Cycling rates, cycle-friendly infrastructure and deprivation in the South London Partnership area

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1 Introduction

The benefits of cycling are widely recognised: cycling is healthy, affordable and often faster than travelling by car or public transport (Handy et al., 2014; Heinen et al., 2010). Therefore, it should be facilitated for everyone.

However, recent research shows that cycling infrastructure is not always well distributed, with the poorest and most disadvantaged areas often least benefited by investment (Teunissen et al., 2015; Tucker and Manaugh, 2018), although this is not always the case (Dill and Haggerty, 2009; Winters et al., 2018).

Guaranteeing the access of disadvantaged communities to cycling should be a priority, as it could help them to overcome daily barriers such as health deprivation, economic difficulties or social exclusion.

This study aims to gain knowledge on the relationship between cycling rates, cycle-friendly infrastructure and deprivation in the South London Partnership (SLP) area, so that its policymakers and practitioners can consider it when planning.

2 Objectives

The objectives of this study are to:

1) analyse if the link between cycling rates, access to cycling infrastructure and deprivation is a fact in the SLP;
2) assess if the cycle-friendly infrastructure is equally distributed among its areas; and
3) reveal areas in which future investment in infrastructure could help to increase cycling among the population from deprived areas.

3 Study area

The South London Partnership (SLP) area is the sub-regional collaboration of the five London boroughs of Croydon, Kingston upon Thames, Merton, Richmond upon Thames and Sutton. It borders with the central sub-region of London and its topography is generally flat, with the exception of the southern parts of Sutton and Croydon. Its public transport supply is poorer than in other areas of London (SLP, 2018) and, consequently, it is more car-dependent and has more cycling potential. It does not have very high levels of deprivation, except for some specific areas in Croydon.

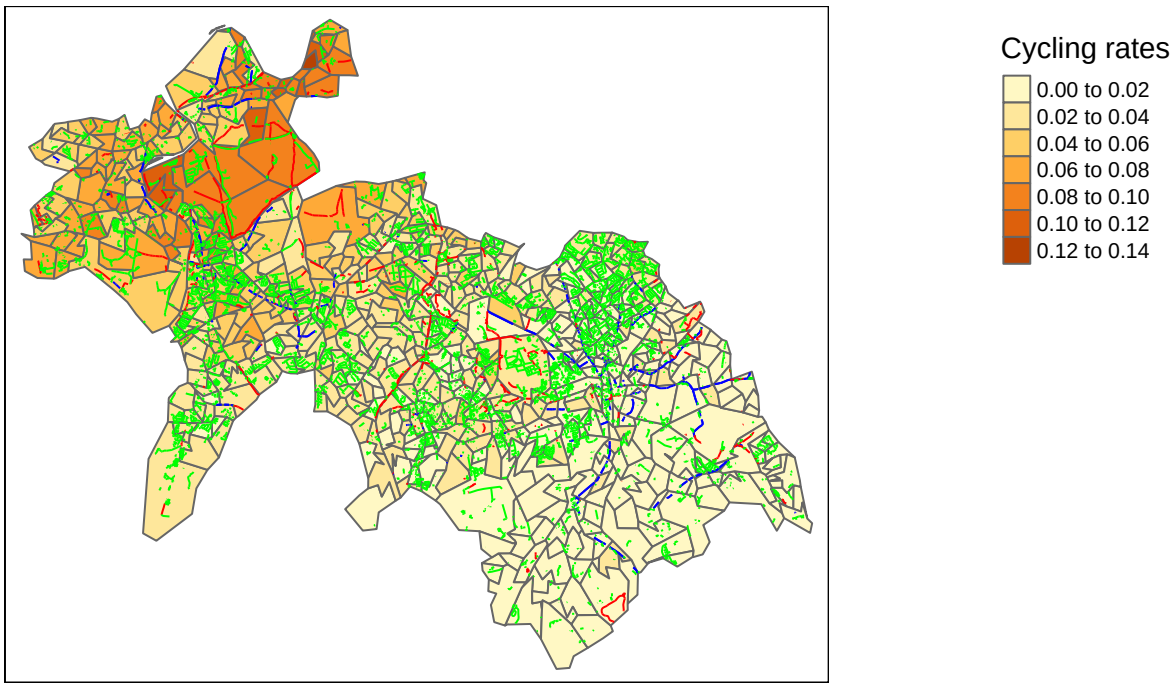
The principal characteristics for each borough are presented in the following table.

Characteristics	Croydon	Kingston	Merton	Richmond	Sutton	SLP
Population	363,378	160,060	199,693	186,990	190,146	1,100,267
Density (people/km2)	4,200	4,297	5,310	3,257	4,336	4,189
Cycling rates (to work)	1.30%	4.45%	3.56%	6.90%	2.25%	3.29%
Length cycle tracks (km)	28.38	19.86	35.65	52.62	36.16	172.67
Length cycle lanes (km)	67.31	20.98	11.69	18.31	3.84	122.14
Length quiet streets (km)	339.03	229.59	185.98	136.26	202.87	1,093.72
Index Multiple Deprivation (IMD)	23.19	10.96	14.76	10.03	14.42	16.08
Areas between 20% most deprived	47	1	4	1	7	60

Table 1 Population, density, cycling rates, cycle-friendly infrastructure and deprivation

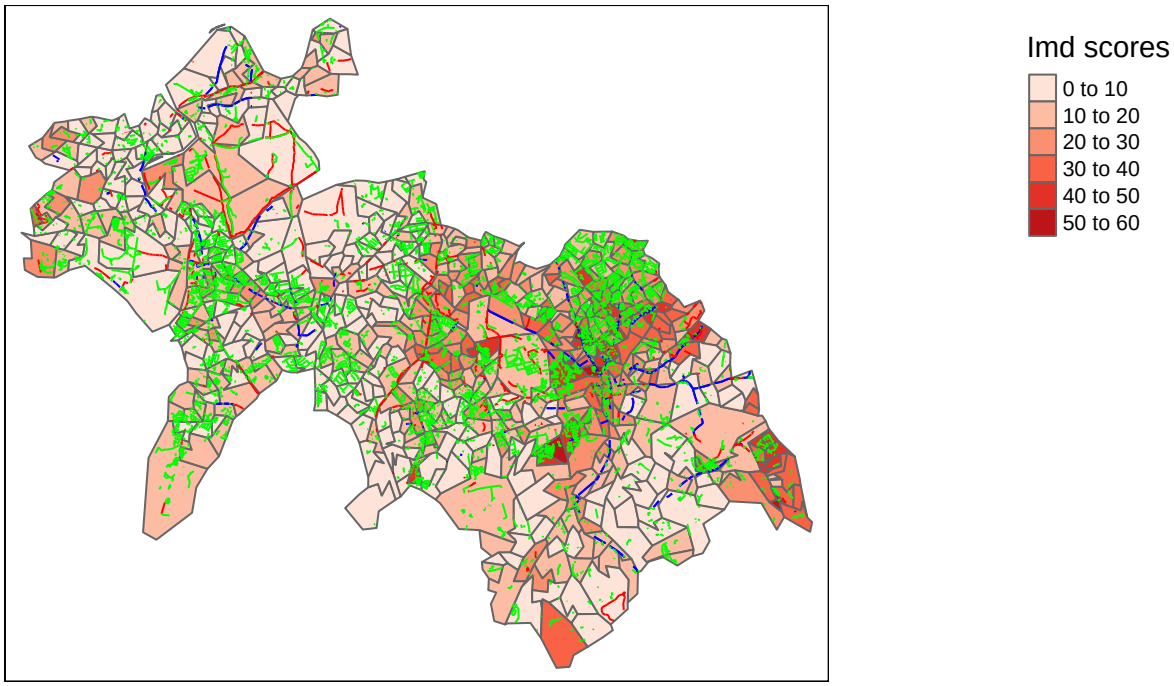
There are 678 Lower Layer Super Output Areas (LSOA) in the SLP area; with an average size of 0.387 km2 and 1,622 inhabitants.

In map 1, we can see the distribution of cycling rates per LSOA area and the provision of cycle-friendly infrastructure divided between cycle tracks (in red), cycle lanes (in blue), and quiet streets (in green).



Map 1 Cycling rates and provision of cycle-friendly infrastructure

Map 2 shows the Index of multiple deprivation (IMD) scores per LSOA area and the provision of cycle-friendly infrastructure.



Map 2 IMD scores and provision of cycle-friendly infrastructure

4 Data and methods

4.1 Data collection and processing

4.1.1 Cycling rates

From the 2011 census, we obtain the `Cycling rates` (proportion of journeys to work by bicycle)[1].

[1] Although TfL has up-to-date origin-destination cycling data for all destinations from the Cycling Network Model for London (Cynemon), this data does not differentiate between journeys made by population from an area and its visitors, so it is not appropriate to analyse the travel behaviour patters of the population of an specific area.

4.1.2 Cycle-friendly infrastructure

From the OpenStreetMap, we gather the cycle-friendly infrastructure data and classify it (based on https://wiki.openstreetmap.org/wiki/Bicycle#cite_note-anyroad-1) into three categories:

- `Cycle tracks` (paths dedicated to cyclists on separate right of way and sections segregated shared with pedestrians);
- `Cycle lanes` (lanes marked on a portion of a carriageway designated for cyclist use); and
- `Quiet streets` (roads shared with motorised vehicles with maxim speed limit 20mph).

The indicators of access to cycle-friendly infrastructure are calculated as follows:

- `Cycle tracks/km2`(length cycle tracks (km)/km2);
- `Cycle lanes/km2` (length cycle lanes (km)/km2);
- `Quiet streets/km2` (length roads speed limit 20mph (km)/km2); and
- `Total cycle-friendly infrastructure/km2` (total length cycle tracks, length cycle lanes and length quiet streets (km)/km2).

4.1.3 Deprivation

From the IMD 2015, we collect the last indices of deprivation published by the Department for Communities and Local Government. The `IMD score` (index of multiple deprivation score) gives us the measure of general deprivation, while the other 7 indices are different domains of deprivations:

- `D1 Income` (domain of deprivation income score);
- `D2 Employment` (domain of deprivation employment score);
- `D3 Health` (domain of deprivation health deprivation and disability score);
- `D4 Education` (domain of deprivation education skills and training score);
- `D5 Barriers` (domain of deprivation barriers to housing and services score);
- `D6 Environment`(domain of deprivation living environment score); and
- `D7 Crime`(domain of deprivation crime score).

4.1.4 Other relevant variables

Other relevant variables[2] taken into consideration are:

- `Public transport rate` (proportion of journeys to work by public transport);
- `Walking rate` (proportion of journeys to work on foot);
- `Distance to work less 10km` (proportion of journeys to work shorter than 10 km);
- `Density` (population/km2);
- `Car ownership rate` (number of cars/1,000 inhabitants); and
- `Hilliness` (average fast route gradient (%) of commute trips in zone with fast route distance <10km).

[2]The variables `Public transport rate`, `Walking rate`, `Working less than 10km away`, `Density` and `Car ownership rate` are based on 2011 census data, and the `Hilliness` is obtained from the Cycling Infrastructure Prioritisation Toolkit project (CyITP) https://www.cyipt.bike/#6/53.690/-2.142/mapnik

4.2 Data analysis

To achieve objective 1 and objective 2 non-spatial techniques such as correlograms and box diagrams are used, while to achieve objective 3 a bivariate choropleth map is created.

All data processing, analysis and maps have been done using `R Statistics 3.4.3`. The use of interactive visualizations (in the html version) allows the reader to explore the data in greater detail. The maps can be zoomed in, information of each specific area explored, the base maps changed and the type of cycle-friendly infrastructure activated or deactivated. The quintiles of the box plots pop-up if the mouse is moved over them.

5 Results

5.1 Cycling rates, cycle-friendly infrastructure and deprivation link

In the following graph, we analyse the correlation between all the variables considered in the study (except the specific deprivation domains examined in the next graph). In red we can see the negative correlation coefficients and in blue the positive ones. Correlations with p-value > 0.05 are considered as insignificant and consequently represented in blank.

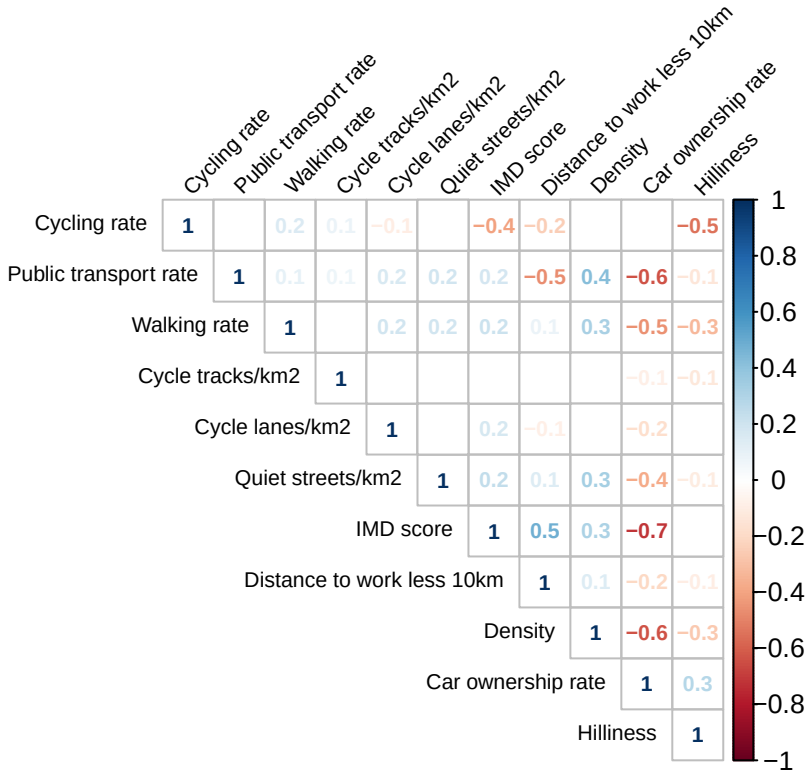


Figure 1 Correlations general variables

Only walking rate and cycle tracks are positively correlated with cycle rate, although rather weakly, +0.2 and +0.1 respectively.

On the other hand, a clear negative correlation between cycling rate and hilliness (-0.5) and deprivation (-0.4) has been found. Distance to work less 10 km is also negatively correlated to cycle rate, although more moderately (-0.2).

Other links to highlight are the existing between deprivation and car ownership rate (-0.7), and between deprivation and distance to work less 10 km (+0.5). Both indicate a high potential for cycling among people living in deprived areas.

In the second correlogram, we analyse the possible correlation between cycling rate and each of the specific deprivation domains.

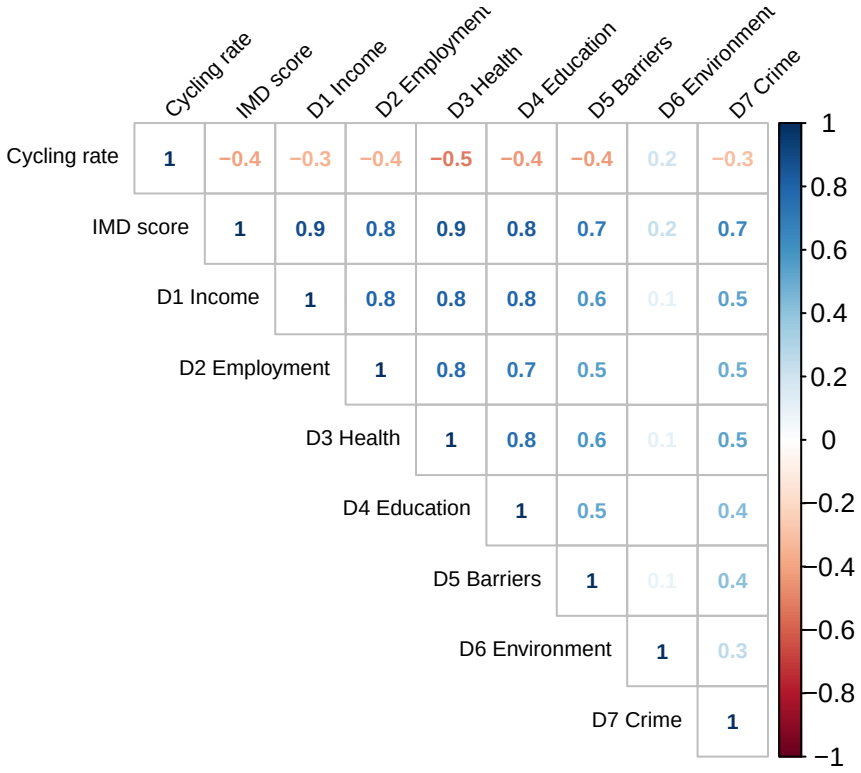


Figure 2 Correlations deprivation domains

All the deprivation domains, except the living environment, are negatively correlated with cycling rate, being health deprivation and disability (D3 Health) the most strongly associated (-05).

5.2 Cycle-friendly network equity assessment

As can be seen in the first correlogram figure 1, there is no negative association between deprivation and access to cycle-friendly infrastructure, rather the opposite. The graph does not show statistical significance between deprivation and cycle tracks (the safest cycling infrastructure), but a modest positive relationship (+0.2) between deprivation and both, cycle lanes and quiet roads.

The following boxplots help to examine this in more detail.

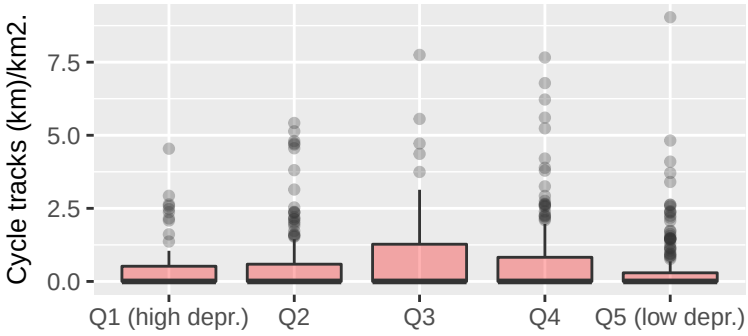


Figure 3 Cycle tracks provision by deprivation quintiles

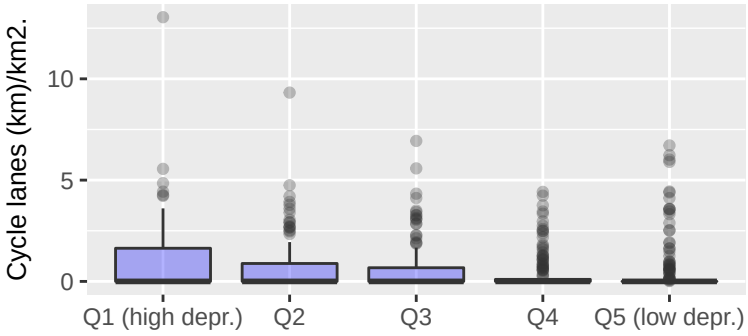


Figure 4 Cycle lanes provision by deprivation quintiles

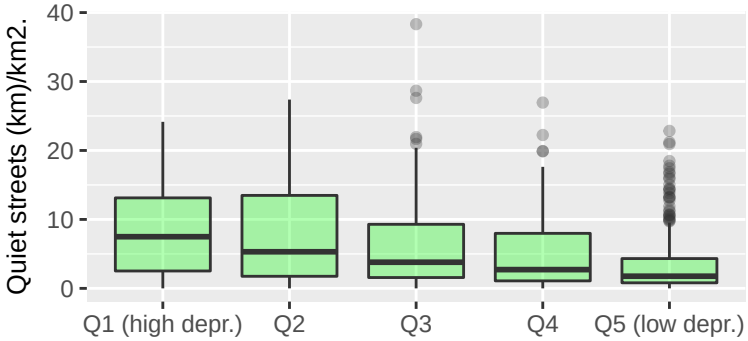


Figure 5 Quiet streets provision by deprivation quintiles

Two ideas emerge from these graphs. First, access to both, cycle tracks and cycle lanes is overall low - only 29.65% and 40.56% of the LSOA areas are provided with these bicycle-specific infrastructures respectively. Secondly, while access to cycle tracks (figure 3) does not follow a clear pattern in relation with deprivation - cycle tracks are particularly low in the areas that are either most deprived or least deprived; the trend in access to cycle lanes (figure 4) and quiet streets (figure 5) is evident: the more deprived the area the more their provision or accessibility.

5.3 Targeting areas for future investment

To target areas where future investment could help to increase cycling equity, a bivariate choropleth map based on Kiefer (2017) has been created.

This technique allows us to graphically illustrate the relationship between the two spatially distributed variables, `total cycle-friendly infrastructure/km2` and `IMD scores`, identifying the LSOA areas in which infrastructure is low and deprivation high at the same time.

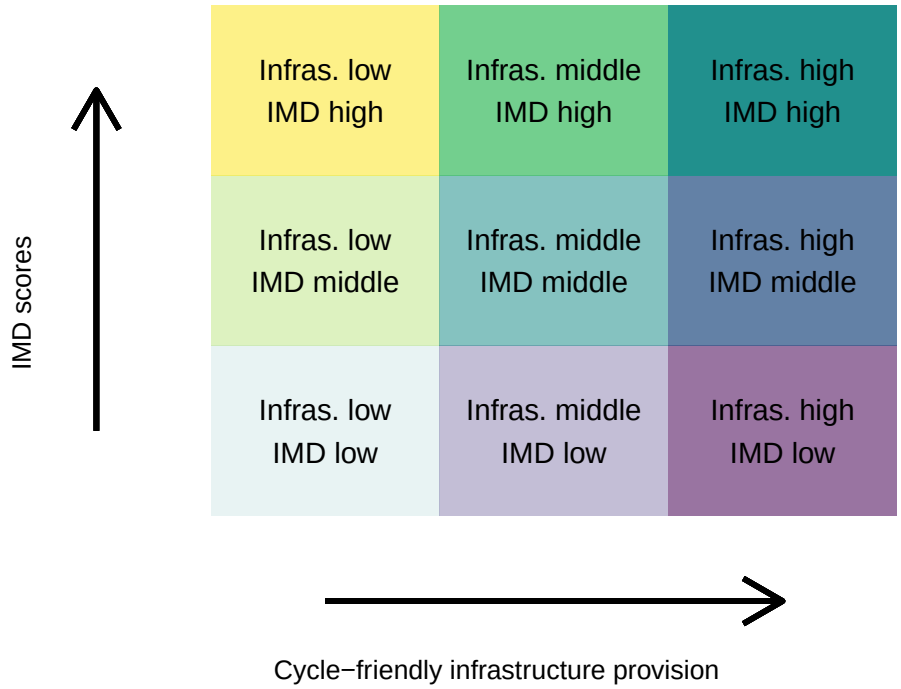
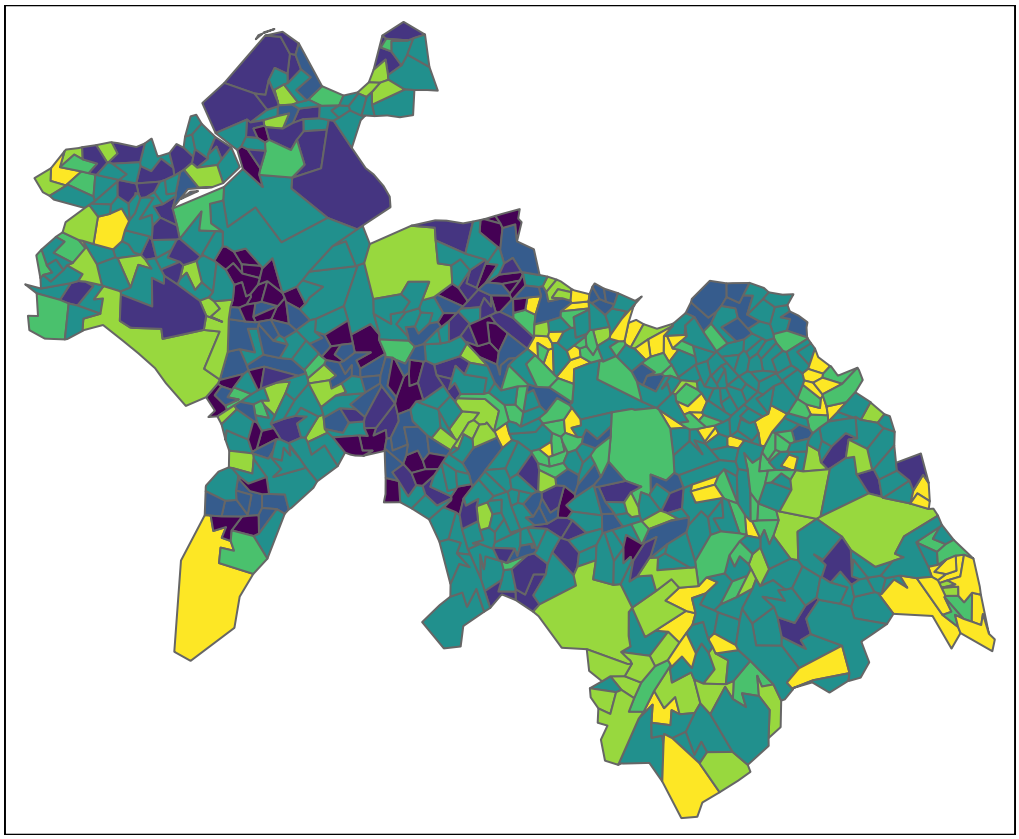


Figure 6 Bivariate colour scheme



Map 3 Potential areas for future investment

The map shows that the areas less provided of cycle-friendly infrastructure and simultaneously more deprived (in yellow colour) are rather scattered across the entire SLP area. However, some clusters in New Addington (with 8 yellow LSOA areas), South Norwood (6), Norbury (6), and Mitcham (5) in the borough of Croydon; and in Purley (4) in the borough of Merton stand out from the rest.

6 Limitations and further work

Unfortunately, time constraints and the word count limit of this report have not allowed considering a couple of aspects that, in our opinion, would have enriched and made more reliable the study:

- the quality and connectivity levels of cycle-friendly infrastructure; and
- the cycling potential per area [3] that could have been incorporated into the map 3 to make it more precise.

[3]Cycling potentiality can be obtained from the Analysis of Cycling Potential 2016 (TfL) http://content.tfl.gov.uk/analysis-of-cycling-potential-2016.pdf or from the Propensity to Cycle Tool (PCT) https://www.pct.bike/

7 Conclusions

This study reveals that the only cycle-friendly infrastructure positively correlated with cycle rates in the SLP area is cycle tracks (the safest one), although very weakly. In addition, a clear negative correlation between cycling rates and deprivation has been found: the more deprivation, the less cycling participation.

Access to both, cycle tracks and cycle lanes is overall low in the SLP area. In addition, and contrary to our expectations, highly deprived areas have a greater density of cycle lanes and quiet streets than non-deprived ones. However, cycle tracks are particularly low in the areas that are either most deprived or least deprived.

Finally, we identified small clusters of spatial areas, particularly in Croydon and Merton, in which future investment in infrastructure should be considered to improve equity. To increase cycling among the most deprived populations in the SLP area, investment in behaviour-change programmes might be also needed.

The non-inclusion of the quality and connectivity levels of the infrastructure and cycling potential should be considered as a limitation of the study. Future work needs to be carried out in this direction.

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