for-detection-of-coronavirus-covid-19-says-mhra

Nishiura, H., & Kamiya, K. (2011). Fever screening during the influenza (H1N1-2009) pandemic at Narita International Airport, Japan. *BMC Infectious Diseases*, 11, 111.

ONS. (2020, June 26). Coronavirus (COVID-19) related deaths by occupation, England and Wales: deaths registered beween 9 March and 25 May 2020.

UK Government. (2020, August 11). *Publications UK Governmnent*. Retrieved from Gov.uk: https://www.gov.uk/government/publications/covid-19-stay-at-home-guidance/stay-at-home-guidance-for-households-with-possible-coronavirus-covid-19-infection

Webber, A. (2020, June 1). *Personnel Today*. Retrieved from https://www.personneltoday.com/hr/staff-support-temperature-checks-and-virus-tests-upon-return-to-work/

Wickramage, K. (2019). Airport entry and exit screening during the Ebola Virus Disease outbreak in Sierra Leone, 2014 to 2016. *Biomed Res Int*, 3832790.

Appendix A Comparisons between experimental and control garages

A.1 Driver demographics

A total of 2,324 drivers from six garages were allocated to the experimental group and 1,621 drivers from four garages were allocated to the control group. Table 11 and Table 12 show the breakdown of the sample by age and gender.

Table 11: Number (proportion) of drivers by age group

Age group	Experimental		Control	
	Number	Percent	Number	Percent
18-30 years	156	7%	137	8%
31-40 years	452	19%	314	19%
41-50 years	645	28%	476	29%
51-60 years	780	34%	517	32%
61-70 years	276	12%	181	11%
Over 70 years	15	1%	4	<1%
Total	**2,324**	**100%**	**1,629**	**100%**

The distribution of drivers by age was similar between the control and experimental groups. About 54% of the drivers were below 50 years of age, about 34% were between 51-60 years of age, and roughly 13% were over 60 years of age.

Table 12: Number (proportion) of drivers by gender

Gender	Experimental		Control	
	Number	Percent	Number	Percent
Male	2,108	91%	1,481	91%
Female	216	9%	148	9%
Total	**2,324**	**100%**	**1,629**	**100%**

The distribution of drivers by gender was the same for both groups, with 91% of the drivers being male and 9% female.

A.2 Garage locations

Control and experimental garages were located across nine London boroughs (Figure 4).

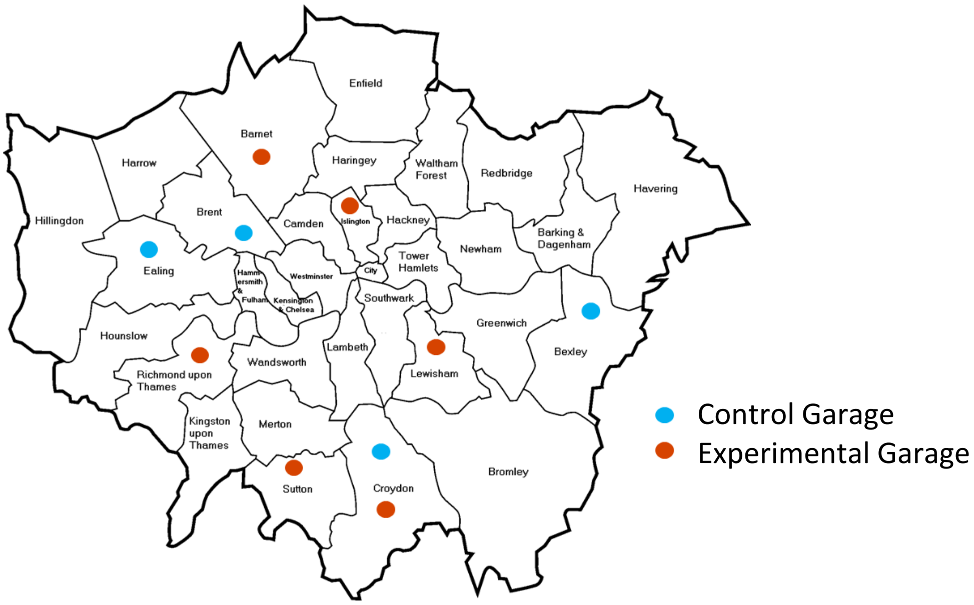


Figure 4: Map of garage locations[7]

To ensure that any differences between the garages can be attributed to the temperature testing rather than external factors, the background infection rates in boroughs with experimental sites, and boroughs with control sites were compared. Infection rate with the borough of the garage will not encompass the true risk that drivers are exposed to, as they will also be exposed within their home neighbourhood (which may be in a different borough) and while on their way to work. There may also be substantial differences within wards of the same borough which cannot be captured by a borough-level infection rate. However, it does give an indication of the overall risk in the area surrounding the workplace and so can be seen as a proxy for the risk level while a driver is at work. If the infection rates were found to be significantly different between these two groups, direct comparisons of test results between the two groups would not be possible.

The rates of infection for each borough were calculated for the four weeks leading up the trial. The rate of infection for each borough was calculated from the number of new infections in the borough over the four weeks leading up to the trial, and the borough population size[8]. The rates for the two groups (experimental and control) were then compared using a statistical test (two-side t-test) which checks whether the infection rates are statistically different between two groups (boroughs with experimental and control garages) (Table 13).

[7] Locations are correct to the borough level. Map is included to show the spatial distribution of sites rather than to identify specific locations.

[8] Number of cases were calculated for the periods using a London data API produced by the Greater London Authority (GLA, 2020a). Borough population size was taken from 2016 projections to 2020 (GLA, 2020b).

Table 13: Operators and garages with location and infection rate

Operator	Garage	Group	Borough	Mean rate of infection for the borough (new cases per 1,000 residents)	
				31st May to 21st June	22nd June to 3rd August
Abellio	Southall	Control	Ealing	0.23	0.32
Abellio	Twickenham	Experimental	Richmond-on-Thames	0.15	0.16
Arriva	South Croydon	Experimental	Croydon	0.13	0.15
Arriva	Thornton Heath	Control	Croydon	0.13	0.15
GoAhead	Bexleyheath	Control	Bexley	0.23	0.30
GoAhead	Sutton	Experimental	Sutton	0.24	0.21
Metroline	Cricklewood	Control	Brent	0.21	0.31
Metroline	Holloway	Experimental	Islington	0.12	0.20
RATP Dev London	Edgware	Experimental	Barnet	0.18	0.31
Stagecoach	Catford	Experimental	Lewisham	0.12	0.22

Average infection rates were not found to be significantly different in boroughs of control or experimental garages for the four weeks preceding the trial (0.20 v 0.15, t-stat -1.77, *p* = 0.11[9]). The same test was also performed at the end of the trial to cover the infection rate for the duration of the trial. The average infection rates were not found to be significantly different for the weeks during which the trial took place (0.22 v 0.25, t-stat -0.46, *p* = 0.33).

[9] T-stat is a statistical value calculated from the data. This is compared to a reference value and a p-value is generated. A large p-value means your sample results are consistent with a true null hypothesis (in this case that the infection rates are equal). The criteria is usually set to be 0.05 (or 5% probability). The p-value in this case is 0.11 which above this threshold so we don't have sufficient evidence to reject the null hypothesis that the infection rates are equal.

COVID-19 Response: London Bus Garage Temperature Testing Trial

In response to staff concerns about the potential transmission of SARS-CoV-2, on-site temperature testing of bus drivers was trialled in bus garages across London.

Six bus garages carried out temperature testing and four garages followed normal reporting procedures to act as a control. Temperatures were tested at the start of driver shifts using either handheld scanners or remote-sensing devices. The analysis aimed to investigate whether rates of infection were the same across experimental and control garages and whether the accuracy of the test could be determined.

Of 55,962 temperature tests administered there were only six instances of high temperature readings that persisted after a 5-minute period (0.0001% of all tests administered). These drivers were asked to take a COVID-19 antibody test to detect infection. None of the drivers with a high temperature subsequently tested positive for COVID-19.

Levels of self-reported illness were similar across control and temperature testing sites. No drivers with self-reported symptoms subsequently tested positive for COVID-19.

As no cases of COVID-19 were detected, it was not possible to measure the accuracy of the test in detecting COVID-19. The trial period coincided with a period of low infection rate. At the same time, garages had also implemented several other measures to limit the spread of SARS-CoV-2.

Many businesses are now temperature testing employees; collecting data in a standardised way and combining datasets from multiple sources would advance knowledge of the effectiveness of temperature testing at detecting COVID-19 to the benefit of those working in public facing roles.

TRL
Crowthorne House, Nine Mile Ride,
Wokingham, Berkshire, RG40 3GA,
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

CPR 2808