



# Gender-related epidemiological characteristics of cauda equina syndrome caused by disc herniation: A 10-year study in Zenica-Doboj Canton, Bosnia and Herzegovina

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## ABSTRACT

**Introduction:** The unrecognized cases of cauda equina syndrome (CES) and the lack of epidemiological data in Bosnia and Herzegovina about this neurosurgical emergency, including the Zenica-Doboj Canton, contribute to the lack of awareness among health-care professionals, potentially leading to delayed diagnosis and referral for surgical decompression. Aim of this study is to analyze gender-related epidemiological characteristics of CES in Zenica-Doboj Canton in 10 years period.

**Methods:** The study was conducted in the Zenica-Doboj Canton, and data were obtained from the time period between 2012 and 2022. The study included a total sample of 1709 patients diagnosed with disc herniation who underwent surgical decompression. In total, 48 patients developed CES.

**Results:** The analysis unveiled noteworthy gender disparities, with male predominance (79.2% vs. 20.8%,  $p < 0.001$ ) and varying employment distributions (males: 23.7% unemployed, 63.2% employed, 13.1% retired; females: 40.0% unemployed, 20.0% employed, 40.0% retired,  $p < 0.001$ ). The calculated OR for 2012-2022 was 2.969 (95% CI: 1.576-5.593), signifying a substantial gender-incidence relationship for CES. CES-I incidence ranged 0.80–1.60/100,000 and CES-R ranged 0.25-0.83/100,000. Highest CES incidence was 4.17/100,000 (2015); the lowest was in 2019 with no CES-R cases reported. Male incidence peaked at 2.64/100,000 (2018), and the lowest was 1.06/100,000 (2013, 2017). For females, the highest was 1.17/100,000 (2018, 2021), with no cases reported in certain years. The affected level demonstrated gender differences, with L4/L5 prevalence in males (47.4%) and L3/L4 in females (50%,  $p = 0.165$ ).

**Conclusion:** This study revealed a higher incidence of CES in males compared to females in the Zenica-Doboj Canton. The heterogeneity of data regarding CES occurring due to the lumbar disc herniation is significant. This indicates a clear need for additional research and epidemiological studies that would highlight the population of patients that have a higher risk of CES onset.

**Keywords:** Gender; neurosurgery; risk; spine; cauda equina syndrome

## INTRODUCTION

The cauda equina represents the bundle of nerves and nerve roots originating from the distal end of the spinal cord. The human spinal cord ceases at the L1-L2 vertebrae level in conus medullaris, which is the anatomical most distal conical part of the spinal cord (1). The collection of spinal

nerve roots that continues distal from conus medullaris, descending toward coccyx and exiting the vertebral canal at a specific vertebral level is marked as cauda equina or "horse tail," which is its Latin translation. This anatomical structure reminding of a rope or tail of fibers, placed at the distal end of the spinal cord, was first described in 1595 by French anatomist Andre du Laurens (2). The nerve fibers that stem from the spinal cord levels L2-S5 and coccygeal nerve contain axons that provide both somatic motor innervation to the muscles of the lower extremities and pelvis, as well as the sensory innervation, such as pain, vibration, and temperature, to the legs, anus, bladder, and perineum (3). The cauda equina contains both

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parasympathetic and sympathetic nerves that regulate bladder function (4,5). Damage to these nerves has serious consequences and significantly impacts a patient's quality of life. Lower back pain is a leading cause of disability globally, particularly in low- and middle-income countries (6). Prior practice indicates a potential avenue for conservative management of herniated discs, which has demonstrated itself as a cost-effective option (7). Despite the advantages inherent to conservative treatment, it is evident that there exists a limitation to this modality in addressing disc herniation, thereby designating surgical intervention as the gold standard (8), particularly in cases where disc herniation culminates in the development of cauda equina syndrome (CES). Removal of sequestered disc material in CES serves to avert numerous protracted complications, underscoring the heightened cost-effectiveness of this therapeutic approach (9).

Hence, CES is an important health condition leading to the compression of the nerve roots of the cauda equina in the lumbar spinal canal leading to the disruption of their structure and function (10). There is a wide palette of symptoms that patients report, ranging from acute or chronic lower back pain, numbness and tingling sensation in legs, muscle weakness, and sciatic nerve pain to the more serious ones, such as the sexual dysfunction, the loss of lower motor function and the bladder and bowel disfunction (11,12). The most common cause of CES is significant herniation of the lumbar disc, usually damaging the L3-L5 nerve roots (13,14). Other potential causes of CES are vascular, traumatic, such as compressive thoracolumbar trauma, inflammatory and neoplastic etiologies (15). The gold standard method for CES diagnosis is the urgent MRI imaging, which should ideally be done in the 1<sup>st</sup> h after the symptoms occur. If the patients have metal in their body or other contraindications to do MRI imaging, the CT myelogram is a possible diagnostic option, although it has limited utility (16).

Lumbar disc herniation (LDH) contributes to approximately 45% of cases of CES, comprising a small fraction (1-3%) of all herniated lumbar discs. Overall, CES incidence, averaged at 1.20/100,000 population annually, consistent with a systematic review indicating an estimated incidence of <1/100,000 population. Notably, CES incidence ranged from 0.5 to 0.6/100,000 annually in asymptomatic community and adult patients, respectively, with a higher incidence of 7/100,000 annually observed in the working-age population (14).

The unrecognized cases of CES and the lack of epidemiological data in Bosnia and Herzegovina about this neurosurgical emergency, including the Zenica-Doboj Canton, contribute to the lack of awareness among healthcare professionals, potentially leading to delayed diagnosis and referral for surgical decompression. Given the rarity of CES and the limited scientific data on its epidemiological characteristics, particularly gender-related information, the aim of this study was to investigate the epidemiological characteristics of patients with diagnosed CES.

**METHODS**

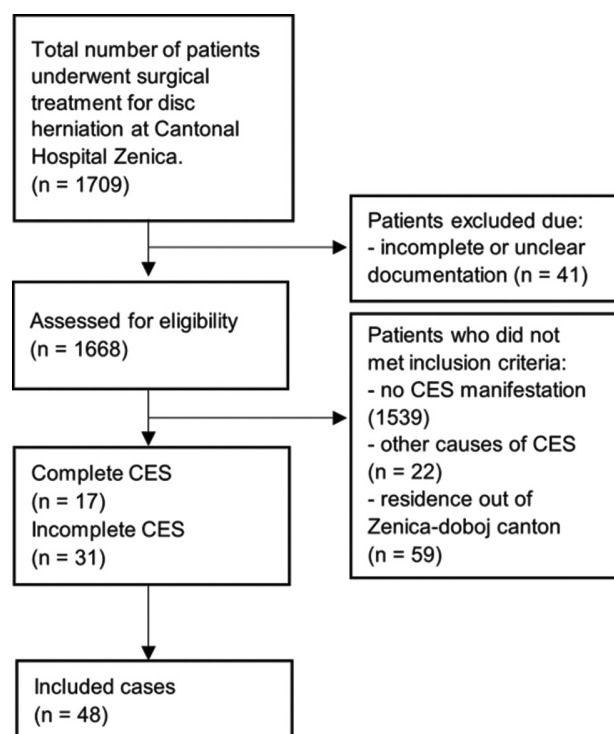
This retrospective epidemiological study was conducted in the Zenica-Doboj Canton from 2012 to 2022. The research

encompassed a total of 1709 patients with confirmed disc herniation, all of whom underwent surgical decompression at the Department of Neurosurgery, Cantonal Hospital Zenica. This department houses a total of 13 beds and serves as the pivotal hub for disc herniation cases in the Zenica-Doboj Canton, catering to an approximate population of 365,000 individuals (17,18), in addition to fulfilling the health-care needs of the Central Bosnia Canton.

Out of 1709 patients, 48 detected that underwent surgical decompression due to the CES caused by the disc herniation. Inclusion criteria for the study were: Patients who underwent surgical decompression as a treatment for CES, patients treated and followed up in the Zenica-Doboj Cantonal Hospital, and patients with disc herniation as a confirmed cause of CES. Patients were excluded if they developed CES due to a tumor or other pathological condition, or if their primary place of residence was outside the Zenica-Doboj Canton (Figure 1).

In addition to collecting patient documentation, the sample evaluation included the analysis of MRI (Magnetom Avanto 1.5 T, Siemens, Erlangen, Germany) or CT (Computed Tomography; Somatom Definition AS, Siemens, Erlangen, Germany) scans. These diagnostic methods were used to further confirm the presence of CES in patients with disc herniation. The categorization of CES into incomplete CES (CES-I) and complete CES (CES-R), was employed (19). CES-I refers to a condition where patients experience dysfunction of the urinary bladder and limited urinary sensation, along with decreased motor sensation, bilateral sciatica, weakness in the legs, and saddle anesthesia. CES-R involves patients with complete urinary retention followed by overflow incontinence, complete loss of bladder control, and fully developed saddle anesthesia (19,20).

Descriptive statistics were used to describe the basic characteristics of the patients. Deviations from normal distribution were ascertained using the Kolmogorov–Smirnov



**FIGURE 1.** Flowchart of data collection strategy.

test. Statistically significant disparities among categorical variables were examined through the Pearson's  $\chi^2$  test. The incidence of CES was calculated using the following formula: (number of CES cases/total number of operated discs herniations)  $\times$  100,000. Odds ratio (OR) was calculated using the formula: (number of males with CES/number of males without CES)/(number of females with CES/number of females without CES). Number of males and females without CES implied the number of operated patients with herniated disc, in whom signs of CES were not manifested. The study is approved by the ethical board of Cantonal Hospital Zenica.

## RESULTS

Table 1 exhibits a notable disparity in gender distribution, with a higher incidence of male cases (79.2%) in contrast to female cases (20.8%), showcasing a statistically significant gender dichotomy ( $p < 0.001$ ). Regarding age distribution, the syndrome manifests predominantly among males aged 18-40 (34.2%), and females aged 41-50 (20.0%) ( $p = 0.207$ ). Significant employment distribution differences were observed between males (23.7% unemployed, 63.2% employed, 13.1% retired) and females (40.0% unemployed, 20.0% employed, 40.0% retired) ( $p < 0.001$ ). The highest OR was recorded in 2014, 4.138 (95% CI: 0.456-37.574), while the lowest was observed in 2013, 0.497 (95% CI: 0.045-5.535). The calculation of the OR for the period from 2012 to 2022 (Table 2) yields a value of 2.969, with a 95% confidence interval ranging from 1.576 to 5.593. This suggests a statistically significant relationship between gender and the incidence of CES.

During the 2012 to 2022 periods, a total of 48 cases of CES were confirmed, of which 31 were classified as CES-I and 17 as CES-R. The number of surgeries performed for disc herniation varied annually, ranging from 105 in 2012 to 199 in 2022, resulting in a total of 1709 surgeries.

The prevalence of CES, relative to the number of disc herniation surgeries, fluctuated between 1.51% and 4.17%. The incidence of CES-I ranged 0.80-1.60/100,000 population, while the incidence of CES-R ranged 0.25 to 0.83/100,000 population. The year with the highest incidence of CES was 2015, with an incidence of 4.17/100,000 population;

**TABLE 1.** Demographic characteristics of patients with cauda equina syndrome (CES)

Variable	Males n (%)	Females n (%)	Total n (%)	p-value
<b>Age (years)</b>				
18-40	13 (34.2)	1 (10.0)	14 (29.2)	0.207
41-50	9 (23.7)	2 (20.0)	11 (22.9)	
51-60	10 (26.3)	2 (20.0)	12 (25.0)	
61-70	2 (5.3)	2 (20.0)	4 (8.3)	
71-80	3 (7.9)	3 (30.0)	6 (12.5)	
>80	1 (2.6)	0 (0.0)	1 (2.1)	
<b>Gender</b>	38 (79.2)	10 (20.8)	48 (100.0)	<0.001
<b>Employment</b>				
Unemployed	9 (23.7)	4 (40.0)	13 (27.0)	<0.001
Employed	24 (63.2)	2 (20.0)	26 (54.2)	
Retired	5 (13.1)	4 (40.0)	9 (18.8)	

N, frequency

the lowest one was 2019 when no cases of CES-R were reported (Table 3).

Among males, the highest incidence of 2.64/100,000 population in 2018, and the lowest one of 1.06/100,000 population in 2013 and 2017, was recorded. For females, the highest incidence of 1.17/100,000 population was observed in 2018 and 2021, in both years; there were no reported cases for females in 2012, 2014, 2015, 2016, 2019, and 2022 (Table 3).

The affected level of the condition showed significant gender differences. Among males, the most frequent affected level was L4/L5, accounting for 47.4% of cases, while in females; L3/L4 was the most common (50%) ( $p = 0.165$ ). The major number of cases in both genders experienced deficits up to 2 days (44.7% for males, 40.0% for females), displaying no gender-specific trend ( $p = 0.788$ ). Furthermore, the evaluation procedures conducted by physicians and specialists did not reveal significant gender disparities. However, it is noteworthy that none of the family doctors or general practitioners conducted a comprehensive neurological examination of the patient (Table 4).

## DISCUSSION

The CES is considered an emergency condition in neurosurgery and if it is not diagnosed on time, the patient can develop life-long disability and health impairment. However, CES is a rare disease and it is noted in 1 in 30,000-100,000 people per year (10). In general, around 45% of CES is caused by the LDH and it composes 1-3% of all herniated lumbar discs. In addition, around 2-6% of lumbar disc operations lead to the CES development (14). Our study showed that the prevalence of CES fluctuated in the 10-year period between 1.51% and 4.17% cases per year in surgically treated disc herniated patients. The overall incidence of CES, encompassing both CES-I and CES-R cases, averaged at 1.20/100,000 population annually. This is in accordance with findings of a systematic review where the estimated incidence of CES was <1/100 000 population. The incidence of CES was up to 0.5/100,000 per year in asymptomatic community patients, while the incidence increased up to 0.6/100,000 per year in asymptomatic adult patients. In the working-age population, the incidence increased to seven patients per 100,000 per year (21).

In our study, individually, the incidence of CES-I stood at 0.77/100,000 population, whereas the incidence of CES-R reached 0.42/100,000 population. The outcome of CES-I more favorable when compared to CES-R, but only if there is an urgent surgical decompression of the cauda equina nerve fibers within 48 h. The surgery is still the best option for CES treatment and it is accomplished by laminectomy or discectomy. After the time period of 48 h, the possibility of permanent damage to the bladder and bowel function is increased, as well as of the sexual impotence and continuous pain (20). Another population study conducted in Scotland by Woodfield et al. (22) recorded the CES incidence to be as high as 2.7/100,000 per year. However, this study showed that the CES developed more often in females and when compared with males. Dias et al. (23) noted that among the cases of CES occurring due to the herniated discs, the percentage of female (59%) patients was higher

**TABLE 2.** Epidemiological data of cauda equina syndrome (CES) from 2012 to 2022 in Zenica-Doboj Canton

Year	N of CES	CES-I	CES-R	N of surgical decompressions of HD	I of HD (%)	Total I (n/100000)	I of CES-I	I of CES-R
2012	3	1	2	105	2.86	0.80	0.25	0.50
2013	3	2	1	161	1.86	0.80	0.55	0.27
2014	4	3	1	120	3.33	1.10	0.83	0.28
2015	5	4	1	144	3.47	1.40	1.10	0.28
2016	5	4	1	150	3.33	1.40	1.11	0.28
2017	3	1	2	177	1.69	0.80	0.28	0.56
2018	7	4	3	196	3.57	1.90	1.11	0.83
2019	4	4	0	182	2.20	1.10	1.12	0.00
2020	5	3	2	131	3.82	1.40	0.84	0.56
2021	6	4	2	144	4.17	1.60	1.10	0.55
2022	3	1	2	199	1.51	0.90	0.28	0.57
Total	48	31	17	1709	2.81	1.20	0.77	0.42

N: Frequency, CES: Cauda equina syndrome, CES-I: Incomplete cauda equina syndrome, CES-R: Complete cauda equina syndrome, HD: Herniated disc, I: Incidence

**TABLE 3.** Gender-related characteristics of patients with cauda equina syndrome (CES) in Zenica-Doboj Canton

Year	Male N (I/100000)	Female N (I/100000)	OR	CI (95%)	
				Lower	Upper
2012	3 (1.43)	0 (0)	3.088	0.316	30.178
2013	1 (0.52)	2 (1.15)	0.497	0.045	5.535
2014	4 (2.09)	0 (0)	4.138	0.456	37.574
2015	5 (2.62)	0 (0)	5.180	0.598	44.899
2016	4 (2.11)	1 (0.58)	4.082	0.451	36.958
2017	2 (1.06)	1 (0.58)	2.011	0.181	22.385
2018	5 (2.64)	2 (1.17)	2.539	0.487	13.248
2019	4 (2.12)	0 (0)	4.090	0.453	36.949
2020	3 (1.6)	2 (1.18)	1.512	0.248	9.199
2021	4 (2.09)	2 (1.15)	2.029	0.366	11.254
2022	3 (1.62)	0 (0)	3.046	0.314	29.534
Total	38 (1.8)	10 (0.52)	2.969	1.576	5.593

N: Frequency, I: Incidence, OR: Odds ratio, CI: Confidence interval

than male (41%), but without statistical significance. In Sweden, between the years 2000 and 2010, in the national Swedish spine register (SweSpine) there was also predominance of males (56%) over females (24). This is also supported by the large study conducted by Fjeld et al. (25) in Norwegian public hospitals showed that in the period 1999-2013. There were 19 623 male and 15 016 female patients diagnosed with LDH (25). Our study findings are consistent with previous observations.

A higher prevalence of CES development in males can be linked to more frequent exposure to intense physical activities related to work (26) or professional sports (27). Body height and weight also constitute risk factors (28), and within the context of Bosnia and Herzegovina, it is recognized that the male gender exhibits greater values of body height, as indicated by Pojskic and Eslami (29). The reduction in spinal canal diameter, as well as its anteroposterior relationship to vertebral body, known as the Torg-Pavlov ratio, according to Jaganjac et al. (6), may represent a risk factor for CES development. The reduction in spinal canal diameter is associated with degenerative spinal diseases, including degenerative disc disease, which in its terminal sequestration stage results in CES occurrence. Age is another risk factor for both male and female populations, with the threshold of 40+ years signifying a significant risk factor according to Schoenfeld and Bader (30).

**TABLE 4.** Public health-related characteristics of patients with cauda equina syndrome (CES)

Variable	Males n (%)	Females n (%)	Total n (%)	p-value
<b>Affected Level</b>				
L2/L3	7 (18.4)	0	7 (14.6)	0.165
L3/L4	8 (21.1)	5 (50.0)	13 (27.1)	
L4/L5	18 (47.4)	3 (30.0)	21 (43.8)	
L5/S1	5 (13.2)	2 (20.0)	7 (14.6)	
<b>Duration of deficit (days)</b>				
up to 2	17 (44.7)	4 (40.0)	21 (43.8)	0.788
3-7	5 (13.2)	3 (30.0)	8 (16.7)	
8-10	9 (23.7)	0 (0.0)	9 (18.8)	
11-30	5 (13.2)	2 (20.0)	7 (14.6)	
31-60	0 (0.0)	1 (10.0)	1 (2.1)	
61-90	1 (2.6)	0 (0.0)	1 (2.1)	
>90	1 (2.6)	0 (0.0)	1 (2.1)	
<b>Examination by family physician or general practitioner</b>				
Yes	0	0	0	1.000
No	38 (79.2)	10 (20.8)	48 (100.0)	
<b>Examination by neurologist</b>				
Yes	19 (73.1)	7 (26.9)	26 (54.2)	0.259
No	19 (86.4)	3 (13.6)	22 (45.8)	
<b>Examination by neurosurgeon</b>				
Yes	19 (86.4)	3 (13.6)	22 (45.8)	0.259
No	19 (73.1)	7 (26.9)	26 (54.2)	

N: Frequency

Length of occupational tenure constitutes a risk factor [27]. According to the study by Batic-Mujanovic et al. (31), it is observed that men have a higher employment rate compared to women in Bosnia and Herzegovina, leading to the conclusion that men are more exposed to physical factors such as lumbar spine loading.

Gender-associated dissimilarities do not manifest in the affected spinal segments, as CES predominantly affects the L4/L5 level in males and the L3/L4 level in females. Rider and Marra (1) highlight L3-L5 as the most frequently affected levels by sequestered discs. Strömqvist et al. (32) report that disc herniation predominantly occurs at the L4/L5 level in both genders. Prior studies have not observed data on discrepant vertebral level involvement in CES. Symptoms were majorly presented up to 2 days without gender-specific trend in this study. Developing countries are often associated with longer symptoms duration (33-35),

which consequently leads to postponement of surgical intervention (20).

Access to patients exhibiting CES symptoms poses a significant public health challenge. Clinical distinctions between disc herniation and CES are evident. Suspicions of CES can arise at primary healthcare centers through neurological examinations. A mere 50% of patients underwent a comprehensive neurological evaluation by neurologists and neurosurgeons, which is additionally concerning. Prior research emphasizes the urgency of this condition (10) and the improved outcomes linked to early intervention (20). Hence, primary healthcare's role is pivotal in suspecting CES and referring patients for neurosurgical treatment (34,35).

Study limitations include its retrospective design potentially introducing bias, limited generalizability due to a single-center approach, and lack of primary healthcare examination data. Therefore, a more comprehensive monitoring across Bosnia and Herzegovina for CES is recommended, along with involving primary healthcare professionals in educational programs to raise awareness about the importance of early CES diagnosis.

## CONCLUSION

CES poses a critical health concern, requiring timely diagnosis and intervention to prevent debilitating consequences. Its rarity belies its significant impact, with LDH as a key contributor. Gender-related differences, occupational factors, and age play roles in CES development, underscoring the need for heightened clinical awareness. Primary healthcare's role in early detection and referral is pivotal to mitigating CES's potentially lifelong effects.

## DECLARATION OF INTERESTS

The authors declare no conflicts of interest.

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