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Application of a geographic information system in the study of spatial aspects of cervical cancer incidence in Belgrade

Primena geografskog informacionog sistema u istraživanju prostornih aspekata obolevanja od raka grlića materice u Beogradu

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Abstract

Background/Aim. Cervical cancer is still an important public health problem in Belgrade. The aim of this study was to explore spatial patterns of cervical cancer, provision and accessibility of women's health service on the primary health care level in Belgrade, as well as the needs for improving cancer surveillance and preventive programs. **Methods.** This study applied a descriptive epidemiological method and a geographic information system based on data on cervical cancer diagnosed among female residents of Belgrade in 2006 and 2011. A map of the density of cases, with precise and complete data on the address of residence at the time of diagnosis, and a map of the distribution of gynecological practices in the primary health care in Belgrade, were generated through the process of georeferencing. **Results.** A total of 569 cases of cervical cancer were registered in 2006 and 2011, without significant differences. Significant associations were noticed for municipality of residence and year of diagnosis (χ^2= 42.99, df = 16, p = 0.000), and year of diagnosis and age groups 30–34 (p = 0.038, f = 3.998, df = 11, ANOVA), 40–44 (p = 0.001, f = 7.545 df = 13, ANOVA) and 45–49 (p = 0.046, f = 2.679, df = 15, ANOVA). The process of georeferencing covered a total of 466 (81.8%) cases with 97.4% of all cases diagnosed in 2006 and 68.6% in 2011. The generated maps showed similar spatial patterns of cases for both years: a higher density of cases with addresses in central parts of urban and suburban municipalities, as well as in parts of densely populated areas of urban municipalities. There was no regularity of grouping found for the cases in relation to the provision of women's health service, or of distance from the place of residence of cases to gynecological practices. **Conclusion.** Our results indicate possibilities for the perception of the spatial distribution of cervical cancer and needs for improving cancer surveillance and preventive programs on small geographical areas.

Key words:
epidemiologic methods; geographic information systems; primary health care; urban population; uterine cervical neoplasms.

Apstrakt

Uvod/Cilj. Rak grlića materice je još uvek značajan javnozdravstveni problem u Beogradu. Ciljevi ove studije bili su istraživanje prostornih obrazaca raka grlića materice, obezbeđenosti i dostupnosti ginekološke zdravstvene zaštite na primarnom nivou u Beogradu, kao i sagledavanje potrebe za unapređenjem epidemiološkog nadzora i programa prevencije. **Metode.** U radu je primenjen deskriptivni epidemiološki metod i tehnologija geografskih informacionih sistema. Uključeni su svi slučajevi raka grlića materice utvrđeni kod stanovnica Beograda u toku 2006. i 2011. godine. Mape gustine slučajeva i mape distribucije ginekoloških ordinacija domova zdravlja u Beogradu su generisane procesom geokodiranja preciznih i kompletnih podataka adrese stanovanja obolelih u vreme utvrđene dijagnoze i adresa ginekoloških ordinacija. **Rezultati.** U toku 2006. i 2011. godine registrovano je ukupno 569 slučajeva raka grlića materice, bez statistički značajne razlike. Statistička značajna povezanost je utvrđena za opštinu stanovanja i godinu utvrđene dijagnoze (χ^2 = 42,99 df = 16 p = 0,000), i godinu utvrđene dijagnoze i dobne grupe 30–34 (p = 0,038, f = 3,998, df = 11, ANOVA), 40–44 (p = 0,001, f = 7,545, df = 13, ANOVA) i 45–49 (p = 0,046, f = 2,679, df = 15, ANOVA). Procesom geokodiranja obuhvaćeno je ukupno 466 (81,8%) slučajeva obolevanja, među kojima 97,4% svih slučajeva utvrđenih u 2006. i 68,6% u 2011. godini. Generisane mape pokazuju slične prostorne obrasce obolevanja za obe posmatrane godine: veća gustina slučajeva među osobama sa adresom stanovanja u centralnim delovima opština gradskog i prigradskog područja, kao i u delovima sa većom gustinom naseljenosti u opštinama užeg gradskog jezgra. Nije uočena

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pravilnost grupisanja slučajeva obolevanja u odnosu na obezbeđenost ginekološke zdravstvene zaštite na primarnom nivou ili udaljenosti mesta stanovanja obolelih do najbliže ustanove koja pruža ovaj vid zdravstvene zaštite. **Zaključak.** Naši rezultati ukazuju na mogućnost potpunijeg sagledavanja prostornih obrazaca distribucije obolevanja od raka grlića materice i potreba za unapređenjem nadzora i programa prevencija na majim geografskim područjima.

Ključne reči:
epidemiološki metodi; informacioni sistemi, geografski; zdravstvena zaštita, primarna; stanovništvo, gradsko; grlić materice, neoplazme.

Introduction

Cervical cancer is the fourth most common malignant tumor among women worldwide, with an expressed disparity in the burden and trends in various parts of the world. It is the second most frequent cancer in the less developed regions, and the eleventh in the more developed regions [1]. The burden on the European continent is increasing from west to east, and it is highest in Central and Eastern European countries (standardized incidence rate of 19.2/100,000 and mortality of 8.0/100,000). The values of the incidence and mortality for countries in the region are about twice those of Northern and Western European countries. Based on the incidence rate, Romania is in the first place (34.9/100,000), while Serbia (the region of Southern Europe) is in the fourth place (28.3/100,000) [2, 3]. Differences are also noted across smaller geographic areas. The area of Belgrade and eastern regions that gravitate towards the Romanian border have been the areas with the highest incidence rates in Serbia for years. Cervical cancer is in the third place regarding incidence and in the fourth place as the cause of death among women due to malignant tumors in Belgrade [3–6].

The differences in geographic burden of cervical cancer and high variation in incidence rate and mortality may arise due to multiple reasons. They mainly reflect the varied distribution of known risk factors, various host sensitivity, differences in the detection, treatment and monitoring of carcinoma patients, methods of registration and reporting system, as well as lack of health care, lack of screening or insufficient coverage of the population by preventive examinations [7–10].

Data on the incidence and mortality due to cervical cancer in most European countries, as well as in Serbia, are part of the surveillance of malignant diseases, and are found in the population cancer registries. Their completeness and quality are the basis for research activities, efficient planning and adaptation of the programs of prevention and suppression of the disease at all levels, from the national to the local one [10–13]. Aiming to provide a comprehensive overview of the epidemiological situation and assess further activities, an increasing level of attention today is dedicated to analyzing the spatial aspects of the disease, by combining a descriptive epidemiological method with the application of a geographic information system (GIS). Contemporary information technologies provide for the detection and visualization of spatial patterns that may be missed by applying the classical descriptive method or with tabular overviews of the results [14–17].

The aim of this study was to determine the spatial distribution of cervical cancer incidence, provision and accessibilty of women's health service on the primary health care level in Belgrade, carried out by descriptive epidemiological method and GIS.

Methods

Study location and population

This retrospective study used a descriptive epidemiological method and GIS based on data on cervical cancer diagnosed among female residents of Belgrade in 2006 and 2011.

The territory of Belgrade covers an area of 322,268 ha (the inner-city area covers 35,996 ha), administratively divided into 16 municipalities – 10 urban (Čukarica, Voždovac, Vračar, Novi Beograd, Palilula, Rakovica, Savski venac, Stari grad, Zemun, Zvezdara) and 6 suburban municipalities (Barajevo, Grocka, Lazarevac, Obrenovac, Mladenovac, Sopot). According to census data (from 2002 and 2011) Belgrade had a total of 828,270 female inhabitants with a median age of 41.6 (for 2006) and 873,614 female inhabitants with a median age of 43.2 (for 2011).

Data collection and management

The source of data was the Population Cancer Registry for Belgrade. The data analysis used the incidence of cervical cancer diagnosed in Belgrade for 2006 and 2011 (International Classification of Diseases, Injuries and Causes of Death, 10th revision, code C 53). We used proportions, crude, standardized and age-specific incidence rates per 100,000 female inhabitants. Crude and age-specific incidence rates were calculated using census data (2002 and 2011). Analysis of standardized incidence rates was performed using the direct method with world standard population [18].

The collected data set included information on the address of residence, year of diagnosis and age of patients at the time of diagnosis.

Maps of cervical cancer density and maps of the distribution of gynecological practices at Primary Health Care Centers (PHCCs) were generated through the process of georeferencing, using the precise data on residence at the time of diagnosis and the addresses of gynecological practices in 2006 and 2011.

Data for the provision of gynecological health care at the primary health care level were taken from the annual report on the plan of work of women's health Belgrade PHCCs in 2006 and 2011.

Provision of gynecological health care was expressed through the number of women per one gynecologist (6,500/1)

among the total adult female population (age 15 and over at the municipality of the health care center), and interpreted according to the Rulebook for providing health services in health care institutions on a daily basis (the measure is 30 visits per day per gynecologist) [19].

Spatial accessibility of gynecological health care was examined as the geographical distance of the registered cases to the nearest gynecological practice in the municipality of residence at the time of established diagnosis (20 min walking distance).

Statistical analysis

The χ^2-test, Student's *t*-test and analysis of variance (ANOVA) were used to assess statistical significance.

Results

There were 569 registered new cervical cancer cases within the territory of Belgrade in 2006 and 2011 (263 and 306, respectively). Crude incidence rate in 2006 was 31.75/100,000, while the standardized one was 20.4 per 100,000. Crude incidence rate in 2011 was 35.0/100,000, and the standardized one was 22.9/100,000. Cervical cancer in 2006 was in the second place (9.3%) in frequency among all female cancers in Belgrade, after breast cancer (30.7%), while in 2011 it was in the third place (8.2%) after breast carcinoma (33.7%) and colorectal carcinoma (8.3%).

Significant differences were noticed regarding municipality of residence and year of diagnosis. Among the total number of registered cases of the disease in 2006, 45.6% were with residence data within 4 municipalities: Novi Beograd, Čukarica, Palilula and Voždovac (with uniform participation between 11.0% and 11.8%). During 2011 nearly all Belgrade municipalities registered a decrease or maintenance of values similar to those in 2006, with the exception of Zemun and Savski venac municipalities, where a nearly threefold increase in the number of female patients was registered (from 8.7% to 24.8%, and from 1.9% to 5.9%, respectively). This difference was statistically significant ($\chi^2 = 42.99$, df = 16, $p = 0.000$).

The municipalities with the highest incidence rate in 2006 were Mladenovac, Vračar, Rakovica and Voždovac, while in 2011 these were Savski venac, Zemun and Mladenovac. The highest increase in the incidence rate in 2011 was registered among the residents of the municipalities of Zemun and Savski venac. A decrease in the incidence rate in 2011 was registered among the residents of the municipalities of Rakovica, Vračar and Mladenovac (Figure 1).

The average age of female patients in 2006 was 54.9 years, while in 2011 it was 53.5 years. The highest age-specific incidence rates in 2006 were registered in the age groups of 55–59 (3.6/100,000) and 40–44 (3.2/100,000). Comparing 2011 with 2006, incidence rates were higher in nearly all age groups, except for 55–59, 65–69 and 70 and over. High values of age-specific rates were registered among women aged 35 to 64 years, with the highest values in the age groups of 40–44 (3.6/100,000) and 45–49 (3.5/100,000) (Figure 2). A statistically significant difference for age groups was noticed by ANOVA. The difference was noticed for the age groups 30–34 ($p = 0.038$, f = 3.998, df = 11), 40–44 ($p = 0.001$, f = 7.545, df = 13) and 45–49 years ($p = 0$ .046, f = 2.679, df = 15).

Among the total of 569 reported cases of cervical cancer during the two observed years, the process of georeferencing made it possible to capture data for 466 (81.8%) patients. Data for 103 patients was not included in the formation of case density maps, since they lacked precise and complete data on the place of residence at the time of diagnosis. The maps were created based on municipal administrative borders.

Among the 263 reported cases of cervical cancer in 2006 complete data was available for 256 (97.4%) and their spatial distribution is shown on a map of Belgrade (Figure 3). The highest density of cases was observed in central parts of urban and suburban municipalities. Nearly all municipalities exhibited areas without a single registered case of disease.

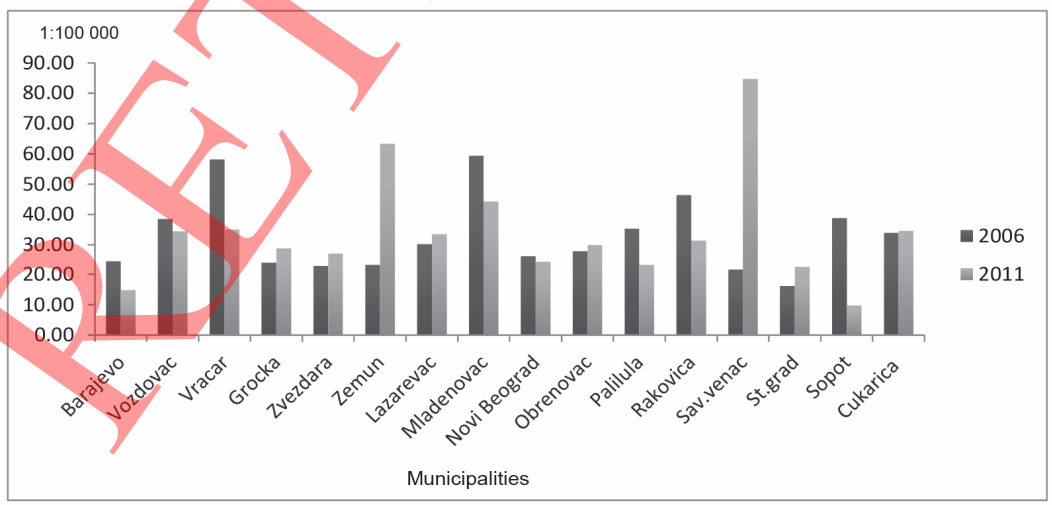

Fig. 1 – Cervical cancer incidence rates (per 100,000) by municipalities, Belgrade, 2006 and 2011.

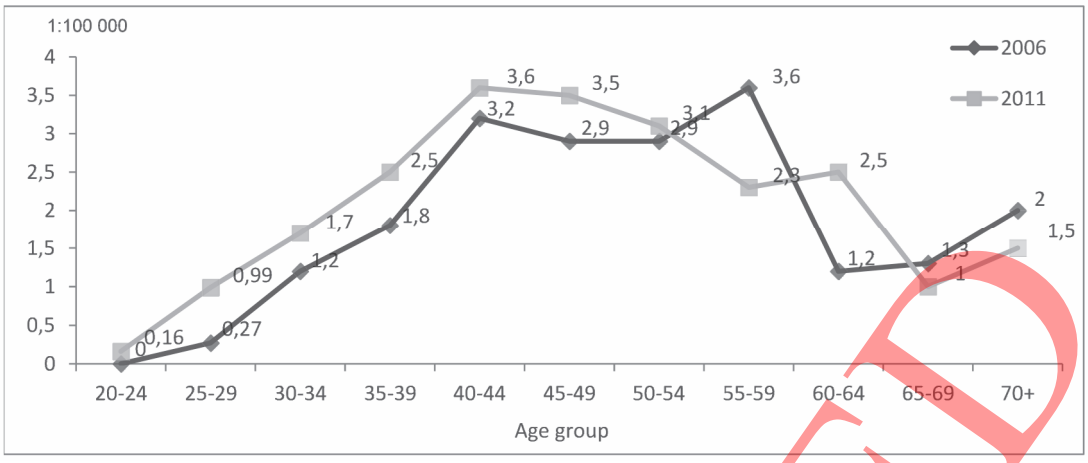

Fig. 2 – Age-specific incidence rates of cervical cancer (per 100,000) in Belgrade, 2006 and 2011.

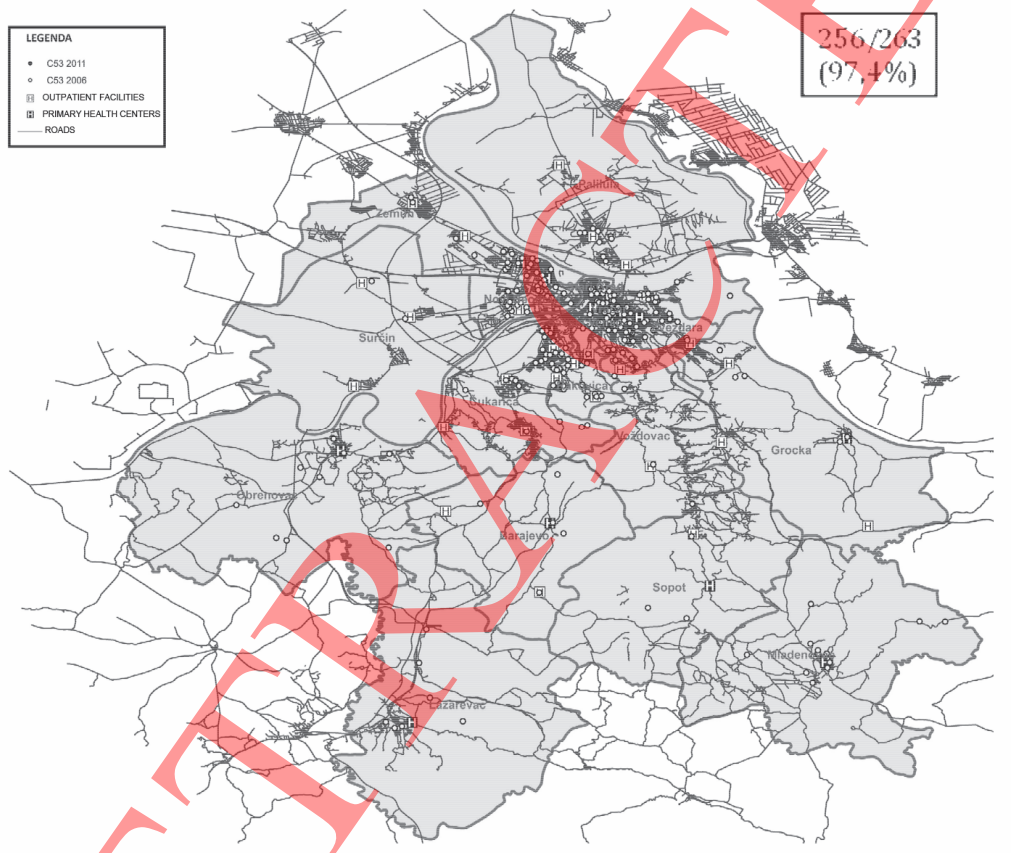

Fig. 3 – Spatial distribution of cervical cancer cases in Belgrade, 2006.
Note: For 256 out of 263 reported cervical cancer patients complete data was available.

The cervical cancer case density map for 2011 was formed by geocoding data for only 210 of the 306 reported cases of the disease. The necessary data was lacking for nearly one third of the cases (31.4%) (Figure 4). The highest number of reports with incomplete geocoding data was related to patients with addresses of residence in the municipality of Zemun (around 47.0%), Voždovac (9.4%), Savski venac and Palilula (8.3% each). The highest percentage of cases not shown regarding the number of registered cases per municipality of residence was in the municipalities of Zemun – 55.2% (42 of 76 cases), Savski venac – 45.0% (8 out of 18 cases) and Palilula -38.0% (8 out of 21 cases).

All usable data, shown simultaneously in a single map, displayed nearly similar spatial grouping patterns of cervical cancer cases in both observed years. A higher density of cases was registered among persons with an address of residence in the central parts of urban and suburban municipalities, as well as in parts of more densely populated urban municipalities (Figure 5). This map, along with the map for 2011, remained without the large amount of data that could affect the spatial distribution of the disease and case density within the territory of the city.

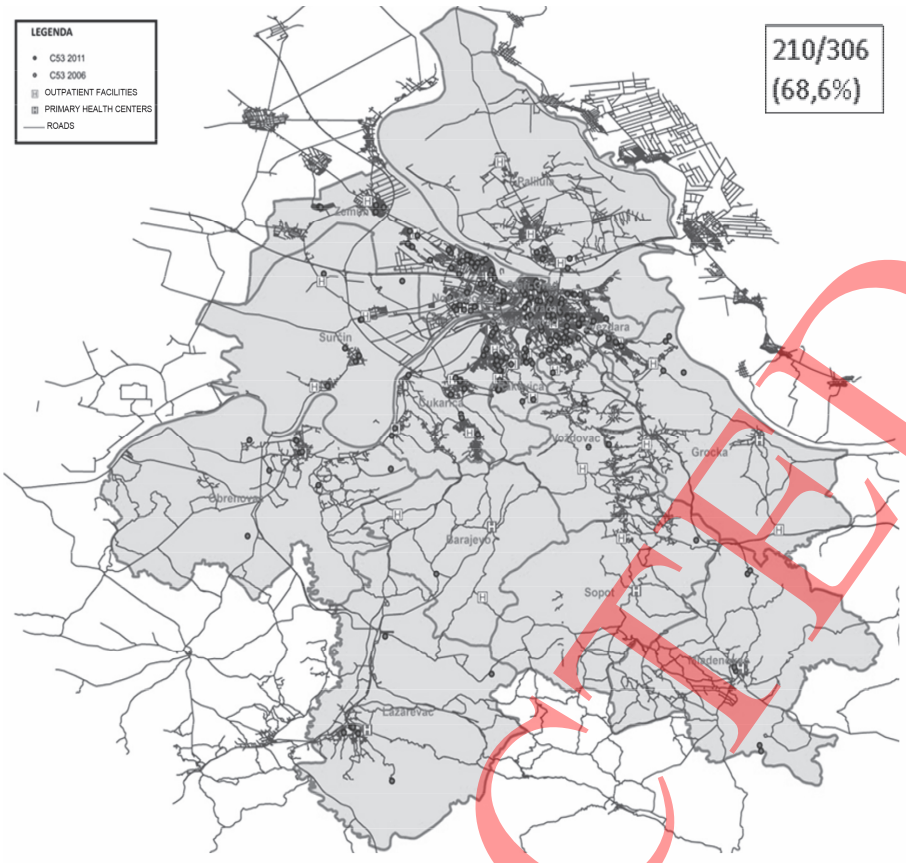

Fig. 4 – Spatial distribution of cervical cancer cases in Belgrade, 2011.
Note: For 210 out of 306 reported cervical cancer patients complete data was available.

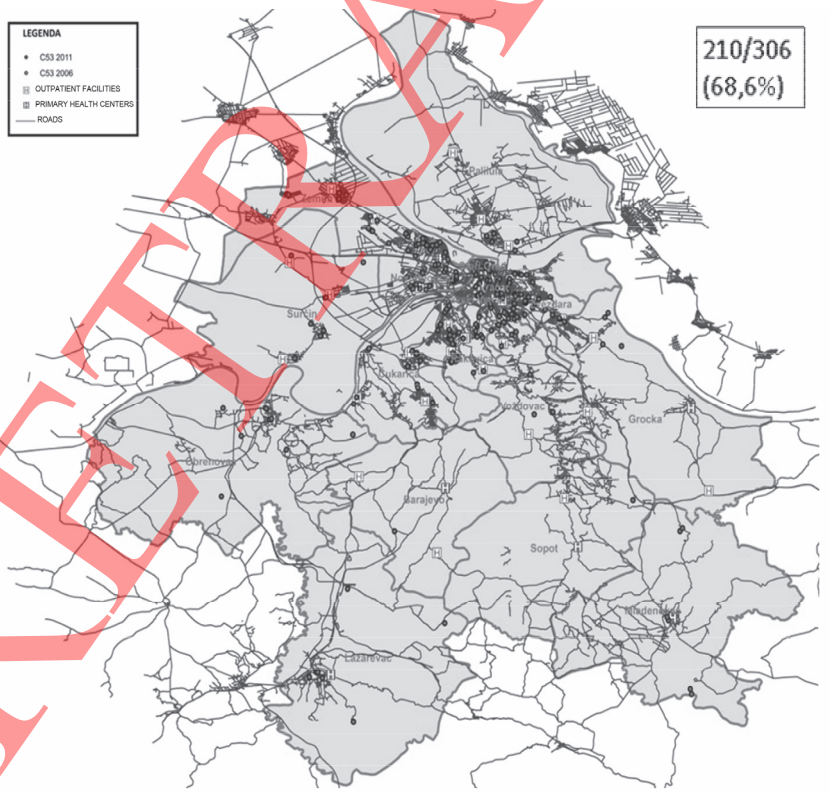

Fig. 5 – Spatial distribution of cervical cancer cases in Belgrade, 2006 and 2011 – a single map.
Note: All usable data simultaneously presented reveals a higher density of cervical cancer patients in the central parts of urban and suburban areas.

A map was formed to analyze the accessibility of gynecological healthcare with data on the spatial distribution of registered cases of cervical cancer in both observed years and the networks of health care institutions of the primary health care where a gynecological examination can be made. The results of mapping the available data did not indicate a regularity of grouping regarding distance from the healthcare institution. Except for parts of municipalities with a higher case density near a health care institution, the registration of individual cases was also noted with residential addresses at up to 20 min of walking distance from the health care institutions, as well as a significant number of cases at destinations farther than the above measure.

The provision of gynecological health care in accordance with current norms for the primary health care during both observed years was met by 13 of 16 Belgrade PHCCs (Table 1). More than 6,500 women per one gynecologist were registered in 2006 in the PHCC in Lazarevac (8,281) and Novi Beograd (7,288), and in 2011 in the PHCC in Zvezdara (7,065), Čukarica (6,875) and Zemun (6,748). The number of women exceeding the amount of the established norm per gynecologist was noted to be higher during this year compared to the previous observed year, despite the average provisions at the city level being at nearly identical values (2006 : 2011 = 5,645 **:** 5,675).

The greatest daily gynecologist workload was reached in 2006 at the health care centers in Lazarevac (44.9), Voždovac (34.8) and Zemun (33.0). During 2011 this parameter of the workload indicator of gynecologists was above 30 visits per day almost only at a single health care centre (Zvezdara 30.5 and Stari grad 33.2) (Table 1). The average daily workload of gynecologists decreased in 2011 compared to 2006 (2006 : 2011 = 28.2 : 21.9).

Table 1

Provision of gynecological health care and daily workload of gynecologists at healthcare centers in Belgrade, 2006 and 2011

Primary Health Center	Number of patients per gynecologist		Average number of daily visits per gynecologist	
	2006	2011	2006	2011
Barajevo	5,282	5,845	22.8	16.7
Voždovac	5,405	5,695	34.8	21.7
Vračar	5,879	4,708	22.4	18.9
Grocka	4,554	5,123	22.2	19.3
Zvezdara	6,125	7,065	25.1	30.5
Zemun	6,546	6,748	33.0	20.8
Lazarevac	8,281	6,402	44.9	13.6
Mladenovac	4,579	4,682	30.4	19.3
Novi Beograd	7,288	5,340	29.1	20.6
Obrenovac	6,076	5,230	30.8	17.5
Palilula	5,037	6,078	25.3	20.2
Rakovica	4,975	5,531	30.5	23.2
Savski venac	2,929	3,794	15.3	19.1
Sopot	4,395	4,472	22.0	10.7
Stari grad	4,649	3,482	27.4	33.2
Čukarica	6,316	6,875	28.4	26.0

Discussion

According to the results of our study, both crude (35.0/100,000) and standardized rate of cervical carcinoma incidence in 2011 (22.9/100,000) was higher than in 2006, but this increase was not significant. The average standardized incidence rate of this malignant tumor among the population of women in Belgrade during the period 2006–2011 was at 21.6/100,000 [6]**.** Within the structure of malignant tumor cases, cervical cancer was in the third place in 2011, after breast cancer and colorectal cancer. Other parts of Serbia had also a higher frequency of colorectal cancer registered [5], explicable through risk factors such as, in addition to the aging population and family history of colorectal cancer, poor diet, smoking, and insufficient physical activity [20]. Similar findings have been noted in other countries, mostly due to the adaptation to lifestyles and behaviors commonly associated with westernization [9, 13, 21].

Incidence rates at the level of municipalities within the territory of Belgrade differed notably. Similar to the results of research abroad, data from research within our area indicates that women living in rural areas are at higher risk of cervical cancer compared to those living in urban areas. This risk is related to failure to undertake preventive examinations, but not because of their place of residence, but the lower level of education and poorer socioeconomic status [22–24]. According to the latest health survey in our country covering the period 2011–2013, the Papanicolaou (Pap) test was undertaken by 75.9% of women from the most prosperous group, 74.0% of highly educated, 72.5% of residents of Belgrade and 62.3% from urban settlements [25]. An unavoidable component was also the positive sum of migration for Belgrade, particularly during the period 1990-1999, when it was altered characteristics (forced migration). Between the last two census years immigration was particularly intensified in settlements outside the core urban area. The highest number of persons arriving found refuge in Zemun settlements, where they comprise around 11% of the population of this municipality [26].

The highest age-specific incidence rates in 2006 were registered in the age groups 55–59 and 40–44, while in 2011 this moved towards younger age groups, 40–44 and 45–49. During the two observed years a statistically significant difference was found for the age groups 30–34, 40–44 and 45–49, pointing towards a necessary analysis of a greater number of years. The risk of cervical cancer increases with age, and in our country the incidence rate was at its maximum between ages 45–49 and 50–54. The shift towards younger age groups can be related to changes in exposure to risk factors. Sexual habits have changed in the sense of earlier onset of sexual activity, a higher number of partners compared to older generations, and tobacco use which is, after oncogenic types of human papilloma virus (HPV), the second most important risk factor for the occurrence of cervical cancer [6, 27, 28].

Applying the process of georeferencing the available data on the precise addresses of residence of patients at the time of diagnosis with the gynecological offices of PHCCs, maps were generated indicating approximately similar spatial patterns of grouping of cervical cancer patients during both observed years.

A higher density of cases was noted in more densely populated areas (in central zones of urban and suburban municipalities) and a lower number of cases in rural municipalities compared to urban parts of the city. Certain parts of the municipalities were with no registered a single case of the disease. During both observed years cases were registered in approximately similar locations compared to the place of residence

Regarding the distance of the place of residence of registered cases of the disease from PHCCs, no correlation or regularity of patient grouping was observed.

Our results are only in regards to the data available for 2006 and 2011, and do not preclude the potential for the existence of a different disease distribution pattern after accounting for data from a greater number of years. Similar study was conducted by researchers from Malaysia. They investigated the spatial distribution cases of colorectal cancer over a ten-year period and measured the distance from existing health facilities. They also had 17.6% of incomplete data. A part of the results revealed higher concentration of cases in major town centers. This concentration of cases is probably due to accessibility of the population to screening facilities. Authors of this study also discussed other results and considered limitations of the study and agreed that it is important to include spatial information as part of the Cancer Registry database. This information can be used for improve efficacy of public health promotion activities, as well as for planning health care delivery [29].

GIS has been used for the needs of the Cancer Registry for more than fifteen years in the USA. Data on all identified cases that are already in the Cancer Registry, are routinely entered into GIS. On that way, it is possible to correlate an incidence with geographical and environmental parameters and discover of the disease emergence patterns within an area [15, 30, 31].

The visualization of case distribution and evaluation of the accessibility of health care institutions can further be used for planning health care services (e.g. screening centers), both in regards to assessing the location of existing health care institutions, as well as to planning the opening of new ones in locations more favorable for the population [31, 32]. The experience of Australian researchers indicates the importance of the distance between the place of residence of those invited for a mammography screening and the place it is being held. A better response was obtained among women from areas where no mammography was organized up to that time and who did not do this preventive examination living up to 3 km from the nearest healthcare units (12%) than among those living at a greater distance (8%). They concluded that the response of the target population could be increased if the existing healthcare facilities were replaced with six new ones, located closer to the areas where the situation is "least favorable" [33]. Researches by a numerous authors produced assessments of the role of accessibility of health care in explaining variations in late-stage breast cancer, by applying GIS and spatial analysis. Researches have shown that poor geographic accessibility regarding distance and time necessary to reach the health care institution, as well as socioeconomic factors, all contribute to the higher development of the late stage of the disease. Similar conclusions were obtained in the studies of the impact of geographical and racial/ethnic variability in uptake of cervical cancer screening, incidence and mortality rate [31, 34–36].

We also analyzed the impact of providing gynecological health care and gynecologist workloads in Belgrade PHCCs during both observed years. The data indicated that the average annual values are below the values recommended by current norms prescribed for performing health care activities at the primary level [17]. Deviations were found in 3 health care centers during each year, with the daily number of gynecologist visits decreasing in 2011 (Table 1). During both observed years gynecological examinations aimed at early detection of malignant disease or examinations containing the Pap test covered around 19% of the population aged 25 and above (19.5% and 18.8%, respectively). Studies have shown that in countries where the incidence of cervical cancer is high, coverage of women through regular gynecological examinations is low. Also, they have shown that the Pap smear use as the primary test, and well organized screening program at the national level could play an important role. These measures could have a major effect on decline in cervical cancer incidence and mortality in the next few decades by detecting and treating precancerous lesions [37–41]. The implementation of organized screening program in Serbia started in December 2012 (in Belgrade at Voždovac, Palilula and Čukarica), but we still are dealing with obstacles, such as low percent of women of target population who have been screened within the program [42, 43].

Limitations of the study

This study had some limitations which have to be pointed out. Case density maps were shown for the two observed years (2006 and 2011), but for 82.0% of the total number of registered cases. For the rest of the cases, precise data on the place of residence at the time of diagnosis were not available. The share of incomplete data was particularly significant in the reports from 2011 (as many as 31.4% of the reports). This data limited the analysis of the spatial distribution of the disease.

Conclusion

The results of cervical cancer incidence mapping in Belgrade showed a greater density of cases among persons with a residential address in central parts of municipalities in the urban and suburban areas during both observed years (2006 and 2011), and identified zones without any registered cases of the disease in nearly all Belgrade municipalities. These zones were noticed due to the visualization method used, and other display methods would left them unrecognized.

Providing a more complete data on precise addresses of residence and expanding research to a wider range of years can initiate the application of other, analytical geographic information system functions. This should contribute to better insight into the epidemiological situation and improving the efficiency of prevention program implementation for cervical cancer.

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