SPATIAL ANALYSIS OF ALCOHOL-RELATED MORTALITY IN SLOVAKIA

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SUMMARY

Objective: The aim of our study was to investigate the relationship between alcohol-related mortality in Slovak regions, as represented by Nomenclature of Territorial Units for Statistics (NUTS) III level.

Methods: We used data from mortality reports spanning 1996–2017 in the Slovak Republic. Data was provided by the National Health Information Centre in Slovakia. We applied two-dimensional correspondence analysis where the dimensions are regions and selected alcohol-related deaths diagnoses are classified by the International Classification of Diseases.

Results: Analysis revealed a relationship between the Prešov region and diagnoses I42 – Cardiomyopathy and K29 – Alcoholic gastritis. Furthermore, the Banská Bystrica and Žilina regions correspond to G31 – Degeneration of nervous system due to alcohol and K86 – Alcohol-induced chronic pancreatitis. In the case of K70 – Alcoholic liver disease – the Banská Bystrica, Trenčín and Nitra regions are identified as regions which have an intermediate relationship with this diagnosis. The Trnava region corresponds to F10 – Acute alcohol intoxication. The Trenčín and Nitra regions correspond closely to G62 – Alcoholic polyneuropathy. Perfect correspondence can be seen between the Košice region and K73 – Chronic hepatitis, not elsewhere classified. K74 – Fibrosis and cirrhosis of liver diagnosis also corresponds with the Košice region.

Conclusions: The results of this analysis provide valuable insights for national and regional health policymakers in the process of preparing high-quality health regional plans, as well as retrospectively assessing the success of existing health policies and interventions in this area. Facts presented in the study justify the need for specialised health care, which is part of the process of building an Integrated Health Care Centre in Slovakia.

INTRODUCTION

The issue of eliminating health inequalities in the regions is one of the key challenges for health policies in EU states. Many socio-economic and socio-demographic factors affect health inequalities, manifesting themselves in varying degrees of morbidity and mortality (1). Their impacts on the economic and social spheres of a given country are very significant. The health of the population is also determined by health behaviour in which risk factors play a decisive role. Important risk factors include the use of alcohol and other addictive substances, an issue which is addressed by many international and national research teams. Alcohol is the third most common health risk factor in the world and is the most common risk factor in low-income countries (2). It is the main cause of more than 200 diseases and injuries, premature disability, and mortality with less than 10% of alcohol-dependent patients being treated (3). The net effect of alcohol consumption on health is detrimental, with an estimated 3.8% of all global deaths and 4.6% of global disability-adjusted life-years attributable to alcohol (4). Recent significant findings declaring the effects of alcohol and drug use on the population of 195 countries and territories in 21 regions, and within seven super-regions, are reflected by the Global Burden of Disease study (GBD) (5). This study examines the association between disease burden and Socio-Demographic Index (SDI) quintiles. Globally, in 2016 a total of 99.2 million Disability-Adjusted Life Years (DALYs) (95% UI 88.3–111.2) and 4.2% of all DALYs (3.7–4.6) were attributable to alcohol use, and 31.8 million DALYs (27.4–36.6) and 1.3% of all DALYs (1.2–1.5) were attributable to drug use as a risk factor. The burden of disease attributable to alcohol and drug use varied substantially across geographical locations, and much of this burden was due to the effect of substance use on other health outcomes (5). The World Health Organisation (WHO) also examines the health, social, psychological and spiritual dimensions of the effects of alcohol use on individuals. Many methodologies are used for economic quantification (decision models, retrospective and prospective studies, averting behaviour method, utility valuation method, willingness-to-pay approach, consumer market method, contingent valuation method, cost-of-illness method etc.). The economic dimensions of the effects of alcohol use are presented in many international and national research studies. The costs associated with alcohol amount to over 1% of the gross national product in high-income and middle-income countries, with the costs of social harm constituting a major proportion besides health costs (4). In this context we mention an important study by Zábranský et al. (6) and the most recent iHETA study (7) on the social cost

of alcohol consumption. Nociar (8–10), Madarasová Gecková and Dankulicová (11), Gavurová et al. (12) and others have published relevant studies in a Slovak context. Their priority was to focus on the use of addictive substances in the younger population, especially pupils and students in higher education. Significant knowledge of the state of the drugs problem is also provided by institutional outputs, e.g. the National Drug Monitoring Centre (13). Few studies have researched regional mortality associations in groups of diagnoses associated with alcohol consumption. These are important not only for the creation of specific prevention programmes but also for the development of regional health policies and for assessing the availability of specialised health care.

Many foreign research studies have examined regional disparities related to alcohol and other drug mortality as well as various socioeconomic factors. The results of these studies are oriented towards making recommendations for policymakers in the health and social systems of the countries involved and open the way for the subsequent examination of new determinants of regional disparities in health. The interconnection of macroeconomic health and socioeconomic indicators with mortality is evident in many studies. For example, Monnat (14) in his study explored and modelled associations between drug-related mortality rates at the district level and the economic, social and health environments using a 2006–2015 US database. The average age-standardised drug-related mortality rate at the district level was 16.6 deaths per 100,000 inhabitants. Significant geographical differences prevailed in the mortality rate. Higher mortality has been reported in districts with greater economic and family problems. Average mortality rates were significantly lower in districts with a higher number of religious institutions, with a higher percentage of migrants and in districts with economies linked to employment in the public sector. Significant demographic differences in mortality have been reported in relation to drug use. Subsequent research plans to focus on exploring the relationship between drug-related mortality and the economic, health and social environment of individuals. Rosicova et al. (15) found that unemployment rates and low education levels are important determinants of regional alcohol-related mortality in Slovakia. Barrios et al. (16) explored the geographical and gender differences in oesophageal cancer mortality related to alcohol consumption and tobacco smoking. Oesophageal cancer incidence data were obtained from 48 cancer registries in 13 countries over a 10-year period. Males had a higher incidence and mortality than females, with the highest rates of oesophageal cancer mortality rates in Brazil, Uruguay, Argentina and Chile in 2003. Geographical differences in oesophageal cancer mortality in Central and South America reflect differences in alcohol use and tobacco smoking. This calls for the implementation of policies to control the use of alcohol and tobacco. Ethnic, gender, regional and age disparities have also been the focus of research by Saint Onge and Krueger (17). Representative US national data was used to target the adult age range of 18 years and older for the period 2004–2009 from the National Health Interview Survey (NHIS). The authors identified 7 distinct groups of health behaviour by examining lifestyle risk factors: alcoholism, smoking, physical inactivity, visits to doctors, vaccination, etc. The authors found significant ethnic, gender, regional and age differences in defined groups of health behaviour which also reflect the lifestyle of the population studied. The authors call for the need to link the results to sociological

theories of health behaviour, as well as the need to implement interventions aimed at improving population health. Gennuso et al. (18) examined the risk factors affecting health differences in geographically defined areas. They used 2014 data from the County Health Rankings for districts in 8 states in the Mississippi River area (Alabama, Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee). They used the Delta Regional Authority definition to identify 252 districts from the Delta area and 468 districts outside these areas. The authors examined 35 indicators in 5 groups: health behaviour, clinical care, social and economic factors, physical environment and demographic variables. The authors found similarities between the Delta districts and districts outside this area in health factors (substance use, nutrition, movement) that significantly affected the results of self-rated health. The results of the study form the basis for the creation of regional health policies aimed at eliminating risk factors and regional disparities in health. Quantifying the regional health differences has also been addressed by Renard et al. (19) who took advantage of the relative scale in the maps, stressing the importance of exploring regional differences between districts in relation to premature deaths. All deaths between 1993 and 1999 and 2003–2009 in the population aged 1 to 74 living in Belgium were included in the analysis. According to the research results, the year-on-year differences in all causes of avoidable mortality increased by 10% between 1993–1997 and 2003–2009 in both genders. Alcohol-related diagnoses, mental and neurological diseases, and road accidents have also been investigated as part of the diagnosis of avoidable deaths. The results of the analysis also pointed to clear regional health disparities in Wallonia. These disparities are the result of complex interactions between various factors, including socioeconomic context, cultural habits, environmental impacts, as well as public health policies. The results of this study point to great potential for improving health in disadvantaged areas. Jeon et al. (20) investigated the prevalence of hypertension in geographically diverse areas, they compared results from urban and rural areas and were also interested in gender differentiation. Their study used data from the Korea National Health and Nutrition Examination for the period 2010–2012 and a national cross-sectional survey of the South Korean population. In addition to basic demographic indicators, the authors also used risk factors such as alcohol use, smoking, body mass index and economic indicators such as monthly income and educational level. A higher prevalence of hypertension has been found in men in urban areas than in rural areas. Regardless of gender and area, younger people had hypertension and diabetes mellitus under control. Regional disparities between urban and rural areas have been reported in the incidence of hypertension in men. In women, disparities of health status in urban areas were recorded. The results of the study also confirmed the necessity of developing differentiated health policies to address individual and regional health inequalities. The great importance of risk factors in examining regional health differences is discussed by Beard et al. (21). Their study focused on the geographical area of England, the population survey included 53,922 adults aged 16+, who participated in the Alcohol and Smoking Toolkit Studies. High-risk alcohol use has been found in the North of England and to a lesser extent in the Midlands, London and East of England. The analysis shows that regional differences in smoking and less risky drinking are explained to some extent by socio-demographic

differences. The East European region is characterised by a high prevalence of alcohol use compared to other European countries (22, 23). In the case of Slovakia, 16.6 litres per capita reflects more a mid-level of consumption as opposed to 19.1 litres in the Czech Republic (24). Differences between these two geographically and culturally similar countries can be found in the patterns of alcohol use and the proportion of preferred alcoholic drinks. Whereas in Slovakia (24) spirits are the most commonly consumed alcoholic drink (42%), in the Czech Republic beer consumption is dominant (54%) and a prevalence of heavy drinking is higher among adult population there (36.2% vs. 42.1%). Regarding illicit drugs, methamphetamine use is typically located in Central Europe, especially in the Czech and Slovak Republics (25). The Czech mental health study (CZEMS) (26) have found that the prevalence of alcohol abuse and addiction in the Czech Republic is 11%. Additionally, Kagstrom et al. (27) suggested that the treatment gap for alcohol abuse/addition is the highest among individuals with mental disorders.

Preventive programmes have been the subject of numerous research studies where they are presented either in their explicit form within defined research goals or as output components of research. An interesting look at the concept of prevention processes with implementation of social marketing in alcohol interventions is offered by Janssen et al. (28). The authors investigated the impact of applying social marketing methods on attitudes or behaviour related to alcohol use. In the literature review of PubMed, PsychInfo, Cochrane and Scopus, 274 research studies were investigated. The authors emphasise the importance of social marketing in educational processes related to the elimination of alcohol use and related impacts. Another view of risk and protective family factors associated with alcohol use in children and adults is offered by Čablová and Miovský (29). Their study was aimed at identifying, describing and comparing the results of research on family structure, parental styles, control and setting of rules, family alcohol consumption and emotional warmth and communication. Knowing these determinants and their effects on alcohol use in children and adults will encourage the creation of quality prevention programmes that can prevent the development of alcohol use, especially among youngsters.

The above-mentioned facts prompted us to carry out research with the aim of studying spatial distribution of causes of death which are the direct consequence of excessive alcohol consumption in the Slovak Republic. The presented study investigates the relationship between alcohol-induced mortality and individual regions of Slovakia, represented by Nomenclature of Territorial Units for Statistics (NUTS) III level.

MATERIALS AND METHODS

Our dataset contains data from 1996–2017 and was provided by The National Health Information Centre, a state-funded organisation under the administration of the Ministry of Health of the Slovak Republic. Data are derived from death certificates because for the purposes of this study the place of death and diagnosis are important.

We have focused our analysis on spatial distribution of causes of death which are the direct consequence of excessive use of alcohol. Hence, we were interested in the following diagnoses: F10 – Acute alcohol intoxication, G31 – Degeneration of nervous system due to alcohol, G62 – Alcoholic polyneuropathy, I42 – Cardiomyopathy, K29 – Alcoholic gastritis, K70 – Alcoholic liver disease, K73 – Chronic hepatitis, not elsewhere classified, K74 – Fibrosis and cirrhosis of liver and K86 – Alcohol-induced chronic pancreatitis.

For data processing we deployed correspondence analysis (30, 31). Correspondence analysis is a multidimensional visual technique that allows us to graphically display rows and columns of the pivot table and specify the measure of correspondence between the rows and columns. Correspondence analysis is conceptually similar to factor analysis and consists of decomposition of the relative frequencies into main components. Correspondence analysis lets us compute the Euclidean distances between the row points in the x-dimensional space (x is the number of columns). The distances between the points in the x-dimensional space summarise all information about the similarities between the rows in the pivot table. Correspondence analysis allows us to determine fewer dimensional spaces, in which it preserves all information about the differences between the rows in the pivot table on a 2-dimensional graph, which is the main output of correspondence analysis. Coordinates in the graph are analogous to factors in a principal component analysis. This method uses nominal variables as inputs. The necessary condition for correspondence analysis use is the existence of the dependence between the observed data.

Data were processed using IBM SPSS® software.

Table 1. Spatial distribution of deaths in 1996–2017

	Initial death diagnosis									Total
	F10	G31	G62	I42	K29	K70	K73	K74	K86	
Bratislava region	6	39	7	273	33	1,576	61	2,063	112	4,170
Trnava region	77	49	3	276	30	1,733	69	1,364	89	3,690
Trenčín region	28	50	5	353	62	1,417	76	1,417	79	3,487
Nitra region	13	71	16	425	42	2,425	91	2,227	122	5,432
Žilina region	31	85	12	598	56	1,657	97	1,717	123	4,376
Banská Bystrica region	11	75	8	642	44	1,949	64	1,955	145	4,893
Prešov region	8	62	5	680	54	1,399	63	1,360	106	3,737
Košice region	28	80	8	616	47	1,651	113	2,187	131	4,861
Total	202	511	64	3,863	368	13,807	634	14,290	907	34,646

RESULTS

Table 1 depicts the spatial distribution of deaths caused by selected diagnoses from the above-mentioned diagnoses F10, G31, G62, I42, K29, K70, K73, K74, and K86.

Diagnoses pertinent to this study contributed to the total number of deaths over the 22-year observation period by 2.96% and thus should not be neglected. Table 1 shows that most grievous of the diagnoses are K74 – Fibrosis and cirrhosis of the liver, K70 – Alcoholic liver disease, I42 – Cardiomyopathy and K86 – Alcohol-induced chronic pancreatitis.

Figure 1 depicts the evolution of mortality from the most serious diagnoses related to excessive alcohol use. We can conclude that mortality related to K70 – Alcoholic liver disease has a known serious increase over time. Also, mortality from I42 – Cardiomyopathy has raised over time. On the other hand, we observed a decrease of K74 – Fibrosis, and mortality from cirrhosis of the liver during the observed period. The number of deaths caused by K86 – Alcohol-induced chronic pancreatitis is also decreasing year by year.

As mentioned above, we were interested in the measure of correspondence between region and selected causes of death which are induced by excessive use of alcohol. In our analysis, we used the chi-square distance measure and symmetrical normalisation
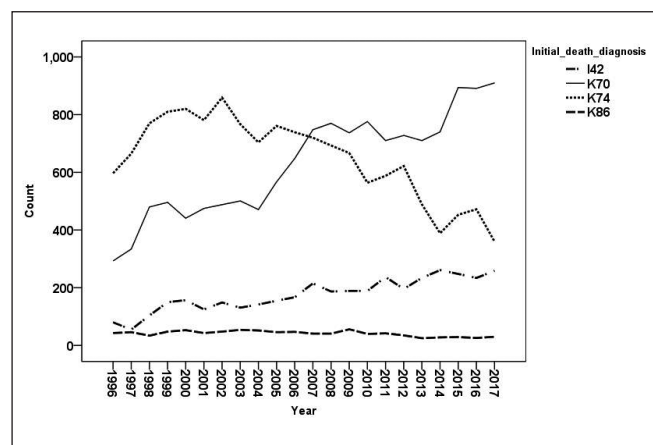

Fig. 1. *Evolution of mortality from I42, K70, K74, K86 within period 1996–2017.*

method. One of the conditions of using the correspondence analysis is the assumption of the existence of dependence between the observed variables. To verify this condition, whether there exists a significant relationship between two nominal variables, we performed Pearson's chi-square test of independence.

H0: There is no significant difference between the observed and the expected value.

H1: There is a significant difference between the observed and the expected value.

According to p-value in chi-square column in Table 2, we rejected the null hypothesis of Pearson's chi-square test of independence and we suppose that there is a dependence between data. Table 2 also shows the proportion of inertia captured by our model.

We can state that our model captures 78.4% of total inertia. The first dimension contributes 55.8% of inertia and the second dimension contributes 22.6%, which is in total 78.4% of inertia. Total inertia is a measure that characterises the quality of the transformation of multidimensional points in the correspondence map. Our model captures 78.9% of total inertia and thus can be perceived as satisfactory.

Figure 2 contains the results of the correspondence analysis. It should be noted that we weighted our dataset by variable Region since the study was focused on spatial distribution of deaths; this allowed us to assign importance to this variable.

We can see on the correspondence map that we have one outlier in terms of diagnosis, which is F10 – Acute alcohol intoxication, and one outlier in terms of region, which is the Bratislava region. In our opinion, this outlying is caused in case of the Bratislava region mainly because it is economically and socio-demographically under a different regime than other regions in Slovakia. In the case of outlying diagnosis F10 – Acute alcohol intoxication, we suppose that this is due to the nature of the cause of death, which has no latent progress but occurs unexpectedly and accidentally. We see that there is a relationship between the Prešov region and diagnoses I42 – Cardiomyopathy and K29 – Alcoholic gastritis. Furthermore, we can observe a cluster of relatively similar regions which signifies that their chi-square distance is quite small. These regions are Banská Bystrica, Žilina, Trenčín and Nitra regions. In any case, we can also find specificities and differences in this cloud of relatively similar regions. Particularly the Banská Bystrica and Žilina regions are fairly close and both correspond with G31 – Degeneration of nervous system due to alcohol, K86

Table 2. *Proportion of inertia*

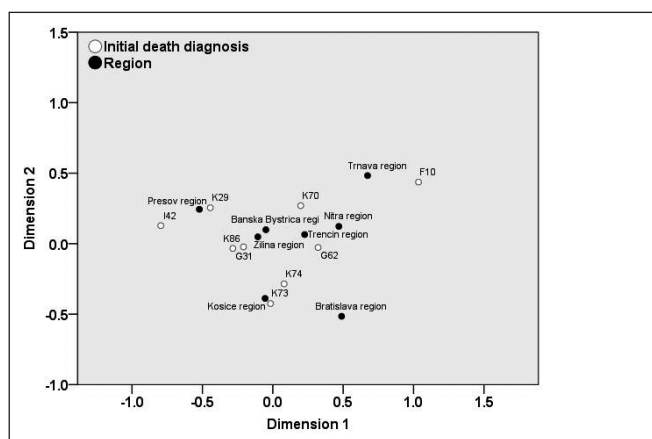| Dimension	Singular value	Inertia	Chi square	p-value	Proportion of inertia		Confidence singular value	
					Accounted for	Cumulative	Standard deviation	Correlation 2
1	0.107	0.012			**0.558**	**0.558**	0.002	0.056
2	0.068	0.005			**0.226**	**0.784**	0.003	
3	0.058	0.003			0.163	0.948		
4	0.025	0.001			0.031	0.978		
5	0.018	0.000			0.016	0.995		
6	0.010	0.000			0.005	1.000		
7	0.003	0.000			0.000	1.000		
Total		0.021	3,313.221	**<0.001**	1.000	1.000		

Fig. 2. Correspondence analysis: region/initial death diagnosis.

– Alcohol-induced chronic pancreatitis. An interesting finding concerned diagnosis K70 – Alcoholic liver disease. In this case, three regions can be identified as regions which have an intermediate relationship to this diagnosis: Banská Bystrica, Trenčín and Nitra regions. Trnava is the only region that corresponds to F10 – Acute alcohol intoxication. Next, the Trenčín and Nitra regions correspond relatively closely to G62 – Alcoholic polyneuropathy. We can find almost perfect correspondence between the Košice region and K73 – Chronic hepatitis, not elsewhere classified. Another disease corresponding with the Košice region is K74 – Fibrosis and cirrhosis of liver diagnosis.

DISCUSSION

The aim of this study was to study spatial distribution of causes of death which are the direct consequence of excessive use of alcohol in the Slovak Republic. We present a closer examination of the relationship between alcohol-induced mortality and individual regions of Slovakia, represented by regions (NUTS III level).

The results of our analysis offer interesting findings. Visualisation of results on the correspondence map highlights one outlying diagnosis, which is F10 – Acute alcohol intoxication, and one separately situated region, the Bratislava region. The Prešov region is related to diagnoses I42 – Cardiomyopathy and K29 – Alcoholic gastritis. Of interest is the cluster of similar regions (their chi-square distance is relatively small) comprising the Banská Bystrica, Žilina, Trenčín and Nitra regions. This cluster is not homogeneous in its mortality structure so the specificities and differences are clear. Especially the Banská Bystrica and Žilina regions are relatively close to G31 – Degeneration of nervous system. An interesting finding is the diagnosis of K70 – Alcoholic liver disease. In this case, three regions with moderate correspondence to this diagnosis can be identified. These are the Banská Bystrica, Trenčín, and Nitra regions. The Trnava is the only region with a slight relationship to F10 – Acute alcohol intoxication. The Trenčín and Nitra regions correspond to the diagnosis of G62 – Alcoholic polyneuropathy. The Košice region corresponds to the diagnosis of K73 – Chronic hepatitis and K74 – Fibrosis and cirrhosis of liver. From the overall assessment of the regions' relationships in alcohol–related mortality we find a breakdown into four groups of diseases according to ICD-10: I – Diseases of the circulatory system, L – Diseases of the digestive system, G – Diseases of the

nervous system, and F – Mental and behavioural disorders. These findings are important for analysis of the structure, availability and efficiency of specialised healthcare facilities where diagnosis and treatment of these serious diagnoses is carried out. For example, F10 – Acute alcohol intoxication is linked to psychiatric examination or hospitalisation regardless of reasons for, and degree of, intoxication. According to experts, uncomplicated alcohol intoxication alone is not an indication for psychiatric examination and patients with severe intoxication should be hospitalised in an intensive care unit at an internal clinic (32). In Slovakia, this problem has for a long time been addressed by several ministries and municipalities. According to Janík and Vašečková (33) it is necessary to establish interdepartmental cooperation as well as to ensure sufficient personnel and technical equipment for the effective functioning of healthcare providers. Psychiatry as a discipline, according to these authors, should not substitute healthcare providers for repressive activities or take responsibility for long-term failure to address the issue. Further research findings are also important for setting up local prevention programmes in individual regions. If we look at the localisation of diagnoses belonging to the group of digestive system diseases, we find intervention in several regions. For this reason, it is necessary to focus on exploring the root causes of the emergence of these diseases which can result in liver transplantation. Liver transplantation is the last alternative and is only implemented after 6-month abstinence with presumption of long-term maintenance. If the abuse is stopped, the prognosis is more than favourable (34). In Slovakia, 30–50 people a year await liver transplantation (35). Liver transplantation is dependent on organ sampling in Slovakia. The sampling programme in Slovakia operates at approximately 50% and is provided by four centres: Bratislava, Martin, Banská Bystrica and Košice. Experts point out insufficient support from the Ministry of Health (36). Circulatory diseases such as I42 – Cardiomyopathy are dominant in the Prešov region which is sufficiently covered by a network of specialised cardiology clinics and has access to the specialised centre of the East Slovak Institute of Cardiovascular Diseases in Košice. Investigating the relationship of alcohol-related mortality and its spatial distribution is also of great importance in the process of building Integrated Health Care Centres, supported by the Ministry of Health of the Slovak Republic. This system prevails in many European countries alongside the complementary introduction of health system reforms which should result in an increase in the number of primary contact physicians, as well as site-specific specialists, increasing healthcare availability and improving patient management. The results of our analysis can help in assessing the demand for specialised health services in the catchment areas of Slovakia's regions and can help create the conditions for access to health care that regional disparities in health reduce.

CONCLUSION

For decades, Slovakia has been solving the problem of eliminating the effects of harmful alcohol use. The consequences of alcohol consumption from social, work-related, psychological and economic perspectives are extensive. To eliminate them it is important to streamline and intensify the systemic approach of relevant institutions to the issues addressed. Timely and good quality health care can improve the course of related diseases

and reduce their health, social and economic consequences. An important role is played by the detailed mapping of risk areas as well as population groups and exploration of determinants supporting the development of alcohol dependence. Our findings can contribute as a key argument for stakeholders to improve the poor level of alcohol policy in the Slovak Republic, especially in terms of alcohol taxation and regulation of alcohol availability and advertisement. Public health interventions such as health promotion, raising awareness of alcohol-related harm and effective population-based prevention strategies should also be considered. The aim of our study was to investigate the relationship between alcohol-related mortality and individual regions of Slovakia, represented by regions (NUTS III level). To achieve these objectives, a correspondence analysis was chosen which allowed to exploration and evaluation of the spatial distribution of alcohol-related mortality in individual regions of Slovakia. Results of the analysis enabled us to identify the regions which correspond to the mortality rate of selected diagnoses while we also revealed a cluster of several regions with their specificities as well as differences. These facts justify the need for specialised health care which is part of the process of building an Integrated Health Care Centre in Slovakia. It is a trend prevalent in many countries to improve the availability of health care. The analysis provides valuable insights for national and regional health policymakers in the process of preparing high-quality health regional plans, as well as retrospectively assessing the success of existing health policies and interventions in this area. A challenge for further research is to determine whether the changes in some diagnoses over the years are due to the changes in the prevalence of those diseases or due to higher/lower awareness of the diseases among doctors, or due to different coding policies.

Conflict of Interests
None declared

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