

## GENDER AND AGE STRUCTURE AS RISK FACTORS OF CAROTID ARTERY STENOSIS AND SPECIFIC THEMES AREAS OF CARTOGRAPHY

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**Abstract:** *The stroke prevention project was implemented in the period between 2012 –2017 in the Republic of Srpska when 38,863 patients of both genders were examined. Each of the patients underwent an ultrasound examination of the blood vessels of the neck on both sides. All the examinations were standardized and carried out by specially trained researchers. The presentation of the research results included descriptive statistics and a certain statistical test, which showed a statistically significant difference in carotid artery stenosis in male and female patients. The Geographic Information System was used for mapping carotid artery stenosis with the aim of determining the susceptibility of the population of a particular area, city and/or municipality to this disease and predicting it. The created epidemiological patterns show correlation between age structure and a particular area.*

**Key Words:** *Carotid Artery; GIS; Mapping; Prevention; Risk factors*

### 1 Introduction

Annually, about 4,5 million people die of a stroke, as one of the toughest and most common diseases of modern man. The stroke, regarding its consequences, is the first cause of disability of modern man and, therefore, its prevention is very important (Primatesta et al., 2007). It requires detection of the people with stroke risk factors (high blood pressure, diabetes, heart disease, high blood lipids, overweight people, smokers, people with a family history of stroke and people exposed to stress), as well as detection of pathological changes in the blood vessels of the neck and the head, whose treatment can lead to stroke prevention (Autret et al., 1987; Hennerici et al.,

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1987; O'Holleran et al., 1987; Norris et al., 1991; Inzitari et al., 2000; Thom et al., 2006; Đajić et al., 2015).

In the Republic of Srpska there is a great number of citizens with so-called stroke risk factors, who cannot afford an ultrasound examination. This project provides citizens with a free and fast ultrasound screening of the blood vessels in the neck and the head thus contributing to stroke prevention. The Geographic Information System (GIS) enables identification of epidemiological connection patterns between the risk factors and a particular area.

The aim of this research is to detect pathological changes in the blood vessels of the head and the neck in the people having stroke risk factors as well as to prevent a stroke in order to determine the asymptomatic carotid disease prevalence in general population on the basis of a random sample of patients who underwent an ultrasound examination of the blood vessels in the neck.

Therefore, the mapping is carried out of carotid artery stenosis by using the GIS with the aim of determining the susceptibility of the population of a particular area to a given disease and of predicting it.

## 2 Material and methods

In the period between 2012-2017, 38,863 patients were examined, i.e. 24,411 (62,8%) females and 14,452 (37,2%) males. All the examinees who had asymptomatic stroke (MU) and transient ischemic attack (TIA) were not included in the project. Before the examination, each patient filled in the standardized questionnaire asking for the following information: gender, age, height, weight, education, personal and family anamnesis of previous MU or TIA, heart disease, diabetes, hypertension, hyperlipidemia, smoking, alcoholism. After filling in the questionnaire each of them underwent an ultrasound examination of the blood vessels in the neck on both sides. All these examinations were standardized and carried out by specially trained researchers.

The stroke prevention project on the territory of the Republic of Srpska is carried out with the aim of determining the prevalence of the asymptomatic carotid disease in a representative sample of citizens in the Republic of Srpska. According to the last Census (published in 2017), 1,228,423 citizens live in the Republic of Srpska (Popis BiH, 2013), that is, 1,170,342 citizens (Rezultati popisa u BiH, 2013) (the difference in the number of citizens is due to different methodologies that were applied to conducting the Census). The previous Census was published in 1991, but, due to the war, there was a big migration of the population. This Census could not be used for calculating the number of patients who needed to be examined in certain municipalities; however, the sample was formed on the basis of the list of voters.

Local media and family doctors were previously informed about the project, as well as the local population, through a campaign which consisted of flyers, billboards, posters, media appearances, and so on. Each project participant was invited to come for an examination by a nurse or a family doctor, or he checked in at the local medical institution on his own.

Tabular presentation was carried out using descriptive statistics and the Mann-Whitney U test, by applying analytic-statistic tools of the SPSS (originally called: Statistical Package for the Social Sciences), version 20, while for conducting graphical presentation, the SPSS, version 20 and Microsoft Excel 2007 were used. Creating thematic maps was done in the software ArcMap 10.2. The statistical data, on the basis

Gender and age structure as risk factors of carotid artery stenosis and specific themes areas... of which mapping was carried out, were prepared in Microsoft Excel 2007 (.csv format).

### 3 Research results

On the territory of the Republic of Srpska, starting from 2012, the stroke prevention project has been carried out, with 38,863 examined patients (Table 1).

**Table 1.** Examined patients in the period from 2012 – 2017

Year of examination	Gender of examinee		Total
	male	female	
2012	2284	4095	6379
2013	2 743	4281	7024
2014	2416	4421	6837
2015	3466	5931	9397
2016	2283	3957	6240
2017	1260	1726	2986
Total	14452	24411	38863

The degree of carotid artery stenosis (blockage) ranged from 0 to 100% (in patients of both genders). Median (Md) of stenosis for all patients is 17,00% (in female patients median is less by 5,00% as compared to male patients), Table 2. The average carotid artery stenosis for all patients is 19,03% (but in female patients average stenosis is less by 3,95% as compared to male patients).

**Table 2.** Degree of carotid artery stenosis

Gender of examinee	N	Minimum	Maximum	Median	Mean	Std. Dev.
Male	14452	0	100	20.00	21.51	15.008
Female	24411	0	100	15.00	17.56	12.556
Total	38863	0	100	17.00	19.03	13.654

Figure 1 shows a degree of the carotid artery stenosis according to the gender of the patient.

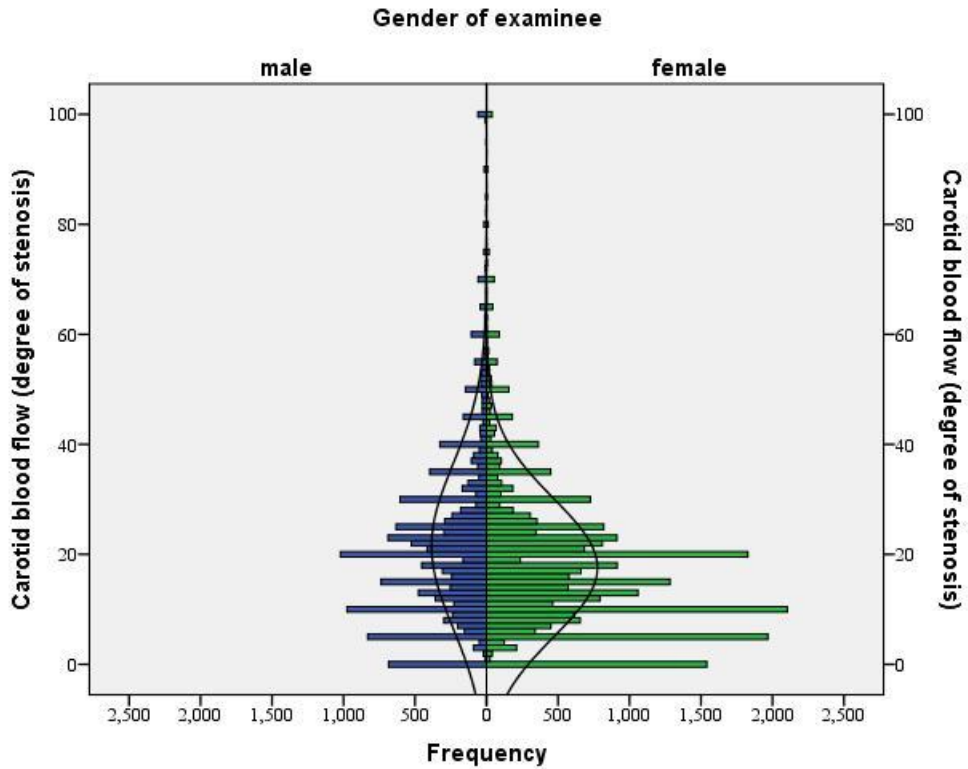
By applying the Mann-Whitney U test, a statistically significant difference is calculated ( $z = -27,485$ ,  $p = 0,000$ ) between carotid artery stenosis in female patients ( $N = 24,411$ ,  $Md = 15,00$ ) and male patients ( $N = 14,452$ ,  $Md = 20,00$ ).

The carotid artery stenosis which is less than 20%, and, therefore, does not require any treatment was found in 21,408 (55,1%) patients (14,631 or 59,9% of all female patients and 6,777 or 46,9% of all male patients).

By observing the percentage of the carotid artery stenosis representation according to gender, one can notice a higher frequency of carotid artery stenosis in male patients (Table 3), as follows:

- stenosis ranging from 20 - 49%: 47,5% in male patients and 37,3% in female patients,
- stenosis ranging from 50 - 69%: 4,1% in male patients and 2,1% in female patients,
- stenosis ranging from 70 - 99%: 1,1% in male patients and 0,5% in female patients, and,

- stenosis of 100%: 0,4% in male patients and 0,2% in female patients.

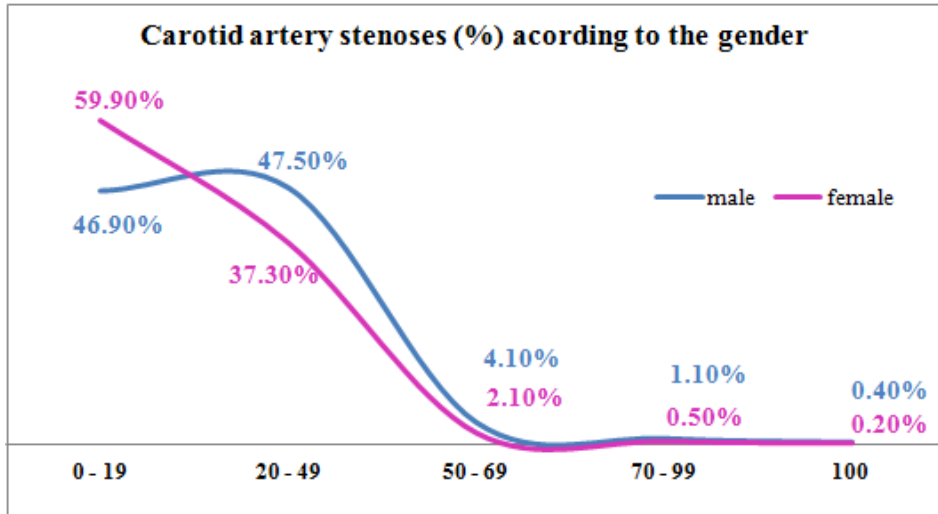


**Figure 1.** Degree of carotid artery stenosis according to the patient's gender

**Table 3.** Degree of carotid artery stenosis /groups/ according to the patient's gender

Carotid artery stenosis (%)		Gender of patient		Total
		male	female	
0-19	N	6777	14631	21408
	%	46.9%	59.9%	55.1%
20-49	N	6870	9109	15979
	%	47.5%	37.3%	41.1%
50-69	N	588	519	1107
	%	4.1%	2.1%	2.8%
70-99	N	157	113	270
	%	1.1%	0.5%	0.7%
100	N	60	39	99
	%	0.4%	0.2%	0.3%
Total	N	14452	24411	38863
	%	37.2%	62.8%	100.0%

Percentage of the presence of carotid artery stenosis /group/ according to the patients' gender is shown in Figure 2.



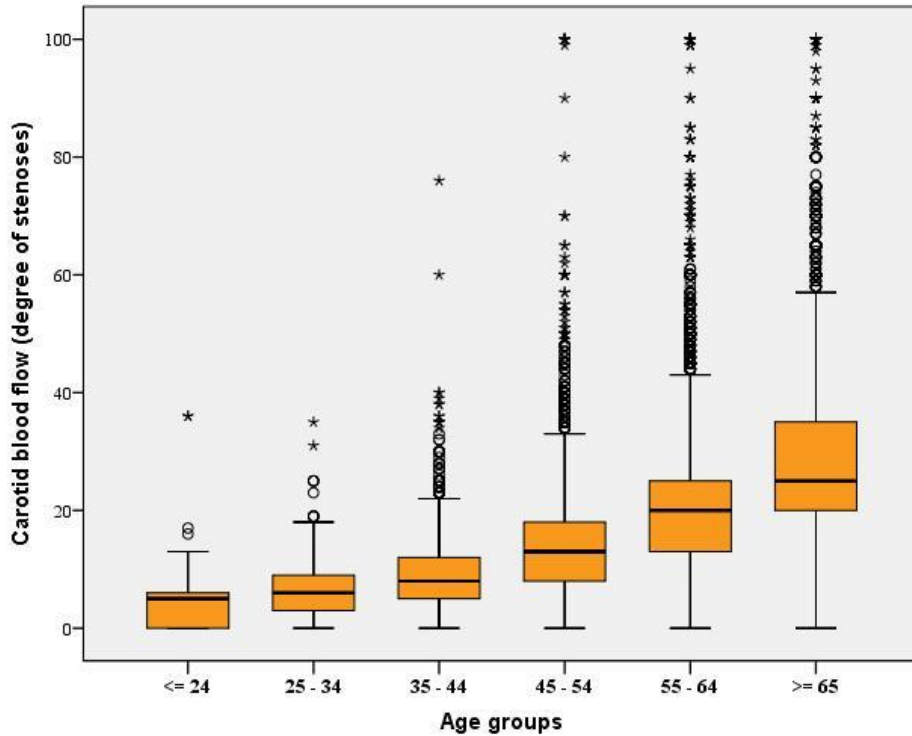
**Figure 2.** Degree of stenosis of carotid artery /groups/ according to the patient's gender

The majority of patients, who underwent an examination, were between 55 and 64 years of age (13,642 or 35,1%); of these 6,679 had carotid artery stenosis ranging from 20 to 49%. Every fourth patient (10,207 or 26,3%) was older than 64, and 779 of them had carotid artery stenosis ranging from 50-69% (70,4% of all patients had carotid artery stenosis ranging from 50-69%); in 189 patients carotid artery stenosis was between 70-99% (70,0% of all patients had carotid artery stenosis between 70 and 99%), and 59 patients had complete blockage of the carotid artery (59,6% of all patients with complete blockage of the carotid artery). The patients who belonged to young age categories had smaller carotid artery stenosis (Table 4).

**Table 4.** Degree of carotid artery stenosis /groups/ according to the patients' age

Age group		Carotid artery stenosis (%)					Total
		0-19	20-49	50-69	70-99	100	
<= 24	N	264	2	0	0	0	266
	%	1.2%	0.0%	0.0%	0.0%	0.0%	0.7%
25 - 34	N	1638	6	0	0	0	1644
	%	7.7%	0.0%	0.0%	0.0%	0.0%	4.2%
35 - 44	N	3915	212	1	1	0	4129
	%	18.3%	1.3%	0.1%	0.4%	0.0%	10.6%
45 - 54	N	6895	2036	33	5	6	8975
	%	32.2%	12.7%	3.0%	1.9%	6.1%	23.1%
55 - 64	N	6560	6679	294	75	34	13642
	%	30.6%	41.8%	26.6%	27.8%	34.3%	35.1%
>= 65	N	2136	7044	779	189	59	10207
	%	10.0%	44.1%	70.4%	70.0%	59.6%	26.3%
Total	N	21408	15979	1107	270	99	38863
	%	55.1%	41.1%	2.8%	0.7%	0.3%	100.0%

Degree of carotid artery stenosis /groups/ according to the patients' age is shown in Figure 3.



**Figure 3.** Degree of carotid artery stenosis /groups/ according to the patients' age groups

#### 4 Creation of thematic maps of the carotid artery

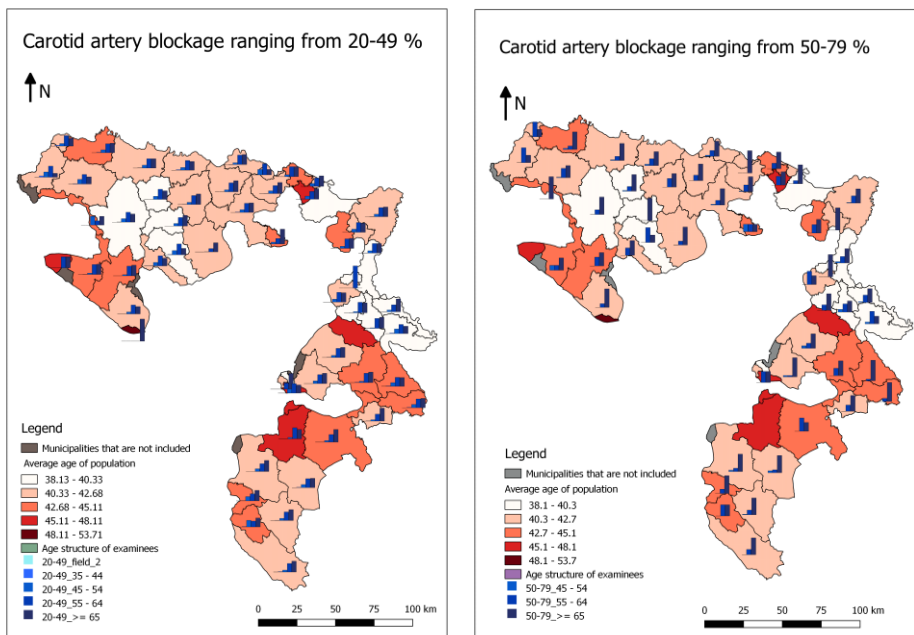
Thematic cartography is a cartographic discipline that enables presentation of spatial arrangement of objects, phenomena and processes that are under study. The Geographic Information System development ensured simpler collecting, processing and visualizing of spatial and associated data. The Geographic Information Systems (GISs) and spatial analysis techniques are powerful tools for describing epidemiological patterns, as well as for detecting, explaining and predicting clusters of diseases in space and time (Tami et al., 2016). The GIS application to mapping anatomic features and clinical events has been infrequent in the GIS and medical literature (Garb et al., 2007). The greatest potential of the GIS is its ability to clearly show the results of complex analyses through maps (Mullner et al., 2004). Unlike tables and spreadsheets with seemingly endless numbers, maps produced by the GIS have the ability to transform data into information that can be quickly and easily communicated. Likewise, these systems also extend the range of problems that can this technology can help solving by allowing the users to more efficiently deal with complex problems (Melnick & Flemming, 1999; Preradović et al., 2017).

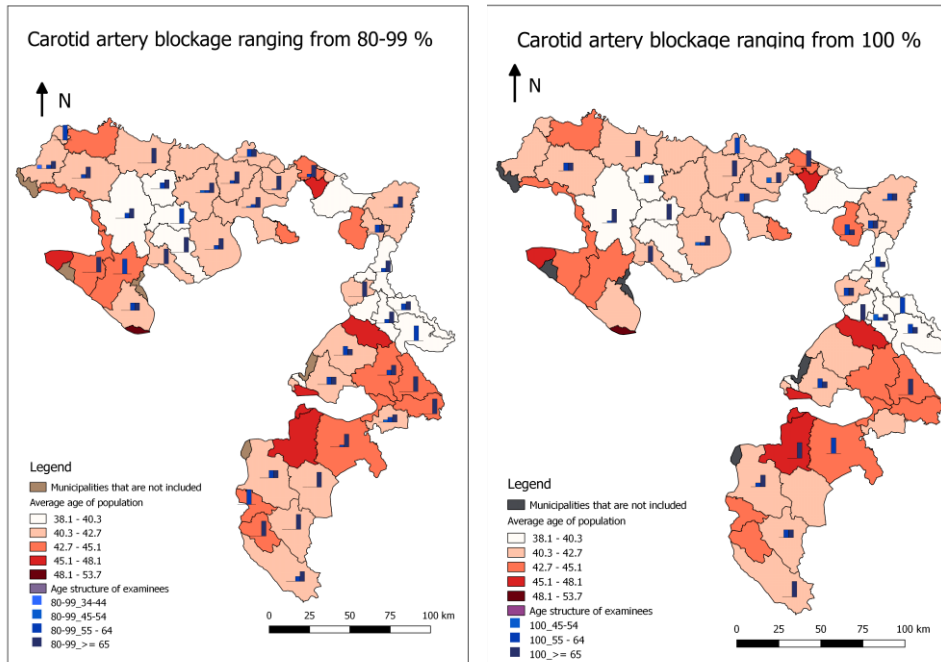
The creation of thematic maps of the carotid artery stenosis (blockage) is done using software of the company ERSI, ArcGIS 10.2. based on data basis. ArcGIS uses an object-relational data base. Simple tables and defined types of attributes allow the

Gender and age structure as risk factors of carotid artery stenosis and specific themes areas... storage of spatial data, and SQL (Structural Query Language) enables creating, modifying and querying the tables. Data are saved in Shapefile format. Geometry of the object in .shp file can be presented by a dot, line or polygon. Apart from the data on geometry, .shp file also contains attributive table which stores descriptive information, such as: the name of municipality, postcode, etc.

Spatial objects (political borders of municipalities in the Republic of Srpska) were used as spatial references for the carotid artery blockage presentation. The borders of municipalities are presented by polygons in .shp format. The cartogram method is used to show prevalence of a certain degree of the carotid artery blockage by the patients' age groups while the average age of population is presented by the coloring method with the category borders defined by the method of natural borders. Data on patients' age and carotid artery blockage are downloaded in .xlsx format. The carotid artery blockage is shown by percentage and sorted in 5 categories (0-19, 20-49, 50-79, 80-99, 100). Average age of population is downloaded from the official site of the 2013 Census of population, households and dwellings in Bosnia and Herzegovina in .xlsx format [10]. As the data in their original form were not suitable for further processing, they were harmonized and sorted. Sorted data were saved in .csv format. .CSV format stores tabular data as plain text and ensures data exchange between different programs and, therefore, it is used in this paper. Connecting spatial and statistical data is carried out on the basis of mutual field (Name of the municipality), by using option *Join*.

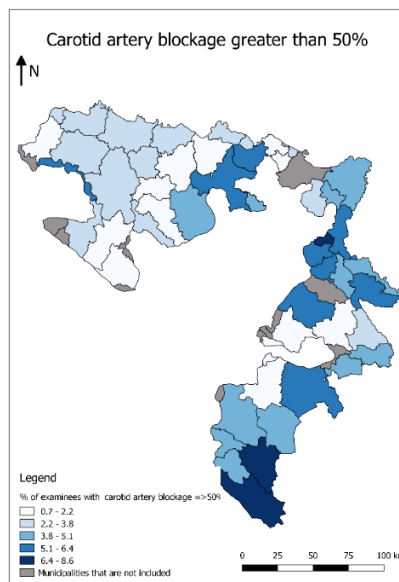
Figure 4 shows carotid artery blockages (separately for each category of carotid artery blockage and age group) by municipalities in the Republic of Srpska.





**Figure 4.** Carotid artery blockage by municipalities in the Republic of Srpska

Figure 5 shows percentages of patients with carotid artery stenosis higher than 50% by municipalities in the Republic of Srpska.



**Figure 5.** Percentage of patients with carotid artery stenosis higher than 50% by municipalities in the Republic of Srpska



Gender and age structure as risk factors of carotid artery stenosis and specific themes areas...

## 5 Conclusion

On the basis of these results, it is evident that the minimal (0 to 19%) carotid artery stenosis in percentage (in relation to the number of examined patients) is more prevalent in female patients, and while the carotid artery stenosis which needs to be treated (conservatively and/or surgically) is more prevalent in male patients. The created epidemiological patterns indicate that the examinees in certain regions (cities and municipalities) have a high risk of a stroke. In accordance with the obtained and presented research results, it is necessary to do an analysis of equipment of medical institutions in vulnerable regions, purchase additional medical equipment and educate health care workers and population, with the aim of reducing the risk of this, very common, disease, with a high mortality rate, whose consequences are very severe – for the patient, family and whole society.

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