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The usability of open source tools to measure access to health services; analysing mobile cancer unit locations

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Summary
A large body of literature supports the use of two-step floating catchment area (2SFCA) methods in measuring healthcare accessibility. Although there are many studies that utilise these tools it is difficult for the non-expert to be able to perform these calculations, and as such there is a need for free and open source software (FOSS) solutions. This paper describes usability issues surrounding the development of such open source tools and their application in a number of different policy scenarios. Applied to data concerning the provision of static and mobile cancer services in Wales, these tools are used to test the suitability of alternative locations for the provision of such services in relation to the potential demand for cancer services.

KEYWORDS: Open Source, Healthcare Accessibility, Two Step Floating Catchment Area (2SFCA), Cancer Services, Optimisation of health services

1. Introduction

Understanding access to healthcare is an essential part of healthcare service provision planning. Apparicio et al (2008) suggest that there are five common methods used: 1) the distance to closest service, 2) the number of services within a certain distance or time, 3) the mean distance to all services, 4) the mean distance to a certain number of closest services, and 5) the gravity model (Joseph & Bantock, 1982). The first four measures are relatively simple to compute and have been used extensively in measuring healthcare accessibility, but as GIS becomes more advanced and computational power becomes cheaper it is easier to compute large and complex calculations.

The two-step floating catchment area (2SFCA) method was introduced by (Wang, 2000) and is a special case of the gravity model. 2SFCA is used considerably in healthcare accessibility studies (McGrail and Humphreys, 2009; McLafferty *et al.*, 2011; McGrail, 2012; Bauer *et al.*, 2017). 2SFCA has two steps that provide an easy to interpret accessibility score, which takes into account both distance and population. Luo and Qi, (2009) suggested enhanced 2SFCA (E2SFCA) which addressed some of limitations in the 2SFCA calculations. There have been many enhancements to the original 2SFCA calculation but in this example a linear distance decay function has been added.

A tool to compute 2SFCA scores that operates in a proprietary GIS (ESRI ArcMap©) has been developed by Langford et al (2015) and has been used in several studies to date (Langford, Higgs and Fry, 2016). This enables users to input their own datasets to calculate E2SFCA scores in an ArcGIS environment. Developed using ESRI ArcObjects and coded in VB.NET, it is dependent on the Network Analyst Extension and is thus strongly tied to the ArcMap GIS.

This project is in partnership with Tenovus Cancer Care who are a Welsh cancer charity that provides chemotherapy in the community using mobile units. It is important for them to understand where to provide their resources, and by having access to a tool that would allow a non-expert user to use more complex accessibility measures it will strengthen their offering. Tenovus Cancer Care along with many other charities and local authorities do not have access to ArcMap and they do not have an in-house GIS expert. As such, a similar tool to the Langford et al (2015) ArcMap add-in has been developed and tested using free and open source software (FOSS). This paper describes the development of the tool, technical and conceptual challenges in its development, and demonstrates it application in a number of different health policy scenarios related to the provision of static and mobile cancer care services.

2. Development of FOSS Tools to perform 2SFCA calculations

There are many ways to develop a tool such as this and several different solutions have been considered (Table 1). Each solution has its advantages and there is no one 'right' way for this tool to be developed. The key considerations are that the tool is FOSS and can be used by the non-expert, but development speed, stability, number of platforms used, computational speed and capacity are all considered.

Table 1 Some potential development options

QGIS	GRASS	Stand alone programme	gvSIG	PostGRESQL/GIS and pgRouting
Stable environment to create the plugin would enable easy development and good community of developers. It lacks a capable network analyst function that creates problems.	Good solution for this problem as it has its own network analyst and stores the data in its own spatial database.	Could provide the most accurate algorithm for the data and could be customised to fit the exact needs of an individual user. The need to replicate lots of existing work would affect development time.	Good solution with its own network analyst capabilities.	Requires a user interface to be created but offers a stable spatial database and strong routing capabilities utilising pgRouting.

The tool (Figure 1) has been developed using PostGRESQL/GIS, pgRouting and C#.net. PostGRESQL is a free and open source database and by utilising PostGIS it has powerful spatial database capabilities. There are many benefits to using PostGIS, and C#.net has been chosen to develop the GUI and manage the SQL calls as Tenovus Cancer Care have experience of this platform in house. The tool utilises many of the built in PostGIS functions such as st_dwithin which uses Euclidean distance to quickly eliminate all the data points that are outside of catchment area, this function eliminates a huge amount of the calculations that would otherwise need to take place and dramatically increases the performance of the tool. In pgRouting, pgr_dijkstracost and pgr_wihpointscost have been utilised to provide the routing information although there are other algorithms that could be capable of completing this task.

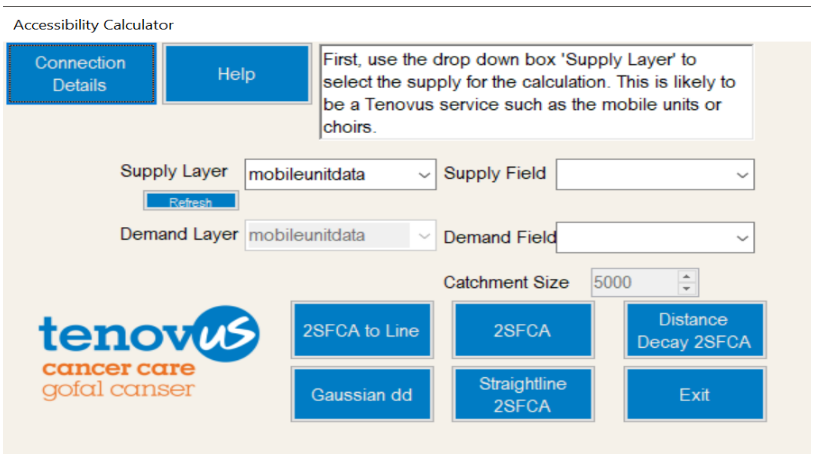

Figure 1 Accessibility Calculator, a tool to perform E2SFCA calculations.

The tool has several features that allow the user to perform multiple tests on the same data. There are both linear and Gaussian distance decay functions. The tool is also able to use a catchment size in kilometres or number of minutes travelled. The tool provides a PostGIS table with the results, which can then be mapped using a GIS (Figure 2). The tool has been designed to be used by non-experts and as such must be kept as simple to understand as possible whilst offering a good level of functionality. In total, there are only five inputs required from the user and then a ready to map data table is produced.

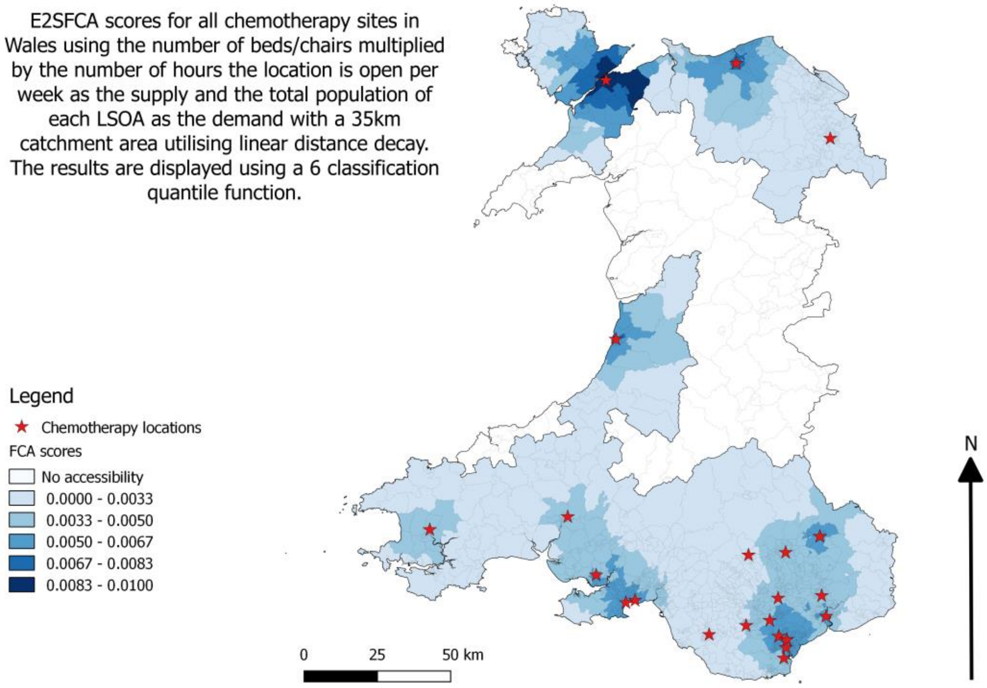

Figure 2 Visualisation of E2SFCA scores, an example output.

3. Application: the use of 2SFCA tools in planning the location of cancer services

3.1 Data Issues

Freedom of information requests (FOI) have been completed to gain a full understanding of the chemotherapy and Lymphoedema provisions in Wales. There is very little data available that looks at Wales as a whole regarding chemotherapy and most of the health boards do not publish where and how often they offer chemotherapy services. This data can be utilised with the current Tenovus Cancer Care mobile unit locations to provide an overview (Figure 3) of chemotherapy sites in Wales.

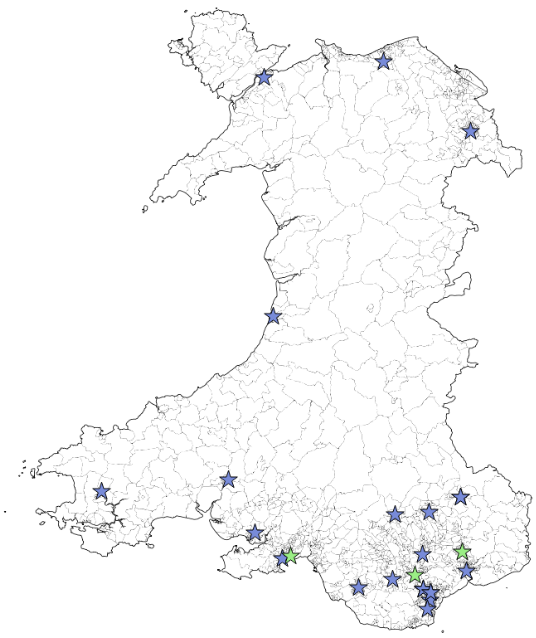

Figure 3 Static chemotherapy sites (blue) and Tenovus mobile units (green).

Drawing on cancer service utilisation data, it has been possible to establish that the average user of services in Wales travels 35km to use their chemotherapy services. Using this information and the total population of each LSOA, it is possible to highlight areas of Wales that have poor access to chemotherapy services (Figure 4). The higher the score the better the accessibility, so the areas in white have no access to chemotherapy services within 35km and the areas of dark blue have the best access.

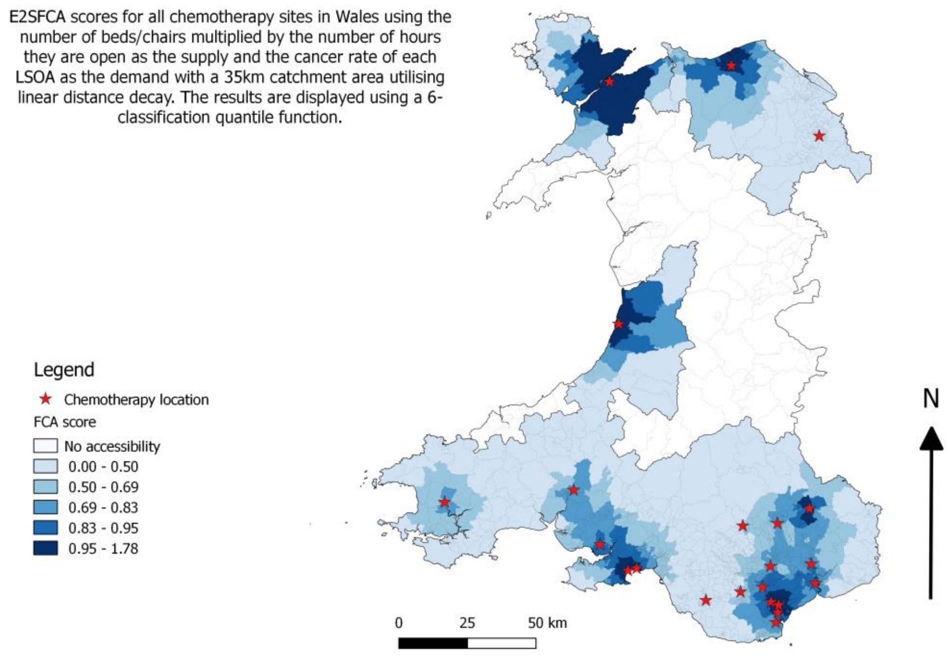

Figure 4 E2SFCA scores of all chemotherapy sites in Wales.

The use of maps to show which areas have poor accessibility is of great use to a healthcare provider such as Tenovus as it allows them to target areas, increase funding and increase awareness of the issue.

3.2 Implementation of Tools to measure access to cancer services

There has been some research concerned with comparing the use of different parameters and decay functions, but there has been a lack of research into the effects that the underlying data used in these methods has upon the overall accessibility score. This project has investigated the effects of the following;

- ***Network quality*** (OSM, OS Open Roads, OS Master Map, Euclidean distance) – By comparing different network types it will be possible to investigate if the quality of the network has any significant effect on the accessibility score and if it does at what point does it become significant. The quality of the network datasets available differs tremendously and to understand the effect that this has will enable researchers to adjust accordingly. OSM data provides street speeds whereas OS Open Roads have to be added manually and at a large scale. There is a lot of room for error in how these speeds are set. When paying for OS Open Roads it is possible to get a very detailed network that highlights one-way streets, bridges and tunnels but these are more difficult to find in the FOSS data available. There are many differences between the data sets and it is key to understand the effect the quality of the network has on the overall accessibility score.
- ***Unit Location Planning*** (Using different scenarios to assess the impact of the Tenovus mobile units in different locations throughout Wales) – It is possible to run a number of scenarios which can inform Tenovus of the impact that their mobile units have in different locations. Utilising car park data to narrow down the number of options, it is possible to provide Tenovus with a number of different scenarios showcasing the differences in accessibility at each location.
- ***Spatial Scale*** (OA, LSOA, MSOA) – Comparing accessibility maps with data of different scales will show if the scale of the data used has any significant effect, and if so at what scale it becomes most noticeable.
- ***Tool Quality*** (Whether the tool connects to the nearest line on the network or the nearest node) – It is possible to connect different data points to a network in two different ways (Figure 5) connecting to the node requires less computation and could provide quicker results but connecting to the nearest line should provide more accurate results. By comparing, the results from both it will be possible to understand if this has any significant effect and if so at what scale it becomes significant.
- ***Network Analyst Quality*** (pgRouting, ESRI's Network Analyst, Google) – It is important to understand the differences between different network analysts and the algorithms that they utilise, is there a difference between how ESRI and pgRouting compute the Dijkstra algorithm, and if so what is the difference.

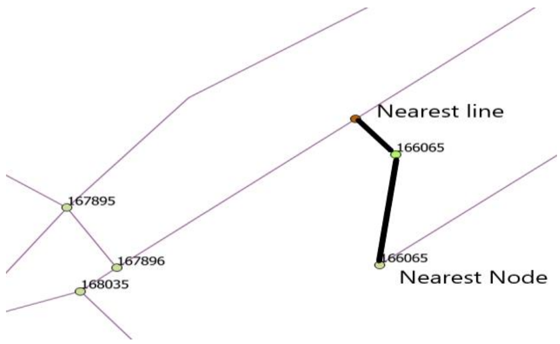

Figure 5 Road network segment.

These tests are designed to see whether the constant movement to more and more accurate algorithms has any effect on the overall result as the improvements to the algorithm normally make it more complex to implement and also more computationally expensive. If there is no significant benefit to these changes, then it may be worth utilising more simplistic data for the day to day calculations. The implications of these different parameters for the calculation of accessibility scores to cancer services will be presented in the paper.

4. Usability of 2SFCA tools in an open source environment

Two user tests have been completed with Tenovus Cancer Care to ensure that non-experts are able to understand the tool and use it with minimal instruction. The user tests have highlighted several factors which were not considered;

- Documentation – The documentation needs to be very specific for each task and there need to be many numbered sections which correlate with numbered pictures. There need to be several sets of documentation for different types of user and this will ensure that the tool is able to be used by anyone.
- Language – The language used needs to be appropriate for the audience; using acronyms and geographical terms does not work for the non-expert user.
- Definition of 2SFCA – It is possible to get the user to follow the instructions and compute the accessibility scores, but it is difficult to get the user to understand exactly what 2SFCA is and why it is relevant. Instructional videos explaining what it does and why it is important are to be produced to ensure that the user understands why they are completing these calculations.

The user tests have included over 20 one-to-one interviews and 2 focus groups with a variety of users at Tenovus and have been used to lead the design of the tool. These will be described in more detail in the presentation.

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Biographies

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