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Cartography of crime: Portrait of metropolitan Vilnius

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ABSTRACT

In Europe, especially in Eastern Europe, geographic research in criminology deals mainly with data analysis and accompanying cartographic communication through the visualisation of crime maps is less developed. Therefore, there is still a dearth of crime maps that could potentially not only show the facts, but also portray the criminal landscape of the city and tell the reader a story in a way that stimulates thinking, and motivates deeper analysis and spatial reasoning. This set of maps, which were designed by the authors, represent specific characteristics, density and temporal distribution of crimes in the city of Vilnius in 2014. It also shows changes in the crime rate from 2012 to 2014. The maps represent generalised data that was derived from detailed tabular data on reported criminal activities in 2012, 2013, and 2014. The primary map reveals some primary factors that allow understanding of spatio-temporal patterns of crimes in modern Vilnius: prevalent crime types with specific territorial and temporal distribution (crimes of violence, property crimes, and distribution/possession of drugs); changes in distribution over the examined period of 3 recent years; overall crime rate and detailed structure of 9 types of crimes, the rate of burglaries and seasonality of violent crimes for all the 21 administrative districts of the city. Original cartographic signs have been designed for the depiction of 11 characteristics. The maps are supplemented by 3D visualisations and a chart that shows changes in the overall crime rate and juvenile crime numbers in the decade from 2004 to 2014. The reference scale is 1:100,000 for the Main map and 1:300,000 for complementary maps.

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1. Introduction

In Lithuania, research into the geography of crime has been limited to separate topical studies with little attention to geographic distribution of crime until 1997–2001 when several works were published, mainly at Vilnius University, and devoted to urban crimes. After a pause of another 10 years, when large-scale spatial and statistical data were made publicly available for the whole country, research at Vilnius University was able to resume at a new level. Methods and tools of spatial analysis were applied in order to understand the specifics of distribution of crimes in the city of Vilnius (Beconytė & Eismontaitė, 2013), that is the capital and the largest city of Lithuania; note that 'Vilnius' in this paper refers to metropolitan Vilnius, that is, the City of Vilnius per se, not the surrounding district which bears the same name. Crime data were analysed together with other spatial data of Vilnius in a search for correlations that yielded some interesting results. These include the possible relationships between overall crime rate and urban fires (Vasiliauskas & Beconytė, 2015); the structure and specifics of thefts in the proximity to shopping centres; the correctness of different visualisation methods (Valukonytė, 2014); the relationship between functional characteristics of city zones and urban open space crimes (Bielinskas, Staniūnas, Beconytė, Balčiūnas, & Vasiliauskas, 2014). Work on large-scale spatio-temporal patterns of crimes and their relationship with characteristics of population continues not only for Vilnius, but also for Lithuania's second and third major cities Kaunas and Klaipėda (Stankevice, Sinkiene, Zaleckis, Matijosaitiene, & Navickaite, 2013). Unfortunately, there are not many examples of high-quality crime maps, especially at a large scale. In the following sections we discuss the problem of visualisation of crimes and introduce a map poster that represents, by diverse methods, the criminal landscape of Vilnius.

2. Printed and digital crime maps

Internationally, the cartography of crime has an almost 200 year long history. Different methods of representation were introduced, including choropleth maps with different levels of detail in 1829–1864 in France and Belgium, later in England (Balbi & Guerry, 1829; Bruinsma & Weisburd, 2013a, 2013b; Friendly, 2009; Glyde, 1856; Guerry, 1864); American socio-ecological maps of the first half of the twentieth century (Burt, 1944; Shaw & McKay, 1942; Shuterland, 1937); the first digital crime maps of the later twentieth century (Brown, 1982; Herbert & Harries, 1986; Rose, 1978) and an ample selection of modern academic and popular maps. Geographic information technology facilitated

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the analysis of spatial patterns. Together with traditional choropleth maps various density maps (Ghosh, Lagenbacher, Duda, & Klofas, 2012) and statistical grid maps (Megler, Banis, & Chang, 2014) are widely used. More sophisticated, 3D, spatio-temporal methods (Frank et al., 2011; McCune, 2010) are much less frequent.

The specifics of interactive internet maps are such that they result in limitations in the choice of representation methods. As more data are made publicly available and more web-service-based maps published, one could expect a lot of simple but correct web maps representing crimes with a large reference scale. Unfortunately, many such maps are compiled using very basic representation methods, such as point/icon signs and sign clusters. They can be very misleading. For example, in Figure 1, a cluster of 19 crimes on an official crime map is randomly placed exactly over the searched location of a national GIS company office. If such visualisation is applied to a block of flats or a private house, there could well be unintended consequences.

Generally, it can be noted that irrespective of the visualisation possibilities provided by GIS and other technologies, crime maps in atlases and on the internet addressed to the general public tend to be simple if not boring and present dry facts instead of telling a story. We therefore propose that professional cartographers ought to be much more involved. The map poster presented in this paper is designed for a wide audience. Though far from exhaustive, it reveals the main things that enable or enhance understanding of the spatio-temporal patterns of crimes in modern Vilnius: prevalent types with specific geographic and temporal distribution; the changes in that distribution over the period of three recent years; overall crime rate and structure, seasonality of violent crimes, and other characteristics.

3. Data and contents of Vilnius crime maps

The maps depict the crime situation in the city of Vilnius (the metropolitan area only, excluding the surrounding Vilnius District), which is both the capital and the largest city of Lithuania (Figure 2). It is spread over an area of 402 km^2, of which almost 42% is covered by urban woodland. In 2014, the city had around 540,000 inhabitants. It is divided into 21 administrative districts that have different characteristics of age, urban functional zones, population density (Figure 3), and socio-demographic structure. Overall crime rate in Vilnius is the highest among all cities of Lithuania.

The maps represent generalised data that were derived from detailed tabular data on registered criminal activities in 2012 and 2014. The geocoded dataset of registered crimes contains 19,665 records for 2012 and 16,936 for 2014. The geocoding hit rate was 97% with an exact match score of 99% with an exact match score of 99%. Statistical grid map and distribution chart of all crimes by type are shown in Figure 4.

Three general and nine more specific types of crimes were distinguished that enabled the resolving of minor inconsistencies in classification of data in the datasets of various years:

(1) Crimes of violence (in 2014: 3412; 20.1%): assault, physical abuse (including sexual abuse), threatening behaviour (ABT), murder, unclear circumstances of death (DTH), robbery (ROB);
(2) Property crimes (in 2014: 9905; 58.5%): cheating/swindling (CHE), destruction of or damage to property (DES), theft (TFT);
(3) Other crimes (in 2014: 3623; 21.4%): drug-related crime (DRU), public nuisance (PUB), various other crimes (VAR).

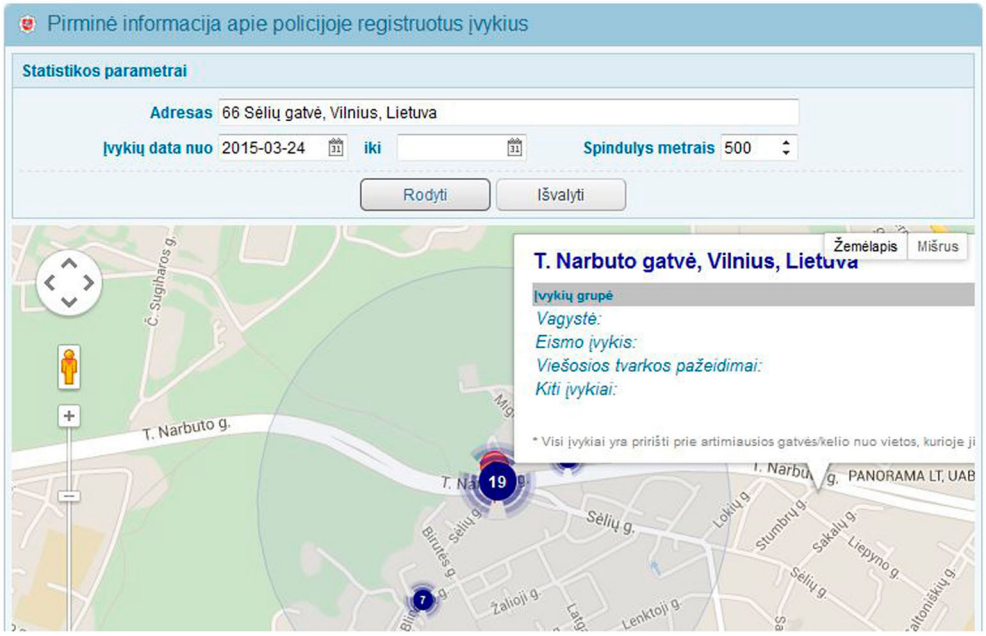

Figure 1. Misleading visualisation of crimes (E-Services of Lithuanian Police, 2015).

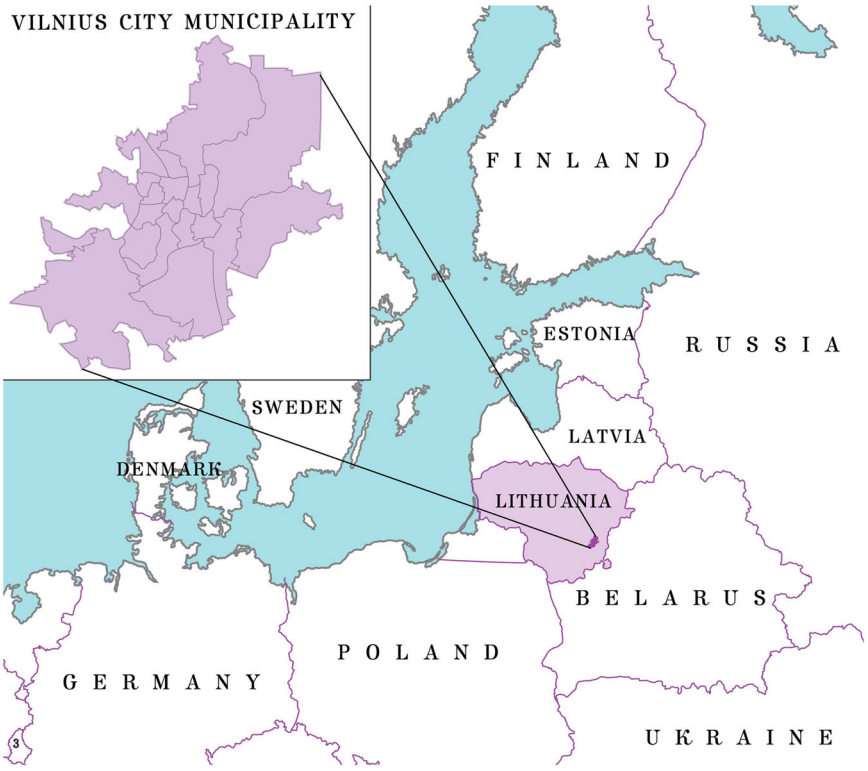

Figure 2. Map of the research area.

Thefts cover burglaries, motor vehicle thefts, and shoplifting. The burglary rate is separately represented on the Main map. Vandalism has been classified under DES or PUB according to its scale and other circumstances. The types that occur more rarely and would not change the general picture if they were separately represented have been classified under 'Various other crimes': manslaughter, kidnapping, arson, extortion, forgery, etc.

Information on the Main map is generalised for 21 administrative districts of Vilnius. The background colour denotes the overall crime rate in the district per 10,000 inhabitants. Original complex cartographic signs have been designed to show the percentage for each of nine groups of crimes studied, for burglaries per 1000 dwellings, and for the seasonality of all instances of violent crime. Census data used to estimate the relative rate of burglaries were derived from square cells of 500 m radius then generalised for the city's districts.

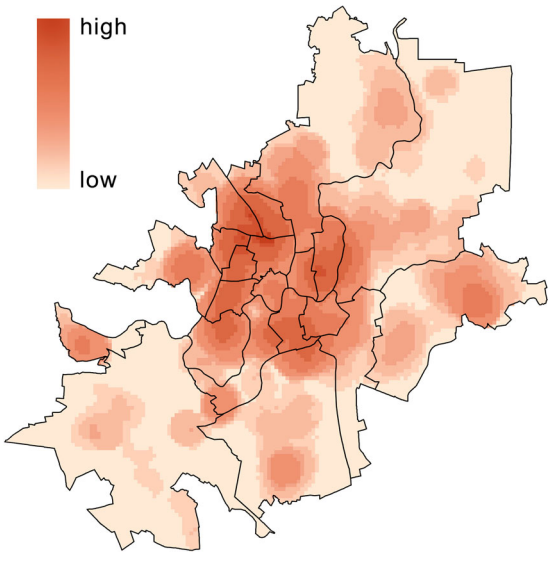

Figure 3. Population density of the city of Vilnius in 2014.

Jenks' natural breaks classification method (Jenks, 1967) was used to determine the six classes of overall crime rate and five classes of burglary rate. In 12 districts, the violent crimes of 2014 are concentrated in either one or two seasons of the year and for these districts those seasons are shown by corresponding associative colours of the inner ring.

The map is supplemented by a chart that shows changes in the overall crime rate and in juvenile crime in Vilnius in the decade from 2004 to 2014.

The complementary maps and charts represent the major groups of crimes: crimes of violence, property crimes, and drug-related crimes:

(1) Density maps show statistical surfaces for each group of crimes, based on absolute values calculated using a 10×10 m size grid and a 700 m radius. For quick assessment of spatial concentration, standard deviational ellipses are drawn for one and two standard deviations (σ).
(2) Maps of changes represent changes in relative crime rate from 2012 to 2014. They are based on compact hexagonal cells with a 500 m radius for

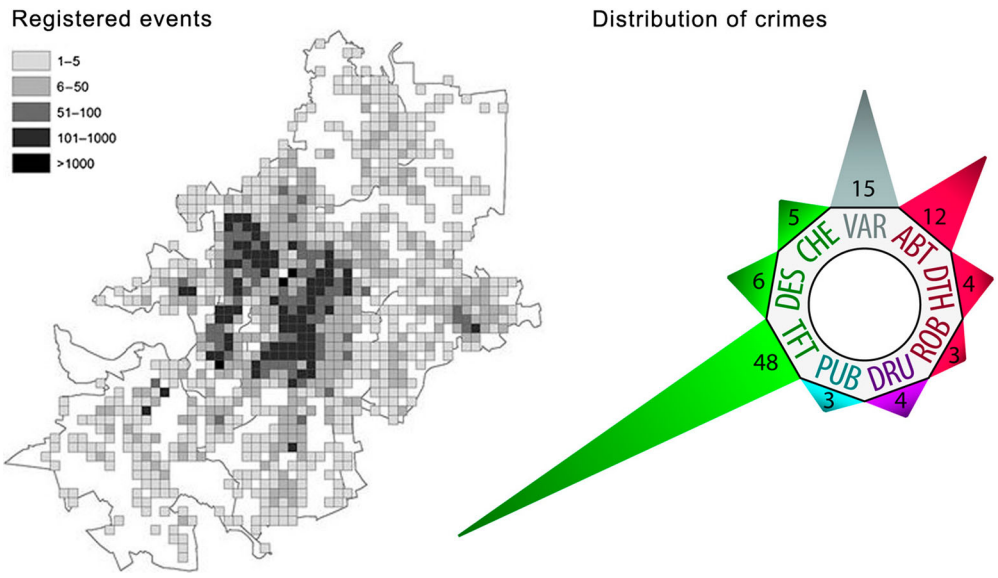

Figure 4. Density and overall structure of crimes in the city of Vilnius in 2014. The figures on the chart show the percentages for different categories of crimes.

which crime data were aggregated. Changes in the relative crime rate (number of crimes per person in an area) in three years are represented by light grey colour of the cell if the absolute value of the change does not exceed 1σ. Lighter and darker red/blue colours represent cells with a deviation of change of correspondingly up to ±2σ and higher. Thick contour lines outline the groups of cells with significant changes (±2σ and higher). Empty areas represent the territory where no crimes were reported. Empty cells mean undetermined values for either 2012 or 2014 because of which the change could not be measured.

(3) The two-dimensional temporal distribution of crimes in 2014 is shown by day of the week and hour. An equal interval classification method was used to determine the five (four for DRU) classes of intensity for each category of crimes.

(4) 3D charts represent absolute values for violent crimes and thefts. As the number of thefts is much higher, different vertical scales (150 and 40 respectively) were used.

4. Spatial insights

Density maps enable quick understanding of patterns of concentration. On the maps we see the two zones where criminality is concentrated, similar to the zones of the highest population density. However, our earlier studies had shown that the correlation between total number of crimes and population density depends on the functional type of urban area and only reaches 0.6 on average. The shape and inner structure of the zones differ for the most common groups of crimes: violent crimes, thefts, and drug-related crimes.

On the Main map, certain prevalent structures of crime can be quickly noticed: thefts dominate everywhere except for one district, but the proportion of physical abuse and drug-related crimes is highly variable. Seasonality of violent crimes is clearly relevant in more than a half of the districts of Vilnius. Often the peak is in autumn or (/and) spring while winter is definitely the 'lowest' season with exceptions in some western districts. It is worth noting that for the entire city total the number of violent crimes is

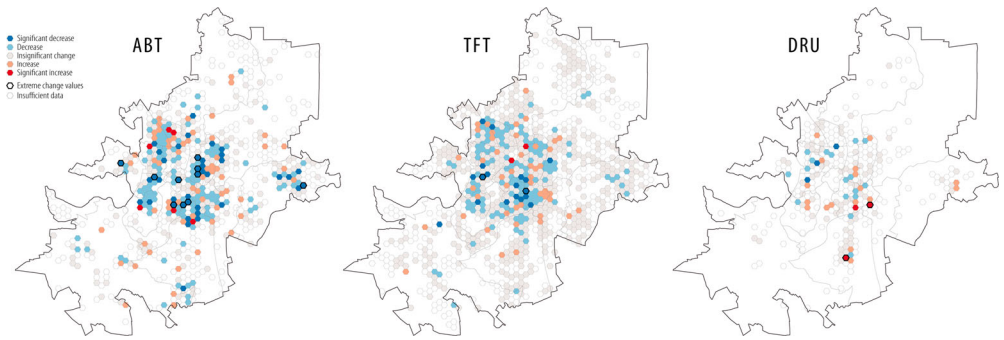

Figure 5. Absolute changes in crime rate for crimes of violence (ABT), thefts (TFT), and drug-related crimes (DRU).

almost constant for all seasons (the greatest variation is only 1.5%).

Clock charts reveal clear trends of temporal distribution of violent crimes that indicate concentrations on weekends between 6 PM and midnight. Thefts concentrate between 5 PM and 7 PM; they rarely occur between 10 PM and 8 AM. Drug-related crimes are mainly reported for the afternoon–night period of working days (3 PM–1 AM).

Maps designed to reflect changes can represent either absolute (Figure 5) or relative changes (map poster) in the number of incidents reported. Charts representing relative changes that are chosen for the map poster are less figurative but more explicit as they show extreme values for changes and eliminate the impact of population density upon the data. Both series of charts reveal that there are large areas with no statistically significant changes at a significance level of .05%. Cells with significant changes, both positive and negative, are characterised by a specific spatial distribution for different types of crimes. The largest changes in relative numbers of violent and drug-related crimes are in the peripheral parts of the city that, according to other studies (Gudelis, 2015), show trends of demographic and economic divergence. A substantial decrease in these crimes may indicate an increase in safety due to the formation of local urban communities. Areas of significant increase show that the most problematic zones are poor peripheral residential areas and, in the case of increases in drug-related crimes, the inefficiency of prevention measures in the area of the Roma *tabor* in the south of Vilnius. Areas with major changes in theft rate are located closer to the city centre and, in instances of increase, the evidence points to specific shopping centres. The charts depicting changes in absolute figures show positive trends in the most densely populated central areas: a decrease in violent crimes and, to a lesser extent, in the number of incidents of theft.

5. Concluding remarks

For a good crime map of a city, a thorough spatial analysis of a detailed data and understanding of cartographic methods are prerequisites. Only competently generalised data and well-readable signs convey proper information about the entire territory covered. We believe that the set of crime maps presented is not only informative but will also enable hypotheses concerning causalities based on analysis of spatial distribution patterns. It is based on competent understanding of prevalent types of crime in Vilnius and demonstrates several cartographic techniques that may productively be used for the representation of urban crime.

Software

The original data was received in *MS Excel* tables and did not include a spatial component. Geocoding of tabular data that were not completely clean and integral was performed by a custom tool developed at the State Enterprise 'GIS-Centras' (www.gis-centras.lt). Spatial data were collected and maintained in an Esri *ArcGIS* geodatabase. *ArcGIS 10.3* and *ArcGIS Pro* were used for data processing. *Adobe Illustrator CC* graphic design software was used for cartographic symbols and overall cartographic design. Hexagonal tessellation for representing changes in crime rate for Vilnius was created using *2D Beehive* tool for ArcGIS. The *Create Data Clock* tool of *ArcGIS Tracking Analyst* was used to create two-dimensional circular charts that show a temporal distribution for crimes.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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