Regional Differences in alcohol mortality in Finland in the early 2000s

Jarno Vanhatalo*, Pia Mäkelä** and Aki Vehtari*

* The Department of biomedical engineering and computational science, Aalto University

** National Institute for Health and welfare In Finland

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Abstract

Alcohol related problems are currently regarded as one of the most serious public health problems in Finland. These problems are not equally distributed around Finland, but they are more common in some areas than others. Purpose of this study is to describe the regional differences in alcohol related deaths in the early 21st century.

The material consists of areally referenced census data, combined with alcohol-based deaths for the years 2001-2005. Statistical analysis is conducted with a Bayesian disease mapping model utilizing Gaussian processes. The results are analyzed and visualized with interactive Google Earth and Google Maps map software.

The research confirms that alcohol related problems are still unevenly distributed in Finland. When taking into account the regional background population and age, sex, and scholarly degree distribution, alcohol related deaths are relatively less common in the southwest coast of Ostrobothnia, and more common in Eastern and south-eastern Finland. Research also highlights the differences in population centers and surrounding areas. Risk of dying from alcohol-based diseases is generally higher in densely than in sparsely populated areas. In overall, the effect of population density on standardized mortality ratio of alcohol related deaths is slightly higher than of other regional differences, which may be caused, for example, by cultural differences or differences in access to alcohol.

Introduction

In high-income countries, alcohol consumption is the second most important determinant, immediately after smoking, of loss of healthy life years due to illness and death (World Health Organization 2009). Similarly, alcohol related deaths in Finland have an important role in the mortality of working-age population, and in the 2000s alcohol related deaths have become even more widespread (Korpi and Huohvanainen 2009). Alcohol related deaths and other problems are not equally distributed around Finland, but they are more common in some areas than others. Interventions to prevent alcohol related problems are increasingly the responsibility of the municipalities, for which reason knowledge of the spatial distribution of alcohol related problems is necessary.

The most commonly used measure to monitor alcohol related problems is the overall alcohol consumption per capita. This information is not useful for interregional comparisons since the estimates for total consumption are based on sales statistics, and the actual consumption by the permanent residents in the region may differ greatly from the amount of alcohol sold. A good example of this is Lapland, where alcohol sells considerably more than on average (Ruuth & al. 2008), but the sale is influenced by the consumption among tourists and passengers that come to Finland for alcohol shopping.

Interregional comparison in the alcohol problems needs information, which explains more precisely the situation among residents of the territory. Statistics concerning alcohol related problems, such as hospital treatments and deaths due to alcohol, fit better for this purpose. Municipality and province wide information on alcohol related hospital treatments is recorded on an annual basis (for example, Ruuth & al. 2008). However, describing the regional differences in alcohol problems faces a practical problem: in order to be useful, the division into regions should be as fine as possible but, when the annual counts of alcohol related deaths in Finland are distributed into small areas, the number of cases per area is so small that the influence of random effects grows large.

In Helsinki University of Technology, statistical models based on the Bayesian probability theory have been developed during a TERANA project (New Analysis Methods in Health Care Process Management), which was part of the TEKES FinnWell Programme during 2005-2009. These models offer a solution to the problem, which results from the need to use small areas in the description of the alcohol problems. With these models the effect of randomness is smoothed out of the results after which the actual phenomenon becomes more visible. The models provide a consistent way to smooth the results more in the areas with a small number of observations, where the random effects play a greater role. With these new models and computational methods the spatial accuracy of the analysis can be enhanced from the earlier municipal level to within the municipalities, in which case the spatial division is not tied to administrative boundaries.

In this study, the data are aggregated into a lattice, formed of 25 square kilometers grid cells. The other advantage of the TERANA project and this paper are the maps published in the internet (http://www.lce.hut.fi/research/mm/finnwell/alcoholFinland/), which allow users to interactively focus the map on areas they are interested in, for example, a given municipality.

In addition to the yearly compilations of statistics on alcohol related deaths their regional differences have previously been studied concerning the years 1991-1996 (Mäkelä et al. 2001). The level of alcohol consumption and alcohol-related deaths is, however, increased significantly from the level of early 1990s , so a new survey is justified. The main objective of this article is to describe the spatial differences in alcohol related mortality in Finland during 2001-2005. Secondly, we show how the level of alcohol related mortality has changed between the years 1991-1995 and 2001-2005, during which time the number of alcohol related deaths in relation to population increased nationwide 46 per cent.

Data and methods

Statistics Finland formed the research material by combining the 2001-2005 death registration data with the census data of the year 2000 using the identity numbers (Statistics Finland's license TK-53-531-05). Background population and the number of deaths were provided as counts pointed to cells. For this research, we further divided the information about the alcohol related mortality and lived person years in the follow-up period for the parameters defined by the categories: age (14 categories), sex, residence of the person (in a 5x5km lattice over the Finland) and scholarly degree (basic education or less, intermediate, higher education).

In this work, alcohol related death stands for all the death cases, in which the cause of death is alcohol related disease (including cirrhosis and alcoholism) or alcohol intoxication (the class number 41 in 54 stage classification by Statistics Finland). Although alcohol intoxication is an acute event, it is justified to combine it with (mainly chronic) alcohol diseases: almost all died of alcohol poisoning have been heavy alcohol consumers in their life time, and at an autopsy from large part of them findings indicating an abundant and long-term use of alcohol, such as fatty liver, are found (Poikolainen 1977). During 2001-2005, there were a total of 7863 alcohol related deaths in Finland which results in an annual average of 1573.

The prevalence of alcohol related deaths is examined in relation to regional variations in the demographic structure of each region. The indicator used is a standardized mortality ratio (SMR), obtained by relating the observed number of deaths to the expected number of deaths. The expected number of deaths is calculated using the age, sex and scholarly degree structure of the population (Ahmad et al. 2000).

The 5x5 km squares cells contain only a few alcohol related deaths. There are approximately 10 600 such cells inhabited in Finland, so each cell has on average less than one alcohol related death in it. Therefore, chance can have a profound impact on the SMR of an individual cell. Generally, it can be assumed that, without the random effect the SMR would be similar in nearby regions. This assumption can be taken into account by constructing a statistical model, where SMR is smoothed by taking into account the correlation between regions that are geographically close to each other. The plain regional correlation did not explain the variations well enough, so we assumed in our final model that, in addition to the spatial correlation, the regions correlate the more the more similar their population densities are. In this work, the statistical disease mapping model is based on the Bayesian probability theory that utilizes Gaussian processes (Vanhatalo et al., 2010). The model is described in more detail in Appendix 1. The used model and computational methods allowed a more accurate analysis than the previously used municipality level analyses.

Results

The smoothed SMR is shown in Figure 1. Value 1 means that such a cell contains, taking the demographic structure into account (the background population, the age, sex and scholarly degree distribution of the cell), as many alcohol related deaths as the national average. Larger values than 1 indicate that based on its demographic structure the cell contains more alcohol related deaths than on average. Similarly, values less than 1 indicate lower mortality than on average. The map contains the county borders and few cities to help locating the regions. The same map can be viewed in more detail in Google Maps or Google Earth applications at www-page http://www.lce.hut.fi/research/mm/finnwell/alcoholFinland/. These programs allow users to interactively focus the map on areas they are interested in, which is illustrated in Figure 2. In addition, those maps are in color, which allows for better separation between empty regions and low-risk areas.

The first observation from Figure 1 is that the cells with the highest mortality risk for alcohol related diseases are located in geographically small areas, which are typically high population density areas. We return to this later in the text. Examination of the entire Finland we can notice a clear distinction between both the whole Ostrobothnia (South, Central and Northern Ostrobothnia and Ostrobothnia) and Lapland and the rest of Finland. Ostrobothnia’s mortality is clearly lower than the national average. Eastern and south-eastern Finland, in turn, contain clear concentration areas where the alcohol related mortality rate is higher than the national average. All the cities adjacent to the Southern Finland's border stations (Hamina, Kotka, Lappeenranta, Imatra) have a fairly high SMR related to alcohol. When considering, if this is a consequence of imported alcohol from Russia, one should take into account that firstly the alcohol related mortality is also higher than the average in the other cities in south-eastern Finland further away from the border, and secondly SMR is not similarly increased in the cities adjacent to the northern border stations (Kitee, Ilomantsi, Joensuu). Helsinki stands out clearly from the other major cities as a high SMR area. The alcohol related mortality is clearly higher than the average also nearby Lappeenranta and Imatra, in the region following river Kymi from Nastola to Kouvola and Hamina, and in the triangle formed by Loimaa, Salo and Forssa. In addition to these areas, the alcohol related mortality has elevated, for example, around Iisalmi, Pieksämäki, Varkaus and Leppävirta, in Jyväskylä and in the area south from it, as well as in Pori and in the area south-east from it.

Figure 1 distinguishes best the nationwide variations. Local variations stand out more clearly in the Google Earth and Google Maps applications, by focusing on a specific part of the map. For example, in Ostrobothnia, which seems to be completely low risk area in Figure 1 because of the low contrast in it, SMR is higher than on average in the area, among others, in Kokkola, Kauhava and Raahe.

From the local differences, one can generalize that SMR related to alcohol is usually elevated in population centers and in the central areas of large cities. In many cases, the mortality ratio at the center of the largest city is up to twice the level in the surrounding areas. Tampere is a good example of this, because there SMR is clearly larger than one in the center areas and well below one outside the center. Figure 3 illustrates how population density affects the alcohol related SMR. Alcohol-related mortality clearly increases as the population density increases. When population density rises from 25 to 250 people per square kilometer (averaged in 25 square kilometers cell), which corresponds to the transition from rural areas to a small city, mortality ratio rises about 50%. Notice, in comparison, that the population density of the cells in the center of Helsinki is about 3000, in the center of Tampere 1600, in Kouvola and Nastola about 300, in Kauhava and Lapua about 150, and in the center of small and rural towns such as Siikainen and Kihniö less than 40 inhabitants per square kilometer.

The strong influence of population density on the level of mortality raises the question of the extent to which Figure 1 reflects the regional differences in population density. To answer this question the part of SMR explained by the population density is separated from the whole SMR and the remaining part, arising from other factors, is drawn in Figure 4. Figure 1 describes, therefore, the actual state of SMR, while Figure 4 is a tool for analyzing where the other reasons than population density originate from. When the effect of differences in population density is removed, the other components of variation between different parts of the country should be more visible, and these regional differences can be thought of as a reflection of regions alcohol culture related to other aspects than urbanization. Figure 4 shows that, the difference between east and west is even more accentuated in comparison with Figure 1. According to our model, the population density explains approximately one half of the whole spatial variation.

Our second objective was to examine whether the spatial variation in the alcohol related SMR has changed over the years between 1991-1995 and 2001-2005, during which time the alcohol related mortality increased nationally 46 per cent. Figure 5 presents the ratio of SMRs between the years 2001-2005 and 1991-1995. For example, the value of 2.0 may have occurred in such a way that SMR has been in the early 1990s, 0.4 (that is SMR of the area was 40 percent of the national average), and in early 2000s 0.8, or so that the SMR has increased from 1.5 (which is 50 per cent more than expected) to 3.0. Similarly, the value of 0.5 may occur when SMR drops from 0.8 to 0,4 or from 3,0 to 1,5. In other words, in Figure 5, the values greater than one indicate a change in a worse and less than one change for the better in relation to the national average. Regional differences have somewhat leveled off in ten years, since the trend of change in SMR has been downward in eastern Finland and upward in western Finland, South-east Finland (Kainuu), South Lapland, and in the north from Salo.

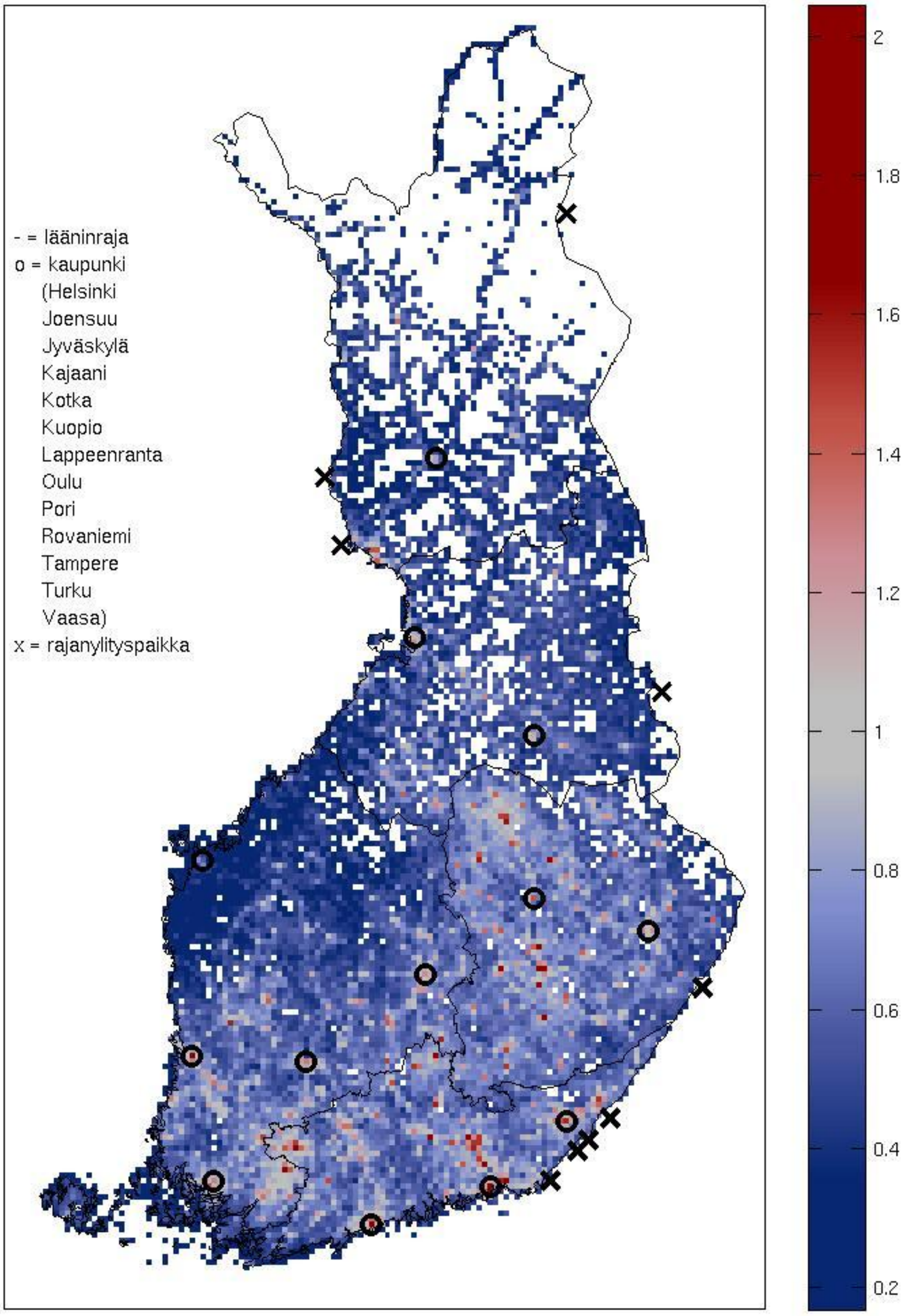

Figure 1. The posterior mean of standardized mortality ratio. Larger values than 1 indicate that based on its demographic structure the cell contains more alcohol related deaths than on average. Similarly values less than 1 indicate lower mortality than on average. (Borderlines _c Affecto Finland Oy, Karttakeskus, License L8573/10).

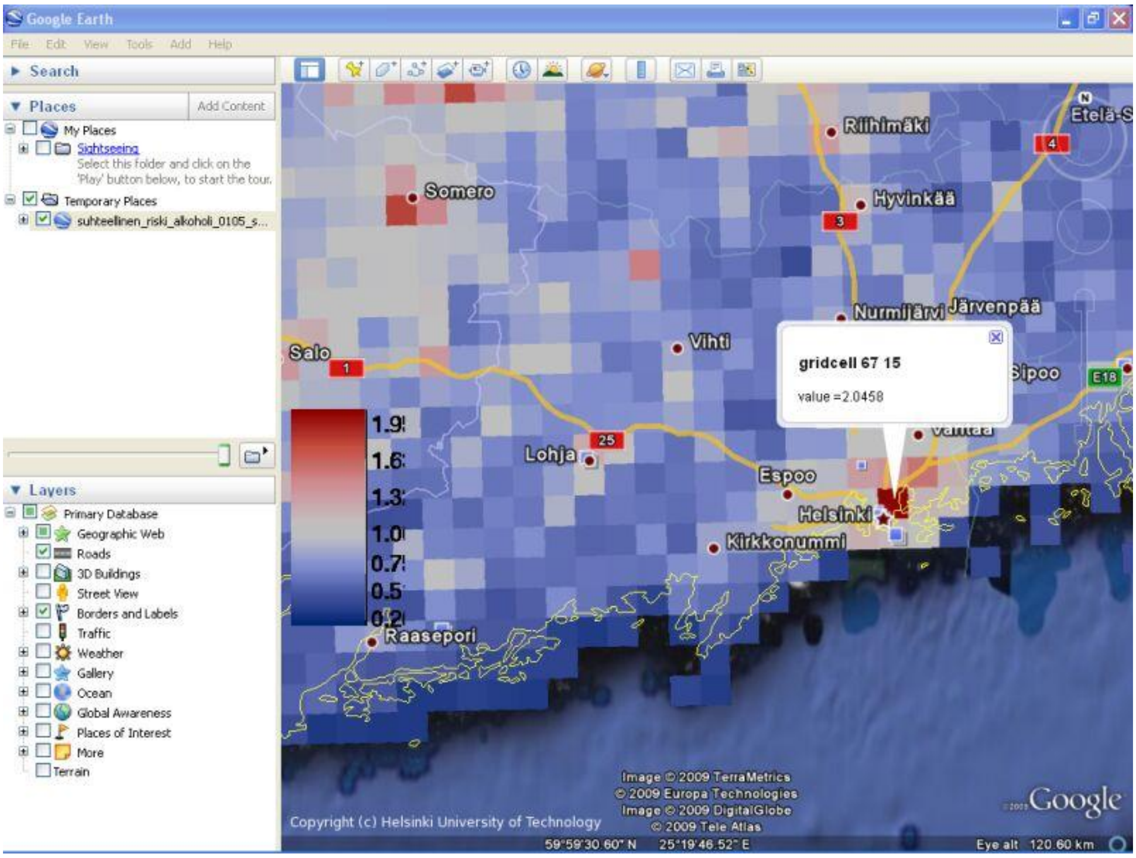

Figure 2. An example of studying the results with Google Earth program. In the figure the map is zoomed to Helsinki and area west from it. On the left are the tools of Google Earth, with which the user can choose the objects shown on the map. Here are visible roads, cities and borders. On the left there is a slide bar, with which the transparency of the SMR information can be increased to make the other information more visible. The exact SMR of each cell can be seen by clicking with mouse. This is illustrated with a cell at the center of Helsinki (gridcell 67 15, value = 2.0458).

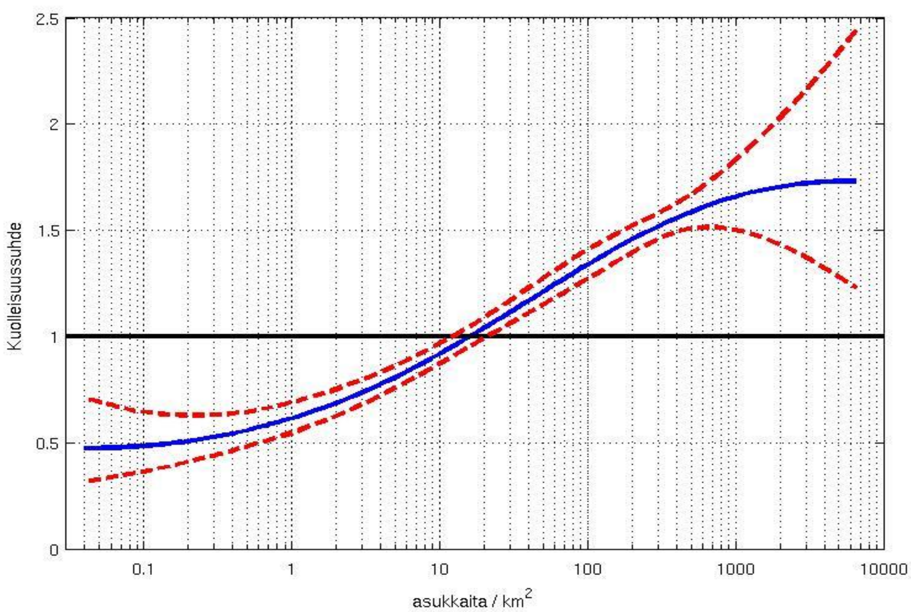

Figure 3. The standardized mortality ratio as a function of population density.

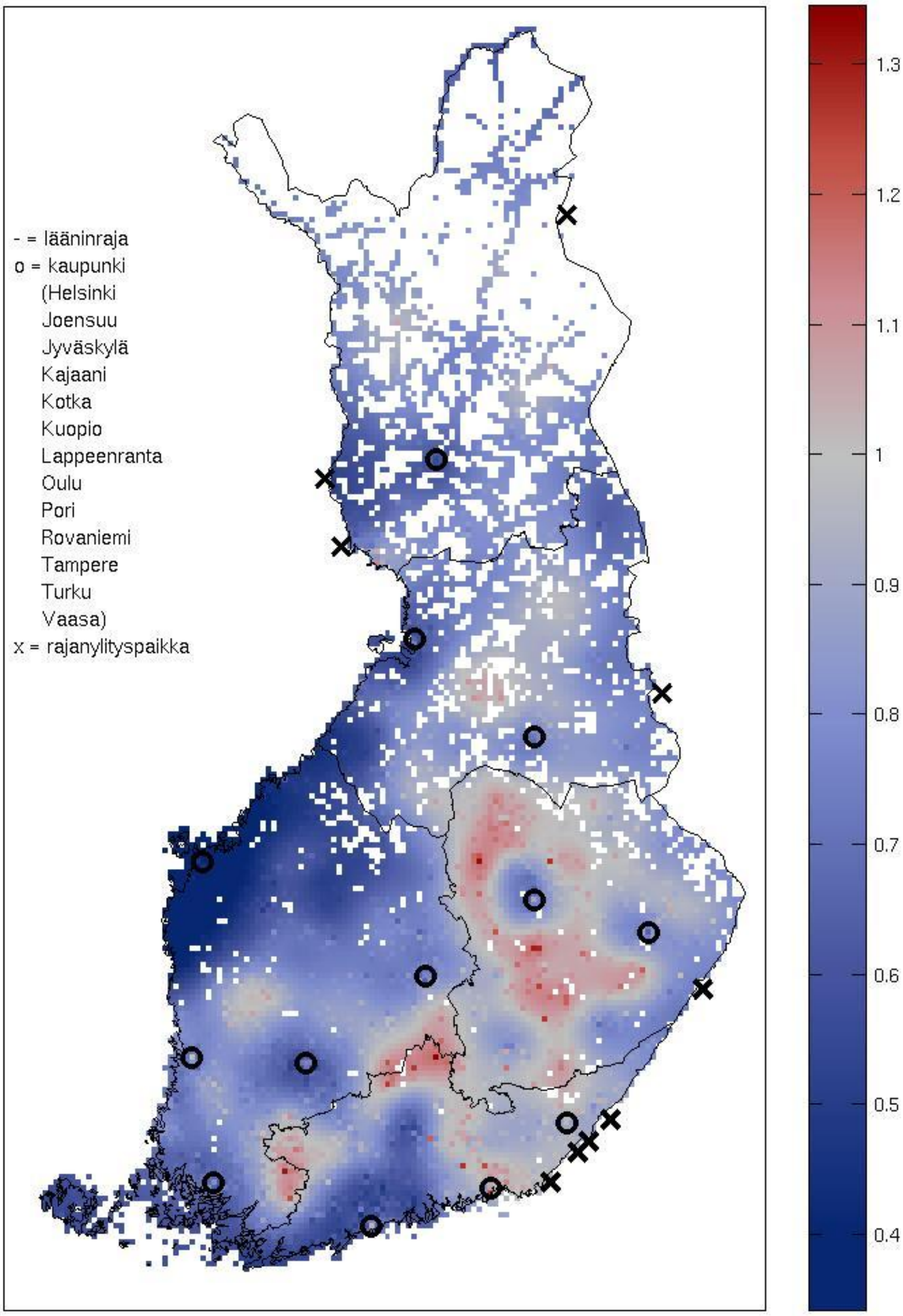

Figure 4. The standardized mortality ratio after removing the component depending on population density.

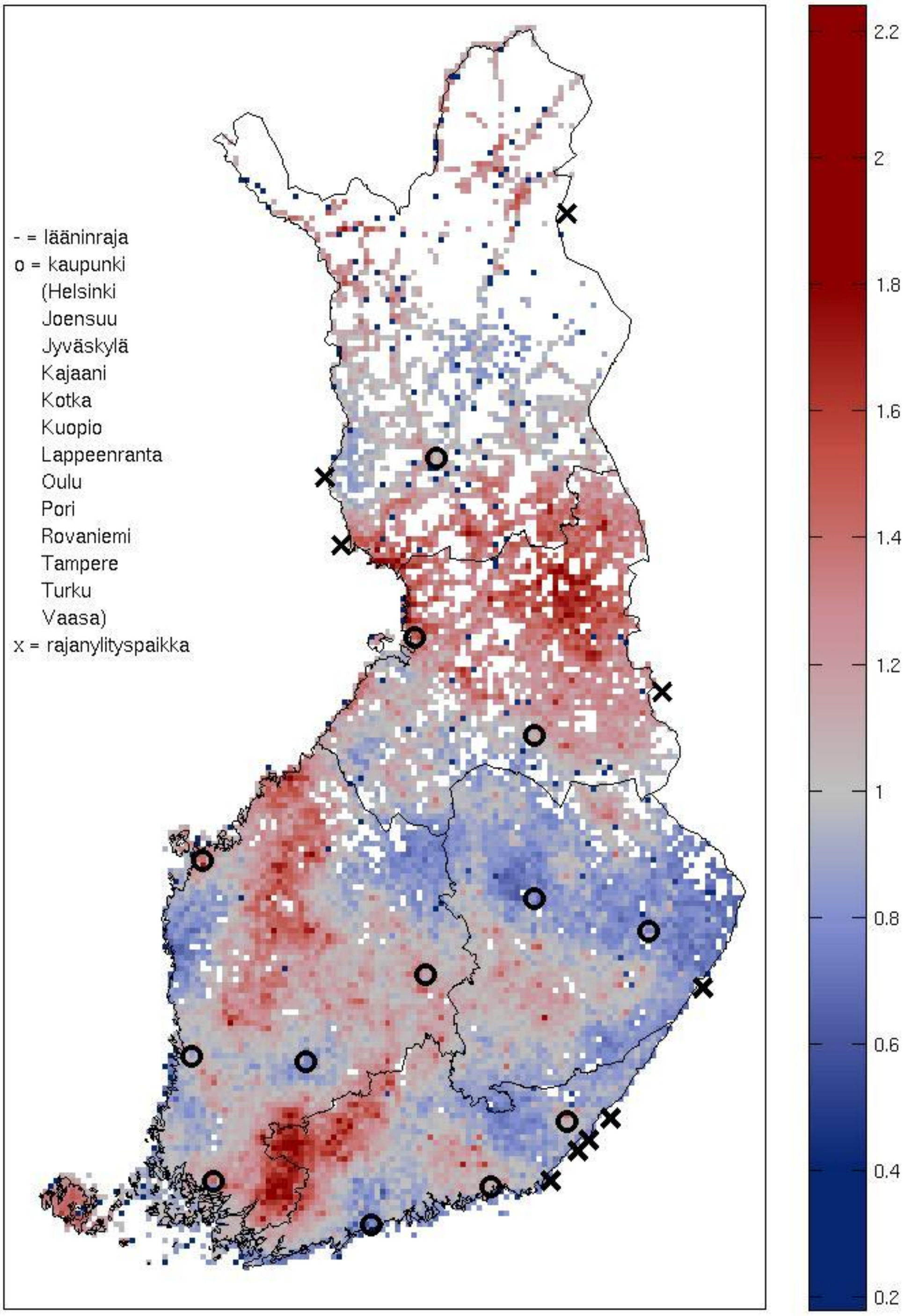

Figure 5. The ration of SMR in 2001-2005 to SMR in 1991-1995. Values greater than 1 tell that the alcohol related deaths have become more common, with respect to the national average, in that area after 1991-1995. Similarly values less than one tell that the alcohol related deaths have become less common. Borderlines _c Affecto Finland Oy, Karttakeskus, License L8573/10).

Discussion

The results suggest that one of the key regional differences in alcohol related SMR in the early 2000s is the distinction between Ostrobothnia and Lapland, where SMR is lower than average, and the rest of Finland. The SMR is high especially in eastern and south-eastern Finland. Similar regional differences have also been observed in life expectancy, so the regional differences are more prevailing than just alcohol related SMR indicates: the life expectancy and morbidity are lower in eastern Finland (but also in Lapland) compared with western Finland (Martel et al. 2005).

Our results on alcohol related SMR are very similar to the results on men's alcohol deaths in 1991-1996, which were analyzed on the municipality level (Mäkelä et al. 2001). Similarly, the regional statistics indicate that Ostrobothnia has a particularly low and Kymenlaakso a particularly high level of mortality due to alcohol (Ruuth & al. 2008). The most striking difference between regional statistics and this study is that regional statistics report Lapland's alcohol related mortality to be significantly higher than the national average. This difference is due to the coarser structure of the regional statistics. In the statistics the results of the whole of Lapland are strongly influenced by the large centers such as Rovaniemi, Kemi, Tornio, Kemijärvi, Sodankylä and Kittilä, where the majority of the people in Lapland live, and where the alcohol related mortality is high based on our study as well. According to our results, there is no evidence of high alcohol related mortality elsewhere in Lapland. Most of the cells in Lapland are either uninhabited or such that only a few people live in them. More than 90 per cent of the cells in Lapland do not contain any alcohol-related deaths and most of the cells that have deaths appointed to them are located in the above-mentioned population centers.

The high SMR of the cities in the vicinity of South-East Finland's border stations raises the question of what role does the imported cheap alcohol from Russia have to regions alcohol deaths. SMR ratio is high in the vicinity of the four most southern (south of Imatra), but not the three more northern (north of Joensuu) border stations. This corresponds quite well the information about where the number of border crossings, and presumably also the import of alcohol are the greatest. According to Border Guard's statistics, for example, in 2003 of the some six million eastern border crossings 40% happened in Vaalimaa, which is the southernmost border station, and three of four crossings happened in the four southernmost border stations. Also, the number of seizures of alcohol is roughly in proportion to the traffic of the border stations (Olli Aalto / Eastern Customs District, oral communication). Based on these data it is estimated that cross-border low-priced imported alcohol, at least weigh in on the South-East Finland's high alcohol related mortality.

Ostrobothnia's low alcohol-related mortality is not specific news. District's alcohol sale was per capita, for example, in 2002 only 65-87 per cent of the general level throughout Finland. One of the main explanations for this is seen the stricter moral climate in the area, and in particular, the strong religious traditions there. One of the reasons may also be that the ratio of Swedish speaking people in the region is high. Some studies show that binge drinking among Finland's Swedish-speaking people is less common than among Finnish speaking (Paljärvi 2003), for which one explanation is probably the already mentioned differences in religious background, but partly it may also be a consequence of other cultural differences

Of all the regional variation in alcohol related SMR the population density explained the higher portion than other regional differences. Alcohol related deaths and, presumably, more generally, the alcohol problems are typical especially for densely populated urban centers and urban areas. There are several explanations for this. On the one hand, the urban culture is closely connected to lifestyle, where much time is spent outside the home in places that have also alcohol serving, such as restaurants, bars, nightclubs, or cultural or sports forums. High demand will also stimulate a varied and plentiful supply, from which several different kinds of customer groups can choose their place better than in small towns, which in turn increases consumption. Municipal planning should support those outside home activities where alcohol serving is not integral part of. The current trend in urban centers has recently been that nearly all leisure events, cafés, and others apply for the right to dispense alcohol.

The greater SMR in larger population centers is not necessarily only a consequence of the characteristics of cities, such as the better availability of alcohol. Selective migration can also increase their alcohol problems, in two ways. First of all, those who decide to stay in rural areas may be less likely to use alcohol than those who want to move to cities. Secondly, people suffering from alcohol problems in rural areas may end up changing to more anonymous and liberal urban environment.

One of our research questions was how the regional differences have changed from the early 1990s, to the early 2000s. Above we mentioned that, compared with Mäkelä et al's (2001) research on the beginning of the 1990s, the regional differences were largely similar. We investigated the change between the time periods 1991-1995 and 2001-2005 also directly, based on our own material, using the same definitions, models and bounds. Also according to this comparison the regional differences have remained similar: in eastern and south-eastern Finland, the standardized mortality ratio was high, and in Ostrobothnia, it was also in 1991-1995 low. Regional differences have, however, somewhat evened out. Throughout the country, alcohol related mortality has increased. The trend has been less bad in comparison with the average in eastern Finland, where the alcohol related mortality relative to the nationwide mortality has decreased. Despite this, alcohol related mortality is still high there, but in the early 1990s eastern Finland's difference from the rest of the country was greater. The change in the alcohol related SMR has, on the other hand, been worse than average in Ostrobothnia, Kainuu, South Lapland as well as in Salo and north from it. Unfortunately, we were not able to study the changes after 2004 since our material ended on 2005.

Municipalities have developed their own drug strategies since the 1990s and they are recorded by the National Institute for Health and Welfare. According to this material, in eastern Finland, Lapland and Ostrobothnia where the direction of the change of SMR has been declining or consistently on a low level, work on drug strategies has been more active than in other regions, such as western Finland or Kymnelaakso (Leena Warsell, National Institute for Health and Welfare, oral communication). In Eastern Finland and Lapland the vast majority of municipalities (33 and 8 municipalities) had drug strategy approved in political bodies at the turn of the 21st century. Ostrobothnia has also been active in the drug strategy work already before the current Ostrobothnia project. The interest in local and regional drug strategies may emerge for various reasons. In some places, the interest may emerge from a concern about a high number of alcohol related deaths (eastern Finland), while elsewhere for the cultural reasons, which keep the alcohol issues on view although alcohol related mortality was low (Ostrobothnia). The drug strategy work on these regions may, however, be an indicator of region's more general interest to invest in reducing alcohol problems and in their treatment, and therefore it does not reflect only the direct impact of the strategy.

More relevant reasons, than the lack of drug strategy, for the unfavorable trend in Kainuu may be firstly structural factors, such as the impact of unemployment, and, secondly, the impact of the large administrative changes: when region's officials were asked, how drug abuse prevention was developed in the restructured governance model, the response was very negative (Warsell and Tenkanen 2009). A new governance model had breached the old structures that had supported the work, but had not yet been able to offer anything similar to compensation. There were also significant ambiguities in the arrangements of drug abuse work and its liability relations.

About the methods

The models and methods used in this work are not limited to studies on alcohol related deaths but they can be applied to any disease mapping problem easily. During the TERANA-project also, for example, cardiovascular diseases and certain cancers have tentatively been studied. Used models can be generalized straightforwardly to take into account the temporal component as well. This makes it possible to analyze the temporal changes in more detail than in this work.

Acknowledgements

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Appendix 1, The method

The Bayesian probability theory provides a consistent way to combine the prior assumptions made of the phenomenon with the information from observations. In Bayesian modeling, probabilities are used to describe the uncertainty. The observation model describes the uncertainty associated with observations, the noise. The modeler's assumptions about the phenomenon before the observations are encoded in the observation model and its parameters and the uncertainty associated with these prior assumptions are described by the so-called prior distributions. The Prior distribution is updated to posterior distribution using Bayes' formula, which combines the information from data and the pre-assumptions into new information.

In our observation model, the number of deaths in each cell is thought to be Negative-Binomial distributed with mean given as expected number of deaths multiplied by the SMR

$$y \sim NB(y \mid e \cdot \mu, r),$$

where e is the expected number of deaths, μ the standardized mortality ratio and r the dispersion parameter. Negative-Binomial distribution is a more robust observation model than traditionally used Poisson distribution since it allows for larger variance than Poisson distribution with the small values of dispersion parameter, and for this reason it fits well the used areally sparse data. We made a prior assumption that cell's SMR correlates with other cells' SMR the more the closer they are spatially with each others. The spatial correlation could not alone describe well enough the variations, for which reason, in the final model, we assumed that in addition to spatial correlation, regions' SMRs correlate the more the more similar their population density is. Both of the correlation components were modeled with a generalization of Gaussian distribution, a Gaussian process, that gave the prior for the log of SMR (Vanhatalo & al, 2010)

$$\log(\mu) \sim GP(0, K_a(x_i, x_j) + K_v(x_i, x_j)).$$

Here $K_a(x_i, x_j)$ is the covariance function that describes the spatial correlation between cells x_i and x_j, and $K_v(x_i, x_j)$ the covariance function describing the correlation due to population density.

Like the Gaussian probability distribution, also Gaussian process is defined by its mean and variance (covariance). The main benefit of the Gaussian process is that by using different covariance function it can be used to define very diverse regional correlation structures. We investigated a wide range of covariance functions during the modeling stage and chose the most suitable for the data. The various models were compared using ten-fold cross validation for the predictive utility (Gelfand & al. 1992), (Vehtari and Lampinen 2002).

The significance of the results was examined with posterior probability maps proposed by Richardsonin et. al. (Richardson & al. 2004). These maps depict areas where SMR is above one or below one with certain probability. Since the results from Bayesian disease mapping models are, in general, conservative and distinguish phenomena with great accuracy even from very sparse data, Richardson et al. recommend 70-80% probability for significance level. The posterior probability maps replicate the clearest results in Figure 1 and, thus, confirm their significance.

A variety of disease mapping models have been studied for a long time, and their common characteristic is that the spatial correlations are modeled with prior distributions. The biggest differences between the different models relate to the choice of the prior distribution. The biggest difference between the now used Gaussian process and a more traditional CAR model (conditionally autoregressive –model, (Best & al., 2005) is that the correlation structure can be modeled in a versatile way with different covariance functions. The problem with Gaussian processes is their computational cost which has, up to date, prevented their use for large data sets. With the present methods, this problem has been alleviated, which has enabled the analysis of more detailed data than former ones. Instead of the earlier municipality level analysis, we are now able to analyze even areas within the municipalities with 5 kilometer accuracy.

Vanhatalo et al. (2010) give an extensive description of the model and compare it with a CAR model. We tested CAR model in this work also and found out Gaussian process to work better. We left out the detailed comparison from this work since our intention was to describe the findings and not to concentrate on the model as such.

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