# Using circuity analysis to explore pedestrian access to healthcare services in York

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# 1 Introduction

Carlos Moreno first proposed the 15-minute city concept in 2016. The focus of the concept is that access to essential services and amenities, such as healthcare and greenspace should be within a 15-minute walk or cycle from a persons home (Moreno et al., 2021). The COVID-19 pandemic then highlighted the importance of local access to essential services, because lockdowns and other restrictions on movement limited the ability to travel beyond ones immediate neighbourhood. The 15-minute city concept has gained traction more recently within the disciplines of urban planning and sustainable development. It also provided a new perspective on "chrono-urbanism", in which there is an inversely proportional relationship between peoples quality of life and the time people invest in transportation and is especially true in the use of motor vehicles (Logan et al., 2022).

Active travel modes such as walking and cycling health outcomes for people. It enables better potential fitness levels and reduces inactivity. Benefits to the economy can be measured through a healthier society, which results in fewer people needing to use the NHS, therefore saving it money. The environment benefits from active travel because these modes of are emission-free, which reduces airborne particulate matter, increasing air quality in towns and cities (DfT, 2023).

However, time and its availability is an important factor when it comes to peoples decisions around mode choice. The study by Ralph et al. (2020) highlights this very well, and is pertinent to the study in this report because it was discovered that people were more likely to overestimate the length of the route, and therefore the time it would take to walk/cycle, along routes where there were barriers to overcome and many turns to take. This decreased the chance of people using an active mode of transport over motorised vehicles. Other reasons for choosing against walking in their study were fears of crime, getting lost, and carrying something heavy. They also found that people were more likely to lower their estimations of the time and distance of a route with experience and familiarity of a route.

Through urban design and service planning, it should be possible to increase active travel, and reduce (private) motorised vehicle use. In order to achieve these goals, understanding the current situation in terms of accessibility is important. This study looks to contribute to this understanding, using the City of York Local Authority District (York LAD), which includes the City of York and the surrounding villages and by analysing peoples access to essential services (healthcare provision in this case), though circuity of walking route measurements.

# 2 Scope

The primary aim of this study is to analyse ease of pedestrian access to basic essential (health) services. This will highlight the the areas in which access is more or less likely to occur by active travel modes and could help towards future policy in urban design that has a focus on economic and environmental sustainability as well as population health.

Access will be measured through defining a reasonable travel time from each service, based on 20 minutes average walking distance. Twenty minutes was chosen, because the average distance walked in around this amount of time is equivalent to one mile (Foundation, n.d.).

In this report, I will firstly describe the methods that will be used, and justify some of the decisions made in regards to the preparation, cleaning and processing of the data, including communicating and visualising the results. I will then comment on how these results may contribute to planning the urban environment in respect of the tenets of the 15-minute city. Finally, I will highlight some of the problems and limitations of the study, and propose any changes that could be made to similar studies in the future.

# 3  Area of study

The York LAD was chosen because the of the physical makeup of the city. It sits in the county of North Yorkshire & The Humber, and has a population of around 200,000, of which there is a large student population of around 48,000 (York Council, 2024), many of which could potentially benefit from cheap and healthy transport options around the city, especially as the main campus of the University of York sits some way outside the centre. Buildings are tightly packed within the walled old center, which is immediately surrounded by decreasingly dense suburban neighbourhoods, and at the periphery by smaller more isolated villages, such as Haxby and Bishopthorpe. This study area should provide a variety of different urban/suburban settings in which analysis can be carried out and compared.

## 3.1  Spatial Scale

The spatial scale for analysis was based upon the smallest or lowest level of geographical area. This is the Output Area (OA), and typically represents between 40-250 households and is made up of around 100-625 people (National Statistics, n.d.).

# 4  Datasets

- The data was extracted, processed and analysed using RStudio 2023.12.1+402 "Ocean Storm".

- The study area boundary was extracted from the Open Geography Portal (National Statistics, 2023).

- Point data for the healthcare services was extracted from OpenStreetMap (OSM) using the `osmdata`, and the services chosen were `"clinic"`, `"dentist"`, `"doctors"`, `"hospital"`, `"pharmacy"`.

- A graph of the study area was locally built using the `opentripplanner` package which is a multi-modal route planner, using imported OSM networks and allowed for both the isochrones around the services, and routes to them to be calculated.

# 5  Pre-Processing, Understanding & Preparation

Once the data was extracted, and in order to be able to process them correctly, it was important to understand their structures and content. The OSM data returned points and polygons. So that we were able to calculate isochrones properly from point data, it was necessary to convert polygons consisting of larger buildings such as hospitals, to points representing the centroid of the polygons. This was done using the `st_intersects` and `st_centroid` functions. It was then possible to combine the data that was originally point data and the new centroid points ready for processing. In addition to these conversion processes, any unwanted data was removed from the datasets to make navigation and further processing easier and more efficient.

# 6  Exploratory data analysis

The cleaned data was then plotted so that we could make sure that both the numerical counts of the different amenities looked feasible, and also the spatial distribution of them was correctly within the study area. This can be see in Figure 1.

Figure 1: Healthcare services in York

# 7 Methodology

## 7.1 Isochrone calculation

Once the data had been prepared, 20-minute walking time isochrones were calculated around each of the healthcare points. This was carried out using the `opentripplanner::otp_isochrone` function. Isochrones were used because we did not want routes to be calculated for origins that were further away than this walking distance. If isochrones were not used, routes would have been calculated to destinations that would not need to be accessed because they were further away than the closest, which would end up skewing the results of the circuity calculations, and provided no benefit to analysing access.

## 7.2 Make the hex grid

It was decided that points fo origin would be created so they act as a proxy for exact origin locations. One of the alternatives would have been to use Output Area (OA) population weighted centroids. This would however have meant that it would have resulted in a single origin location for each OA. Postcodes could have also been used, but this would have resulted in more processing power being required (something that is limited at this time), so the most effective solution was to calculate a hexagonal grid using `st_make_grid` from the `sf` package, with a `cellsize` of 250 (units). The grid was then transformed from polygons to points/centroids (so 7 in total for each hexagon). Duplicate points for those neighbouring polygons were then removed and the final point data was then ready for calculating routes from.

## 7.3 Calculating routes & circuity

Once the point data was clipped to the isochrones, routes were calculated from each point within each isochrone to the relevant amenity destination. This was done using the `opentripplanner::otp_plan` function using `walk` as the only valid method of transit.

Circuity was then calculated for each route using the following formula: -

$$k_{ij} = \frac{(l_{ij} - d_{ij})}{l_{ij}}$$

Where $k_{ij}$ is the circuity, $l$ is the route distance between node $i$ to node $j$, and $d$ is the geometric distance between node $i$ and node $j$. The resulting measurement will be between 0 and 1, with the least circuitous (straightest) routes being closer to 0 and the most circuitous routes being closer to 1.

## 7.4 Output Areas

Output areas were then loaded and the origins that intersect with each were calculated. The mean circuity for each OA to provide the final results for the study area. These were then plotted and can be seen in Figure 2.

# 8 Results

Figure 2 shows the spatial distribution of the mean circuity for each OA in York. We can see a number of places with relatively high circuity; one area in the south and one in the north-east and the OAs with the lowest circuity seems to be mainly in the east, with a small area around Haxby in the north displaying particularly a low mean circuity. This however does not show the numeric distribution of the mean values, so a histogram was produced to visualise this.
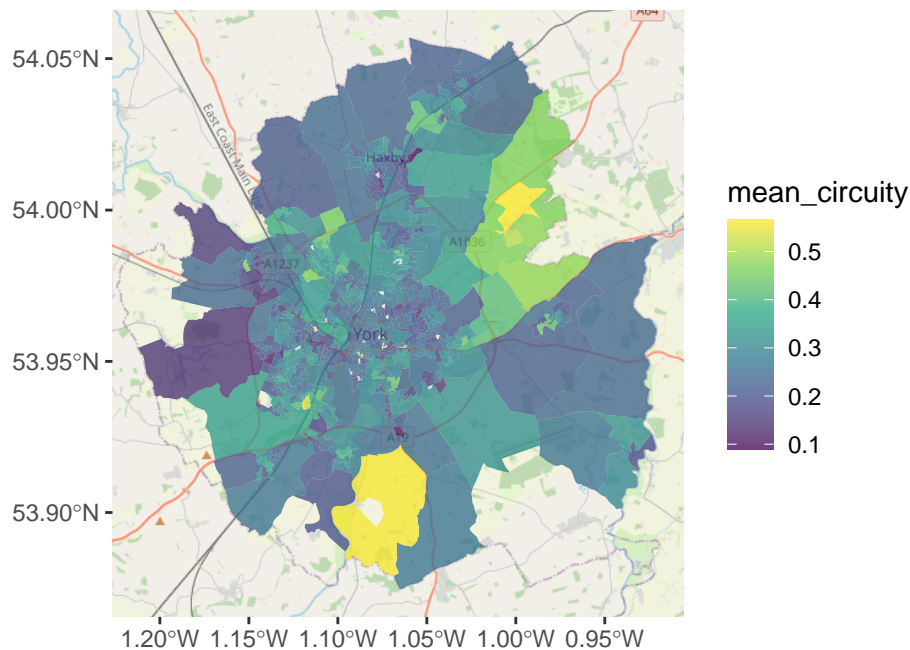


Figure 2: Mean circuity of routes to healthcare services in York

As we can see in Figure 3 the distribution displays a small right-skew, equating to a somewhat low circuity overall in York.

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.08912 0.22369 0.26001 0.26708 0.30076 0.56583
```

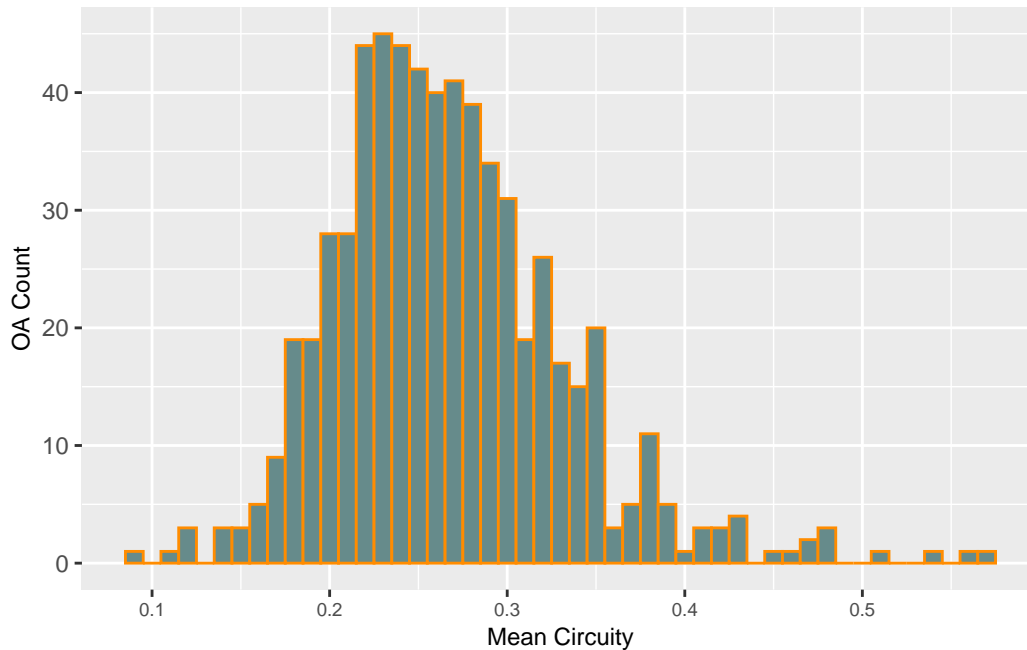

Figure 3: Distribution of mean circuity for York OA's

To try to better understand why these two OAs routes result in circuity calculations that are so different, plots were created to visualise the routes that make up those calculations. Figure 4 clearly shows that the OA with the lowest circuity is in the village of Haxby to the north of York. This circuity implies that the structure of the village is such that services are centered around the high street, which itself consists of a single fairly straight road through the village. By contrast, the OA with the highest circuity was to the north-west of York and is overall more rural, and is less densely built up. The location of the service is important to the calculations here, because it sits away from the main street through the village of Stockton on the Forest. This means that the route to the service is longer and more circuitous than it would be if the service was located on the main street.

rural locateions have higher car use and ownership, so planning should put services in the most accesible place
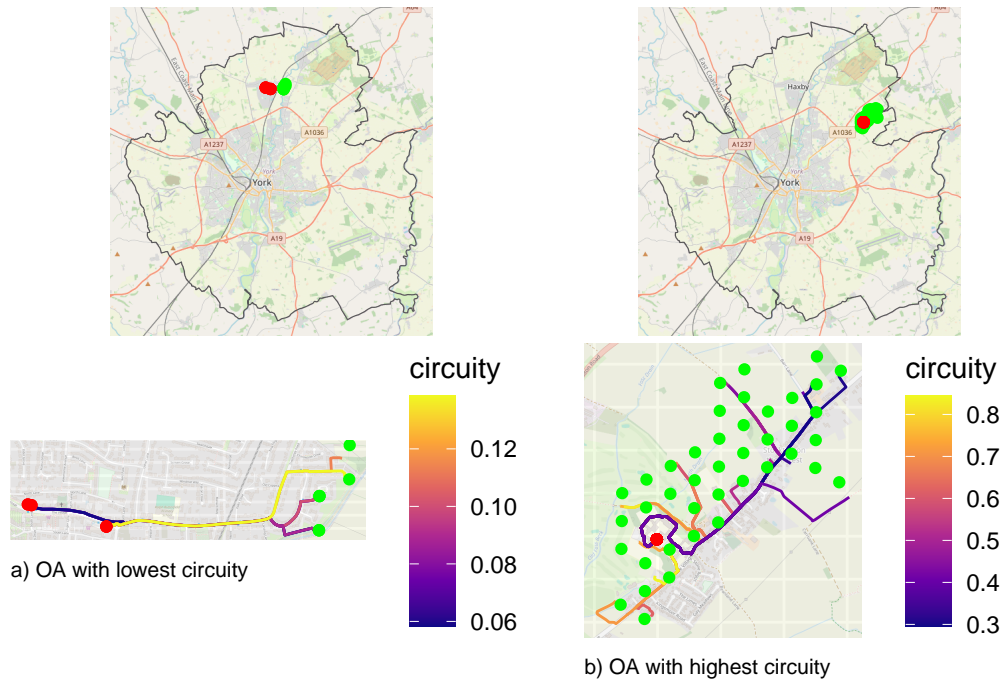
Figure 4: OAs with the lowest and highest mean circuity routes

# 9 What are the demographics of the best areas?

# 10 What does car ownership look like in these areas?

# 11 Discussion

In retrospect i could have not used isochrones to calculate route circuity. I should have used all hexpoints and then aggregated over OAs because the way I did it means that some OAs that may only have a single amenity at the edge may sit outside the isochrone. I could have taken the travel time as an average. However, this would have resulted in routes to all amenities, so using a route to the closest amenity was the most practical way of measuring the access

Make sure to point out limitations of the method Could have used a crossings file to make routes shorter for people etc.

Also there are other factors like crossings that could shorten routes

Could have used population density measure to weiight circuity

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# 13  Appendix