

GIS Assignment - SDSS for Mumps in Swansea

by Shannon Boulting

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Geodemographic Analysis using GIS

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1. Introduction

1.1 Geographical Information Systems (GIS)

A Geographic Information System (GIS) is a system for collecting, managing and analysing data. GIS can analyse any data containing a spatial location and organise layers of datasets into visualisations through maps. This provides a deeper insight into the data, showing patterns, relationships and situations which may have otherwise been missed using other analysis methods. Therefore, GIS is very effective in aiding decision making [1]. The origins of GIS are commonly associated with John Snow and his discovery of the source of cholera using point mapping; depicting cases of cholera which led to locating the water pump which was spreading the disease [2].

Almost all organisations can incorporate GIS into their work [3]. Today GIS has various users ranging from the following sectors; education, health, natural disaster management, environment and government [1].

There are many different GIS providers; ArcGIS, MapInfo and QGIS being the main ones [4]. The most popular programming languages for use in GIS include JavaScript, Java, Python, C++, C# and SQL, and there are also GIS-specific adaptations such as Arcpy [5] [6].

1.2 Spatial Decision Support Systems (SDSS)

Spatial Decision Support Systems (SDSS) analyse both spatial and non-spatial data, whereby the spatial data is facilitated, analysed and presented through GIS, in order to explore the nature of problems and produce a variety of informed solutions. SDSS are intended to aid decision makers in solving complex spatially related problems and provide a basis for integrating various data, knowledge and capabilities [7].

Geographic information is essential for decision making across all types of organisations; approximately 80% of the data utilised by managers and decision makers is spatially related [8].

SDSS are currently being used in many industries to support decision makers; two examples being business analysis and crime mapping [8]. In relation to health, GIS has become a routine tool in tackling epidemics. For example, in the 2014 Ebola outbreak in West Africa, the role of GIS was to identify hot spots of outbreak, by plotting where Ebola cases had been recorded, and then develop a holistic plan for organisations and agencies to ensure that resources were put in the areas of current and forecasted need. GIS was a vital tool in facilitating and supporting the huge logistical obstacle required to provide these resources [9].

1.3 Case Study: Mumps

GIS analysis can also be applied to the current mumps outbreak in South Wales, in order to uncover patterns and potential solutions. In 2019, there has been five reported cases at Swansea University and the number for Cardiff, Cardiff Metropolitan and University of South Wales has risen from 28 to 92 cases [10].

Mumps is a contagious viral infection, most recognisable by its symptom of painful swelling in the side of the face, under the ears. Mumps is spread in the same way as the cold or flu, through infected droplets of saliva. These can be inhaled or spread through contact with an infected surface, and the infection is then transferred through the mouth or nose [11].

Those who are most at risk are the young adults who were born between 1980 and 1990 and did not receive the MMR vaccine within their childhood vaccination program or those who did not contract mumps as a child [11]. They are considered particularly vulnerable [12]. Public Health Wales' advised that 94.5% of children had the MMR vaccine in 2018-19, compared to 94.7% in the previous financial year. The vaccination target is 95%. The age group most affected are 18-25 years; accounting for over a third of the mumps cases so far in 2019 [13].

The decrease in vaccination rate is often linked to the 'anti-vax' movement which led to rates dropping around 80% in the 1990s and 79% in 2003 [12]. This movement argues many things; that vaccinations are a medical experiment, that they cause unknown and potentially long-term negative effects and specifically that the MMR vaccine can be linked to autism [13].

The recent outbreak of mumps in Swansea will be used as a case study to show the effectiveness of geodemographic analysis using GIS software. Swansea is in the county of Glamorgan, in South West Wales. It is situated alongside the Bristol Channel and Swansea lies at the mouth of the River Tawe (see Figure A). [14] It is the second largest city in Wales, with a total population of 310,051 [15].



Figure 1: Case Study Location Plan

GIS will be used to develop a SDSS to investigate the current (2019/20) mumps outbreak in Swansea.
The hypotheses of the research will be:

- Those in dense population areas, particularly the city centre, are more at risk of contracting and spreading mumps
- Student populations, as well as young people, are more at risk of contracting and spreading mumps
- Those living in lower income areas are more at risk of contracting and spreading mumps

2. Methodology

To create a SDSS, a GIS workspace must first be built. For this case study, MapInfo will be used.

2.1 Creating a new workspace in MapInfo

Firstly, the user has the option to open a previous workspace or create a new one (Figure 2). The workspace saves all the links to the data in the map in a project file type.

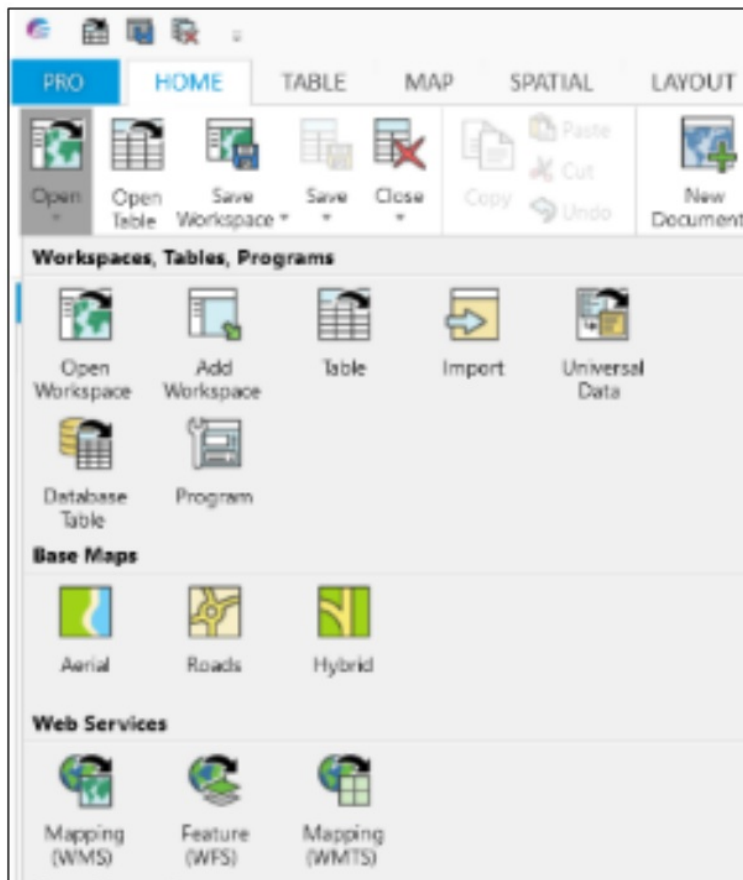


Figure 2: Creating a workspace

2.2 Adding background mapping to workspace

MapInfo contains a built-in background mapping facility in the form of “Basemap Layers”, with the choice of aerial, roads or hybrid background mapping. Figure 3 shows the Bing road layer used in the SDSS, giving locational information.

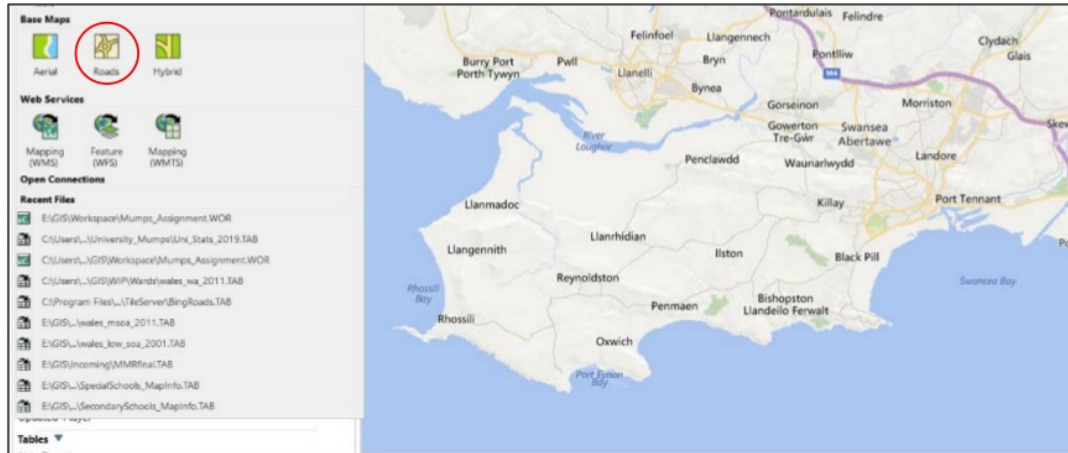


Figure 3: Adding base mapping to workspace

2.3 Adding data to workspace

2.3.1 Data types

There are two main types of GIS data. Firstly, Vector data, known as feature data, comprises of points (x and y coordinates), lines (sequence of points) or polygons (closed set of lines). Secondly, Raster data includes thematic data, continuous data and pictures [16].

2.3.2 Data file types

GIS supports a variety of different file formats such as CSV (Comma Delimited files), TAB (MapInfo), Raster image files (.gif, .bmp, .jpg) and SHP (ESRI Shapefiles) [17]. TAB is MapInfo's native format. It is a geospatial vector data format developed by MapInfo itself. A spatial dataset within MapInfo composes of various files with .tab, .map, .dat extensions [18].

2.3.3 Downloading datasets

A SDSS is only as good as the data it contains [19]. For the Swansea Mumps SDSS, datasets for public health boards, health services and schools were downloaded from the Lle Website (Figure 4), a geo-portal for Wales (*Lle.gov.wales*). These were a mixture of point datasets (e.g. locations of schools, doctors and hospitals) and polygon datasets (e.g. health board boundaries). The data was not available to download in a MapInfo supported filetype, therefore it was downloaded in shapefile format and exported to .MIF files using QGIS.

2.3.4 Creating the Townsend Index

The Townsend Index, named after Professor Peter Townsend, is an index of material deprivation calculated using four census-based variables (households with a car, overcrowded households, households which are not owner-occupied and unemployment). It was first proposed in 1987 and has been widely used ever since. It is area-based, so contains a spatial element that can be used in GIS analysis [20].

To calculate the Townsend Index of deprivation, data was collated from the UK Data Service using INFUSE, which allows users to access 2011 census data. Figure 6 shows an example of a set of statistics which allowed for the calculation of the Townsend Index for Swansea.

Download

[Show Guidance](#)

Selected Category Combinations

- 2158 - Occ rate bedrooms : Occupancy rating (bedrooms) of -1 or less - Unit : Households
- 2159 - Occ rate bedrooms : Total: Occupancy rating (bedrooms) - Unit : Households
- 2164 - Occ rate bedrooms : Occupancy rating (bedrooms) of -2 or less - Unit : Households
- 2347 - Tenure : Total: Tenure - Unit : Households
- 2351 - Tenure : Owned outright - Unit : Households
- 2353 - Tenure : Owned with a mortgage or loan - Unit : Households
- 248 - Age : Age 16 to 74 - Economic activity : Unemployed - Unit : Persons
- 256 - Age : Age 16 to 74 - Economic activity : Part-time - Unit : Persons
- 260 - Age : Age 16 to 74 - Economic activity : Full-time - Unit : Persons
- 267 - Age : Age 16 to 74 - Economic activity : Full-time student - Unit : Persons
- 323150 - Age : Age 16 to 74 - Economic activity : Unemployed (excluding full-time students) - Unit : Persons
- 556 - Age : Age 16 to 74 - Economic activity : Part-time - Unit : Persons
- 557 - Age : Age 16 to 74 - Economic activity : Full-time - Unit : Persons
- 989 - Car or van availability : Total: Car or van availability - Unit : Households
- 991 - Car or van availability : No cars or vans in household - Unit : Households

Selected Areas

- All Output Areas and Small Areas (792 areas) in Local Authorities (22 areas) - Swansea
- Swansea

File reference

[Previous](#) [Get the Data](#)

Figure 6: Downloading census data from UK Data Service

Figure 7 is a screenshot of the data within excel. See Appendix A for the detailed Townsend Index Calculation.

Self-full	Self-part	Car-total	No-cars	bed-1	bed-total	bed-2	T-total	T-outright	T-loan	Owner	Ruemp	Rnchome	Rncocur	var1	var2	var3	var4	Zscore1	Zscore2	Zscore3	Zscore4	Townsend
2	6	101	5	0	101	0	101	32	40	0	1.904762	8.910891	4.950495	0	0.481111	8.910891	4.950495	-1.89728	-1.54421	-1.02917	-1.20128	-5.4311304
2	4	128	9	2	128	0	128	68	42	1.5625	3.493604	14.0625	7.01225	0.408864	0.683098	14.0625	7.01225	-0.47383	-0.68135	-0.82995	-1.08177	-5.0459002
0	4	102	20	0	102	0	102	70	26	0	2.739726	5.882353	16.60784	0	0.57284	5.882353	16.60784	-1.89728	-0.96954	-1.46444	-0.34576	-4.2905152
0	7	112	7	2	112	1	112	63	37	2.678071	6.903693	10.71429	6.25	0.565679	0.869311	10.71429	6.25	0.050034	0.145202	-0.9595	-1.12943	-1.89089495
3	5	115	10	0	115	0	115	70	40	0	3.030303	4.347826	8.695652	0	0.605338	4.347826	8.695652	-1.89728	-0.80857	-1.20385	-0.8835	-4.88516095
0	6	112	17	0	112	0	112	80	24	0	2.5	7.142857	15.17857	0	0.544068	7.142857	15.17857	-1.89728	-1.08778	-1.09767	-0.60462	-4.60734465
0	9	125	15	1	125	0	125	86	35	0.8	4.301075	3.2	12	0.255273	0.724564	3.2	12	-0.9896	-0.45226	-1.25022	-0.79038	-1.47031568
1	0	134	13	1	134	0	134	79	45	0.746269	2.803189	8.955224	9.703493	0.242111	0.588222	8.955224	9.703493	-1.02951	-0.93406	-1.02755	-0.92471	-3.91588627
2	7	125	13	2	125	0	125	88	34	1.6	2.12766	2.4	10.4	0.4514073	0.405219	2.4	10.4	-0.45278	-1.23457	-1.28217	-0.88389	-1.80241086
4	11	136	17	3	136	0	136	66	55	2.205882	4.918033	12.5	12.5	0.505948	0.772177	12.5	12.5	-0.14925	-0.2889	-0.89041	-0.76116	-2.08971577
0	4	104	24	7	104	1	104	22	18	7.692308	6.666667	61.53846	23.07662	0.930135	0.889607	61.53846	23.07662	1.29652	0.994994	1.00882	-0.14301	2.25488904
5	15	169	35	2	169	0	169	103	40	1.884432	5.479452	13.60947	20.71006	0.33054	0.821538	13.60947	20.71006	-0.70378	-0.1540	-0.94048	-0.28134	-1.8891026
2	1	149	70	7	149	1	149	21	18	5.389128	28.08089	73.8255	46.97987	0.80408	1.463742	73.8255	46.97987	0.945426	1.073453	1.482266	1.253051	5.6541011
0	0	148	20	1	148	0	148	80	49	0.675676	3.164557	12.83784	13.51351	0.234519	0.615969	12.83784	13.51351	-1.0893	-0.80998	-0.87734	-0.70193	-3.47804068
1	4	127	19	3	127	0	127	81	38	2.362205	3.478261	6.299213	14.96063	0.526624	0.651109	6.299213	14.96063	-0.08027	-0.70228	-1.13031	-0.61753	-2.53021875
0	6	136	16	4	136	1	136	53	66	3.676471	5.555556	12.5	11.76471	0.666918	0.82461	12.5	11.76471	0.397854	-0.13738	-0.89041	-0.80413	-1.43390911
0	5	156	26	2	156	0	156	46	55	1.734218	5.511811	12.33103	22.41379	0.435229	0.813702	12.33103	22.41379	-0.38619	-1.54711	-0.87373	-0.18177	-1.58789110
1	1	126	67	11	126	1	126	11	20	9.52382	23.80952	75.39483	53.1746	1.022173	1.384618	75.39483	53.1746	1.573094	1.894401	1.540363	1.615951	6.56856946
0	4	131	23	0	131	0	131	70	47	0	5.042017	10.68702	17.55725	0	0.782182	10.68702	17.55725	-1.89728	-0.23835	-0.96055	-0.4656	-3.52157767
0	0	107	45	3	107	0	107	35	29	2.803738	9.638554	40.18692	42.05607	0.580211	1.026883	40.18692	42.05607	0.085517	0.580796	1.08797	0.966189	1.82629822
1	2	120	38	7	120	1	120	45	27	6.666667	11.92661	40	31.66667	0.884607	1.111484	40	31.66667	1.114293	0.889669	0.172365	0.338999	2.51622607
0	0	133	49	9	133	2	133	19	25	8.270677	12.12121	66.95729	51.8797	0.967111	1.117934	66.95729	51.8797	1.389129	0.865267	1.244901	1.540113	5.03649056
0	0	140	34	3	140	0	140	62	50	2.142857	9.090909	20	24.28571	0.697255	1.003301	20	24.28571	-0.17882	0.502425	-0.60023	-0.07237	-0.34821556
0	4	118	29	4	118	0	118	37	46	3.388015	7.864737	20.46502	24.57627	0.642448	0.949153	20.46502	24.57627	0.306162	0.315152	-0.22645	-0.05539	0.31964741
1	1	156	76	9	156	0	156	32	21	5.769231	12.35922	66.02564	48.71795	0.850539	1.349457	66.02564	48.71795	0.933705	1.682226	1.180495	1.35553	5.15195413
1	5	118	15	4	118	1	118	32	66	4.237288	2.083333	16.94915	12.71186	0.739106	0.488902	16.94915	12.71186	0.561924	-1.25534	-0.71827	-0.74878	-2.16086079
1	3	119	12	5	119	1	119	49	54	5.042017	6.20155	13.44538	10.08403	0.781182	0.827426	13.44538	10.08403	0.76903	0.052385	-0.85183	-0.90236	-0.98497187
1	3	150	68	13	150	0	150	21	17	8.666667	15.94915	74.66667	44	0.883277	1.254048	74.66667	44	1.469995	1.159439	1.148514	1.079798	5.40115175

Figure 7: Townsend Index Data in spreadsheet format

Data is cleansed prior to importing into MapInfo [21]. This means:

- Spaces are removed and replaced with “_” or “-” to comply with GIS but retain clarity
- Fields containing numbers are changed from text-type into number-type
- Duplicates are removed
- Table headers are amended and simplified so that only one row is used for headings, this is important because GIS only takes the first row as the column heading

These amendments can be seen in the before and after example below (Figures 8 and 9).

A	B	C	D	E	F	G	H	I	J	K
CDU_ID	GEO_CODE	GEO_LABEL	GEO_TYPE	GEO_TYP2	F248	F256	F260	F267	F556	F557
					Age : Age 16 to 74 - EconAge : Age 16 to 74 - EccAge : Age 16 to 74 - Economic Age : Age 16 to 74 - EconAge : Age 16 to 74 - Econ					
286653	W0000394	W0000394 Output Ar OASA			2	33	59	5	2	6
286654	W0000394	W0000394 Output Ar OASA			4	29	72	4	2	4
286655	W0000394	W0000394 Output Ar OASA			2	21	45	3	0	4
286656	W0000395	W0000395 Output Ar OASA			7	33	57	4	0	7
286657	W0000395	W0000395 Output Ar OASA			3	29	59	3	3	5
286658	W0000395	W0000395 Output Ar OASA			2	27	36	3	0	4
286659	W0000395	W0000395 Output Ar OASA			4	26	54	4	0	9
286660	W0000395	W0000395 Output Ar OASA			3	30	72	3	1	0
286661	W0000395	W0000395 Output Ar OASA			2	23	58	4	2	7
286662	W0000395	W0000395 Output Ar OASA			6	34	72	1	4	11
286663	W0000395	W0000395 Output Ar OASA			5	13	57	1	0	4
286664	W0000395	W0000395 Output Ar OASA			8	32	84	10	5	15
286665	W0000396	W0000396 Output Ar OASA			25	30	50	6	2	1
286666	W0000396	W0000396 Output Ar OASA			5	36	114	8	0	0
286667	W0000396	W0000396 Output Ar OASA			4	32	74	4	1	4
286668	W0000396	W0000396 Output Ar OASA			9	47	100	9	0	6
286669	W0000396	W0000396 Output Ar OASA			7	46	72	4	0	5
286670	W0000396	W0000396 Output Ar OASA			20	28	52	2	1	1
286671	W0000396	W0000396 Output Ar OASA			6	30	85	0	0	4
286672	W0000396	W0000396 Output Ar OASA			8	21	56	6	0	0
286673	W0000396	W0000396 Output Ar OASA			13	28	75	3	1	2
286674	W0000396	W0000396 Output Ar OASA			12	31	65	3	0	0

Figure 8: Townsend Index spreadsheet before data cleansing

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
CDU_ID	GEO_CODE	GEO_LABEL	GEO_TYPE	GEO_TYP2	Unemploy	Part-time	Full-time	student	Self-full	Self-part	Car-total	No-cars	bed-1	bed-total	bed-2	T-total	T-outright
286653	W0000394	W0000394 Output Ar OASA			2	33	59	5	2	6	101	5	0	101	0	101	52
286654	W0000394	W0000394 Output Ar OASA			4	29	72	4	2	4	128	9	2	128	0	128	68
286655	W0000394	W0000394 Output Ar OASA			2	21	45	3	0	4	102	20	0	102	0	102	70
286656	W0000395	W0000395 Output Ar OASA			7	33	57	4	0	7	112	7	2	112	1	112	63
286657	W0000395	W0000395 Output Ar OASA			3	29	59	3	3	5	115	10	0	115	0	115	70
286658	W0000395	W0000395 Output Ar OASA			2	27	38	9	0	6	112	17	0	112	0	112	80
286659	W0000395	W0000395 Output Ar OASA			4	26	54	4	0	9	125	15	1	125	0	125	86
286660	W0000395	W0000395 Output Ar OASA			3	30	72	3	1	0	134	13	1	134	0	134	79
286661	W0000395	W0000395 Output Ar OASA			2	23	58	4	2	7	125	13	2	125	0	125	88
286662	W0000395	W0000395 Output Ar OASA			6	34	72	1	4	11	136	17	3	136	0	136	66
286663	W0000395	W0000395 Output Ar OASA			5	13	57	1	0	4	104	24	7	104	1	104	22
286664	W0000395	W0000395 Output Ar OASA			8	32	84	10	5	15	169	35	2	169	0	169	101
286665	W0000396	W0000396 Output Ar OASA			25	30	50	6	2	1	149	70	7	149	1	149	21
286666	W0000396	W0000396 Output Ar OASA			5	36	114	8	0	0	148	20	1	148	0	148	80
286667	W0000396	W0000396 Output Ar OASA			4	32	74	4	1	4	127	19	3	127	0	127	81
286668	W0000396	W0000396 Output Ar OASA			9	47	100	9	0	6	136	16	4	136	1	136	53
286669	W0000396	W0000396 Output Ar OASA			7	46	72	4	0	5	116	26	2	116	0	116	46
286670	W0000396	W0000396 Output Ar OASA			20	28	52	2	1	1	126	67	11	126	1	126	11
286671	W0000396	W0000396 Output Ar OASA			6	30	85	0	0	4	131	23	0	131	0	131	70
286672	W0000396	W0000396 Output Ar OASA			8	21	56	6	0	0	107	45	3	107	0	107	35
286673	W0000396	W0000396 Output Ar OASA			13	28	75	3	1	2	120	38	7	120	1	120	45
286674	W0000396	W0000396 Output Ar OASA			12	31	65	3	0	0	133	69	9	133	2	133	19
286675	W0000397	W0000397 Output Ar OASA			12	38	83	11	0	0	140	34	3	140	0	140	62

Figure 9: Townsend Index spreadsheet after data cleansing

The “GEO_CODE” column can be utilised to link the Townsend Index scores directly to the data already in the MapInfo workspace. A common denominator (i.e. a field) is required to perform a join operation to another layer in the map; in this case, the “GEO_CODE” column in the Townsend Index dataset will join to the same “GEO_CODE” column in the Wales_OAC_2011 dataset in order to display the Townsend scores on the map (Figure 10). Essentially, geocoding transforms a description of a location such as an address to a location on the earth’s surface [22]. Data analysis can then be undertaken to identify patterns.

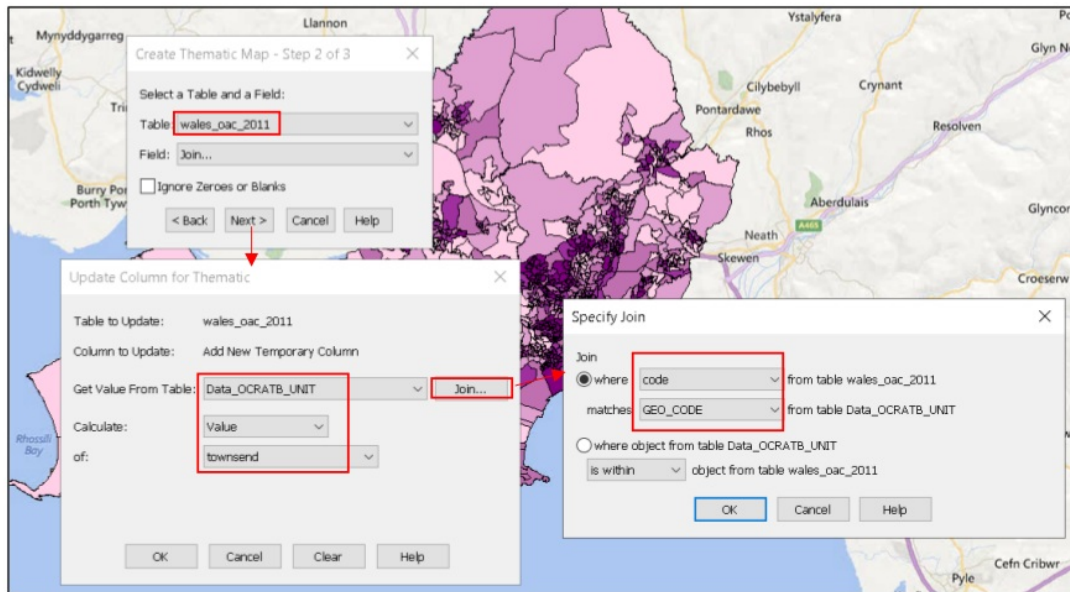


Figure 10: Joining the Townsend Index to the wales_oac_2011 layer

2.3.5 Thematic Mapping

A theme can be used to illustrate the range of Townsend Scores across Swansea. In Figure 11, the higher the Townsend score, the darker the colour of the polygon. This is known as thematic mapping and is useful for examining the spread of results, as well as highest and lowest scores.

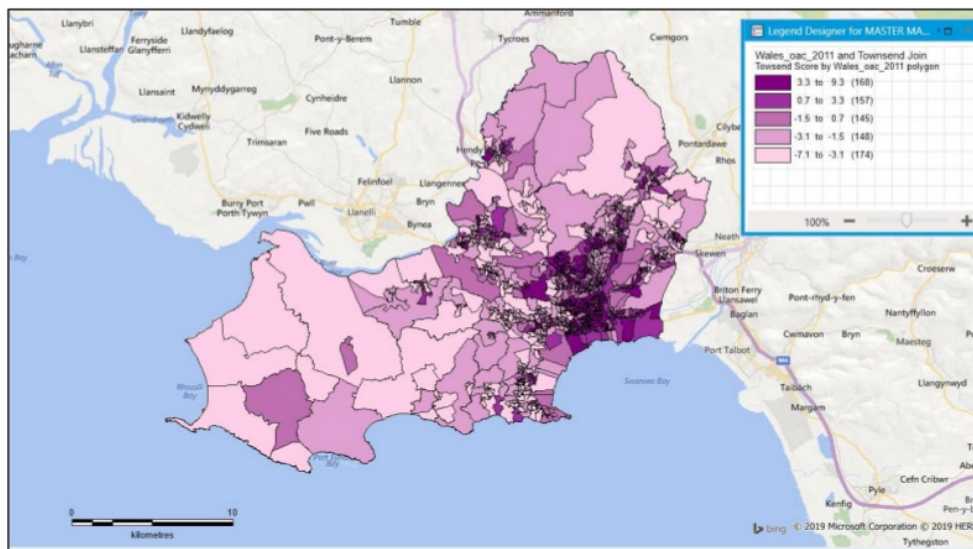


Figure 11: The Townsend Scores for Swansea

The steps for creating thematic mapping are as shown in Figures 12-15 below, where the unemployment point dataset is examined as an example.

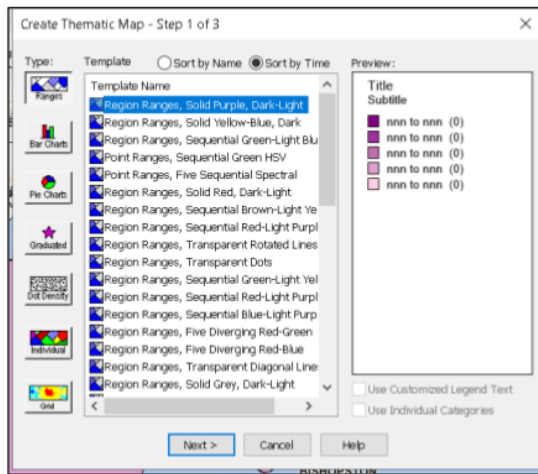


Figure 12: Selecting the appropriate theme to best highlight the patterns within the data

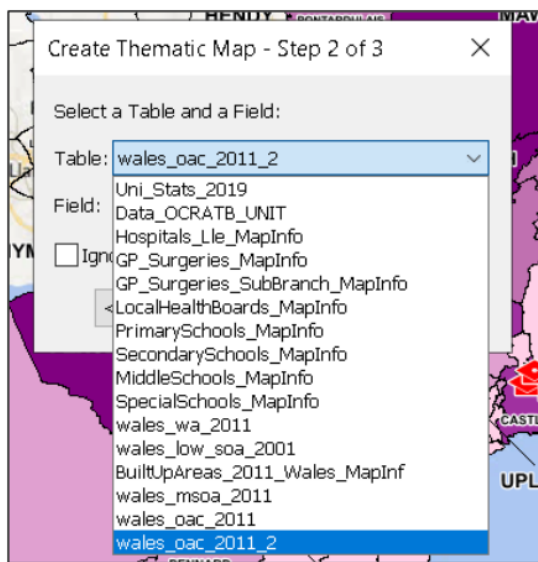


Figure 13: Choosing the data set to base theme on (already imported into MapInfo)

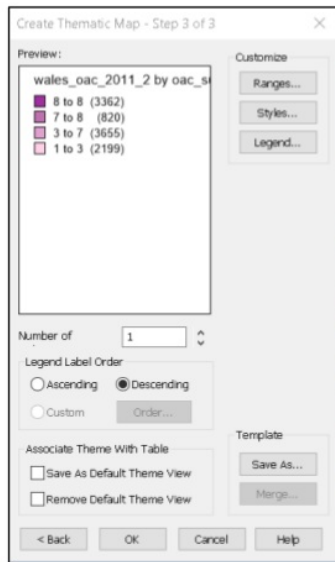


Figure 14: Preview of the spread of the dataset values and further customisation

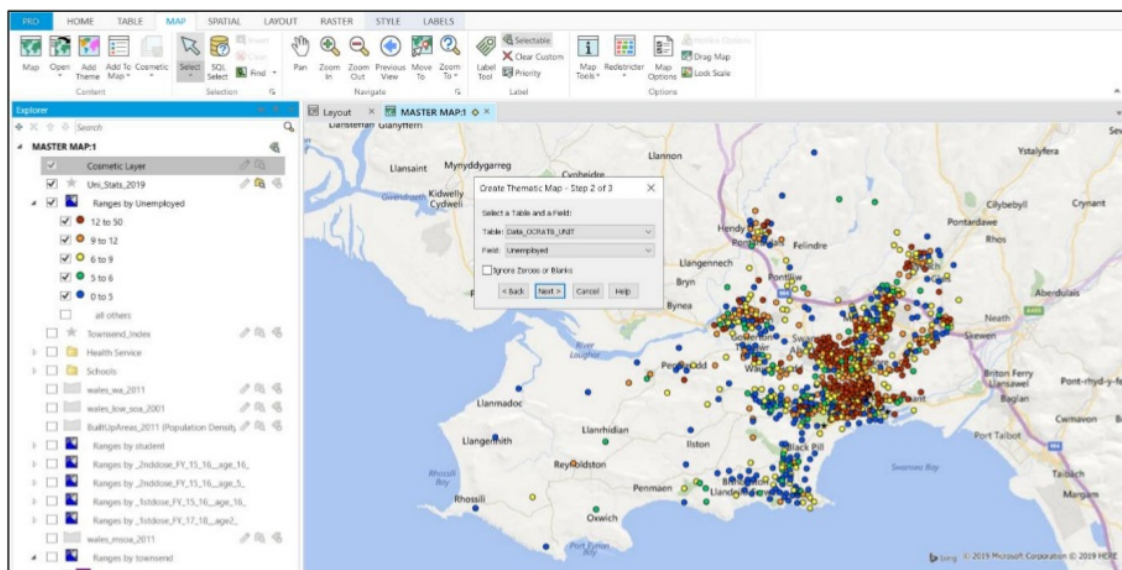


Figure 15: Unemployment point range theme – values shown in layer panel

2.3.6 Layer and Map Customisation

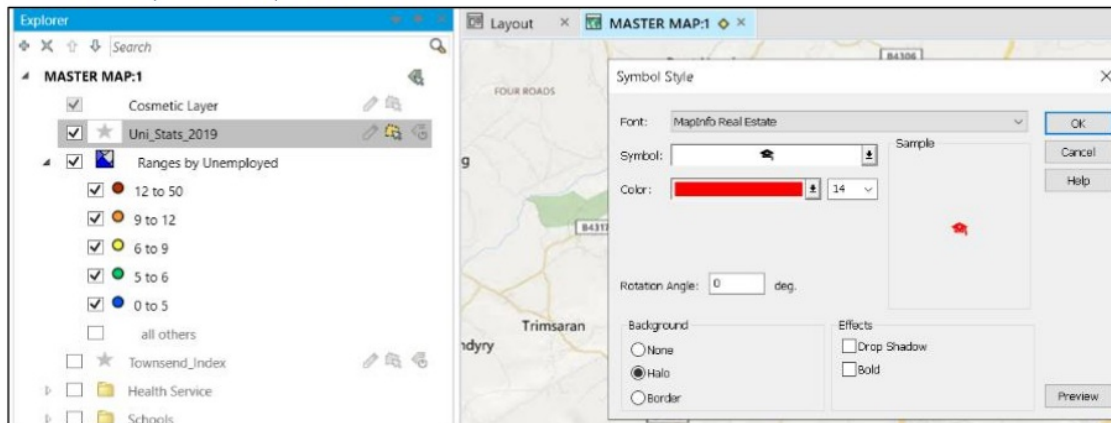


Figure 16: Customisation of points

The map and its layers can be enhanced through customisation. This can be in the form of symbolisation, transparency and labelling and allows better data management.

Firstly, the 'Symbol Style' option box provides various symbol choices. For example, in the SDSS workspace, University locations are represented with a graduation hat (see Figure 16). This gives the reader a better understanding of what the dataset represents.

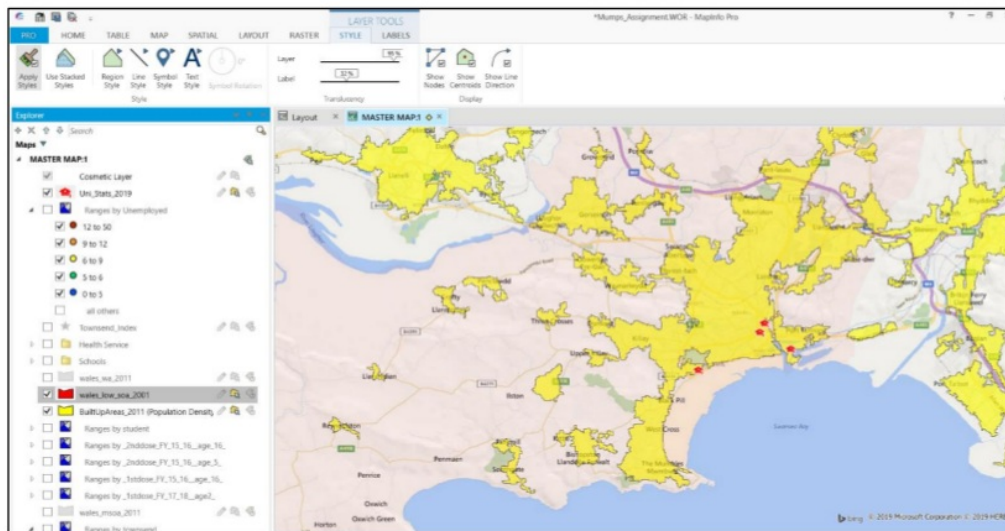


Figure 17: Use of transparency for Built Up Areas layer

Transparency is another useful tool and can be altered within the layer properties window (see Figure 18). For example, in Figure 17, the map illustrates University locations (points) and built up areas within Swansea (polygons). The built-up areas layer has been made translucent, so the road names and areas are still visible, and the reader has information about where these places are.

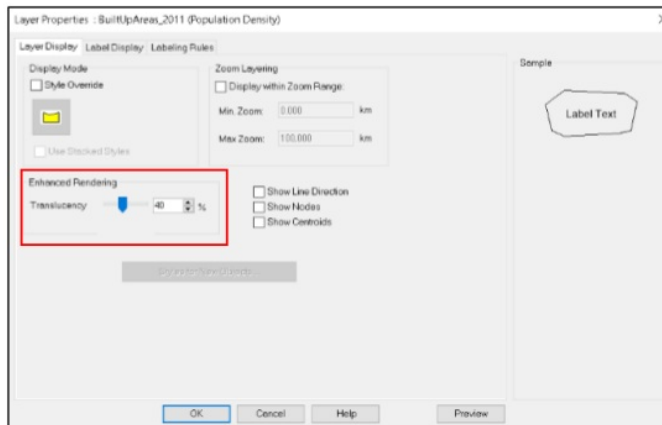


Figure 18: Layer Properties

Furthermore, labels can be turned on to give the reader additional information about the dataset. Figure 19 demonstrates the use of labels for the University dataset.



Figure 19: Use of Layer Labels in the University dataset

Queries and expressions can be used to further customise aspects of symbology and labelling. Figure 20 shows how an expression has been utilised to customise label generation for the University layer.

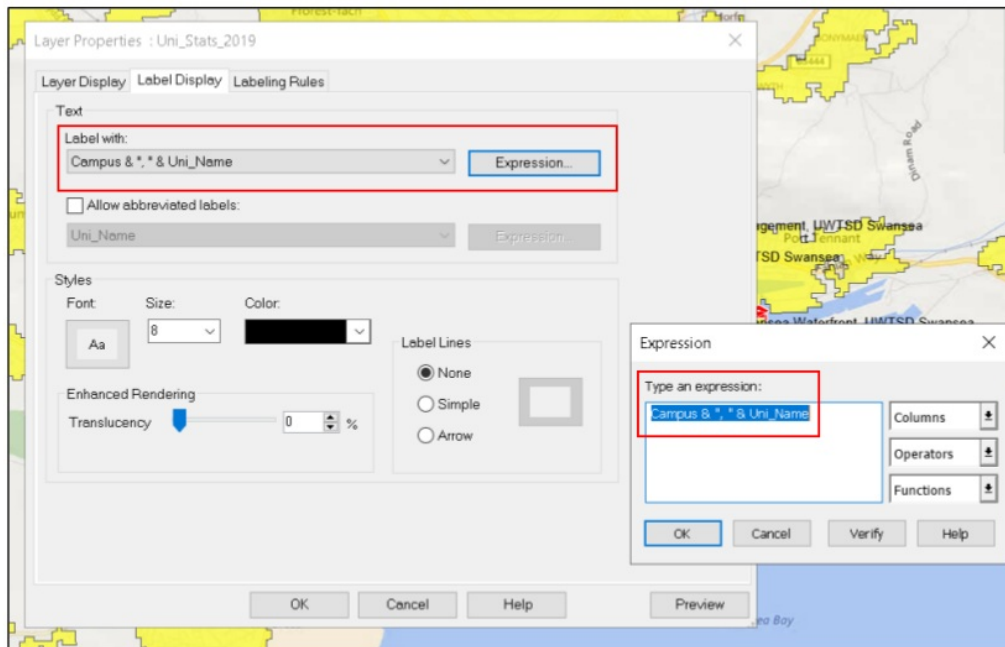


Figure 20: Use of queries within the University layer

3. Data analysis & results discussion

This section will test the hypotheses using the 'Mumps Risk in Swansea' SDSS built through the methodology above.

3.1 Student population and higher mumps risk

As previously discussed, students are at a high risk of contracting mumps and evidence already shows that many outbreaks of mumps have been in universities. This is for a number of reasons; they are the most at-risk age group due to the 'anti-vax' group movement in the 1990's and lastly, because they are in proximity of one another for large periods of time [23].

The University Statistics dataset, created for the SDSS, shows that there are four university campuses which fall within the Swansea county boundary. An SQL Query was used to determine which fell within the Swansea polygon boundary. During 2019 and early 2020, a mumps alert has been issued for all University campuses in Swansea [10]. From the map, it is evident that all these university campuses are in close proximity. The Ruler Tool can be used to determine the exact distance, which shows that the most distant campuses are just under 2.5 miles apart (see Figure 21). This indicates that there will be a dense population of students within and around these areas. The Townsend Index can be utilised to investigate this further.



Figure 21: Ruler Tool determining distance for University Campuses

Creating a theme using the student population figures within the Townsend Index indicates where most students live around the campuses (Figure 22). Turning on MSOA labels allows us to identify the three areas with the highest student populations, these are Sketty, Uplands and Landore (with darkest green polygons to symbolise a high student population). Although there may be other areas in Swansea with a high population of students, these areas are surrounding the university campuses and overall will contain the most students either residing or visiting these areas regularly. As hypothesised, these areas will provide extensive opportunities for mumps to spread among students and young people; already identified to be some of the most vulnerable groups.

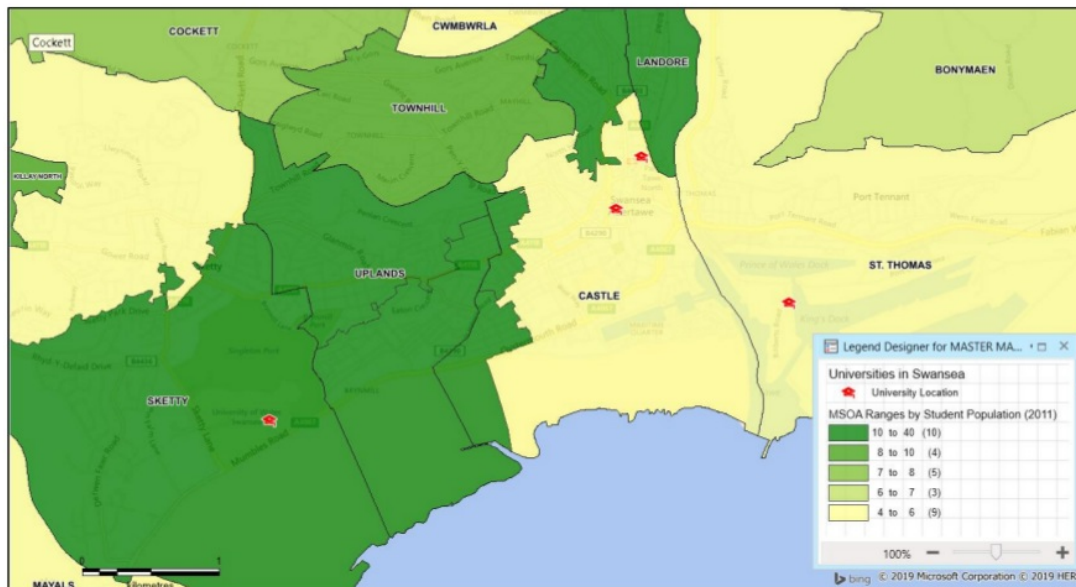


Figure 22: Theme applied to student population figures in Townsend Index

The theme range can be calculated using different methods (Figure 23). Therefore, it is important to realise that thematic maps are open to interpretation and need to be backed up with other data. As with any system, the map is only as good as the data it is based on.

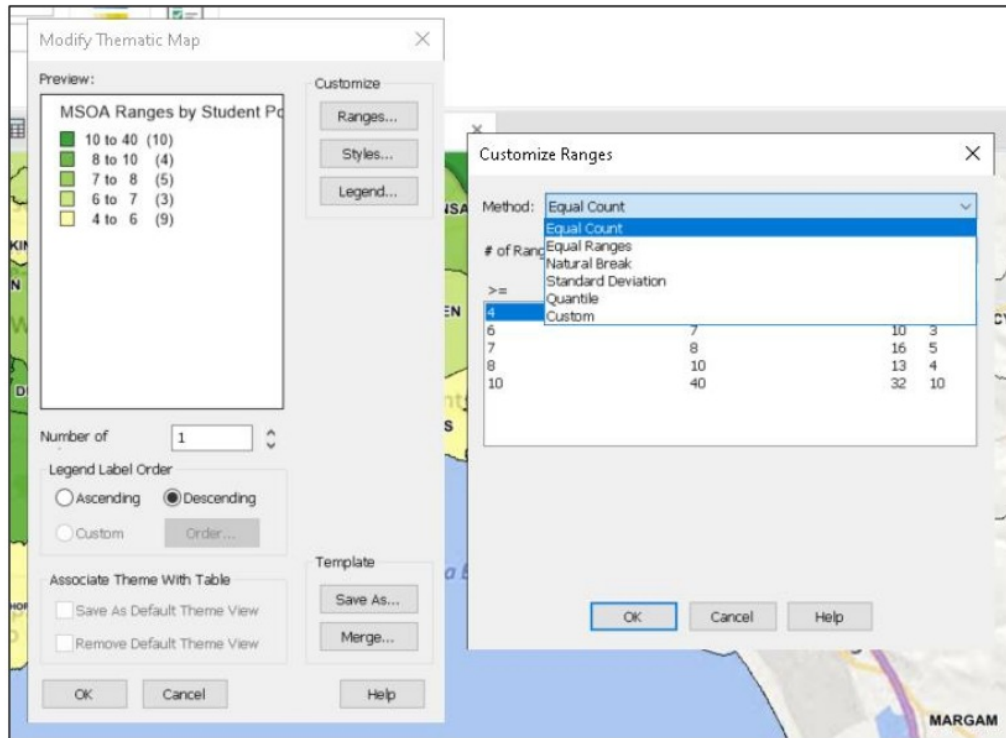


Figure 23: Calculation of theme range

3.3 Poverty and increased mumps risk

The Townsend index shows the levels of material deprivation across Swansea. Figure 26 shows a cluster of high unemployment around the town centre. Upon zooming into this area, figure 27 shows that the area around two of the Universities, particularly in Castle, shows high levels of deprivation. Whereas the University campus situated in Sketty, shows slightly lower levels of deprivation, indicating this is a more affluent area. This is also true for the University located in St Thomas. High student population areas, previously identified as Llandore, Uplands and Townhill, also show high deprivation levels.

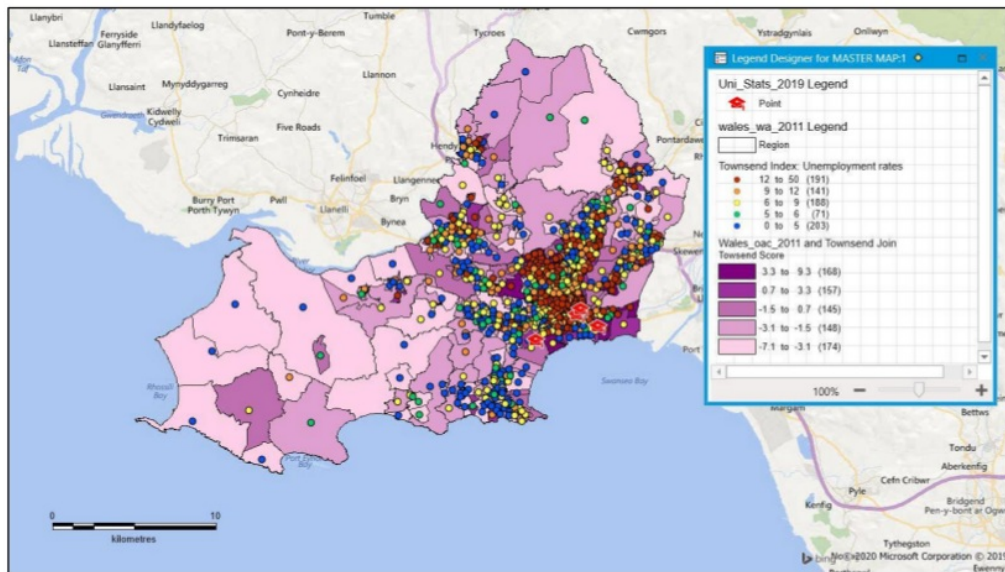


Figure 26: Unemployment rates and Townsend index score across Swansea

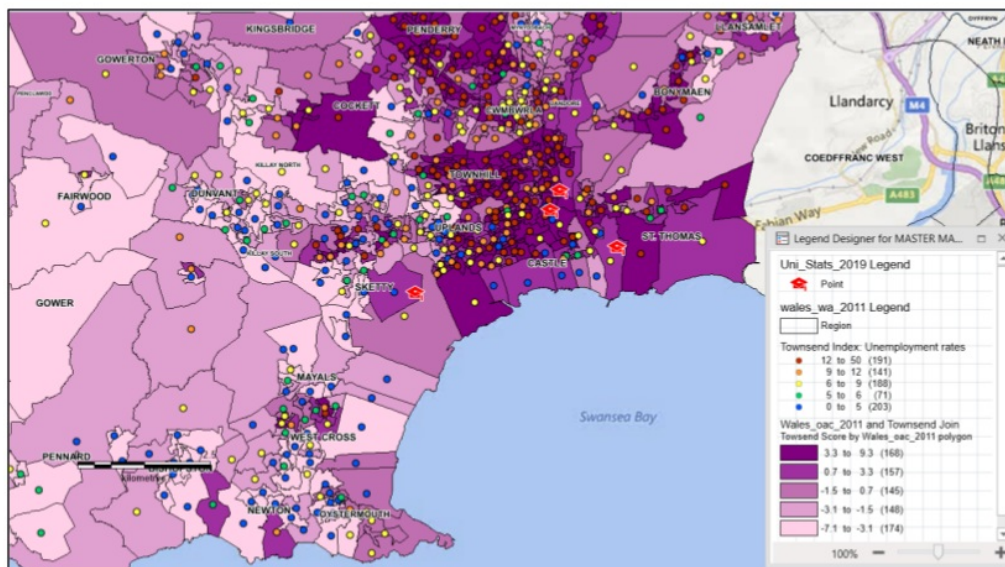


Figure 27: Townsend Index and rates of Unemployment (zoomed in)

The Unemployment Point layer highlights that the highest rates of unemployment are in the highest areas of deprivation, where the universities also are, in Castle. Figure 27 shows a hot spot of red points around the Castle area. The university campus location in St Thomas also shows high levels of unemployment. This links to the third hypothesis of a higher mumps risk in more deprived areas.

3.4 The Combined Mumps Risk

The analysis has already shown that students are likely to be the most vulnerable group to catch and spread mumps and that they also live in the most vulnerable areas; overcrowded and with higher deprivation levels. Furthermore, most students currently at university would have been those affected by the fall in vaccination uptake rates in the 1990s. To gain a further understanding of this, the MMR rates dataset for 16-year olds in 2015/2016 has been added to the map; who would now be of university age.

Figure 28 shows how those in Sketty and Castle have lower levels of immunisation, compared to the rest of Swansea. St Thomas shows a slightly higher level of immunisation, but it is still relatively low. In relation to levels of employment, this shows that despite Sketty displaying low levels of immunisation, it does have high levels of employment rates. In comparison to Castle, which has both lower rates of immunisation and high levels of employment rates and is around two university locations. It is also highlighted by the Townsend Index that Castle has high levels of deprivation. Student areas such as Townhill and Llandore show a slight increase in levels of immunisation compared to Castle and Sketty.

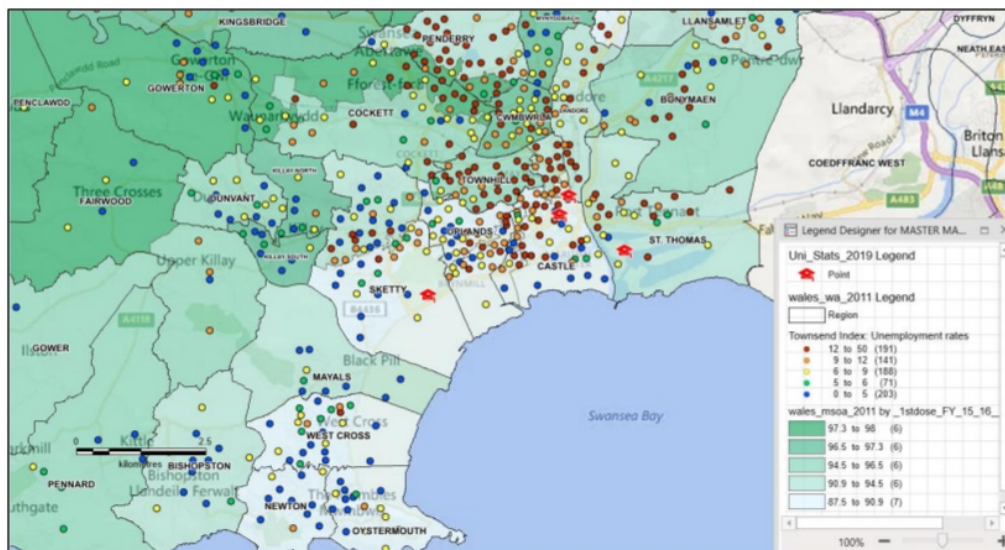


Figure 28: First dose MMR

Figure 29 shows the 2nd dose of MMR during the year of 2015-16. It shows that Sketty and St Thomas continue with the same levels of immunisation. However, Castle's levels of immunisation increase dramatically. Llandore's rate of immunisation decreases, whereas Townhill levels remains the same. This could highlight errors in the data; since the second dose rate in Castle is much higher than the first dose rate. Alternatively, it could show changing attitudes towards the vaccination [25]. This would need to be investigated further before drawing conclusions.

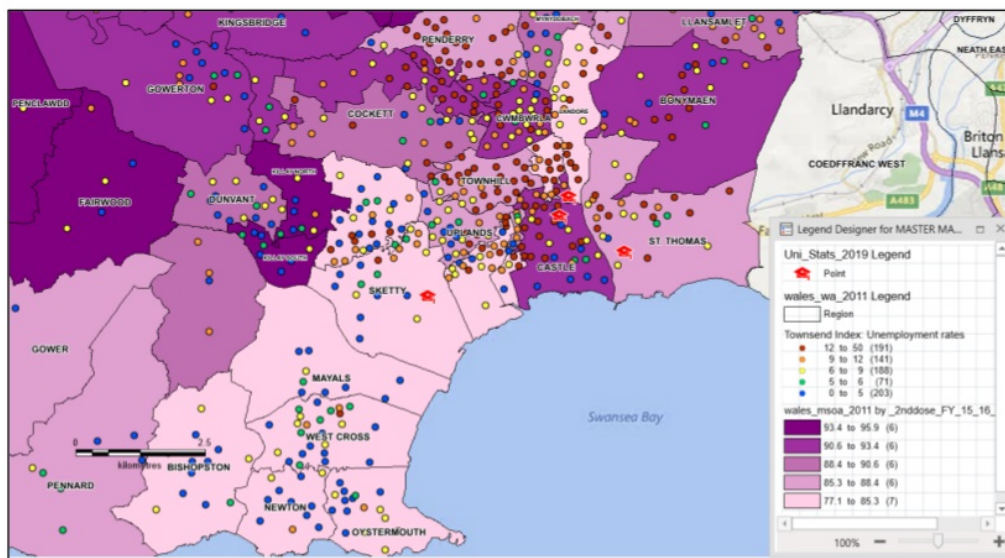


Figure 29: Second Dose MMR

In terms of Castle, Llandore and Townhill, families could be faced with barriers of access to immunisation services, as these may not meet the needs of the community. Lower immunisation could be the result of unregistered children, young children from large families or children with learning disabilities, communities with religious or cultural beliefs. If there are many unvaccinated individuals which live in close proximity, this increases the community's vulnerability to outbreaks [25]. Overall, the same areas identified as vulnerable previously show low levels of immunisation.

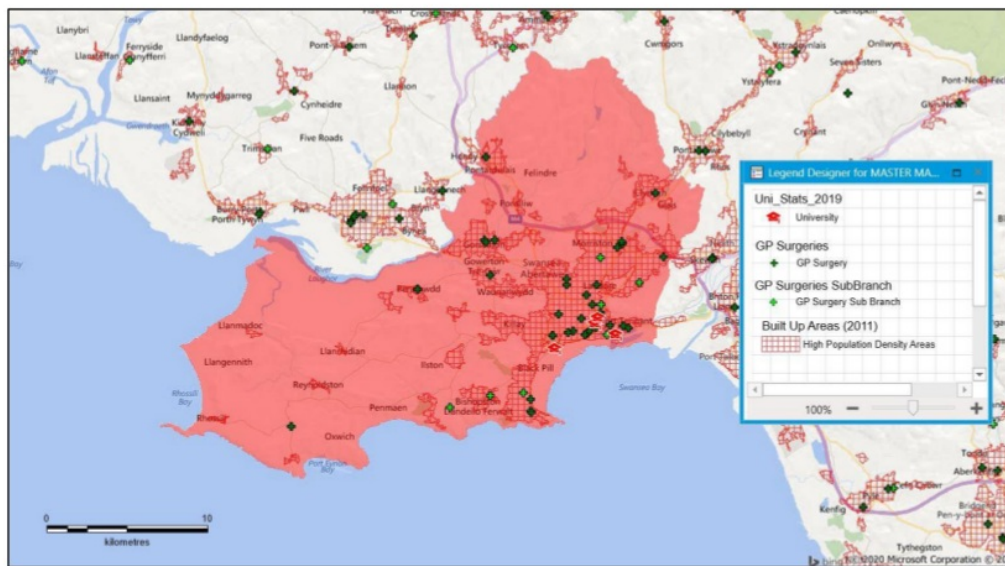


Figure 30: GP Surgeries

Vulnerable groups such as ethnic groups and those with chaotic lifestyles, particularly students, could result in a lack of access to appointments and they may also have difficulties registering with a GP or getting to appointments at a given time [26]. Figure 30 shows GP locations.

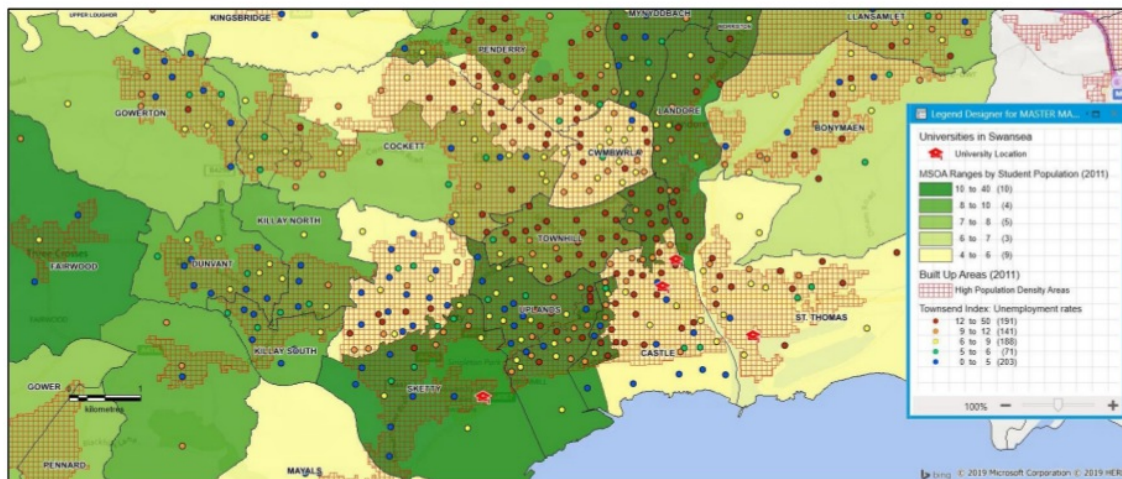


Figure 31: Levels of Unemployment, Built-up Areas and Student Population

From the analysis there is a notable overlap between the areas/populations hypothesised to be most at risk; students, deprived areas and overpopulated areas (figure 31).

3.5 Drawbacks of SDSS

A disadvantage specific to MapInfo is that the interface could be more user-friendly and furthermore not all file formats are supported, which means that other software may be needed to convert file formats. Other software, such as QGIS and ArcMap, are arguably more user friendly [4].

MapInfo presents the data in a visual and easier to view format than excel. However, large trend datasets such as immunisations may be easier to view and analyse in an excel graph format [27].

There are also limitations in the data used to build this SDSS. For example, many of the datasets are outdated, some over 5 years old, and the data may no longer be accurate.

The ultimate disadvantage of GIS, and the SDSS built through this project, is that it is only as good as the data it is built on. If the data has errors, then these may follow through into the conclusions drawn from GIS. Also, the results of spatial analysis can be subjective and interpreted differently by different users [28].

For these reasons, GIS should not be used independently to make decisions. Its results should be used to point the user in the right direction and show where further research is needed to back up the results [29]. In terms of this SDSS, additional research is required to support the patterns identified, such as high student population areas are linked to lower immunisation levels, research is required to support this statement and to provide information on why this might be – GIS can only identify patterns, it cannot tell you why they are so.

4. Conclusion

The SDSS has effectively uncovered several patterns which support the hypotheses:

- Students in Swansea are within close proximity for long periods of time such as in halls of residence and lecture theatres, they share many common areas, which facilitates the spread of mumps
- Swansea has a high and dense population of students across four university campuses; the areas around these, most notably Castle, are most vulnerable to an outbreak of mumps
- Current students were affected by the anti-vaccination and fake news movement which resulted in a drop in the uptake of immunisations, increasing their vulnerability when at University
- Low immunisations in areas of high deprivation can be the result of barriers in accessing GP appointments, such as having a chaotic lifestyle and the timing of appointments, making it more difficult to attend. Students are often affected by these barriers
- As shown in Swansea, there is often an overlap between areas with high student populations, overcrowded areas and areas with high deprivation. Students, and also young people living in these areas, will be the population most at risk of catching and spreading mumps.

In conclusion, the SDSS can be used to help understand why the outbreak has occurred in certain locations and indicate possible solutions to tackle and minimise the risk in the future. Most importantly it shows the most at-risk areas where these solutions and resources should be focused. However, as discussed, the findings are an indication only and should always be supported with further research.

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Appendices

Appendix A – Calculating a Townsend Score using Infuse Data [30]

The calculations were as follows:

F248: Age 16 to 74 - Economic activity: Economically active\ Unemployed - Unit: Persons

F256: Age 16 to 74 - Economic activity: Economically active\ Employee\ Part-time - Unit: Persons

F260: Age 16 to 74 - Economic activity: Economically active\ Employee\ Full-time - Unit: Persons

F267: Age 16 to 74 - Economic activity: Economically active\ Full-time student - Unit: Persons

F556: Age 16 to 74 - Economic activity: Economically active\ Self-employed with employees\ Part-time - Unit: Persons

F989: Car or van availability: Total\ Car or van availability - Unit: Households

F991: Car or van availability: No cars or vans in household - Unit: Households

F2158: Bedrooms; occupancy rating [E][W]: Occupancy rating (bedrooms) of -1 or less - Unit: Households

F2159: Bedrooms; occupancy rating [E][W]: Total\ Occupancy rating (bedrooms) - Unit: Households

F2164: Bedrooms; occupancy rating [E][W]: Occupancy rating (bedrooms) of -2 or less - Unit: Households

F2347: Tenure: Total\ Tenure - Unit: Households

F2351: Tenure: Owned\ Owned outright - Unit: Households

F2353: Tenure: Owned\ Owned with a mortgage or loan - Unit: Households

The following calculations were applied:

Overcrowding:

"**F2376**", "All households"

"(**F2380** + **F2381**)", "Households with an occupancy rating of -1 or less"

(Hint choose Bedrooms, occupancy rating [E][W])

Unemployed:

"**F256**", "People aged 16-74: Economically active: Employees Part-time"

"**F260**", "People aged 16-74: Economically active: Employees Full-time"

"(**F557** + **F556**)", "People aged 16-74: Economically active: Self - employed"

"**F248**", "People aged 16-74: Economically active: Unemployed"

"**F267**", "People aged 16-74: Economically active: Full-time student"

(Hint select by person Age/economically active)

Owner Occupancy:

"**F2347**", "All households"

"**F2351**", "Households:Owner occupied: Owns outright"

"**F2353**", "Households:Owner occupied: Owns with a mortgage or loan"

(Hint select by household then tenure)

No Car:

"**F989**", "All households"

"**F991**", "Households (number of cars or vans): None"

Calculation:

Stage 1:

%Overcrowding = ("(F2380 + F2381)", "Households with an occupancy rating of -1 or less*" / F2376", "All households")*100

% Unemployed = ("F248", "People aged 16-74: Economically active: Unemployed" / sum("F256", "People aged 16-74: Economically active: Employees Part-time*", "F260", "People aged 16-74: Economically active: Employees Full-time*", "(F557 + F559)", "People aged 16-74: Economically active: Self - employed", "F248", "People aged 16-74: Economically active: Unemployed", "F267", "People aged 16-74: Economically active: Full-time student"))*100

%Not Owner Occ (non home owners) = 100 – (("F2351", "Households:Owner occupied: Owns outright" +

"F2353", "Households:Owner occupied: Owns with a mortgage or loan" / F2347", "All households")*100)

%NoCar = ("F991", "Households (number of cars or vans): None" / "F989", "All households")*100

Stage 2:

Var1 = Log(%overcrowding +1)

Var2 = Log(%unemployed +1)

Var3 = %not Owner Occupancy

Var4 = %NoCar

Stage 3:

Zscore1 = (Var1 – Mean(Var1))/S.D.(Var1)

Zscore2 = (Var2 – Mean(Var2))/S.D.(Var2)

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$Zscore3 = (Var3 - Mean(Var3))/S.D.(Var3)$

$Zscore4 = (Var4 - Mean(Var4))/S.D.(Var4)$

Stage 4:

$Sum(Zscore1 : Zscore4) = Townsend\ Index$

GIS Assignment - SDSS for Mumps in Swansea

GRADEMARK REPORT

FINAL GRADE

82/100

GENERAL COMMENTS

Instructor

Generic Assessment Criteria Shannon Boulting	Marks available	Marks awarded
1. Engagement with Literature Skills		
<i>Investigating the fundamentals of visual perception, cartographic visualisation and the map as a visual information system. Explore the origins of GIS and cartographic representation.</i> Excellent introduction supported by well research and relevant sources of research to support your case study. You demonstrate a good understand of the task and you discuss the case study well within the context of your supporting research material. Some well used visuals in this section paint a great opening to the paper.	25	20
2. Knowledge and Understanding Skills		
<i>Discuss the principles of thematic mapping and data</i>	35	28

visualisation within a software environment. Use the evidence that you have collected and exerts from the GIS system that you have developed to help with your discussion and analysis. You will be measured on good use of case study data.

You have introduced a clear statement of intent for your study via your hypothesis in section 1. This has helped with your research journey and you have provided a reflective account of the GIS build and analysis. The detailed description of your methodology has helped to support your analysis of the given data. Your use of the Lle website has added some great additional layer and helped with your data correlation and aided the overall discussion on our findings.

Throughout you have related to your literature research and provided clear visual drawn from your own case study build. You demonstrate a sound understanding of the data requirements and you have provided an interesting read. Maybe use your Townsend data a more as you could have looked at unemployment and therefor education as one of the factor for lack of uptake of the vaccination

3. Cognitive and Intellectual Skills		
<i>Provide a description of suitable additional case study data that may enhance your study and research paper (to be discussed with to Module tutor prior to assignment completion)</i> Again, you have selected relevant additional data sets, this has helped with a critical evaluation of the mmr data and you have looked at possible causes for the increase in the Mumps virus by not only concentrating on the student population but reflecting on built up areas comparing the Townsend index results and location of educational sites.	15	12
4. Practical Application Skills		

<i>Identify types of data involved in Geo-information systems. Briefly describe the use of Excel to gather data. Use of GIS to analyse data that you have collected for the study.</i> You demonstrate an in-depth understanding of the software. You have presented excellent results and you have explored and accurately evaluated your data results. You use MapInfo well and via your screenshot you have been able to draw on the results within your research and your case study analysis.	15	14
5. Transferable Skills for Life and Professional Practice		
<i>All work suitably presented and referenced and concluded</i> A thoughtful conclusion you have reflected on the positives and negatives of the software. Your report has been presented to a very high standard and throughout it has been a very enjoyable read. Perhaps a little over the word count guidelines. Good references and excellent layout. Total 82%	10	8

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