Overweight Children and their School Environment – A Small-scale Spatial Approach

Bettina NEUNEGGER and Melanie N. TOMINTZ

Abstract

The increasing number of overweight and obese people is a big global problem, as overweight is the activator for many diseases like cardiovascular diseases or diabetes type 2. These non-transmitted diseases can lead to death and have subsequently a great impact on the health budget. Especially the increase of overweight and obese children is alarming. The aim of this project is to apply spatial statistical analysis in combination with Geoinformation Systems (GIS) to analyse if the surroundings of secondary modern schools and places of pupil’s residence have an influence on the body weight of secondary modern school children in Villach focusing on fast food outlets in first place, e.g. is there a spatial correlation between a higher amount of fast food outlets and obese children. For the analysis three main datasets are chosen: (i) anonymous data of secondary modern school children holding e.g. information about the Body Mass Index (BMI) and area of residence, (ii) location data (fast food outlets, secondary modern schools and further relevant localities from the Herold business dataset) and (iii) road network data from Tele Atlas. Initial findings show that that the rates of overweight/obese children vary within the schools from 25.7% – 38.1% as well as the number of fast food outlets around schools. Next steps of this project will distribute a questionnaire to secondary school children to gain knowledge about the children’s eating habits, activity levels and their attitude of buying food on their way to/from school and home aiming to support our assumptions. In addition further analysis will show if the distance to fast food outlets has an impact on the weight of secondary modern school children and which other environmental factors cause variations respectively to weight, e.g. offer of parks or playgrounds.

1 Introduction

Overweight and obesity have reached epidemic proportions worldwide and many countries have the problem of an increasing expenditure of the public health budget. Obesity usually results from an unbalanced way of food intake and physical activity although in some cases diseases such as Hypothyreose (underproduction of thyroid hormone) or Cushing's syndrome (overproduction of cortisol) can be the activator. There are different ways of measuring obesity and one well known measure is called Body Mass Index (BMI) as this is a fast way of analysing obesity in comparison to the hip/waist ratio. The latter is more accurate but often too time consuming and hence too expensive. The BMI is calculated by dividing the weight of a person through the height of this person squared. According to the Austrian health report the BMI is classified in four different groups: (i) underweight (< 18.4 kg/m²), (ii) normal weight (18.5 – 24.9 kg/m²), (iii) overweight (25.0 – 29.9 kg/m²) and (iv) obese (> 30 kg/m²) (ELMADFA et al. 2009). Globally, there are more than 1 billion overweight...
adults and at least 300 million of them are obese. In Austria, 44% of men and 55% of women are categorized as normal weight (BMI 18.5 – 24.9 kg/m²). More than half of the male population is therefore overweight (43%) or obese (12%) whereas women are less overweight (29%) than men but the proportion of obese women is slightly higher (13%) (KLIMONT et al. 2007). Alarming is the fact that overweight is becoming increasingly prevalent among younger adults and children worldwide. Figures from the Austrian nutrition report shows that 22% of 6 to 15 year old school children are overweight and 16% obese (ELMADFA et al. 2009) and the numbers are increasing since years. One main problem is that overweight children are likely to become overweight adults, which leads to different health related problems like diabetes type 2, high blood pressure, cardiovascular disease and other consequential diseases that can lead to a higher chance of premature death.

According to the National Institutes of Health (NIH) fast food is characterized as 'easily accessible, quick, and cheap alternatives to home-cooked meals'. Normally fast food is associated with unhealthy food as it is high in calories, fat, sugar, salt and saturated fat. However, some fast food chains have responded to growing public awareness about offering healthy nutrition like salad bars, yoghurt, grilled chicken and lean meats and a number of fast food outlets provide an information sheet on the nutritional content of the food (NATIONAL INSTITUTES OF HEALTH 2009). Besides the big fast food chains, also snack bars, food offers at petrol stations and grocery stores can nowadays be seen as fast food.

Policy targets mainly focus on interventions without considering the spatial component and therefore this research aims to contribute spatial analysis to better understand the association between obesity and the surroundings of obese children in comparison to underweight and normal weight children. This project is carried out in the course of an ongoing Master thesis to locally investigate if an increased number of fast food outlets and easy accessibility to them are associated with a higher number of overweight and obese school children. The study area is Villach in Carinthia, Austria, counting approximately 60,000 inhabitants. A cooperation between the city of Villach, Department of Health was established and the results of this thesis will be presented to policy makers to support them in future planning policies against the increasing number of childhood obesity.

The remaining paper is structured as follows. Chapter 2 presents a state of the art analysis to show what was done in this area of research so far in Austria and internationally. Chapter 3 focuses on an overview of the datasets that are accessible and used in this study whereas Chapter 4 gives an overview about the spatial statistical methods used. Chapter 5 states the preliminary results and Chapter 6 presents future work as this is still an ongoing project. Chapter 7 concludes with a discussion and final conclusion.

2 State of the Art Analysis

A study according the spreading of the BMI among Austrian school children was done by the Federal Ministry of Health (table 1) that shows that 8% of the school children were obese and 11% were overweight. Affected by underweight were only a small amount of Austrian school children (5%). There are only small variations between girls and boys with girls tending to be more underweight in comparison to boys.
**Table 1:** Spreading of BMI among Austrian school children (after ELMADFA et al. 2009)

<table>
<thead>
<tr>
<th></th>
<th>BMI (%)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Underweight (%)</td>
<td>Normal weight (%)</td>
<td>Overweight (%)</td>
<td>Obese (%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>984</td>
<td>5</td>
<td>75</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>471</td>
<td>6</td>
<td>76</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Boys</td>
<td>513</td>
<td>5</td>
<td>75</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-9 years</td>
<td>371</td>
<td>4</td>
<td>76</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>10-15 years</td>
<td>613</td>
<td>6</td>
<td>75</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>

The Austrian National Nutrition Action Plan (NAP.e) sets many policy intervention according to healthy nutrition, e.g. offering more healthy food in schools. The goal is a reduction of over-, under-, and malnutrition or at least stop the rising overweight and obesity rates by 2020 (FEDERAL MINISTRY OF HEALTH 2011). Target groups are infants, children, teenagers and pregnant women. An important project within this strategy is the project about healthy schools and healthy school catering. Respective to the part of spatial analysis and the relationship between fast food outlets and overweight, no publication have been released to our knowledge in Austria to date, especially not considering the local scale.

Galvez and colleagues analyzed childhood obesity and neighborhood food store availability for inner city communities in New York (East Harlem). They used data (height, weight) of 6 to 8 year old boys and girls (n=323). Height and weight was conducted with a standardized protocol and via a field survey food store data were collected. For computing age- and sex- specific BMI percentiles they used the national norms of the Centers for Disease Control and Prevention. With the help of the odds ratio they calculated the risk of a child’s BMI being in the upper BMI level based on the number of fast food stores in their surroundings. 55% of children in the study had a convenience store and 41% had a fast food outlet in their surroundings. Children (n=177) having one or more convenience stores in their surroundings were more likely to have a BMI percentile in the top tertile compared with children having no convenience store in their surroundings (n=146) (GALVEZ et al. 2009).

The University of Leeds in UK conducted a research according on the association between the geography of fast food outlets and childhood obesity rates (FRASER & EDWARDS 2010). The focus was to explore the density and proximity of fast food outlets in relation to the child’s residential postcode. The study group were 3 to 14 year old children out of 42 secondary schools (n=33594) from Leeds metropolitan areas. They used the following methods: (i) simple pearson correlation (ii) density model and (iii) proximity model. The result of this study showed that 27.1% of the children were overweight and 12.6% were classified as obese. There was a significant positive correlation between density of fast food outlets, higher deprivation and higher child obesity.

Another study by the University of Minnesota investigated if fast food outlets are an environmental risk factor for obesity. This study explored if living or working near a fast food outlet has an influence on the BMI. The result was that eating in fast food outlets has a positive association with having a BMI in the upper level. The proximity of fast food outlets to homes and working places was not associated with a higher BMI or eating in such fast food outlets (JEFFERY et al. 2006).
A study in Edmonton at the University of Alberta was conducted to explore the relation between local environments and obesity among adults (n=2900). They set the focus on the question if fast food outlets near people’s homes have an impact on their body weight. For the calculation they used an 800m and 1600m buffer, which were placed around the people’s residences. They used the ODDS ratio combined with the Retail Food Environment Index (RFEI) to make a logistic regression. The result of this calculation was that the lower the ratio of fast food outlets, the lower the ODDS of being obese (SPENCE et al. 2009).

A study by the University of London analysed the neighbourhood of fast food environment and area deprivation. The research team used the Yellow Pages website to search for all McDonalds, Burger King, KFC and Pizza Hut restaurants in Scotland and England (n=2535). Population data was used to calculate density measures of McDonalds, Burger King, KFC and Pizza Hut restaurants per 1000 people. The research team found that there was a statistically increase in density of outlets from more affluent to more deprived areas (MACDONALD et al. 2006).

A study by Pearce and colleagues in New Zealand explored the association between neighborhood access to fast food outlets (retailers), diet and the weight of local residents. This study appraises whether neighborhood access to fast food outlets is in association with individual diet-related health outcomes. Results show that residences with travel distances to closest fast food outlets were more likely to eat the recommended intake of vegetables but were also more likely to be overweight. The access to locally operated fast food outlets has no association with the consumption of the intake of fruit and vegetables or being overweight. However, neighborhood access to fast food outlets has no influence for inequalities in diet-related health outcomes in New Zealand (PEARCE et al. 2008).

Summarized it can be said that internationally there are ongoing research projects in the area of body weight (mainly overweight and obesity) in relation to food outlets and accessibility issues. Studies mainly focus on large-scale datasets as detailed data for individuals are often not available or easily accessible. Therefore, this study will look at these issues at a local scale trying to receive significant results to support local policy interventions.

### 3 Datasets

The availability and quality of data is a main aspect for receiving significant results. Especially in the area of health, the data issue is a sensible topic and it is often difficult to gain access to data sources, as the privacy of people needs to be protected. One way is to receive data in an anonymous form where it is impossible to link data to identify a person’s identity. Other possibilities include certain types of visualisation methods, e.g. by aggregating data to certain geographical levels where it is impossible to identify a person but where results are still meaningful for further interventions. For this project, the following data is used:

- **Individual data:** Data of secondary modern school children including sex, height, weight, BMI, place of residence and post code was provided by the city of Villach, Department of Health in an anonymous form (table 2). A proofed confidential agreement between the city of Villach and the Carinthia University of Applied Sciences, Department of Geoinformation and Environmental Technologies was signed. Based on
the height and weight of a school child, the BMI was calculated and categorized into three classes: (1) underweight, (2) normal weight and (3) overweight. Data was provided for all third and fourth classes from 2011 (n=701) as well as from all third and fourth classes in 2010 (n=657). For mapping the location data, georeferencing is necessary which can be conducted using the open source web portal for the management of open worldwide geolocated postal addresses (OPENADRESSES 2011). This process is carried out by joining the table (individual data) with the data from openAddresses to spatially analyse and visualise them using geographical information software.

- **Location data**: The school locations, fast food outlets and other important localities for this study, such as bus stations, are accessed through the Herold Business dataset from 2010 provided by WiGeoGIS GmbH. The data accuracy according to the fast food outlets in the city centre of Villach was proofed with a 95% correctness through the conduction of a field survey in summer 2011.

- **Roads data**: Roads data from 2008 are available from Tele Atlas available by the Carinthia University of Applied Sciences. We assume to receive more reliable results when using a road network in comparison straight line distance. The road network was built with the network modeller from ArcGIS 10. In addition to this it is important to make a customized network which means to extract highways and motorways because children will not walk on such streets, so it’s not important for considering these streets in our analysis. More likely, children go by bike and therefore bicycle paths are added to the network to conduct analyses that match better with reality.

- **Questionnaire**: To support the results from the spatial statistical analysis a questionnaire was designed. The aim of this questionnaire is to receive background information relating to eating habits, activity level and questions regarding to the way to school/way home. It will be given to the secondary modern schools, third and fourth classes in Villach which are included in this study.

**Tab. 2:** Data example of secondary school children in anonymous form

<table>
<thead>
<tr>
<th>Gender</th>
<th>Height</th>
<th>Weight</th>
<th>BMI 2011</th>
<th>Height</th>
<th>Weight</th>
<th>BMI 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>175</td>
<td>75.5</td>
<td>25.23</td>
<td>167</td>
<td>68</td>
<td>24.38</td>
</tr>
<tr>
<td>W</td>
<td>161.5</td>
<td>58.8</td>
<td>22.54</td>
<td>156</td>
<td>53.3</td>
<td>21.9</td>
</tr>
<tr>
<td>M</td>
<td>175</td>
<td>71.7</td>
<td>23.41</td>
<td>166</td>
<td>70</td>
<td>25.4</td>
</tr>
<tr>
<td>M</td>
<td>152</td>
<td>39.9</td>
<td>17.27</td>
<td>148.5</td>
<td>37</td>
<td>16.78</td>
</tr>
</tbody>
</table>

As mentioned above, location data of food outlets were accessed from Herold Business data. The definition and categorization of fast food outlets often vary depending on the study area. Here, we have defined three main categories for food access based on the study area of Villach where pupils are tempted to buy less healthy food: fast food chain, grocery shop and snack bar (table 3).

**Tab. 3:** Categorization of fast food outlets for Villach

<table>
<thead>
<tr>
<th>Fast Food Chain</th>
<th>Grocery Shop</th>
<th>Snack Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>McDonald’s</td>
<td>Billa, Spar, Adeg, Merkur, Hofer</td>
<td>Sausage take away</td>
</tr>
<tr>
<td>Nordsee</td>
<td>Bakery</td>
<td>Döner, Kebab</td>
</tr>
<tr>
<td>Pizza chain take away</td>
<td>Petrol station</td>
<td>Cafe take away</td>
</tr>
<tr>
<td></td>
<td>Railway station buffet</td>
<td>Bistro</td>
</tr>
</tbody>
</table>
4 Methodology

For this project, spatial statistical analyses are used to explore whether the environment, focusing primarily on fast food outlets, has an influence on the body weight of secondary modern school children and to identify correlations between the body weight and other factors like access to fast food outlets. Therefore, the statistics software SPSS 17 and the GIS software ESRI ArcGIS 10 are used.

First, hot spot analyses are applied to explore areas with higher and lower densities of overweight and obese secondary modern school children. Also, the density of fast food outlets around secondary modern schools and homes can be identified. With such analysis it is possible to see whether areas with an increased amount of fast food outlets also consist of a higher number of overweight children.

Second, the ODDS ratio is used to compare two binary data values, meaning to calculate the strength of dependency between one and another variable. In the case of our project, the strength of the association between the BMI (higher than 25) and fast food outlets can be calculated. The ODDS ratio is written as follows (BLAND & ALTMAN 2000):

\[ \text{ODDS} = \frac{a \times d}{b \times c} \]

The result of the ODDS ratio calculation is a number 0 and \( \infty \) (BLAND & ALTMAN 2000).

- 1 means no difference between the ODDS
- >1 means that the ODDS of the first group is bigger
- <1 means that the ODDS of the first group is smaller

In other words, the ODDS ratio is a measure of how much greater the chance is to get overweight (in terms of a ratio) in the group of risk factor compared with the group with no risk factor. In our study the result of the ODDS calculation will show, if there is a risk of child’s BMI lying in the upper level of the BMI categories based on the presence of fast food outlets in his/her area. For proofing if the results are significant we will use the Pearson Chi-Squared test, which will be calculated with the crosstabs statistic function in SPSS. This will show if the ODDS calculation was significant or not and cause the results from the upcoming analysis (DEVORE & PECK 2005).

Third, the neighborhood analysis is applied to analyze the environment of school and homes according to fast food outlets, for example how many fast food outlets are located around a secondary modern school. For doing the buffer analysis is used. These buffers are placed around schools and homes in a distance of 500m and 100m, what we defined as walking distance for school children. Later on also activity possibility are considered in the study such as parks and playgrounds.

Fourth, accessibility analyses will be done between homes to schools using ArcGIS 10. For calculating the shortest path analysis, the road network will be implemented in the study to determine the distances from the way to school and vice versa. With this analysis we will find out how the surroundings according to fast food outlets on the way to school and vice versa look like, e.g. how many outlets (and therefore possible temptations) are on the way. If school children buy food from outlets on the way home/school will support questionnaire.
Fifth, the answers from the questionnaire will be analyzed to explore the eating habits, the activity level and the food and sports offer around home and school as well as the travel mode between home and school. The results of the questionnaire should underpin our assumptions and the results of the spatial statistical analysis.

5 Preliminary Results

This project is to date in its initial phase and preliminary results in relation to the variation of the BMI in different schools as well as the availability of fast food outlets near school is explored. The data analysis so far is based on all third and fourth class secondary modern school children (n=701) for 2011 which was available in a complete form. Data for first and second year classes will follow within the next months when the data collection in schools is finished and this data is available by the city of Villach, Department of Health.

Figure 1 shows the distribution of the BMI of school children for all four secondary modern schools in Villach, which are located in Auen (main focus on music and computer science), Völkendorf (main focus on computer science), Landskron (main focus on music) and Lind (main focus on sports). In figure 1, category 1 is defined as ‘underweight’, category 2 is defined as ‘normal weight’ and category 3 is defined as ‘overweight’ or ‘obese’. Although the initial focus of the study is overweight, we have found high proportions of underweight school children in all four schools. Therefore, we aim to find answers to explain reason for the underweight children in relation to eating habits and activity level after analysing the questionnaires. The highest rate (38.1%) of overweight third and fourth class school children was found in Völkendorf whereas the lowest rate (25.7%) was found in Lind. The average counts 31.9%. One impact could have the main focus of the schools as in Lind the main focus is sport meaning that more sport is offered during schooldays and these children are more likely to be active than children from other schools. In general it can be concluded that based on our data set for Villach, the rates of overweight/obese and underweight school children vary in comparison to the Austrian rates (see Table 1).
Next, buffer analyses were done using ArcGIS 10 to explore the number of fast food outlets (as defined in Table 3) within a certain distance. A 1 km buffer was defined as we assume that this is within walking distance of a child in the age group between 12 and 15 years. In total, there are 85 food outlets accessible of 1 km away from school. 306 school children live within one 1 km of the four buffers and therefore it is likely that these children walk home or go by bus. The other 399 children live further away. Further analyses showed that only 14.2% of the children living within these buffers are overweight or obese and therefore questionnaire should reveal if school children living within 1 km distance between school and home consume less fast food than school children living further away. For example do more school children buy food during waiting time for bus or train?

Also the ODDS ratio was calculated using the BMI (overweight/obese) and fast food outlets to explore if a higher BMI of a school child is associated with a fast food outlet within 500m (straight line distance) of place of residence (n=701). The result shows that the chance that a child’s BMI is lying in the upper level of the BMI categories based on the presence of fast food outlets within 500m in his/her area is 1.049 higher than in an area with no fast food outlets. However, this is not significant (p=0.873) after Pearson Chi-Squared test defining a p-value of 0.05.

First hot spots analysis showed that the amount of fast food outlets in the area of Villach are located in the inner city center, many of them close by the central railway station. Next, deprivation maps should show if there are also associations with a higher amount of fast food outlets and more deprived areas.

6 Future Work

One main question that will be explored through the MSc project is to find a relationship between body weight of secondary modern school children and fast food outlets as well as activity offers near schools and homes of residence. This is interesting as there are variations of research outputs that have found dependencies between higher an amount of fast food outlets and overweight, no dependencies or it was not possible to do a significant statement. So we want to see the results for our small-scale study to propose aimed suggestions for policy support.

Analysis based on a customized road network will done from each point of residence of a pupil to school within a certain distance to calculate fast food outlets and activity areas which will be set in relation to the body weight. The mode of travel will also be considered for home to school analysis. A challenge will be the definition and data collection for green spaces and activity offers respectively and to put this in relation to fast food outlets and weight.

A questionnaire was designed and is currently distributed to the school children of secondary modern schools to better understand their activity and eating habits as well as to find out relationships between body weight and buying food on the way from school to home. From this questionnaire we expect to find attitudes of school children that support our assumptions.

Further, all data will be prepared using statistical methods (see chapter 3) and appropriate significance tests will be applied to underpin findings. In the end, the findings are visual-
ized in form of figures and maps to make them understandable also for non-experts in the field of spatial analysis.

7 Discussion and Conclusion

As mentioned before in this paper this research is based on a small-scale study whereas most research published apply large-scale data sets often due to the fact of missing data as surveys are highly time consuming and expensive. However, there are good alternatives for estimating missing small area data including spatial microsimulation models (TOMINTZ et al. 2008). Here, the advantage is to work with real data although the numbers are not that high which could lead to insufficient significant results.

The main focus in this research is to explore the spatial influence of a school child’s environment at home and school and if this possibly has an effect on the body weight. However, there are many other (spatial) factors that influence the eating habits and activity level such as family, friends or income. Further, in this study we assume that school children walk to nearby fast food outlets around schools without considering the food offer within schools including chocolate and soft drinks vending machines. These assumptions will be underpinned by the ongoing.

Summarized it can be said that many policy interventions are done without considering the spatial environment around children’s homes and schools. Spatial statistical analysis in the area of fast food offer and overweight/obese children was not done in the proposed study area before and we have not found published literature that shows such a study in Austria at all. Reasons can include that the area of health and GIS is not so widely distributed in Austria yet and that the accessibility to health related data sets are often difficult or even impossible. Further, required data for certain health conditions are not available for smaller scales or insufficient to gain significant results. Nevertheless, the combination of the real data of children’s BMI in combination with the ongoing questionnaire will highlight a different view on this topic. This research shows a first approach including the spatial statistical analysis and mapping possibilities for supporting future local policy interventions against overweight and obese children.

Acknowledgements

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References


PEARCE, J., HISCOCK, R., BLAKELY, T. & WITTEN, K. (2008), A national study of the association between neighborhood access to fast-food outlets and the diet and weight of local residents. New Zealand. Health & Place, 193-197.
