

GIS report - Laurice Keogh

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ANALYSIS OF THE FACTORS THAT ARE AFFECTING MMR UPTAKE IN SWANSEA, AND SUGGESTIONS TO HEALTHCARE PROFESSIONALS TO IMPROVE THE SITUATION BASED ON THIS ANALYSIS

Geographical Information Systems

Abstract

Geographical Information Systems are an effective visualization tool for analysis by location. Problem areas can be found easily on a map by finding trends and patterns. This type of analysis could help healthcare professionals prevent or stop epidemics such as MMR which this report will demonstrate.

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Introduction

In 2013 there was an outbreak of measles in Wales, where Swansea was particularly worse than other cities due to low MMR vaccination uptake. An operation to vaccinate those who had not had their MMR vaccinations was launched to prevent further deaths and infections. This report will look at the current MMR uptake in Swansea and offer suggestions that may be beneficial to healthcare professionals in spotting patterns, preventing an outbreak, and also identify where the best areas to bring in new measures would be. The current situation will be compared to 2014-2015 (the period after the outbreak) to see if the vaccination uptake has gotten better or worse.

Data such as Wales boundaries and MMR vaccinations were gathered as a group for this investigation. Other data sets featured were gathered individually to allow deeper analysis. The visualisations have been created in a workplace within MapInfo which all analysis and conclusions are based on.

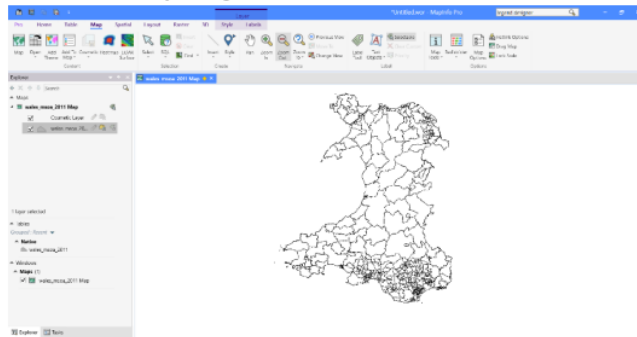
Principles of thematic mapping and data visualisation

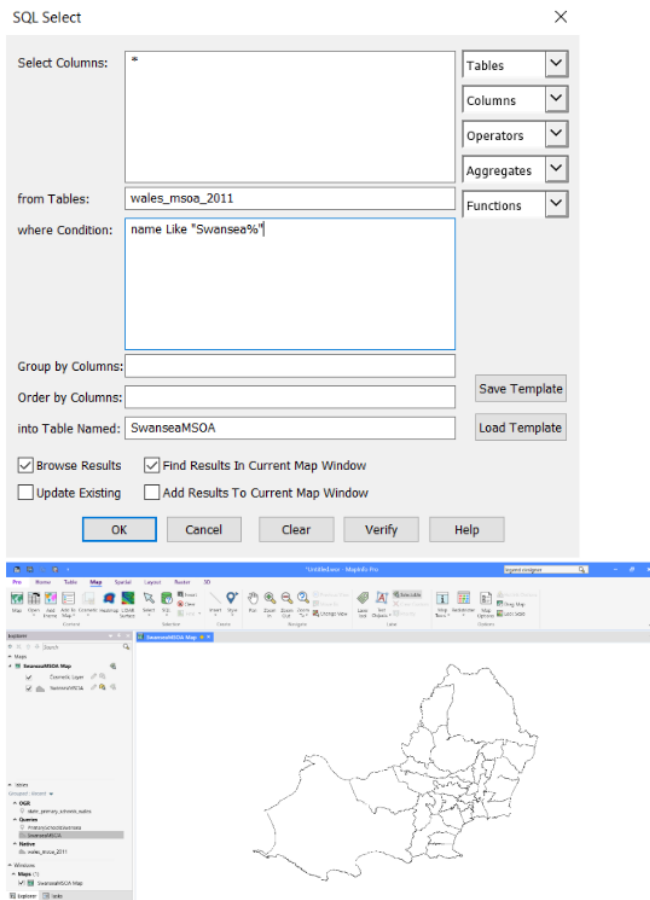
[10] Thematic mapping is used to tell a story of a certain geographical location. For example, it is a good way of showing which areas have higher deprivation or health issues. There are different types of thematic mapping including 'dot density' where sites could be plotted, or 'proportional symbols' where areas with a higher population would have a bigger symbol than those with a lesser population, or a 'choropleth' map where different areas are shaded a different colour in line with their value. Choosing the right thematic mapping technique is important as it is telling the story of an area, and sometimes it might be useful to use two or more different thematic mapping techniques to display different data at the same time. [11] Whilst it is useful to show different information at once, it is important to make sure that it is useful, answers the question and is easy to understand. [11] When using colours

representing different values it is important that these are easy to differentiate so that the viewer can understand the picture quickly.

GIS build and analysis.

Spatial queries are a quick way to select only the information that you want. I started this build with an MSOA map of Wales, but I knew I wanted to investigate just the Swansea area due to the previous measles outbreak in 2013. The spatial query selected everything where the area name included 'Swansea'.





[12] [1] Geocoding is a way of turning a physical address/code into a geographical location on a map. The MMR vaccine data was able to be geocoded by linking the MSAO Code to the MMR MSAO code column where the values matched.

Geocode

Geocode Table: MMR_2nd_dose_by_age_5_upta

using Column: MSOA_CODE

Boundary Column: none

Search Table: SwanseaMSOAshp

for Objects in: code

* indicating the table or column is indexed

Mode: ☒ Automatic ☐ Interactive

Symbol: ☆

Optional

Refine Search with Table: none

using Boundary Name: none

OK Cancel Options... Help

MapInfo

Geocoding of table MMR_2nd_dose_by_age_5_upta completed.

31 geocoded

0 not geocoded

0 previously geocoded

OK

Once the datasets have been geocoded, they can be thematically mapped. The most appropriate way is to shade different MSOA areas by colour. Ranges can be created so that values within the ranges are a specific colour. Colours used should be easy to be differentiated allowing for quick understanding of the data.

The tables need to be joined for the thematic map to work.

Specify Join

Join

☒ where code from table SwanseaMSOAshp

matches MSOA_CODE from table MMR_2nd_dose_by_age_5_upta

☐ where object from table MMR_2nd_dose_by_age_5_upta

is within object from table SwanseaMSOAshp

OK Cancel Help

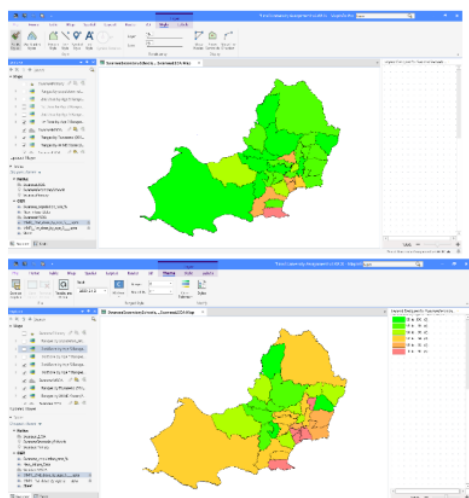
A range has to be created so I decided to avoid misleading data the ranges should be the same on each dose and year. This allows the data to be more easily read when changing layers and comparing to each other.

[7] This method has been used to create thematic maps for the MMR 1st dose by age 2 and [8] 2nd dose by age 5. I have looked at this data based on two different time periods including 2014-15 and 2020-15. The 2014-2015 data is useful to show the MMR uptake after the outbreak because there were extra vaccination centres encouraging people who were unvaccinated to get the MMR vaccine. You'd expect the vaccination rate in 2014-15 to be high which was the case for both the 1st and 2nd doses shown below. Although the uptake was lesser for the 2nd dose this can be expected because getting people to have their first dose would have been the priority at the time of the epidemic. The deprivation is at it's worst in the same general areas of Swansea indicating that this area is definitely less vaccinated than the rest.

I also looked at MMR vaccinations for 1st dose before age 2 in 2020-2021 to look at how the uptake is now, and it is clear that there has been a decline across the Swansea area particularly noticeable in central Swansea and surrounding areas showing more orange and red. I then looked at the MMR uptake for the 2nd vaccine under 5 years old in 2020-2021. Whilst it looks like the northeast of Swansea has improved a little since 2014/2015, central and West Swansea have declined in their MMR uptake. The 2020-21 data follows the same pattern as 2014-15 where the uptake is lesser for the second dosage. This could indicate to healthcare professionals that there needs to be a better MMR vaccination service for dose 2 than what is in place currently.

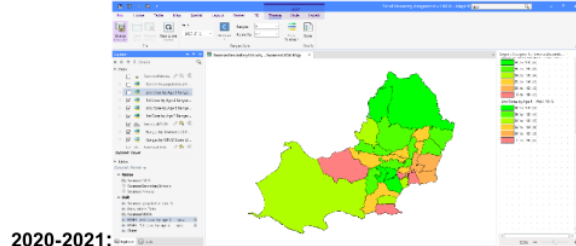
MMR vaccination 1st dose by age 2 for 2014-2015:

MMR vaccination 2nd dose by age 5 for 2014-2015:

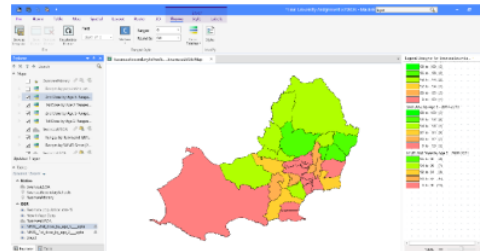


MMR vaccination 1stst dose by age 2 for 2020-2021:

MMR vaccination 2nd dose by age 5 for



2020-2021:



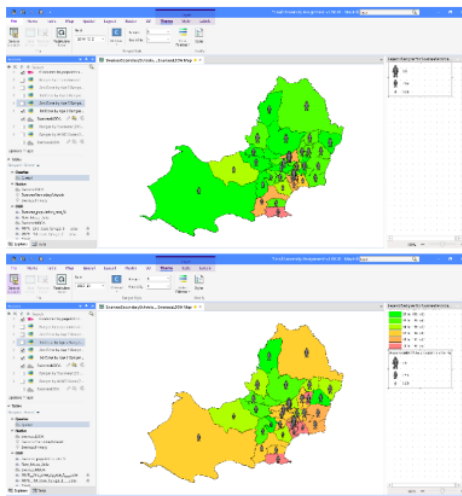
The areas shaded in red are the biggest cause for concern because it is likely to be where the MMR infections would spread the most and the quickest with more people being vulnerable.

[5] I then thought it would be interesting to see whether the areas shaded red have big populations. By using graduated thematic mapping, it is clear to see the correlation between the populations for each of the doses and years because they can be displayed on the same map with different sizes symbols. The bigger the symbol, the bigger the percentage of the population resides there. Penderry and Townhill area of Swansea in particular had a very large population for a physically small area which is a cause for concern because if areas are highly populated, in a smaller physical space, whilst unvaccinated, the rate that MMR related infections could spread is far quicker. To create the percentage rate of population for each MSOA I divided it by the total population of Swansea and multiplied by 100. The population data only included children ages 0-15 as this is the closest age range that I could get the data in, in relation to the vaccinations before age 2 and 5. This does allow for inaccuracies due to not knowing how many of the children in the area are between 0- 5 but each MSOA rate was calculated in the same way which gives some validity and indication of population density.

The below maps show the population in different MSOA for each dose and year.

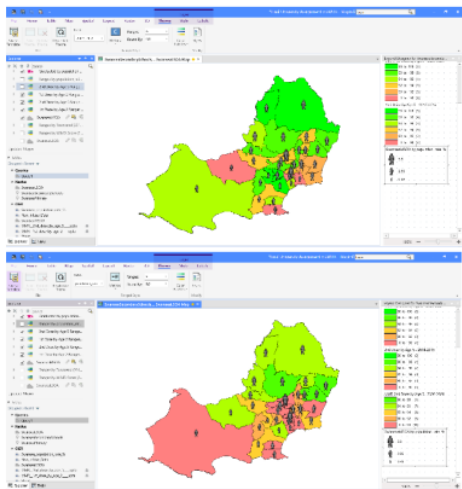
MMR vaccination 1stst dose by age 2 for 2014-2015:

MMR vaccination 2nd dose by age 5 for 2014-2015:



**MMR vaccination 1st dose by age 5 for 2020-2021:
2020-2021:**

**MMR vaccination 2nd dose by age 2 for
2020-2021:**



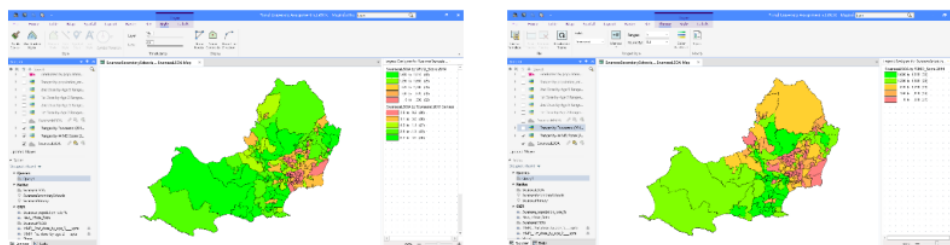
Due to the middle of the map being more populated and less vaccinated I wanted to investigate whether deprivation could impact on the uptake of the MMR vaccine. [6] The Townsend index is a method used to show deprivation. [13] The Townsend index made by Peter Townsend in 1988 looks at unemployment, overcrowded homes, how many of the households are owned, and whether the household has any cars/vehicles. The percentages of these aspects are calculated and then 1 is added to each in a log in order to prevent skewed data. Then the Z scores are calculated by getting the mean and dividing by the standard deviation creating a reliable average/score. The 4 Z scores are then added up to give the Townsend index. Negative values show wealth whereas positive values show higher deprivation. [2] I decided to look at deprivation in more detail at LSOA level because each MSOA could contain LSOA areas of both affluent and deprived and if there is a correlation

between deprivation and lower MMR vaccine uptake it provides more specific areas for the health board to bring new measures in place for. The Townsend Index created is based on 2011 census data due to the 2021 census data being incomplete. By using the 2021 we might get an incomplete story told by the visualisations, so it is more reliable to use a full dataset. By thematically mapping the Townsend index based on its value to the LSOA boundary map for Swansea (created in the same way as the MSOA boundary map for Swansea using SQL spatial queries) it shows that the areas with a lower MMR uptake are the areas with more deprivation. This suggests that people living in these areas do not have good transportation links so might not be able to attend hospital sites. The health authorities could see this data and make the decision to start setting up mobile vaccination hubs visiting every local town within these areas to encourage MMR vaccinations. This data could also suggest that there are more people to bedrooms on average in these houses meaning that children may need to share bedrooms causing a risk of spreading measles, mumps, or rubella in the household. The limitations to the Townsend index are that some areas may have really good transportation links but not good employment rates and, in this instance, the mobile vaccination hub wouldn't be as effective. It can be assumed that the areas shaded red have an overall higher deprivation rate and would need the most support/preventative measures.

I wanted to double check my findings because I created the Townsend Index myself and wanted to ensure that the data found for 2011 is similar to the mid 2014 [9] Welsh Index of Multiple Deprivation figures (WIMD). WIMD is a more in depth look at deprivation in Wales as it looks at [14] Income, Employment, Health, Education, Access to Services, Community Safety, Physical Environment, and Housing. I chose to look at the mid 2014 figures because I have MMR vaccination data for 2014-2015 and this helps gather an accurate visualisation for comparison and analysis. The WIMD thematic map layer shows that the areas of high deprivation in the Townsend deprivation layer are within the WIMD deprivation layer. The WIMD data shows that there are other locations in the surrounding areas and north Swansea that aren't very affluent.

**Townsend Index 2011
mid-2014**

| Welsh Index of Multiple Deprivation



Considering MMR vaccinations are aimed at children of school age I wanted to investigate what impact the schools could have on vaccination uptake and prevention of an outbreak. [3] I downloaded data for primary schools and [4]

secondary schools because although MMR vaccinations are aimed at primary school children, if they carry one of the MMR infections and share a bedroom with an older sibling who is also unvaccinated for instance it could affect other unvaccinated secondary children too, where this scenario could be realistic in the more deprived areas. I downloaded data containing the latitude and longitude of the schools so that they could be plotted using the 'create points' spatial query. The British Grid is used as a reference for the X and Y points where the X points are the longitude, and the Y points are the latitude. This data was for all Wales schools, so I ran a spatial SQL query to select the primary schools within the Swansea MSOA boundary, followed by another query for the secondary schools within the Swansea MSOA boundary. The majority of the schools are in areas of deprivation and have lower MMR uptake. This is concerning for health professionals because schools would be where measles, mumps, or rubella would spread amongst the children, and this would happen at a more concerning rate if children were going to schools where a large number of children haven't been vaccinated. However, the positioning of schools could be a solution to children having better access to the MMR vaccinations. The MMR vaccinations could be given at school for any children who didn't have their first vaccinations before age 2 and for those that need their 2nd dose before age 5. This solution of using the schools to vaccinate should prevent any outbreaks caused by the placement of the schools where access to transport is an issue because they are in school anyway.

SQL spatial query for primary schools in Swansea:

SQL Select

Select Columns: *

from Tables: state_primary_schools_wales, SwanseaMSOA

where Condition: state_primary_schools_wales.obj Within SwanseaMSOA.obj

Group by Columns:

Order by Columns:

into Table Named: PrimarySchoolsSwansea

☒ Browse Results

☒ Find Results In Current Map Window

☐ Update Existing

☐ Add Results To Current Map Window

OK

Cancel

Clear

Verify

Help

Tables

Columns

Operators

Aggregates

Functions

Save Template

Load Template

SQL spatial query for secondary schools in Swansea:

SQL Select ✕

Select Columns: *

from Tables: state_secondary_schools_wales, SwanseaMSOA

where Condition: state_secondary_schools_wales.obj Within SwanseaMSOA.obj

Group by Columns:

Order by Columns:

into Table Named: SecondarySchoolsSwansea

☒ Browse Results ☒ Find Results In Current Map Window
☐ Update Existing ☐ Add Results To Current Map Window

Tables
Columns
Operators
Aggregates
Functions

Creating points using latitude and longitude:

Create Points ✕

Create Points for Table: state_primary_schools_wales

Projection: British National Grid ...

Add to Map: state_primary_schools_walk

☐ Overwrite points using Symbol:

Coordinates

Get X Coordinates from: lon

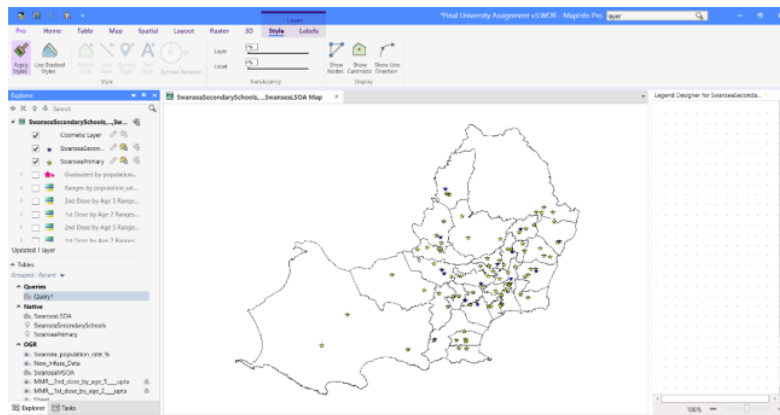
Multiply by: 1

Get Y Coordinates from: lat

Multiply by: 1

☒ Display non-numeric fields

Primary and secondary schools plotted using latitude and longitude:



Conclusion

It has become clear through the use of spatial queries, thematic mapping, and map visualisations that socio-economic factors can affect the uptake of MMR vaccinations. The 2014-2015 data tells the story after the epidemic where there was previously an operation to mass vaccinate people in an effort to slow down and end the epidemic. The visualisations show this picture because the vaccination rates for 2014-2015 are quite high. The visualisations showing MMR uptake in 2020-2021 show a decline in MMR vaccination uptake through more red and orange areas being present on the map. In both time periods there are less people getting their second vaccinations than the first which could tell healthcare workers that they need to target this group of people. In the areas where MMR uptake is lower, the deprivation is also lower. The WIMD and Townsend Index show some of the same areas in central Swansea having a lower deprivation so these areas could be targeted by the health board with mobile vaccination hubs helping those with a lack of transportation methods. Furthermore, the areas of low deprivation and MMR uptake have quite high populations compared to the outskirts/countryside areas of Swansea. Where there are higher populations in a smaller space, infections can spread quicker and with these areas also being where people are unvaccinated it is a clear sign that measures should be implemented here to get as many people vaccinated as possible to prevent a future outbreak especially because so much fewer people are getting vaccinated recently than in 2014-2015 and it is not good if the rates keep declining. Since MMR primarily effects children I looked at primary and secondary school locations in Swansea and it was interesting that there were more of them in the more deprived and less vaccinated areas. This is concerning because the infections could quickly spread in a school environment. However, if measures are put in place to utilise the schools as vaccination hubs, then it could prevent a future outbreak. Children are already in the schools so it would be effective especially for those deprived with a lack of transport that they don't need to find transport to anywhere else.

There is clearly a growing problem where the MMR vaccination rates are on the decline. If the vaccination rates are allowed to decline it could be disastrous to people's health, causing deaths like there were in 2013 when there was the last measles outbreak. Health authorities could implement measures such as mobile vaccination hubs, and school vaccination hubs in an attempt to get more of the children population vaccination and eliminate a divide in the vaccinated and unvaccinated by deprivation because everyone is equally entitled to access to these vaccinations.

References

Data sources

MSOA boundaries

[1]

"Middle Layer Super Output Areas (MSOAs) - Wales - 2011 | DataMapWales," *datamap.gov.wales*. Available: https://datamap.gov.wales/layers/appdata-ons:msoa_wales_2011

LSOA boundaries

[2]

"Lower Super Output Areas (LSOAs) - Wales - 2011 | DataMapWales," *datamap.gov.wales*. Available: https://datamap.gov.wales/layers/appdata-ons:lsao_wales_2011

Primary School Latitude and Longitude

[3]

"State Primary Schools Wales | DataMapWales," *datamap.gov.wales*. Available: https://datamap.gov.wales/layers/geonode:state_primary_schools_wales

Secondary School Latitude and Longitude

[4]

"State Secondary Schools Wales | DataMapWales," *datamap.gov.wales*. Available: https://datamap.gov.wales/layers/geonode:state_secondary_schools_wales

Population estimates

[5]

"Population estimates by local authority, upper super output area and age group," *statswales.gov.wales*. Available: <https://statswales.gov.wales/Catalogue/Population->

[and-Migration/Population/Estimates/Small-Area/populationestimates-by-localauthority-uppersuperoutputarea-agegroup](#)

Townsend Index

[6]

“InFuse 2011,” *infuse2011gf.ukdataservice.ac.uk*. Available: <https://infuse2011gf.ukdataservice.ac.uk/infusewizgeo.aspx>

MMR vaccination 1st dose before age 2 - Swansea

[7]

“DHCW – Data Explorer,” *www.healthmapswales.wales.nhs.uk*. Available: <https://www.healthmapswales.wales.nhs.uk/data-catalog-explorer/indicator/11541?features=158>

MMR vaccination 2nd dose before age 5 - Swansea

[8]

“DHCW – Data Explorer,” *www.healthmapswales.wales.nhs.uk*. Available: <https://www.healthmapswales.wales.nhs.uk/data-catalog-explorer/indicator/11542?features=158>

Welsh Index of Multiple Deprivation 2014

[9]

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Information Sources

[10]

“Thematic mapping techniques | Blog,” *Ordnance Survey*. <https://www.ordnancesurvey.co.uk/blog/thematic-mapping-techniques>

[11]

E. Owens, “Research Guides: Data Visualization Guide: Principles,” *shsulibraryguides.org*. <https://shsulibraryguides.org/dataviz/principles>

[12]

“Geocoding,” *Precisely*, 2023. <https://www.precisely.com/glossary/geocoding> (accessed Jan. 11, 2024).

[13]

J. M. Last, *A Dictionary of Public Health*, 2nd ed. 2007. Available: <https://www.oxfordreference.com/display/10.1093/acref/9780191844386.001.0001/acref-9780191844386-e-4486>

[14]

“Welsh Index of Multiple Deprivation (WIMD) 2014.” Available:
<https://www.gov.wales/sites/default/files/statistics-and-research/2019-04/welsh-index-of-multiple-deprivation-2014-revised.pdf>

GIS report - Laurice Keogh

GRADEMARK REPORT

FINAL GRADE

73/100

GENERAL COMMENTS

A good introduction and a clear statement of your aims for your research. Some suitable references and explanations of your data capture and your intent on the usage of data.

A very clear explanation of the data that you were going to use for your MMR uptake investigation with some interesting facts found regarding the most recent outbreak in Swansea. Although the report is clearly written you should write in third person. As you are relating a practical build of your GIS it can be confusing but this is a report on the data analysis and therefore should be written in third person.

You have explained your findings in great detail verbally however it is a shame that your map images were so small. Within the text they therefore became a little bit lost and it was very difficult to read the legends on the right hand side. The very nature of GIS is that it is visual so don't be afraid of putting in lots of map images throughout the text to convey your message in a more visual way. Also, rather than a screenshot of the software print out the map with the appropriate legend at the side this gives the reader a better overview of the data.

That said, your overall report provides some comprehensive analysis of your data analysis and you have looked at both healthcare and deprivation data and provided thoughtful conclusions to your analysis.

Good overall participation in the group work and clear definition of your direction of research from the gathered data.

21/25 17/25 30/40
5/10 total 73%

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