

Location Analysis of Smoking Cessation Services in Austria

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Abstract

Lung cancer is still at the top of the list of commonly preventable diseases, for both men and women, and smoking is the major trigger that causes lung cancer. The Austrian Health Ministry implements different actions to decrease lung cancer in the future. For instance, it offers smoking cessation services; but are these services always located in the right places to efficiently reach the target groups? This paper highlights the advantages of location analysis methods to spatially estimate the need at local level (i.e. where are clusters of smokers distributed at a small spatial level), and correspondingly position (more accurately) the offer of such services. With the help of our solution framework called simSALUD, we estimate the smoking prevalence by using Spatial Microsimulation Modelling in this project. Then, location-allocation modelling can be applied to find the places with the highest demand for smoking cessation services. The results of our project might be highly relevant for future health policy planning to decrease smoking prevalence, and therefore lung cancer.

1 Introduction

According to recent OECD figures, 23.2 % of Austrians smoke daily, but a reduction of smoking prevalence has been recognized over the last decades (OECD 2012). However, a higher smoking prevalence amongst 15-year-old children (29% of girls and 25% of boys) is alarming, with Austria having the highest rates in Europe (OECD 2012). Furthermore, although the gap between men and women is closing, higher rates for women have meant an increase in lung cancer cases for women.

have meant an increase in lung cancer cases for women. The Austrian Cancer Program has six main goals, and one of these goals is to provide equal access to health services, independent of age, sex, ethnicity, and socio-economic background. In relation to smoking and lung cancer, one policy action is to promote smoking cessation services for low-threshold and specific target groups based on geographical province (BMG 2014).

Smoking prevalence data is only available at the province level (there are nine provinces in Austria), and the source of these data, the Austrian Health Survey, is conducted every ten years by Statistics Austria (KLIMONT et al. 2008). Smoking cessation services are often located mainly in the largest cities or highly-populated areas, as data on local prevalence is missing. This location strategy is likely to result in (spatial) inequalities in accessing the

service, especially for people living in rural areas (and in turn, for many people from lower socio-economic levels). A regionally based study of smoking distribution could highlight local areas of high and low smoking prevalence, and thus more effectively support planning actions. However, such surveys are too costly to undertake. Therefore, we propose to firstly utilize spatial microsimulation modelling in order to create a large-scale synthetic smoking population based on individuals or households by combining different datasets (see section 3.1), and then to use the results to determine our demand for the application of location analysis.

There are various stop-smoking support programs in Austria, i.e. 48 ambulant services, five stationary programs, 250 doctors and 280 psychologists that are qualified to provide stop smoking support, and three support groups. Additionally, there are online programs (www.endlich-aufatmen.at), mobile applications (www.rauchfreiapp.at; www.stopsmokingcoach.eu) and a phone support line (<http://rauchfrei.at>) (see section 2). With simSALUD (which is the name of our solution framework and of its software implementation) we aim to examine gaps in provision where people are most likely in need of stop-smoking support. The input data for simSALUD is the digital model of smoking prevalence for small areas and the stop-smoking facilities. The analytical algorithms in simSALUD are combined with the *location-allocation* method in order to assign the demand to services or to calculate the gaps based on the existing demand. A spatial mapping of the results can be done with the software ESRI ArcGIS 10. These results are also presented to policy makers for optimizing future planning. This is very valuable as such analysis methods are not yet widely applied in Austria.

2 Input Data and Data Processing

To perform a location-allocation analysis for smoking cessation services, we firstly need the data representing an estimation of smoking prevalence for small areas. These estimates are conducted using spatial microsimulation modelling that requires two main data sources; the Austrian Health Survey 2006/07, and the registered-based census 2011. Further, the geographical distribution of existing smoking cessation services is required to perform the location analysis. The current distribution of facility locations can be gained through mapping the existing service locations (based also on their different categories for better further interpretation). In addition, the location analysis requires a distance measure; for example straight-line distance, Manhattan distance, or a street network. The choice depends on the study purpose; here we use the street network to get more accurate models.

2.1 Austrian Health Survey 2006/07

The Austrian Health Surveys are conducted by the Statistics Austria every ten years, and the last published survey is for 2006/07 (KLIMONT et al. 2008). This national survey holds more than 15.000 persons aged 15 and above. Based on this sample, individual persons are allocated a numeric weight value to represent the entire Austrian population. Data is available for more than 600 variables, mainly including health related variables, but also demographic and socio-economic variables. The latter are important, as variables common to both data sets are required so that the spatial microsimulation modelling can be undertaken. The datasets can be accessed free of charge if for academic purposes. Within this study,

variables related to smoking behaviour are of interest; for example “do you smoke daily?”, “how many cigarettes do you smoke a day?”, “when did you start smoking?”, “did you ever attempt to quit smoking?”, “did a doctor inform you about smoking cessation services?”, and others. The variables of interest are checked and coded according to needs (for example age groups). Further spatial analyses, including Chi-square, Cramers-V, and logistic regression, are undertaken to examine the relationship between the dependent variable (smoker) and independent variables (demographic and socio-economic variables) in order to identify most influential drivers of being a smoker. This step is essential for the spatial microsimulation modelling process (see section 3.1).

2.2 Registered-based Census 2011

Demographic and socio-economic variables are accessible for small areas down to the municipality level (or raster cells), but are not free of charge. A Web portal allows the downloading of data at the municipality level for distinct data resources. The advantage of the Web portal is the different combinations of data variables that can be downloaded, for example “singles, male, 30 to 45”. The data can then be exported to different formats, i.e. comma separated values (csv), and further processed in order to fit the data structure that is required to run the spatial microsimulation model with the simSALUD application (see section 3.1). Data are also available for raster cells down to 250-metre resolution, but only predefined packages are available, and thus our analysis is based at municipality level. A disadvantage of using smaller areas is the existence of empty cells, as this data is not provided due to privacy issues for a certain threshold of persons with specific characteristics.

2.3 Smoking Cessation Services

There are different kinds of smoking cessation services offered in Austria. In this paper we are only interested in services that have to be physically reached by people in need of them. This excludes, for example, the quit-smoking help line. Information about the services of interest was collected from the various Websites, for example the Austrian health insurance company. In October 2014, 586 service points were collected from the Websites, and their addresses were geocoded, so that they can be mapped and used for further geographical analysis. Further information about the service on offer was collected as well, e.g. the opening hours. *Ambulant services* are defined as services where a person does not stay overnight in the hospital or institution, but goes home on the same day. The health insurance company pays the costs for smoking cessation at ambulant services, and sometimes a patient contribution is required. *Stationary smoking cessation services* are normally for heavy smokers or people who have illnesses due to smoking. Further, stationary smoking cessation is also for people who have tried to quit smoking several times. Here, people need to stay overnight and often such services are coupled with treatments. Here, the health insurance company and a patient’s contribution cover the costs. There are *doctors*, who have a special training to help smoking cessation that can include medical therapy (e.g. smoking cessation aids), acupuncture, or laser therapy. However, the health insurance company does not cover the costs of such smoking cessation treatments. Further, there are *psychologists* who have special training to support smokers and offer single or group therapy, sometimes also with hypnosis. When psychologists cooperate with the health insurance company, patients get their money back for the cost of the therapy. And last but not least, there are *self-help groups* for information exchange, and to facilitate the meeting of people with the same

problems and barriers. There are only three self-support groups in Austria. In total there are 586 access points that support smoking cessation.

2.4 GIP – Street Data

GIP (German: Graphenintegrationsplattform) (<http://www.gip.gv.at>) hosts the transportation network for Austria following a common standard. The data can be requested directly from GIP; for this research project, it was provided free of charge. The geographical data is offered as a shapefile, and contains information about the type of streets, length of segments, allowed driving time on a street segment, etc. However, the street data is not usable for routing, so it was necessary to build the street network using the software ArcGIS 10.2. For this network, the following types of data were used: highways, motorways, state roads, rural roads, and communication roads. This network does not include public transport. We used the network for further location analysis, i.e. for performing location-allocation analysis (see chapter 3.3).

3 Methods

To perform location analysis using *location-allocation modelling* the following data are required. First, the demand needs to be known. As the smoking population is only available at the province level, we need to estimate this for smaller spatial scales using spatial microsimulation modelling (section 3.1). Second, the supply needs to be known – in this case the smoking cessation services. In total there are more than 500 possible locations where smokers can get support, but for this analysis we will focus on ambulant services only (as they are more helpful due to repeated sessions over time) in order to examine the gaps (section 3.2). Third, location-allocation analysis is explained to help understand which settings are important for finding the best model (section 3.3).

3.1 Estimating Demand Using Spatial Microsimulation Modelling

Spatial microsimulation modelling can be used to build large-scale data sets based on individuals or households by merging different data sets. This is a novel approach for producing data that is usually not available or accessible; so called missing data. Here, spatial microsimulation is applied to estimate the smoking population and specific target groups for small areas. This provides us with a more detailed picture of high and low smoking prevalence. For the modelling process, our simSALUD (www.simsalud.org) solution framework is used, which is implemented as a wizard-based Web application with an embedded deterministic reweighting algorithm. Details on the embedded algorithm and the software components are described in KOSAR & TOMINTZ (2014). Two data sources are additionally used for the modelling process; first the Austrian Health Survey 2006/07, and second the registered-based census 2011. These two data sets will be merged based on variables (so called constraints) that are available in both data sets. Using these constraints to estimate the geodemographics of the local population, these data can be used to model the health outcome variable of smoking. The selection of the constraints is based on statistical pre-analysis including Chi-square test, Cramers V, and logistic regression. The model is sensitive to the number of constraints used and the number of categories for a constraint.

In the literature it is stated that around four to six constraints make a good model (EDWARDS & CLARKE 2013). More constraints can lead to multicollinearity. Often they are simply not available in both datasets, which is required for this approach. The constraints used in this model are age (15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65 above), sex (male, female), marital status (single, married, widowed, divorced) and highest completed education level (no A-level, A-level, University degree) (see Table 1).

Table 1: Results of the binary logistic regression to predict the smoking population

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Step 1 ^a			632,526	10	,000			
Age 15-19			64,064	1	,000	2,191	1,808	2,654
Age 20-24	,784	,098	53,858	1	,000	2,125	1,737	2,598
Age 25-29	,754	,103	36,623	1	,000	1,880	1,532	2,306
Age 30-34	,631	,104	33,250	1	,000	1,802	1,475	2,202
Age 35-39	,589	,102	51,500	1	,000	2,069	1,696	2,523
Age 40-44	,727	,101	25,334	1	,000	1,696	1,381	2,083
Age 45-49	,528	,105	7,464	1	,006	1,359	1,091	1,694
Age 50-54	,307	,112	,340	1	,560	1,068	,855	1,335
Age 55-59	,066	,114	1,677	1	,195	,854	,673	1,084
Age 60-64	-,157	,121	127,673	1	,000	,265	,210	,334
Age 65 above	-1,328	,118	89,818	1	,000	,675	,622	,732
Sex Female	-,393	,041	201,490	3	,000			
MS Single			45,597	1	,000	,674	,601	,755
MS Married	-,395	,059	2,406	1	,121	,825	,646	1,052
MS Widowed	-,193	,124	49,417	1	,000	1,873	1,572	2,231
MS Divorced	,627	,089	199,488	2	,000			
University			18,634	1	,000	1,650	1,314	2,070
A-Level	,501	,116	114,911	1	,000	3,073	2,503	3,774
No A-Level	1,123	,105	261,786	1	,000	,129		
Constant	-2,048	,127						

Occupational status and ethnicity were also added to the model, but with these constraints the model performed poorer than without these constraints. The spatial microsimulation model performance is validated using different statistical analysis, including the Total Absolute Error (TAE) and the R-square.

3.2 Mapping the Supply

The institution responsible for the Website “www.rauchfrei.at” provides smoking cessation support via a telephone hotline. The Website also provides information about several service locations that people can go to. This was the main source for collecting the location of the current smoking cessation services. As shown in figure 1, some places are very well served for facilities; this is mainly because of the support from of doctors and psychologists. However, there are large areas with none of these support options. For such areas, the telephone helpline would be an option, but the question arises concerning whether people are aware of such a service. In addition, people often prefer personal contact to telephone calls. Services are mainly located in highly populated areas, with doctors and psychologists only covering some parts of the country outside of the main cities. Where it does exist, such support only comprises brief consultations with smokers so that they know where they can receive help over a longer time period. The smoking prevalence shown in figure 1 is the estimated prevalence produced by the spatial microsimulation model.

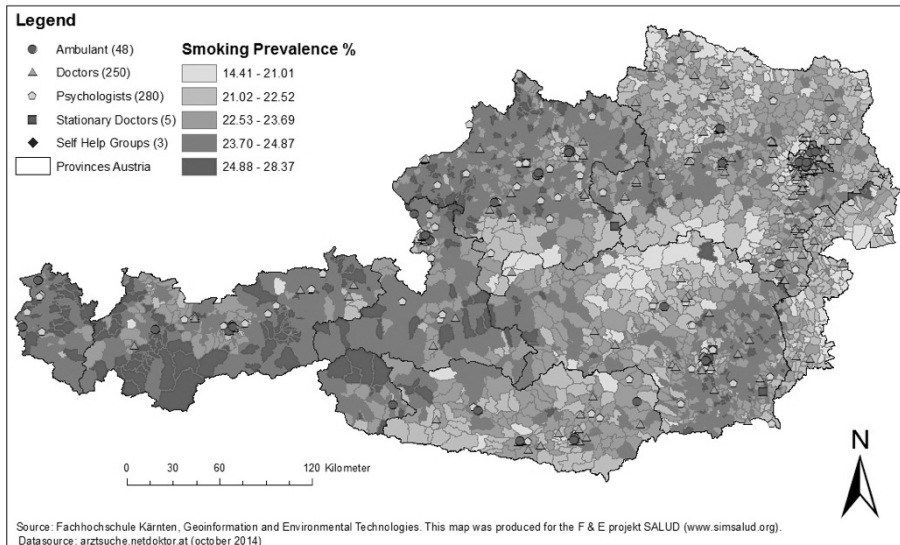


Fig. 1: Locations of smoking cessation support in Austria in relation to estimated demand (Data collection: October 2014)

3.3 Location-allocation Modelling

Location-allocation modelling has been used since the 1960s in various application fields, including retail, health, security, or transportation (TOMINTZ et al. 2015). It aims to locate facilities in an optimal way to best serve the demand under certain criteria, as different location problems require different solution approaches according to the purpose. ESRI's software packages allow location-allocation analysis. Prior to the availability of ArcInfo, the user had to use command line programming to solve location-allocation problems. Since version 10 of ArcGIS, location-allocation analysis has been embedded within the toolbox with a user-friendly interface. The only requirement is the additional licence for the Network Analyst. This interface allows non-experienced programmers to perform such analysis. ArcGIS 10 has embedded seven different problem types, those are:

- Minimize impedance
- Maximize coverage
- Maximize capacitated coverage
- Minimize facilities
- Maximize attendance
- Maximize market share
- Target market share

Depending on the purpose, one of seven problem types can be selected. For this project, the *minimize impedance* is used, as the aim is to minimize the travel distance for smokers to their next smoking cessation service. Minimize impedance is normally used when working with public sector facilities, including health services.

The location-allocation model requires at least two input datasets. The first dataset is the facility layer, where the user needs to specify how each facility is treated in the model: either it is a *candidate* facility (that is a facility that might be part of the solution); a *required* facility (that is a facility that must be part of the solution); a *competitor* facility (that removes demand from the problem and is used to solve problem types such as to maximize target share and target market share); and *chosen* facility (that means the facility is treated as part of the solution). The second dataset is the demand layer. In our case this is the data containing the simulated smoking population. Here it is necessary to transform the demand polygons (areas) into points, so that we have one centroid for each area (that holds the smoking population), as point data is required for the analysis. Location-allocation requires a lot of computing power and therefore various heuristics are implemented to guarantee feasible solutions, e.g. Teitz and Bart heuristics.

4 Results

In this section, we summarize the location analysis results for ambulant services. As mentioned above, there are 48 ambulant services provided in Austria. Burgenland, in the east of Austria, has no ambulant services, although the last Austrian Health Survey 2006/07 shows that Burgenland has the highest smoking prevalence with 27.5 % and Styria the lowest prevalence with 20.1 %. Here we present two scenarios. First, we analyse the distances from smokers to the current 48 ambulant smoking cessation services, and, second, we examine best locations for ten service locations in addition to ambulant services out of the 250 locations provided by doctors. For both analyses, the problem type *minimize impedance* is used, as the aim is to minimize the total travel distance for individuals. The results are calculated using the road network and the distance to services.

Figure 2 shows the results of the location-allocation model, where the focus is on ambulant services. Here, the input data are the estimated smokers at the municipality level (calculated at the centroids) and the 48 existing ambulant smoking cessation services. In the program, the 48 facilities are set as “required” facilities, so that the analysis needs to make sure these facilities are located first. This shows the travel distance to existing services and the coverage or catchment area of each facility. The lines in figure 2 show the centroid of municipalities containing smokers, connected or assigned to an ambulant smoking cessation facility. The graphic shows the line as straight lines, although the calculations are based on the street network. The straight lines provide a simpler visualisation. The closest municipality assigned to a service is only 110 metres away, and the furthest total travel distance is 121 km. People from Vienna have the shortest journeys to smoking cessation services, and smokers in areas around Salzburg travel the furthest distances.

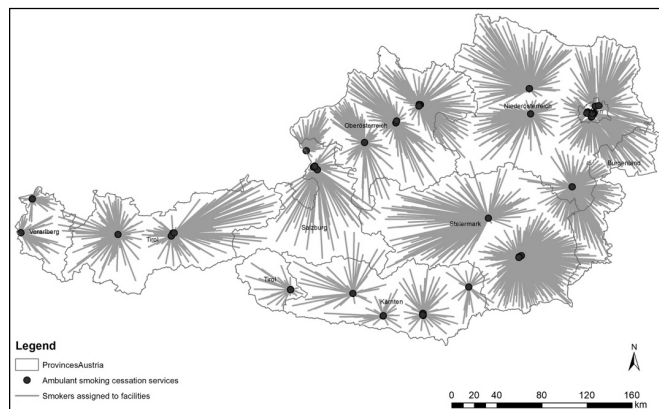


Fig. 2: Location-allocation model for existing 48 ambulant smoking cessation services

The second scenario is shown in figure 3 and models ten best new locations in addition to the 48 ambulant smoking cessation access points. The input data for the demand is again the smoking population at the municipality level. The input data for the facilities are first the 48 ambulant services that are set as “required” facilities, (meaning that the analysis needs to consider these 48 existing services) and second the 250 location points of doctor’s surgeries that provide smoking cessation support. The latter is set to “candidate” facilities, meaning that the computation chooses the 10 optimal ones out of the 250 potential sites given the 48 existing ambulant service points. The results are shown in figure 3 as spider visualisations; some with squares as the central symbol (which are the existing 48 ambulant services), and others without a central symbol. The 10 spiders without a central symbol represent the ten location points recommended by the location-allocation for areas most in need. These smoking cessation facilities could in future provide more intensive smoking cessation support in the form of repeated sessions with extra trained staff.

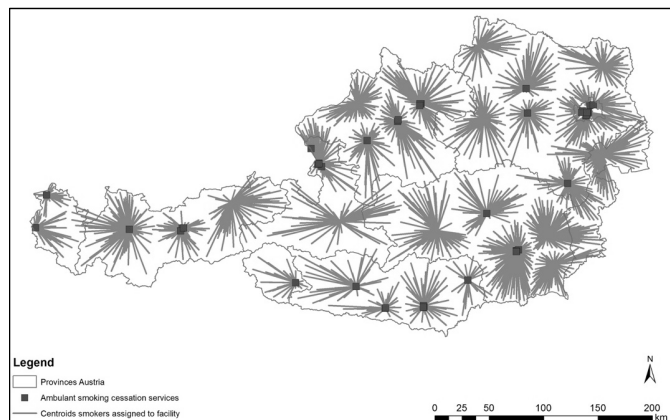


Fig. 3: Location-allocation analysis that suggests the ten best locations for further smoking cessation support (considering 48 ambulant services points)

These two scenarios show the advantages of location-allocation modelling for location analysis. It is a powerful tool with the flexibility for incorporating different settings, e.g. to add the capacity of facilities, or when the assigned demand to a facility has reached its

capacity, to assigned the remaining demand to another facility. Further distance and travel time thresholds can also be set. For a more sensitive analysis, appropriate input data is required.

5 Discussion

In this paper we combine two methodologies, namely, spatial microsimulation modelling and location-allocation modelling, to explore the service provision of smoking cessation services in Austria. This approach has already been applied in Leeds (UK), and made a valuable contribution to planners of smoking cessation services (TOMINTZ et al. 2009). For the spatial microsimulation model we are constrained by the variables available from the register-based census 2011. The regression analysis done in the course of the pre-analysis has shown that the available variables are good drivers for describing smoking behaviour, but that there are also other factors that are not explained by this model. However, the key drivers such as age, sex, marital status and education are included in the model, and with the validation analysis we can be confident of a successful model. However, more choice regarding the constraints and a more up to date health survey would improve the model results.

The location-allocation model provides a good overview of service provision available to smokers in different municipalities. Figure 2 shows that ambulant services are mainly offered in large cities only, leaving big gaps in service provision. The days and time when services are offered were not considered in the model. However, it was noted that their opening hours are not very favourable for people working during the day. In addition, there are no accessible data sets about persons who attend the services, with which to conduct further regional analysis, i.e. to explore from which areas services are attended most or least, and if people actually go to their nearest services or maybe attend a service close to their work-place. While writing this paper, our project group is trying to obtain more information about service attendance, illustrating importance of on-going data collection. It can be argued that these analyses are the first steps in the provision of additional smoking cessation support, including the first-time integration of the geographical aspect *distance* into the planning actions.

6 Conclusion and Outlook

Location-allocation is a useful analysis tool for service optimization and planning. Smoking is an addictive behaviour and therefore people need special support. It is known that the uptake of services decreases with distance, and therefore it is important to provide services, which are as close to home as possible. This is often challenging, as resources are limited. In this paper we have presented the approach of spatial microsimulation, which provides regional estimates of smokers for regional planning purposes. The focus is on the 48 ambulant smoking cessation services, as they offer repeated sessions for smokers. Further, the current locations of doctors offering smoking cessation support are considered. In total, two scenarios are presented to show the power of location-allocation modelling. In this paper, the focus lies on the distance from the centroids of municipalities to a service, without con-

sidering opening hours. Shortest and furthest distances from centroids (smokers) to their nearest smoking cessation facility were computed. A limitation is that no public transport is considered, so the assumption for this analysis is the shortest path on a street network.

Including public transportation in these analyses will be valuable for future research as it is known that people with lower social status have a higher smoking prevalence, often smoke more cigarettes, and are often more dependent on public transport. It is interesting to note the fact that in bigger cities, such as Vienna, people tend to use public transport more often than a private car. Also not included in this analysis is the option that people may go to their nearest smoking cessation facility from their workplace, which can be more convenient. Data on the attendance of services can enhance the results of using location planning to spot gaps and to see where services are in need; further, it can be analysed why certain services are more accessed than others (location, opening hours, day of service offer, etc.). These examples show the line of our future work within the context of location analyses, with the aim of contributing to better future health policy planning.

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