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 (which is especially true in the use of motor vehicles) (Logan et al., 2022).

Active travel modes such as walking an cycling are better for peoples health outcomes. 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 increased active travel because these modes of transport 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 importantly in the context of this study, 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 that route(s).

Through urban design, 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 will help towards future policy in urban design that has a focus on economic and environmental sustainability and 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.).

I will firstly describe the methods that will be used, and justify some of the decisions made in regards to the preparing, 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 countyo f North Yorkshire & The Humber andhas a population of around 200,000, of which there is a large student population of around 48,000 (York Council, n.d.), 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. It has a tightly packed walled old center, that is immediately surrounded by increasingly less dense suburban suburban neighbourhoods and at the periphery by smaller more isolated villages, such as Haxby and Bishopthorpe. This provides a variety of different settings in which analysis can be carried out and compared.

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 multimodal 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. It was then possible to combine the data that was originally point data and the new centroid points ready for processing.

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.

7 Methodology

7.1 Isochrone calculation

Once the data had been prepared, 20-minute walking time isochrones were able to be 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, origins may have had access to different destinations within 20 minutes, and this would have skewed the results.

Figure 1: Healthcare services in York

7.2 Make the hex grid

It was decided that points would be created to 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 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 Figure 2.

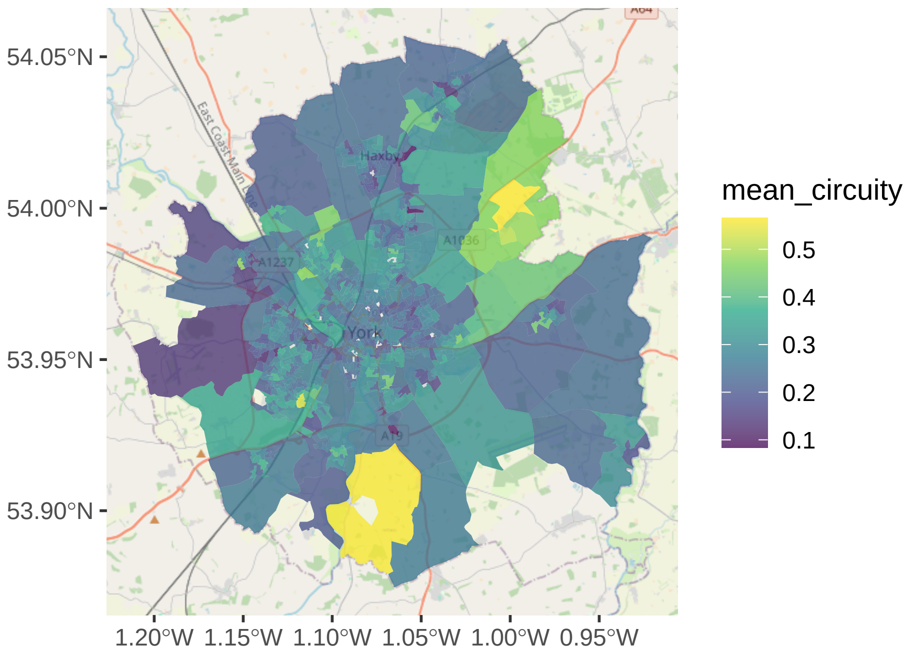

Figure 2: Mean circuity of routes to healthcare services in York

8 Results

Figure 2 shows a number of places with relatively high circuity, but this does not show the distribution of the means. This can be seen in Figure 3.

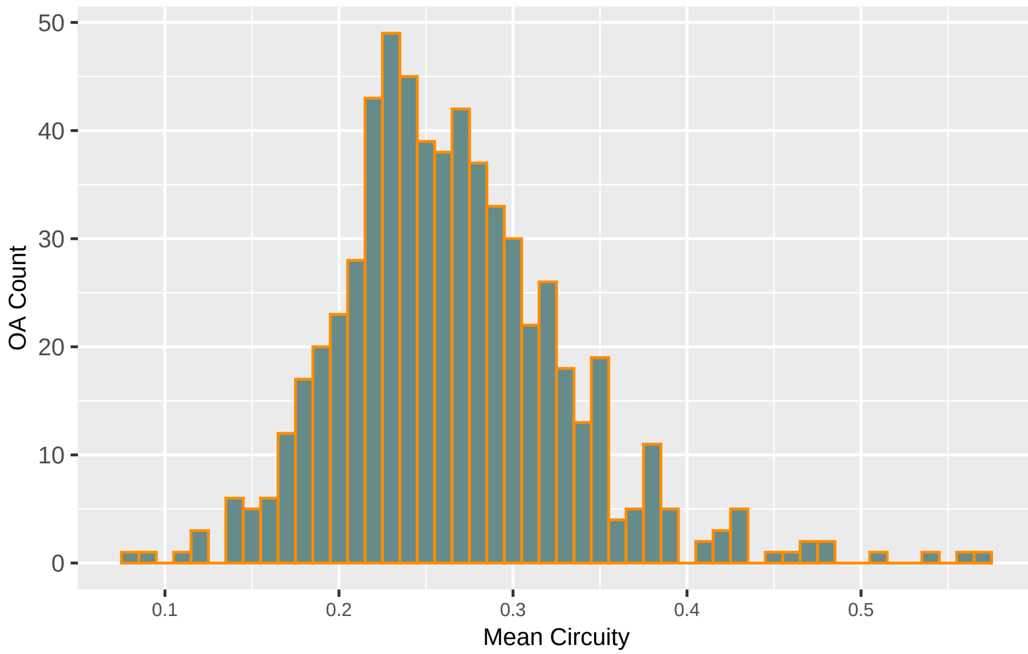

Figure 3: Distribution of mean circuity for York OA's

9 Where is circuity best/worst?

10 What are the demographics of the best areas?

11 What does car ownership look like in these areas?

12 Discussion

In retrospect i could have not used isochrones to calculate route circuity. I should have used all hex-points 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

13 References

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14 Appendix