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A vulnerability-based approach to human-mobility reduction for countering COVID-19 transmission in London while considering local air quality

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Article history:
Received 5 May 2020
Received in revised form 22 June 2020
Accepted 24 June 2020
Available online 25 June 2020

Keywords:
COVID-19
Human mobility
Air pollution
Particulate matter (PM2.5)
Nitrogen dioxide (NO2)
Transport

An ecologic analysis was conducted to explore the correlation between air pollution, and COVID-19 cases and fatality rates in London. The analysis demonstrated a strong correlation ($R^2 > 0.7$) between increment in air pollution and an increase in the risk of COVID-19 transmission within London boroughs. Particularly, strong correlations ($R^2 > 0.72$) between the risk of COVID-19 fatality and nitrogen dioxide and particulate matter pollution concentrations were found. Although this study assumed the same level of air pollution across a particular London borough, it demonstrates the possibility to employ air pollution as an indicator to rapidly identify the city’s vulnerable regions. Such an approach can inform the decisions to suspend or reduce the operation of different public transport modes within a city. The methodology and learnings from the study can thus aid in public transport’s response to COVID-19 outbreak by adopting different levels of human-mobility reduction strategies based on the vulnerability of a given region.

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1. Introduction

The current outbreak of novel coronavirus COVID-19 or severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has resulted in the World Health Organization (WHO) declaring it as a global pandemic (World Health Organization, 2020). Reported first within the city of Wuhan, Hubei Province of China in December 2019, the COVID-19 exhibits high human-to-human transmissibility and has spread rapidly across the world (Qun et al., 2020). The human-to-human transmission of COVID-19 can occur from individuals in the incubation stage or showing symptoms, and also from asymptomatic individuals who remain contagious (Bai et al., 2020). The COVID-19 has been reported to transmit via the inhalation of exhaled respiratory droplets (Guangbo et al., 2020) that remain airborne for up to 3 h (Neeltje et al., 2020). The extent to which COVID-19 induces respiratory stress in infected individuals may also be influenced by underlying respiratory conditions (Wei et al., 2020) like acute respiratory inflammation, asthma and cardiorespiratory diseases (Centers for Disease Control and Prevention, 2020). Various studies have reported an association between air pollution levels and excess morbidity and mortality from respiratory diseases (Adamkiewicz et al., 2004; Dockery, 2001; Yan et al., 2003) with children and elderly people being at most risk (Department for Environment, Food, and Rural Affairs, 2017). 20% of England’s population is at risk of mortality from COVID-19 due to underlying conditions and age (Amitava et al., 2020).

The simultaneous exposure to air pollutants such as particulate matter (PM2.5) and nitrogen dioxide (NO2) alongside COVID-19 virus is also expected to exacerbate the level of COVID-19 infection and risk of fatality (Transport and Environment, 2020; European Public Health Alliance, 2020). Recent studies have also suggested that exposure to NO2 and PM2.5 may be one of the most important contributors to COVID-19 related fatalities (Xiao et al., 2020; Ogen, 2020; Travaglio et al., 2020). Moreover, the adsorption of the COVID-19 virus on PM could also contribute to the long-range transmission of the virus (Guangbo et al., 2020). For example, an ecological analysis of the 2003 severe acute respiratory syndrome coronavirus 1 (SARS-CoV-1) reported that infected patients who lived in moderate air pollution levels were approximately 84% more likely to die than those in regions with lower air pollution (Yan et al., 2003). The aerosol and surface stability of the COVID-19 or SARS-CoV-2 is reported to be similar to that of SARS-CoV-1 (Neeltje et al., 2020). Given the limited understanding of the epidemiology of COVID-19, social-distancing and human-mobility reduction measures can contribute greatly to tailoring public health interventions (Shengjie et al., 2020).

2. Human-mobility reduction

Countries across the world have enforced lockdowns and other coordinated efforts to reduce human-mobility (European Commission, 2020; Anderson et al., 2020; Matteo et al., 2020; Edward et al., 2020). The UK’s national framework for responding to a pandemic states that public transport should continue to operate normally during a pandemic, but users should adopt good hygiene measures, and stagger journeys where possible (Department of Health, 2007). Within the UK, London has recorded the highest COVID-19 related fatalities (i.e. 30.2% of UK’s deaths as of 31 March 2020) (National Health Services, 2020). On 18 March 2020, further to the UK government’s advice, Transport for London (TfL) closed 40 out of 270 London Underground (LU) stations that do not serve as interchanges with other lines and announced a reduced service across its network (Transport for London, 2020). This is also because 30% of TfL’s drivers, station staff, controllers and maintenance teams were not able to come to work, including those self-isolating or ill with COVID-19 (Transport for London, 2020).

The UK’s current human-mobility reduction response reflects the need to maintain business continuity, near-normal functioning of society and enable critical workers to make essential journeys (Department of Health, 2007; Joy et al., 2011). However, a statistically significant association exists between human-mobility through public transport and transmissions of acute respiratory infections (ARI) (Joy et al., 2011; Lara and Anders, 2018). It was found that using public transport in the UK during a pandemic outbreak has an approximately six-fold increased risk of contracting an ARI (Joy et al., 2011). Moreover, the pandemic case rates for London boroughs with access to interchange stations are higher (Lara and Anders, 2018), as individuals would interact with more people in comparison to through stations.

One of the most controversial debates in pandemic countermeasures is the potential benefit of human-mobility reduction and social-distancing attained by the closure of public transport systems. From a public policy perspective, there is a need to achieve a trade-off between the potential public health benefits of closing public transport during a pandemic thereby delaying the community spread, against the socio-economic impacts of curtailing/reducing human mobility. Determining the vulnerability of regions/locations to COVID-19 might help achieve such trade-offs. The proposed approach can be employed to rapidly identify regions that are highly vulnerable to COVID-19 and accordingly inform human-mobility reduction measures across the city’s public transport network.

3. Materials and methods

An ecologic analysis was conducted to explore the correlation between short-term air pollution (of PM2.5 and NO2 levels) and COVID-19 cases and fatality rate in each London borough/region. To this end, a linear regression model was fitted to the data for regions with more than 100 reported cases and 10 COVID-19 related deaths as of 31 March 2020. Accordingly, the vulnerabilities of different boroughs in London to COVID-19 was measured.

3.1. Fatality data

As the COVID-19 is an evolving pandemic, the available data as of 31 March 2020 on COVID-19 morbidity and mortality for different boroughs in London was collected (Public Health England, 2020; National Health Services, 2020) The Office of National Statistics (A Baker, personal communication, 2020) confirmed that they are unable to provide COVID-19 related fatality data categorized by each London borough or local authority. To this end, the deaths reported by individual NHS Hospitals in London were employed to inform the reported deaths for each London borough. The fatality rate across each London borough was estimated by dividing the number of reported deaths by the number of reported positive COVID-19 cases.

3.2. Air pollution data

The air pollution data associated with particulate matter (PM2.5) and nitrogen dioxide (NO2) for each London borough was collected from (King’s College London, 2020). NO2 data was available for 15 boroughs namely Barking and Dagenham, Bexley, Wandsworth, City of London, Croydon, Greenwich, Havering, Hillingdon, Kensington and Chelsea, Lewisham, Reading, Redbridge, Sutton, Tower Hamlets and Westminster. While, the PM2.5 data was available only for 8 boroughs (Barking and Dagenham, Wandsworth, City of London, Croydon, Hillingdon, Kensington and Chelsea, Lewisham). Time series of available air pollution (PM2.5 and NO2) and COVID-19 cases could be seen in Fig. 1, which shows that COVID-19 cases increase with increasing air pollution at London boroughs.

The average NO2 concentration within the LU network was reported to be 51 μg m⁻³ (James David et al., 2016). The PM2.5 concentration within different LU stations was recorded by Smith et al. (2020) with an average concentration of was 88 μg m⁻³.

4. Results

A strong correlation between short-term NO2 and PM2.5 pollution concentrations and COVID-19 cases with R² values of 0.82 (COVID-19)
cases = \(-29.345 + 10.306\times NO2\) concentration) and 0.72 (COVID-19 cases = \(-215.63 + 40.997\times PM2.5\) level) were observed respectively (see. Fig. 2). In particular, COVID-19 fatality rate increased with increase in short-term air pollution, where a significant correlation between COVID-19 fatality and NO2 and PM2.5 pollution concentrations with \(R^2\) of 0.90 (fatality rate = 1.864 + 0.5787\times NO2 level) and 0.67 (fatality rate = \(-7.733 + 2.3399\times PM2.5\) level) were found (see. Fig. 3).

The median PM2.5 levels recorded for 27 of 40 closed LU stations range from 0 to 50 \(\mu\)g m\(^{-3}\) (5 stations), 50–100 \(\mu\)g m\(^{-3}\) (9 stations), 100–200 \(\mu\)g m\(^{-3}\) (5 stations), 200–300 \(\mu\)g m\(^{-3}\) (6 stations) and greater than 300 \(\mu\)g m\(^{-3}\) (2 stations) (see Table A1). Of the 230 operating stations, the median PM2.5 levels recorded for 219 stations range from 0 to 50 \(\mu\)g m\(^{-3}\) (56 stations), 50–100 \(\mu\)g m\(^{-3}\) (15 stations), 100–200 \(\mu\)g m\(^{-3}\) (15 stations), 200–300 \(\mu\)g m\(^{-3}\) (18 stations) and greater than 300 \(\mu\)g m\(^{-3}\) (7 stations) (Smith et al., 2020) (see Table A1). This suggests that approximately 40% of the stations in operation during the current COVID-19 outbreak in London are up to 26 times more polluted than the ambient background locations and the roadside environment which has a median PM2.5 level of 14 \(\mu\)g m\(^{-3}\) (Smith et al., 2020). Moreover, the average NO2 concentrations across the LU network is 27.5% higher than the NO2 limit values for the protection of human health (European Environment Agency, 2014).

5. Concluding discussion

Our analysis shows that short-term exposure to air pollution (both NO2 and PM2.5) is significantly correlated with an increased risk of contracting and dying from COVID-19, expanding on previous evidence linking high mortality rates in England (Travaglio et al., 2020), Northern Italy (Ogen et al., 2020) and USA (Xiao et al., 2020). Biologically, either long-term or short-term exposure to air pollutants such as PM2.5 and NO2 can compromise lung function and therefore increase the risk of dying from COVID-19 (Wei et al., 2020). Given that the immunity to the 2003 SARS-CoV-1 was reported to be relatively short-lived (around 2 years) (Li-Ping et al., 2007), achieving herd immunity for diseases like COVID-19 or SARS-CoV-2 would be unlikely without overwhelming the healthcare system (Edward et al., 2020). Human-mobility reduction measures provide the greatest benefit to COVID-19 mitigation (Matteo et al., 2020; Anderson et al., 2020) as prevention is potentially cost-effective than cure (Lara and Anders, 2018) or death.

The results from this study demonstrate that the air pollution levels can serve as one of the indicators to assess a region’s vulnerability to COVID-19 and accordingly adopting human-mobility reduction strategies. For instance, the London Borough of Kensington and Chelsea is seen to be highly vulnerable to COVID-19 fatality from our analysis (see Fig. 3a). Table A1 shows that all the through stations and 3 out of 4 interchange stations (South Kensington, Sloane Square, Earl’s Court, Notting Hill gate) in this borough are currently operational. Such a vulnerability-based assessment might aid decision-makers in selecting appropriate human-mobility reduction measures to COVID-19 in London’s different local authorities/boroughs (such as apportion of transport staff across railway stations, arranging dedicated shuttling services for key workers, scheduling bus operations etc.) while adhering to the UK’s national framework for response to pandemic outbreaks (Department of Health, 2007) of not isolating towns or even cities (Department of Health and Social Care, 2020).

We support the UK government’s existing COVID-19 guidance (Department of Health and Social Care, 2020) to exercise good hygiene and to avoid unnecessary travel. While considering the evidence that COVID-19 can be transmitted from an asymptomatic individual (Bai et al., 2020), the currently implemented countermeasure of suspending operations only on the stations that do not serve as interchanges is not effective. This is because of the statistically significant risk of contracting ARI’s on UK’s public transport and higher pandemic case rates within London boroughs that have comparatively easier access to interchange stations. Moreover, the PM2.5 and NO2 levels, potential contributors to COVID-19 transmission and fatalities, are relatively higher in LU stations than other transport environments. E.g. the median level of airborne PM2.5 in LU stations is several times higher than cycling (35 \(\mu\)g m\(^{-3}\)), bus (30.9 \(\mu\)g m\(^{-3}\)), cars (23.7 \(\mu\)g m\(^{-3}\)) (Vania et al., 2015; Smith et al., 2020).

It has to be noted that the number of positive COVID-19 cases considered within this study are only those reported at the hospitals and does not include the growing number of people who are self-isolating at home due to mild COVID-19. While the individual risk of contracting and dying from COVID-19 is dependent on various factors (including age, underlying conditions, availability of health care, population density etc.), these results are informative for both scientists and decision-makers in their efforts to reduce the transmission and socio-economic impact of the ongoing COVID-19 outbreak through appropriate human-mobility reduction strategies. It is also recommended to expand the study further to understand the effect (if any) of other air quality parameters such as volatile organic compounds (VOCs) and nitrogen oxides (NOx), on COVID-19 transmission and fatality rate.
CRediT authorship contribution statement

Manu Sasidharan: Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing.
Ajit Singh: Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing.
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Ajith Kumar Parlikad: Conceptualization, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thank Anne Baker from the Office for National Statistics for very kindly providing her input to the COVID-19 related fatality data. We appreciate the work of J.D. Smith, B.M. Barratt, G.W. Fuller and team that captured the levels of PM$_{2.5}$ exposure in London Underground.

Funding

This work was supported by the Engineering and Physical Science Research Council (EPSRC) through the grant EP/N021614/1 (CSIC Innovation and Knowledge Centre Phase 2) and EP/N010523/1 (Balancing the Impact of City Infrastructure Engineering on Natural Systems using Robots), and Innovate UK through the grant 920035 (Centre for Smart Infrastructure and Construction).

Appendix A

Table A1

Status of LU stations (as of 31 March 2020) and their mean PM$_{2.5}$ levels adapted from (Smith et al., 2020; Transport for London, 2020a, 2020b, 2020c).

| Borough                  | Line   | Station                      | Mean PM$_{2.5}$ level in the station (µg m$^{-3}$) | Status (as of 31/03/2020) |
|--------------------------|--------|------------------------------|---------------------------------------------------|---------------------------|
| Barking and Dagenham    | District | Becontree tube station       | 6                                                  | Open                      |
| Barking and Dagenham    | District | Dagenham Heathway tube station | 4                                                  | Open                      |
| Barking and Dagenham    | District | Upney tube station           | 3                                                  | Open                      |
| Borough                  | Line                  | Station                      | Mean PM$_{2.5}$ level in the station (μg m$^{-3}$) | Status (as of 31/03/2020) |
|-------------------------|-----------------------|------------------------------|--------------------------------------------------|---------------------------|
| City of Westminster     | Central               | Bond Street tube station     | 367                                              | Open                      |
| City of Westminster     | Central               | Oxford Circus tube station   | 338                                              | Open                      |
| City of Westminster     | Northern              | Embankment tube station      | 316                                              | Open                      |
| City of Westminster     | Bakerloo              | Edgeware Road tube station   | 311                                              | Open                      |
| City of Westminster     | Victoria              | Green Park tube station      | 308                                              | Open                      |
| City of Westminster     | Central               | Marble Arch tube station     | 307                                              | Open                      |
| City of Westminster     | Central               | Tottenham Court Road tube station | 298 | Open                      |
| City of Westminster     | Victoria              | Oxford Circus tube station   | 296                                              | Open                      |
| City of Westminster     | Northern              | Leicester Square tube station | 287                                              | Open                      |
| City of Westminster     | Bakerloo              | Baker Street tube station    | 273                                              | Open                      |
| City of Westminster     | Bakerloo              | Maida Vale tube station      | 268                                              | Open                      |
| City of Westminster     | Bakerloo              | Oxford Circus tube station   | 263                                              | Open                      |
| City of Westminster     | Victoria              | London Victoria station      | 253                                              | Open                      |
| City of Westminster     | Jubilee               | Bond Street tube station     | 245                                              | Open                      |
| City of Westminster     | Bakerloo              | Piccadilly Circus tube station | 244 | Open                      |
| City of Westminster     | Jubilee               | Westminster tube station     | 242                                              | Open                      |
| City of Westminster     | Northern              | Tottenham Court Road tube station | 239 | Open                      |
| City of Westminster     | Jubilee               | Green Park tube station      | 236                                              | Open                      |
| City of Westminster     | Bakerloo              | Embankment tube station      | 227                                              | Open                      |
| City of Westminster     | Piccadilly            | Piccadilly Circus tube station | 176 | Open                      |
| City of Westminster     | Jubilee               | Baker Street tube station    | 174                                              | Open                      |
| City of Westminster     | Piccadilly            | Leicester Square tube station | 148                                              | Open                      |
| City of Westminster     | Piccadilly            | Green Park tube station      | 144                                              | Open                      |
| City of Westminster     | Jubilee               | St. John’s Wood tube station | 131                                              | Open                      |
| City of Westminster     | District              | Embankment tube station      | 104                                              | Open                      |
| City of Westminster     | District              | Westminster tube station     | 104                                              | Open                      |
| City of Westminster     | Circle                | Westminster tube station     | 89                                               | Open                      |
| City of Westminster     | District              | London Victoria station      | 75                                               | Open                      |
| City of Westminster     | Circle                | Embankment tube station      | 61                                               | Open                      |
| City of Westminster     | Hammersmith & City    | Baker Street tube station    | 57                                               | Open                      |
| City of Westminster     | Circle                | Baker Street tube station    | 50                                               | Open                      |
| City of Westminster     | Metropolitan          | Baker Street tube station    | 42                                               | Open                      |
| City of Westminster     | Circle                | London Victoria station      | 42                                               | Open                      |
| City of Westminster     | Hammersmith & City    | Edgeware Road tube station   | 39                                               | Open                      |
| City of Westminster     | Hammersmith & City    | Paddington tube station      | 19                                               | Open                      |
| City of Westminster     | Circle                | Edgeware Road tube station   | 10                                               | Open                      |
| City of Westminster     | Hammersmith & City    | Royal Oak tube station       | 9                                                | Open                      |
| City of Westminster     | Circle                | Paddington tube station      | 6                                                 | Open                      |
| City of Westminster     | Circle                | Royal Oak tube station       | 4                                                 | Open                      |
| City of Westminster     | Hammersmith & City    | Westminster tube station     | 4                                                 | Open                      |
| City of Westminster     | Circle                | Westminster tube station     | 3                                                 | Open                      |
| City of Westminster     | Circle                | Bayswater tube station       | 3                                                 | Closed                    |
| City of Westminster     | Piccadilly            | Covent Garden tube station   | 132                                              | Closed                    |
| City of Westminster     | Circle                | Great Portland Street tube station | 91 | Closed                    |
| City of Westminster     | Metropolitan          | Great Portland Street tube station | 48 | Closed                    |
| City of Westminster     | Hammersmith & City    | Great Portland Street tube station | 99 | Closed                    |
| City of Westminster     | Piccadilly            | Hyde Park Corner tube station | 148                                              | Closed                    |
| City of Westminster     | Central               | Lancaster Gate tube station  | 260                                              | Closed                    |
| City of Westminster     | Victoria              | Pinlico tube station         | 460                                              | Closed                    |
| City of Westminster     | Central               | Queensway tube station       | 277                                              | Closed                    |
| City of Westminster     | Bakerloo              | Regent’s Park tube station   | 243                                              | Closed                    |
| City of Westminster     | Circle                | St. James’s Park tube station| 53                                               | Closed                    |
| City of Westminster     | District              | St. James’s Park tube station| 94                                               | Closed                    |
| City of Westminster     | District              | Temple tube station          | 82                                               | Closed                    |
| City of Westminster     | Circle                | Temple tube station          | 14                                               | Closed                    |
| City of Westminster     | Bakerloo              | Warwick Avenue tube station  | 277                                              | Closed                    |
| Greenwich               | Jubilee               | North Greenwich tube station | 103                                              | Open                      |
| Hammersmith & City      | Circle                | Ladbroke Grove tube station  | 5                                                 | Open                      |
| Havering                | District              | Elm Park tube station        | 5                                                 | Open                      |
| Havering                | District              | Hornchurch tube station      | 3                                                 | Open                      |
| Havering                | District              | Upminster Bridge tube station| 2                                                 | Open                      |
| Hillingdon              | Piccadilly            | Heathrow Terminals 2 & 3 tube station | 50 | Open                      |
| Hillingdon              | Piccadilly            | Heathrow Terminal 4 tube station | 47 | Open                      |
| Hillingdon              | Piccadilly            | Hatton Cross tube station    | 44                                               | Open                      |
| Hillingdon              | Metropolitan          | Uxbridge tube station        | 31                                               | Open                      |
| Hillingdon              | Metropolitan          | Ruislip Manor tube station   | 30                                               | Open                      |
| Hillingdon              | Metropolitan          | Eastcote tube station       | 29                                               | Open                      |
| Hillingdon              | Metropolitan          | Ruislip tube station         | 29                                               | Open                      |
| Hillingdon              | Metropolitan          | Hillingdon tube station      | 28                                               | Open                      |
| Hillingdon              | Metropolitan          | Ickenham tube station       | 28                                               | Open                      |
| Hillingdon              | Metropolitan          | Northwood Hills tube station | 23                                               | Open                      |

(continued on next page)
Table A1 (continued)

| Borough                  | Line        | Station                      | Mean PM$_{2.5}$ level in the station (µg m$^{-3}$) | Status (as of 31/03/2020) |
|--------------------------|-------------|------------------------------|--------------------------------------------------|-----------------------------|
| Hillingdon               | Metropolitan| Northwood tube station      | 23                                               | Open                         |
| Hillingdon               | Central     | Ruislip tube station        | 19                                               | Open                         |
| Kensington & Chelsea     | Piccadilly  | Gloucester Road tube station| 147                                              | Closed                       |
| Kensington & Chelsea     | Circle      | Gloucester Road tube station| 5                                                | Closed                       |
| Kensington & Chelsea     | District    | Gloucester Road tube station| 24                                               | Closed                       |
| Kensington & Chelsea     | Central     | Holland Park tube station   | 123                                              | Closed                       |
| Kensington & Chelsea     | Central     | Notting Hill Gate tube station| 200                                           | Open                         |
| Kensington & Chelsea     | Piccadilly  | South Kensington tube station| 178                                             | Open                         |
| Kensington & Chelsea     | Piccadilly  | Knightsbridge tube station  | 137                                              | Open                         |
| Kensington & Chelsea     | District    | Earl's Court tube station  | 105                                              | Open                         |
| Kensington & Chelsea     | Circle      | Sloane Square tube station  | 57                                               | Open                         |
| Kensington & Chelsea     | District    | South Kensington tube station| 45                                               | Open                         |
| Kensington & Chelsea     | Circle      | Sloane Square tube station  | 33                                               | Open                         |
| Kensington & Chelsea     | District    | Earl's Court tube station  | 21                                                | Open                         |
| Kensington & Chelsea     | Circle      | High Street Kensington tube station| 4                                              | Open                         |
| Kensington & Chelsea     | Circle      | Latimer Road tube station   | 4                                                | Open                         |
| Kensington & Chelsea     | Circle      | Notting Hill Gate tube station| 3                                               | Open                         |
| Kensington & Chelsea     | Circle      | Ladbroke Grove tube station | 2                                                | Open                         |
| Kensington & Chelsea     | Central     | Latimer Road tube station   | 2                                                | Open                         |
| Redbridge                | Central      | Newhey Park tube station    | 56                                               | Open                         |
| Redbridge                | Central      | Gants Hill tube station     | 55                                               | Open                         |
| Redbridge                | Central      | Redbridge tube station      | 75                                               | Closed                       |
| Redbridge                | Central      | Wanstead tube station       | 35                                               | Open                         |
| Redbridge                | Central      | Bankside tube station       | 31                                               | Open                         |
| Redbridge                | Central      | Fairlop tube station        | 12                                               | Open                         |
| Redbridge                | Central      | Hainault tube station       | 9                                                | Open                         |
| Redbridge                | Central      | Snaresbrook tube station    | Open                                              |                             |
| Redbridge                | Central      | South Woodford tube station| Open                                              |                             |
| Redbridge                | Central      | Woodford tube station       | Open                                              |                             |
| Tower Hamlets            | Central      | Mile End tube station       | 186                                              | Open                         |
| Tower Hamlets            | District     | Tower Hill tube station     | 91                                               | Open                         |
| Tower Hamlets            | Central      | Mile End tube station       | 82                                               | Open                         |
| Tower Hamlets            | District     | Aldgate East tube station   | 64                                               | Open                         |
| Tower Hamlets            | Central      | Tower Hill tube station     | 59                                               | Open                         |
| Tower Hamlets            | District     | Bromley-by-Bow tube station| 56                                               | Open                         |
| Tower Hamlets            | Central      | Hammersmith & City tube station| 45                                           | Open                         |
| Tower Hamlets            | Central      | Hammersmith & City tube station| 42                                           | Open                         |
| Tower Hamlets            | Central      | Hammersmith & City tube station| 40                                           | Open                         |
| Tower Hamlets            | Central      | Hammersmith & City tube station| 76                                           | Closed                       |
| Tower Hamlets            | Central      | Bow Road tube station       | 80                                               | Closed                       |
| Tower Hamlets            | District     | Stepney Green tube station  | 127                                              | Closed                       |
| Tower Hamlets            | Central      | Stepney Green tube station  | 74                                               | Open                         |
| Tower Hamlets            | District     | Millwall tube station       | Open                                              |                             |
| Tower Hamlets            | Central      | St Katharine Docks tube station| Open                               |                             |
| Wandsworth               | Northern     | Tooting Broadway tube station| Open                                             |                             |
| Wandsworth               | Northern     | Tooting Bec tube station     | 284                                              | Open                         |
| Wandsworth               | Northern     | Clapham South tube station  | 234                                              | Open                         |
| Wandsworth               | Northern     | East Putney tube station    | 203                                              | Closed                       |
| Wandsworth               | Northern     | Southfields tube station    | Open                                              |                             |

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