

ASSESSING THE COVERAGE AREA AND DISTRIBUTION OF HEALTHCARE FACILITIES IN SHEFFIELD, UK USING GEO-SPATIAL TECHNOLOGY

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ABSTRACT

RESEARCH ARTICLE

The paper focuses on accessibility and dispersion of healthcare facilities which are crucial for upholding social stability as well as the protection of fundamental human rights to healthcare. Access to healthcare services means a timely use of available care services to achieve the best health outcomes, and its influence on the overall physical, social, and mental health status. Geographic Information System (GIS) emphasizes the spatial pattern i.e. accessibility while the rest of the dimensions may be seen as non-spatial. The 2021 population census data of Sheffield was obtained from www.nomisweb.co.uk/source/census_2021 was used in this study. The location and coordinates of all the healthcare facilities was also sourced from Google Earth Pro software. Buffering, Erase, Queries and Nearest Neighbor Analysis operations were carried out to determine the coverage area of those healthcare facility deprived areas and also the population deprived of easy utilization and accessibility to those healthcare facilities.

KEYWORDS: Geo-Spatial Technology, Healthcare, Accessibility, Distribution, Health Services

INTRODUCTION

The accessibility and dispersion of healthcare facilities are crucial for upholding social stability as well as the protection of fundamental human rights to healthcare. The purpose of this research work was to evaluate Sheffield's healthcare facility coverage area with regard to accessibility and distribution.

It has long been understood that long-term health-care delivery systems depend on having access to healthcare facilities and services. Human well-being and sustainable urban development have made it clear that basic service like healthcare facilities must be accessible to people from all socioeconomic backgrounds. (Shanmathi, R, Shayesta. W 2017)

Access to health care services means timely use of available health services to achieve the best health outcomes, and it influences the overall physical, social, and mental health status; prevention of disease and disability; detection and treatment of health conditions; quality of life; preventable death; and life expectancy and it is central in the performance of health care system around the world (Levesque. J.F, Harris. M.F, Russell. G. 2013, RUPRI Health Panel 2014) In contrast, limited access to health care is a significant problem which results in unmet health care needs, delays in receiving appropriate care, inability to get preventive services, and hospitalizations that could have been prevented. (Novartis. 2016)

Geographic accessibility to health care is concerned with the relationship between the spatial separation of the population and the supply of health care facilities, and thus has a strong underlying geographic component (Ursulica. T.E 2016). Accessibility (geographic) is a measure of the distance between locations and it is restricted by factors such as travel time, distance to facilities and quality of roads (Delamater. P.L, Messina. J.P, Shortridge. 2012, Edusei J and et al 2014).

Geographical information systems (GIS) emphasizes the spatial dimension i.e. accessibility (McLafferty, 2003), while the rest of the dimensions may be seen as non-spatial. Prospective accessibility presumes that all members of a population are prospective users of medical services located within a specified distance or travel time (a catchment area).

Hence, to get a complete understanding of the coverage area and distribution of healthcare centers and the regions deprived of these healthcare facilities, a study has to be done with the following objectives:

- To locate the Health care facilities within Sheffield.
- Determining the coverage area of those healthcare facilities.
- To identify the Health care facility deprived areas.
- Determine the spatial distribution of those facilities

2. Methods

2.1 Study Area

Sheffield is a large city and a modern community situated in South Yorkshire, which is in the central United Kingdom (UK) with latitude 53.381129 and longitude -1.470085. GPS coordinates of 53° 22' 52.0644"N and 1° 28' 12.306"W with the elevation of 81.700

The latest census was held on 21st March, 2021. At census date, Sheffield had a population of 556,500 individuals, in 232,000 households. This is 0.7% higher than at the 2011 census (552,698)

2.2 Database creation

The heart of a GIS is the spatial database. The process of designing such a database is called data modeling. Kufoniyi (1998) define database as the process by which the real world entities and their relationships are analyzed and modeled in such a way that maximum benefits are derived while utilizing minimum amount of data

Geographic Information System (GIS) database design process consists of three phase, these are conceptual design phase, logical design phase and physical design phase

Conceptual design phase is the representation of human conceptualization of reality and how the view of reality will be represented in a simplified manner but still satisfy the information requirement of the organization concerned. For this study the view of reality are Sheffield boundary and wards as polygon, Roads as line and healthcare facility as points.

FID	Shape	hcmm	msoa2fcd	msoa21nm	Code	Population
0	Polygon	Springvale & Steel Bank	E02001638	Sheffield 028	Sheffield 028	12362
1	Polygon	Firth Park	E02001623	Sheffield 013	Sheffield 013	5320
2	Polygon	Ecclefeast & Greystones	E02001657	Sheffield 047	Sheffield 047	5183
3	Polygon	Gleadless	E02001664	Sheffield 054	Sheffield 054	5028
4	Polygon	Richmond & Stradbroke	E02001655	Sheffield 045	Sheffield 045	3838
5	Polygon	Cathedral & Kelham	E02006843	Sheffield 073	Sheffield 073	9248
6	Polygon	Wadley & Marcliffe	E02001626	Sheffield 016	Sheffield 016	6403
7	Polygon	Nether Edge	E02001660	Sheffield 050	Sheffield 050	6772
8	Polygon	Brinccliffe & Sharrow Vale	E02001656	Sheffield 046	Sheffield 046	5535
9	Polygon	Norfolk Park	E02001653	Sheffield 043	Sheffield 043	3685
10	Polygon	Woodhouse Hill	E02001654	Sheffield 044	Sheffield 044	2488
11	Polygon	Acornthorne	E02001658	Sheffield 048	Sheffield 048	5170
12	Polygon	Charnock & Basegreen	E02001672	Sheffield 062	Sheffield 062	3368
13	Polygon	Littledale & Handsworth North	E02001642	Sheffield 032	Sheffield 032	3004
14	Polygon	Wakley	E02001634	Sheffield 024	Sheffield 024	6336
15	Polygon	Shiregreen North	E02001617	Sheffield 007	Sheffield 007	3628
16	Polygon	Woodthorpe	E02001649	Sheffield 039	Sheffield 039	3499
17	Polygon	Woodhouse West	E02001659	Sheffield 049	Sheffield 049	2524
18	Polygon	Fulwood & Lodge Moor	E02001651	Sheffield 041	Sheffield 041	256
19	Polygon	Dore & Vinton	E02001678	Sheffield 068	Sheffield 068	736
20	Polygon	Southey Green West	E02001622	Sheffield 012	Sheffield 012	4272
21	Polygon	Heeley & Newfield Green	E02001681	Sheffield 051	Sheffield 051	4961
22	Polygon	Herdings & Gleadless Valley	E02001670	Sheffield 060	Sheffield 060	4237
23	Polygon	Intake	E02001662	Sheffield 052	Sheffield 052	4582
24	Polygon	Chapelton	E02001614	Sheffield 004	Sheffield 004	2067
25	Polygon	Crookes	E02001639	Sheffield 029	Sheffield 029	7333
26	Polygon	Westfield & Waterthorpe	E02001675	Sheffield 065	Sheffield 065	2944
27	Polygon	High Green & Burncross	E02001613	Sheffield 003	Sheffield 003	2390
28	Polygon	Darnall	E02001637	Sheffield 027	Sheffield 027	2008
29	Polygon	Blaydon	E02001686	Sheffield 056	Sheffield 056	2745
30	Polygon	Main Bridge & Wisewood	E02001631	Sheffield 021	Sheffield 021	5549
31	Polygon	Birley	E02006869	Sheffield 076	Sheffield 076	3062
32	Polygon	Shirecliffe & Parkwood Springs	E02001629	Sheffield 019	Sheffield 019	3798
33	Polygon	Burnsall & Greenthorpe	E02001632	Sheffield 022	Sheffield 022	2232
34	Polygon	Mosborough & Halfway	E02006803	Sheffield 072	Sheffield 072	1592
35	Polygon	Sheffield Lane Top & Longley Park	E02001621	Sheffield 011	Sheffield 011	4076
36	Polygon	Dugthorpe & Bradfield	E02001618	Sheffield 008	Sheffield 008	78
37	Polygon	Hilbarough, Overton & Wadley Bridge	E02001627	Sheffield 017	Sheffield 017	1854
38	Polygon	Woodseats	E02001669	Sheffield 059	Sheffield 059	5549

Fig. 1: Database created for Wards

FID	Shape	hcmm	msoa2fcd	msoa21nm	Code	Population
0	Polygon	Springvale & Steel Bank	E02001638	Sheffield 028	Sheffield 028	12362
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36	Polygon	Woodseats	E02001669	Sheffield 059	Sheffield 059	5549

Fig. 2: The database table for healthcare facility

2.3 Data Sources

The 2021 population census data for Sheffield was obtained from www.nomisweb.co.uk/sources/census_2021_bulk was used in this study and the borderline data from borders.ukdataservice.ac.uk. The road dataset was sourced from www.data.gov.uk/dataset/95f58bfa-13d6-4657-9d6f-020589498cfd/major-road-network. The location and coordinates of all the health facilities was also sourced from Google Earth pro software. The Google earth was used in absence of getting the location data (coordinates) of all the healthcare facilities and also the study is limited to just the main Hospitals (excluding private hospitals and clinics)

Table 1: Data types and Data source

S/N	DATA	SOURCE
1	Borderline (Administrative boundary)	borders.ukdataservice.ac.uk .
2	Population data	www.nomisweb.co.uk/sources/census_2021_bulk
3	Road dataset	www.data.gov.uk/dataset and Google Earth Pro
4	Hospital Coordinate	Google Earth Pro

2.4 Scope of the Study

The paper is limited to determine the coverage area of the healthcare facilities, and the ratio of healthcare facilities to the population in each wards within Sheffield. The spatial distribution of those healthcare facilities are also determined if they are either clustered or dispersed

Private hospitals were not considered in this study

Table 2: Some of the Healthcare facilities within the study area

S/N	NAME	X	Y
1	Northern General Hospital	-1.45752	53.4106
2	Royal Hallamshire Hospital	-1.49276	53.3784
3	Sheffield Teaching Hospital	-1.49234	53.3792
4	The Global Clinic	-1.47265	53.3637
5	Ivy Lodge Clinic	-1.46752	53.3985
6	One Health Clinic	-1.53785	53.3757
7	Sheffield Clinic	-1.49945	53.3733
8	Regent Street Clinic	-1.47584	53.3806
9	Central Health Clinic	-1.4665	53.3819
10	Sheffield Walk-in Clinic	-1.47739	53.3829
11	Courthouse Clinic	-1.48519	53.3801
12	University Health Service	-1.48267	53.3863
13	Private walk-in Clinic	-1.47541	53.3686
14	Traveldoc Clinic	-1.47584	53.3806
15	Active Health Clinic	-149206	53.3704

What makes Geographical Information System different from other information system is the potentiality of carrying out spatial analyses. These analyses involves the synthesizing different geospatial data by aggregating, comparing and combining various pieces of data

stored in database to making meaning out of it and generate information to support decision making. The spatial data created for this paper were Roads and Healthcare facilities.

The following operations were performed in order to determine how accessible the healthcare facilities are in term of distance covered or service area and to determine if the number of facilities commensurate with the number of people in the study area through spatial search (selection by attributes and selection by location)

Buffer analysis, a fundamental function in a geographic information system (GIS), identifies areas by the surrounding geographic features within a given distance. A buffer in a geographic information system (GIS) is defined as the zone around a spatial object, measured by units of time or distance (Mengyu Ma et al 2018)

Buffering operation was performed on Hospitals using WHO standard of 5km for hospitals to determined their coverage area, the buffered zone which shows the service area for the healthcare facilities was erased to determine the areas that outside the coverage area of those healthcare facilities. A query was performed to know those areas with more than 500 populations without any healthcare facility

The criteria use to determine the coverage area of the Healthcare facilities were (WHO 2007)

- The healthcare centre should not be more than 5km from residential area i.e 5km coverage area
- An area with a population of 500 people should have access to one healthcare facility

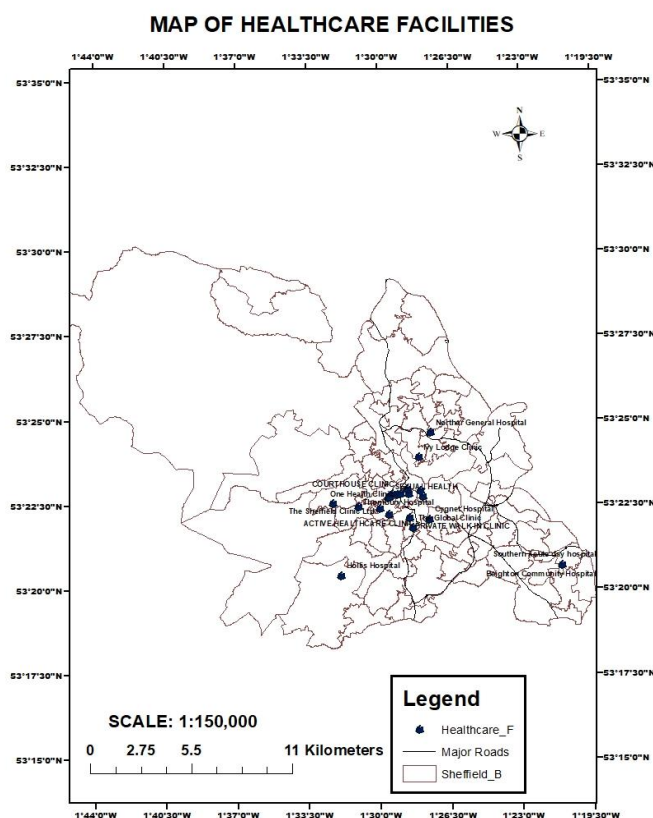


Fig 3: Showing the healthcare facilities

3. Analysis and Results

3.1 Buffer Operation

Buffering which is one of the most important functions of spatial analysis in GIS. Its basic idea is to create a zonal area of a certain distance around its boundary, namely buffer zone, and to identify the impact range and service range tom surrounding environment (proximity) (Peng Dong 2020)

In this paper, buffering was carried out in order to see the extent of coverage which various healthcare facilities covers over the study area. A buffering of 5km was done on each healthcare facility since the maximum distance a healthcare facility must be from a residential area must not exceed 5 km

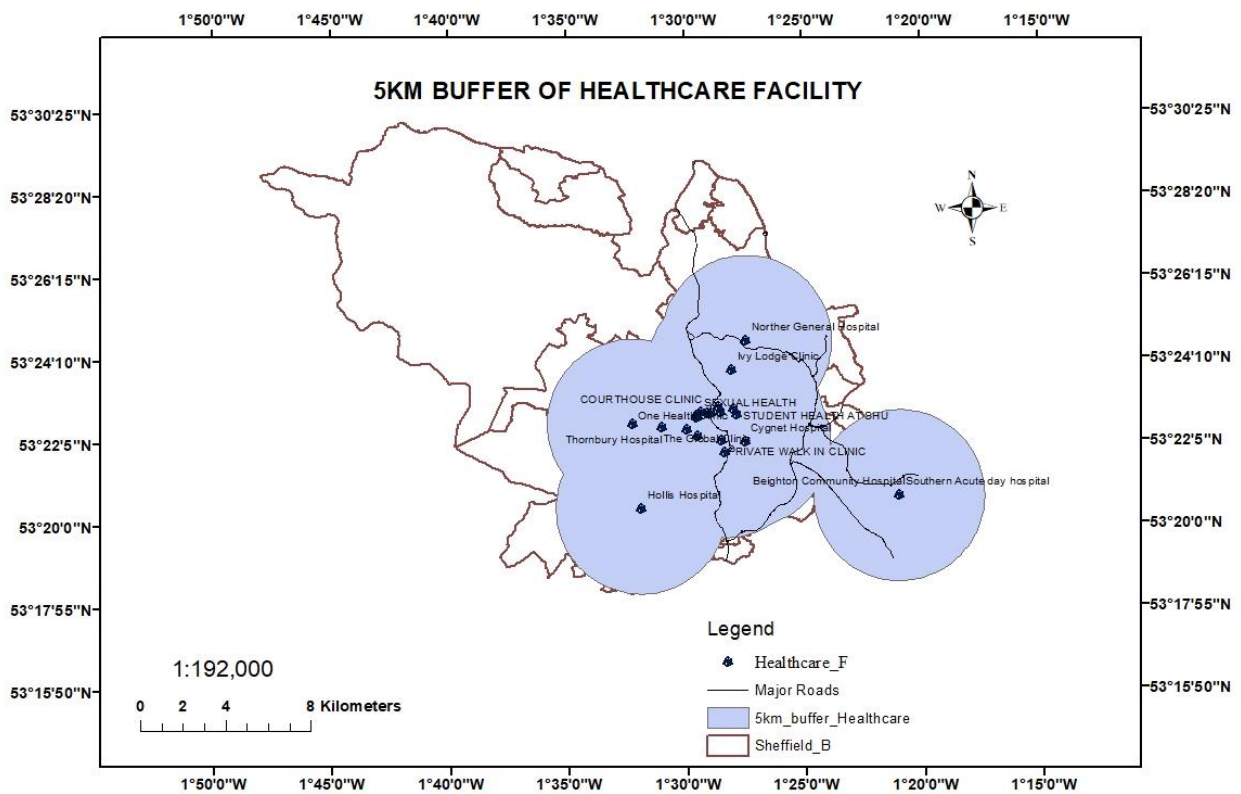


Fig. 4: Map of 5km buffer of healthcare facilities

Mengyu Ma 2018 Buffer analysis, a fundamental function in a geographic information system (GIS), identifies areas by the surrounding geographic features within a given distance. A buffer in a geographic information system (GIS) is defined as the zone around a spatial object, measured by units of time or distance.

The above map showed the coverage area for the healthcare, area covered are those areas with easy access to those facilities based on the 5km radius recommended by WHO (2007)

3.2 Erase Operation

In GIS. The erase function is an analytical process in which the output feature class is created by copying the portion of input features that lie outside the boundaries of the erase feature (ArcGIS 10 Help). In this case the buffer created was used as erase feature and Sheffield boundary as input feature, this is done to know or determine those areas outside the service area for those healthcare facilities.

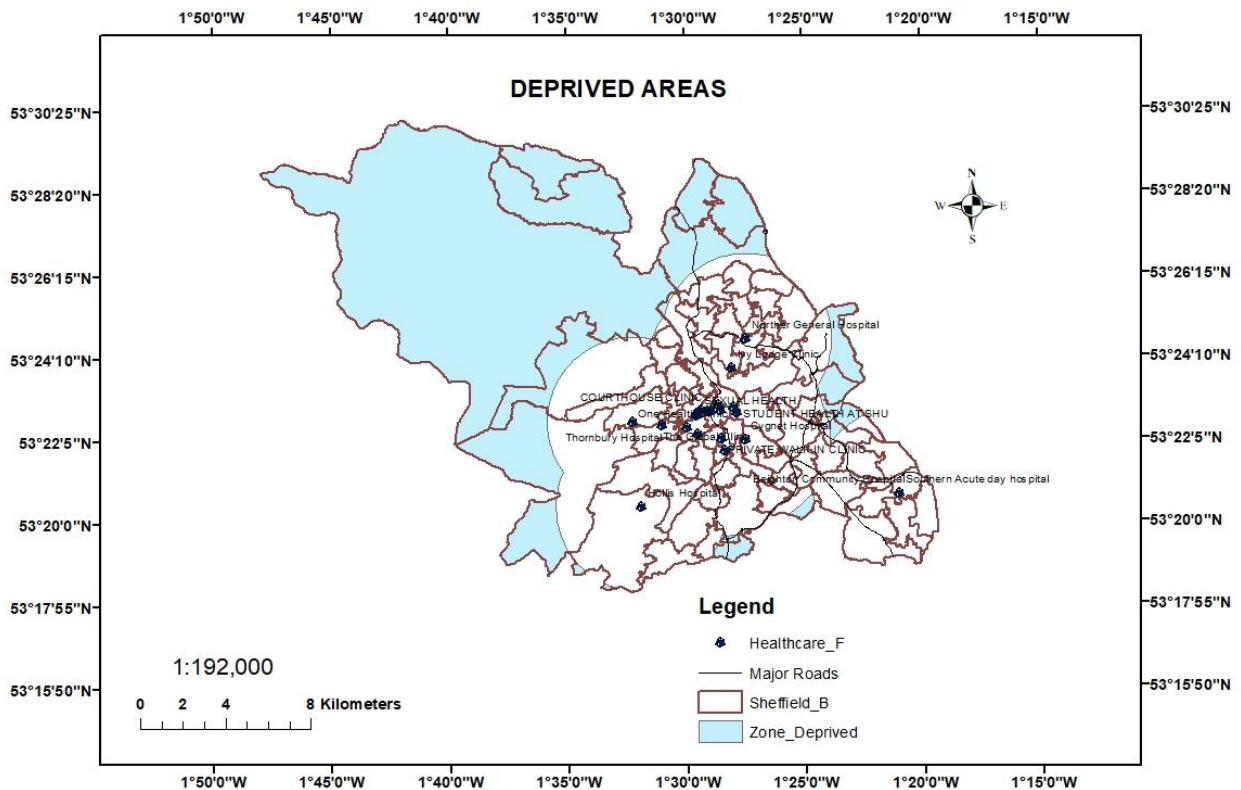


Fig. 5: Areas deprived of easy accessibility to healthcare facilities

The above figure 5 show areas that do not have easy access to the available health facilities by walking more than recommended 5km to use a healthcare facility. There is a need to provide healthcare facilities in those areas to reduce the walking/traveling distance in order to access and utilize those facilities.

3.3 Queries

The population data from Nomis was used in order to know those areas that have more than 500 inhabitants and with at least one healthcare facility and also those areas with more than 500 inhabitants without healthcare facility. This is done to determine the ratio of population to healthcare facility. A Spatial search operation of areas with more than 500 population with one or more facility and areas with more than 500 population without healthcare facility was used to test database created by looking for certain attributes within the neighborhood. This is to determine the wards/areas that have more than 500 populations with or without healthcare facility.

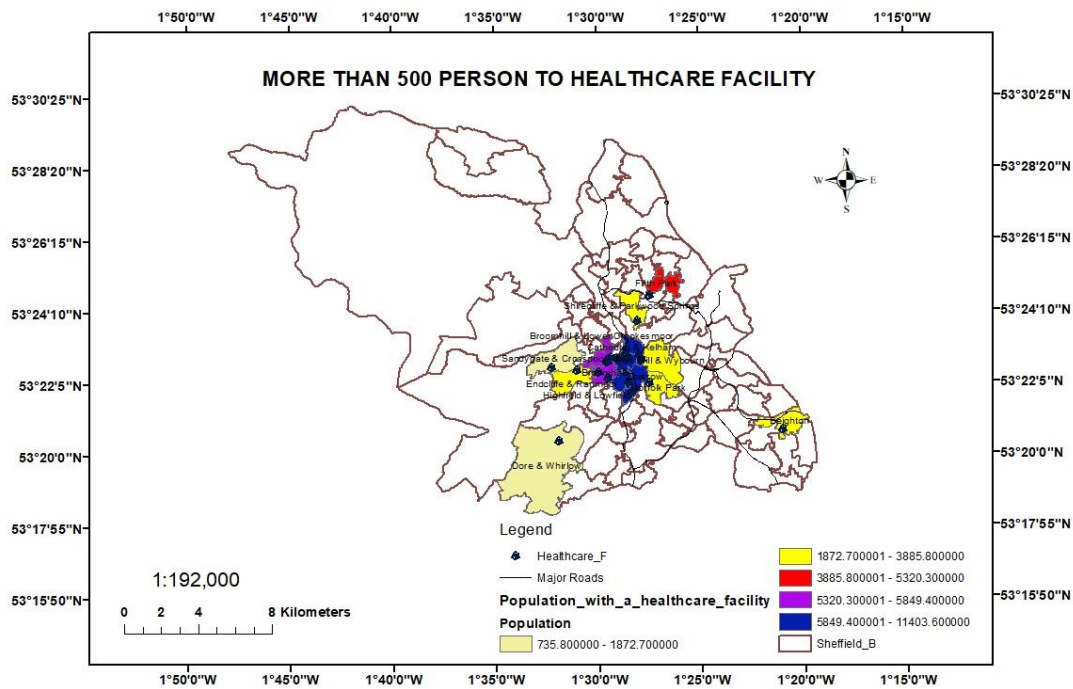


Fig. 6: Areas with more than 500 people with at least one healthcare facility

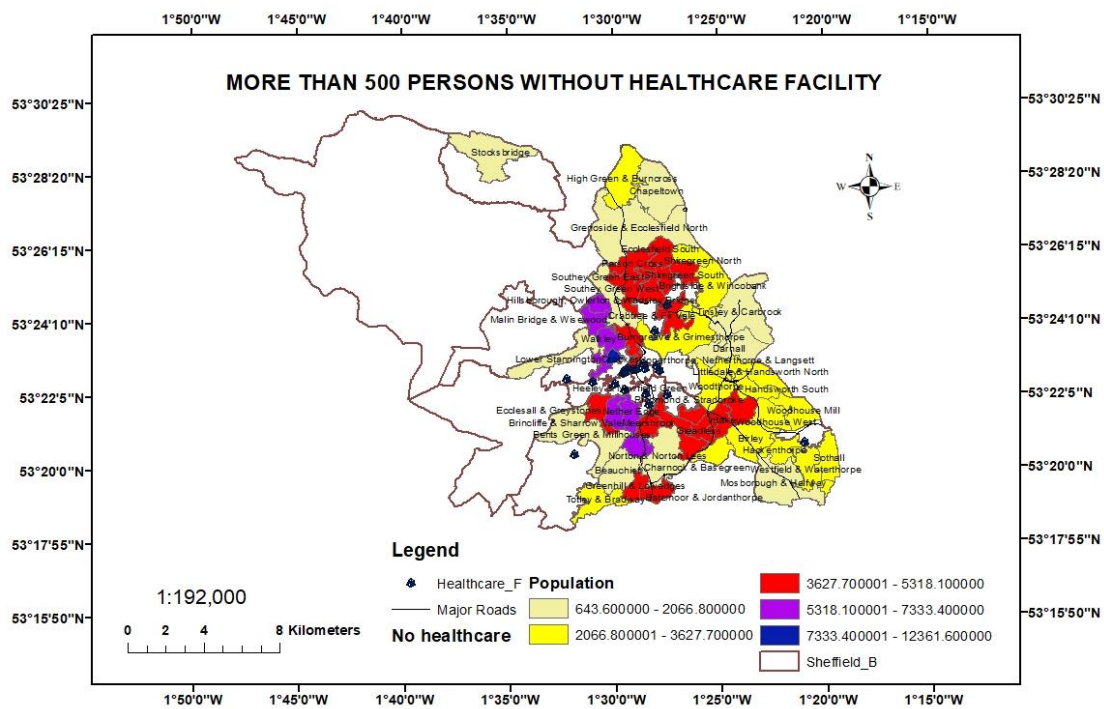


Fig. 7: Areas with more than 500 people but without Healthcare facility

All the wards in Sheffield have population of more than five hundred people, which indicate that each ward must have at least one (1) healthcare facility. Using the population data of Sheffield for spatial search it was shown that there were many areas without a healthcare facility as shown in fig 7, while there were also some areas within Sheffield with population of more than 500 people with at least one healthcare facility. The importance of this to determine if the number of healthcare available is enough for usage

3.4 The Nearest Neighborhood

The nearest-neighbor analysis calculates the average distance between each feature's centroid and its nearest neighbors' centroid location, and is an indicator of clustering, random, or regular point patterns (Micheal P. and et al 2002).

The nearest neighborhood was done to know how close one healthcare facility is to nearest facility. The nearest neighborhood operation used to determine whether the healthcare centers are disperse, random or clustered in Sheffield.

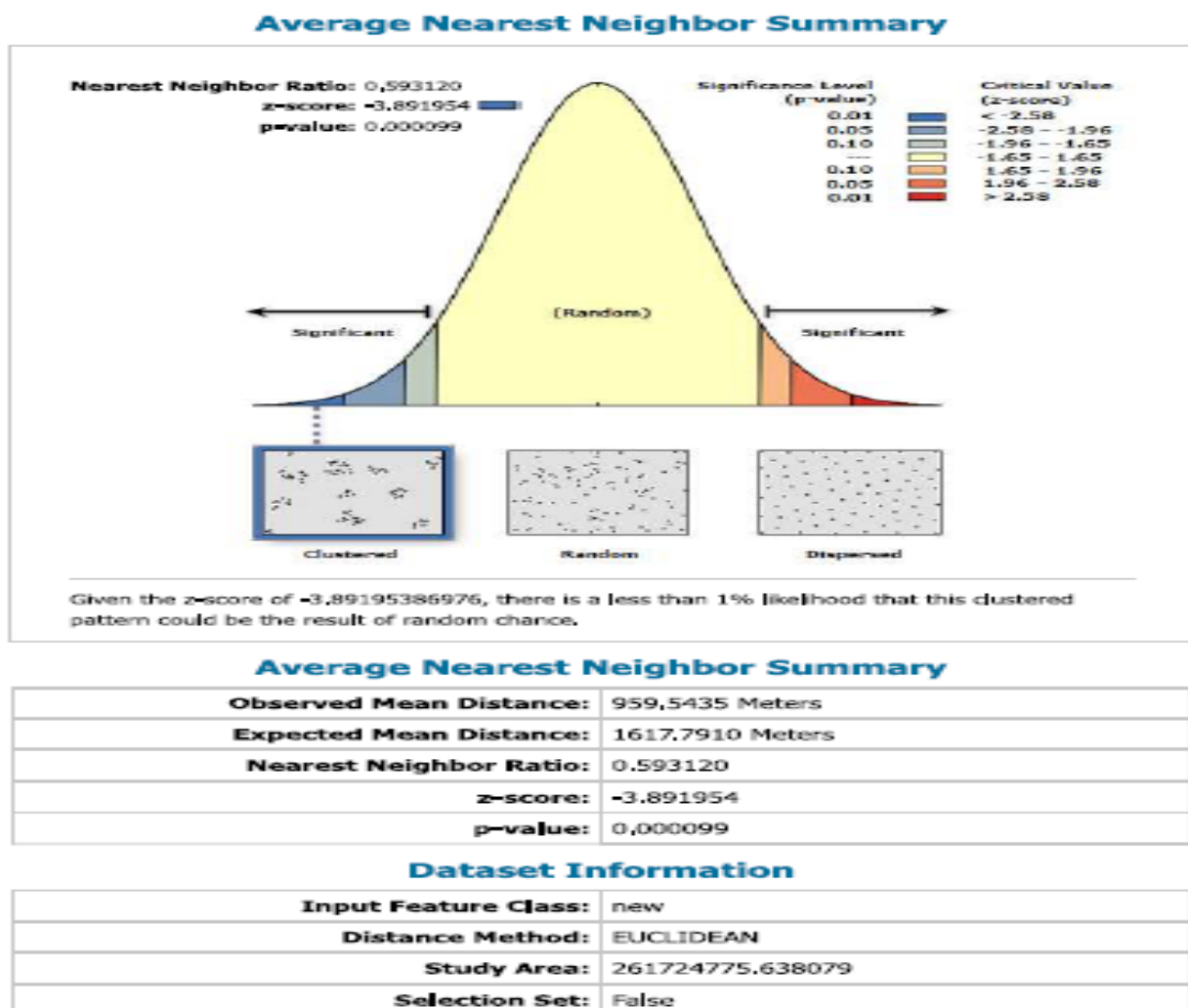


Fig 8: The Nearest Neighborhood result

H null hypothesis states that "The spatial pattern observed is not different from random

Since NNR of 0.59 is less than 1 the pattern is clustered. The P-Value of 0.000099 is less than 0.01 alpha level, H null hypothesis is rejected. This then implies that the pattern is clustered. The Z score of -3.89 which is less than -2.58 at 99% level of significant also signifies that there is less than 1% likelihood that this clustered pattern could be the result of random chances.

4. Conclusion

Access to healthcare has been recognized as an important contributor to health and wellbeing. To this end, access to healthcare is widely accepted as a fundamental human right enshrined in many international instruments (WHO 2007). This study indicates the spatial discrepancy of access to healthcare facilities in Sheffield, and it was discovered that the healthcare facilities were clustered together in a particular areas which deprived other areas of easy access to those facilities. Based on then findings, the areas or wards can be categorized into five parts based on coverage area of the healthcare centers and the number of people living in an area to a facility

Categories

1. Those areas with easy access to healthcare facility in term of service area (5km) of the healthcare facilities which were shown in fig 4
2. Those areas with at least one healthcare facility and with more than 500 inhabitants. This areas were well represented in fig 6
3. Areas with easy access to healthcare facility with both the coverage area (5km) and with at least one healthcare to 500 people.
4. Areas that were deprived of easy access to healthcare centers in term of distance. These areas were shown in fig 5 of this study
5. Areas that were more than 500 people with no healthcare facilities. Fig 7 displayed those areas that fall under this category

It was observed that some of the areas that were not served when population is considered were served when considered the service area of those Healthcare facilities.

It is recommended that the criteria for citing healthcare facility should be adhere to strictly when citing in term of distance to healthcare facility and the population of the people that the facility is meant to serve.

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