







EPIDEMIOLOGICAL STUDY OF TRAUMATIC FRACTURES IN THE CERVICAL SPINE IN A PUBLIC HOSPITAL IN THE STATE OF SÃO PAULO

ESTUDO EPIDEMIOLÓGICO DAS FRATURAS TRAUMÁTICAS DA COLUNA CERVICAL EM UM HOSPITAL PÚBLICO DO ESTADO DE SÃO PAULO

ESTUDIO EPIDEMIOLÓGICO DE FRACTURAS TRAUMÁTICAS DE COLUMNA CERVICAL EN UN HOSPITAL PÚBLICO DEL ESTADO DE SÃO PAULO

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ABSTRACT

O estudo teve como objetivo realizar análise retrospectiva dos pacientes com fratura traumática de coluna cervical realizado no Hospital Estadual Mário Covas localizado no município de Santo André no estado de São Paulo, nos meses de janeiro de 2018 a dezembro de 2022. Os dados foram coletados dos prontuários e do banco de imagem radiográfico no serviço de arquivo médico-estatístico do Hospital. As variáveis analisadas foram: faixa etária, sexo, mecanismo do trauma, vértebras acometidas, tipo de fratura e déficit neurológico. 89 indivíduos satisfizeram os requisitos de inclusão e exclusão. As lesões traumáticas da coluna cervical foram mais frequentes nos adultos com idade produtiva do sexo masculino, o mecanismo de trauma mais prevalente foi queda de altura, a vértebra mais acometida foi C2 seguida por C6, a grande maioria dos pacientes não tinha déficit neurológico e o tratamento mais indicado foi o não cirúrgico. Obtendo uma compreensão dos fatores envolvidos nesse processo e das consequências de lesões, é de suma importância o planejamento da saúde pública e estratégias de promoção e prevenção das lesões traumáticas da coluna cervical. **Nível de Evidência III; Estudo Retrospectivo.**

Descritores: Fraturas da Coluna Vertebral; Vértebras Cervicais; Epidemiologia.

RESUMO

The study aimed to carry out a retrospective analysis of patients with traumatic fractures of the cervical spine carried out at Mário Covas State Hospital in Santo André, São Paulo, from January 2018 to December 2022. Data were collected from medical records and radiographic image database in the Hospital's medical-statistical service. The variables analyzed were age group, gender, mechanism of trauma, affected vertebrae, type of fracture and neurological deficit. 89 individuals met inclusion and exclusion requirements. Traumatic injuries to the cervical spine were more frequent in working-age male adults, the most prevalent trauma mechanism was falling from height, the most affected vertebra was C2 followed by C6, the vast majority of patients had no neurological deficit and the most recommended treatment was non-surgical. Obtaining an understanding of the factors involved in this process and the consequences of injuries, public health planning and strategies for the promotion and prevention of traumatic cervical spine injuries are paramount importance. **Level of Evidence III; Retrospective Study.**

Keywords: Spinal Fractures; Cervical Vertebrae; Epidemiology.

RESUMEN

El estudio tuvo como objetivo realizar un análisis retrospectivo de pacientes con fracturas traumáticas de la columna cervical realizado en el Hospital Estatal Mário Covas ubicado en la ciudad de Santo André en el estado de São Paulo, de enero de 2018 a diciembre de 2022. Los datos se recolectaron de las historias clínicas y del banco de imágenes radiográficas del servicio de archivo médico-estadístico del Hospital. Las variables analizadas fueron: grupo de edad, sexo, mecanismo del trauma, vértebras afectadas, tipo de fractura y déficit neurológico. 89 individuos cumplieron con los requisitos de inclusión y exclusión. Las lesiones traumáticas en la columna cervical fueron más frecuentes en hombres adultos en edad laboral, con una distribución uniforme entre los grupos de edad, el mecanismo traumático más frecuente fue caída de altura, la vértebra más afectada fue la C2 seguida de la C6, la gran mayoría de los pacientes no presentaban déficits neurológicos, y el tratamiento más recomendado fue el no quirúrgico. Obtener una comprensión de los factores implicados en este proceso y las consecuencias de las lesiones, la planificación de salud pública y las estrategias para la promoción y prevención de las lesiones traumáticas de la columna cervical son de suma importancia. **Nivel de Evidencia III; Estudio Retrospectivo.**

Descriptor: Fracturas de la Columna Vertebral; Vértebras Cervicales; Epidemiología.

Study conducted by the Faculdade de Medicina do ABC (FMABC), Orthopedics and Traumatology Specialization Service in Spine Surgery, Santo André, SP, Brazil.

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INTRODUCTION

The cervical spine consists of seven highly specialized vertebrae located between the skull proximally and the thoracic vertebrae distally. The cervical spine supports the head and its movements, protects the spinal cord, and is a channel for the brain's vascular supply through the transverse foramen located laterally in the C3 to C7 vertebrae.¹

The incidence of traumatic cervical spine fractures is estimated at 15–65/100,000 hospital admissions annually. And most cervical spine fractures are not associated with spinal cord injury.²

A study conducted in the United Kingdom estimated that approximately 1,000 people suffer a spinal cord injury every year, with cervical spine injuries accounting for a significant proportion of these injuries.³ There are 10,000 to 12,000 new spinal cord injuries every year in the USA, with two-thirds of the patients being under 30 years old.¹

The literature reveals that traumatic spinal cord injury occurs predominantly in males, at a ratio of 4:1, in the age group between 15 and 40 years, that is, at the peak of their productivity.⁴

Vertebral fractures usually result from high-energy trauma; however, in elderly patients or those with comorbidities, they can result from low-energy trauma (such as a fall from standing height).⁵

Spinal trauma is a significant source of morbidity and mortality in the USA. Cervical spine trauma, in particular, is associated with high costs and longer hospital stays.⁶ Given the risk of irreversible sequelae, which affect not only the patient but also the family and society, there is a significant impact on Public Health in Brazil.⁷

The existing scientific literature in Brazil provides little epidemiological information on traumatic cervical spine fractures, therefore the present study aimed to conduct an epidemiological analysis of patients with traumatic cervical spine fractures treated at the Mario Covas State Hospital.

METHODOLOGY

Research design

This is an observational, descriptive, retrospective, cross-sectional quantitative study. Conducted at the premises of the Mário Covas State Hospital located in the municipality of Santo André in the state of São Paulo, from January 2018 to December 2022.

Inclusion and exclusion criteria

Patients treated with a diagnosis of fracture and/or dislocation of the cervical spine at the Mario Covas State Hospital from January 2018 to December 2022, who underwent surgical or non-surgical treatment, were included. The exclusion criteria were patients with fracture and/or dislocation of the spine outside the established period; patients with thoracolumbar spine fracture; non-traumatic fractures; pathological fractures and patients with incomplete data in their medical records.

Data collection procedure

The data were collected from the medical records and the radiographic image bank filled and archived at the Mário Covas State Hospital from January 2024 to February 2024, after approval by the ethics and research committee by Plataforma Brasil. (CAAE: 75334523.6.0000.0082)

The variables analyzed were: age group, gender, education level, marital status, trauma mechanism, affected vertebrae, type of fracture (AO Spine classification)⁸ and neurological deficit (ASIA classification - American Spinal Injury Association/ Frankel).^{9,10}

Data analysis

The data were consolidated in the form of relative and absolute numbers, as well as ratio and proportion. Presented in the form of tables and graphs. Stored in Microsoft® Excel spreadsheets and Google® forms and analyzed with descriptive statistics using the BioEstat 5.3 program, with a p-value of 5% (0.05) being accepted as a significant difference.

Inferential analysis was performed using non-parametric statistical tests, Chi-square Goodness of Fit for equal expected proportions, and G Test of Independence, all applied considering the significance level $\alpha = 0.05$.

RESULTS

Initially, 115 patients were identified as hospitalized between January 2018 and December 2022 with a diagnosis of cervical spine fracture and/or dislocation. Of these, 26 were excluded for not meeting the established inclusion and exclusion criteria. In the end, 89 patients were included in the study, with 79% being male and 21% female, with an average age of 49.7 years (standard deviation of ± 18.4). Female individuals with an average age of 64.6 years, and men with 45.7. The male individuals had a uniform distribution across age groups, and in females, we observed a higher prevalence > 60 years. According to Tables 1 and 2 and Figure 1.

Table 1. Information about the epidemiological data of the researched patients, referring to the period from January 2018 to December 2022, at the Mario Covas State Hospital - Santo André, São Paulo, Brazil.

| Variable | Quantity (n = 89) | Percentage | p-value |
|--------------------------|-------------------|------------|---------|
| Age Range (Years) | | | |
| 0- 18 | 0 | 0.00% | 0.1135 |
| 19- 30 | 15 | 16.85% | |
| 31- 40 | 16 | 17.98% | |
| 41- 50 | 14 | 15.73% | |
| 51- 60 | 16 | 17.98% | |
| > 60 | 28 | 31.46% | |
| Sex | | | |
| Male | 70 | 78.65% | <0.0001 |
| Female | 19 | 21.35% | |

p-value < 0.05 (Chi-square Goodness of Fit Test); Significance level $\alpha = 0.05$. Source: SAME of Hospital Mario Covas - Santo André.

Table 2. Age group and gender of the patients surveyed, referring to the period from January 2018 to December 2022, at the Mario Covas State Hospital - Santo André, São Paulo, Brazil.

| Age Group | Sex | | | | Total | Percentage | p-value |
|-----------|------|------------|--------|------------|-------|------------|---------|
| | Male | Percentage | Female | Percentage | | | |
| 0- 18 | 0 | 0.00% | 0 | 0.00% | 0 | 0.00% | 0.0493 |
| 19- 30 | 14 | 15.73% | 1 | 1.12% | 15 | 16.85% | |
| 31- 40 | 13 | 14.61% | 3 | 3.37% | 16 | 17.98% | |
| 41- 50 | 13 | 14.61% | 1 | 1.12% | 14 | 15.73% | |
| 51- 60 | 15 | 16.85% | 1 | 1.12% | 16 | 17.98% | |
| > 60 | 15 | 16.85% | 13 | 14.61% | 28 | 31.46% | |

p-value < 0.05 (G Test of Independence); Significance level $\alpha = 0.05$. Source: SAME of Hospital Mario Covas - Santo André.

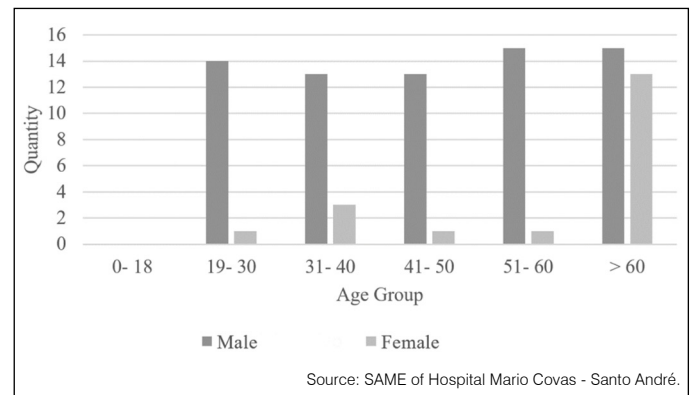


Figure 1. Age group and gender of the patients surveyed, referring to the period from January 2018 to December 2022, at the Mario Covas State Hospital - Santo André, São Paulo, Brazil.

Regarding the trauma mechanism, the highest prevalence was falling from a height, accounting for 34% of the participants, according to Table 3.

The Frankel scale E (63%) was the most prevalent, followed by types D (15%) and A (12%). According to Table 4.

Non-surgical treatment was the most performed with 54% of participants, being surgical in 46% of cases (Figure 2).

The most common type of subaxial fracture/dislocation was A0, based on the AO Spine classification, with 23% of cases, followed by type C (20%). According to Table 5.

As noted in Table 6, the most affected vertebra in our study was C2, accounting for 24% of the cases, followed by the C6 vertebra (14.4%). The vast majority of fractures occurred in the subaxial segment (C3-C7), accounting for 68.3% of the cases.

Table 3. Mechanism of trauma of the researched patients, referring to the period from January 2018 to December 2022, at the Mario Covas State Hospital - Santo André, São Paulo, Brazil.

| Mechanism of Injury | Quantity | Percentage | p-value |
|------------------------------------|----------|------------|---------|
| Car accidents | 21 | 24 | <0.0001 |
| Motorcycle accidents | 10 | 11 | |
| Fall from height | 30 | 34 | |
| Fall to the ground | 14 | 16 | |
| Gunshot wound | 2 | 2 | |
| Shallow water diving | 4 | 4 | |
| Cycling accidents | 1 | 1 | |
| Physical aggression | 1 | 1 | |
| Heavy material falling on the body | 4 | 4 | |
| Others | 2 | 2 | |
| Total | 89 | 100 | |

p-value < 0.05 (G Test of Independence); significance level $\alpha = 0.05$. Source: SAME of Hospital Mario Covas - Santo André.

Table 4. Frankel scale of the patients surveyed, referring to the period from January 2018 to December 2022, at the Mario Covas State Hospital - Santo André, São Paulo, Brazil.

| Frankel Scale | Quantity | Percentage | p-value |
|---------------|----------|------------|---------|
| A | 11 | 12 | <0.0001 |
| B | 3 | 3 | |
| C | 6 | 7 | |
| D | 13 | 15 | |
| E | 56 | 63 | |
| Total | 89 | 100 | |

p-value < 0.05 (Chi-square Goodness of Fit Test); significance level $\alpha = 0.05$. Source: SAME of Hospital Mario Covas - Santo André.

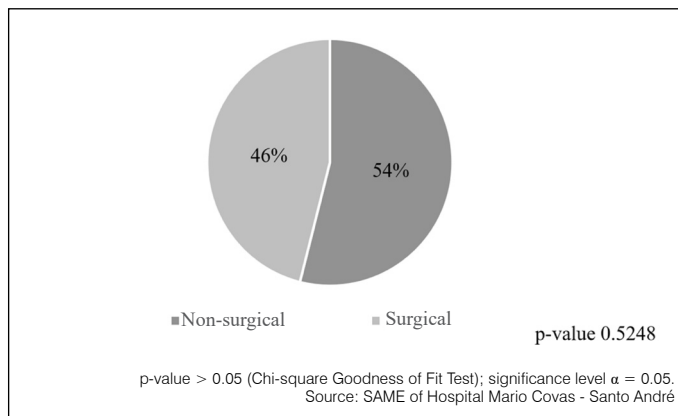


Figure 2. Therapeutic outcome of the researched patients, referring to the period from January 2018 to December 2022, at the Mario Covas State Hospital - Santo André, São Paulo, Brazil.

Table 5. AO Spine classification of subaxial fractures (C3-C7) of the researched patients, referring to the period from January 2018 to December 2022, at the Mario Covas State Hospital - Santo André, São Paulo, Brazil.

| AO Spine Classification (Subaxial C3-C7) | Quantity | Percentage | p-value |
|--|----------|------------|---------|
| A0 | 16 | 23% | <0.0001 |
| A1 | 9 | 13% | |
| A2 | 2 | 3% | |
| A3 | 1 | 1% | |
| A4 | 12 | 17% | |
| B1 | 4 | 6% | |
| B2 | 10 | 14% | |
| B3 | 3 | 4% | |
| C | 14 | 20% | |
| Total | 89 | 100% | |

p-value < 0.05 (Chi-square Goodness of Fit Test); significance level $\alpha = 0.05$. Source: SAME do Hospital Mario Covas - Santo André.

Table 6. Consolidated on the vertebrae or segments affected of the researched patients, referring to the period from January 2018 to December 2022, at the Mario Covas State Hospital - Santo André, São Paulo, Brazil.

| Vertebral/ Affected Segment | Quantity | Percentage | p-value |
|-----------------------------|----------|------------|---------|
| C0 | 1 | 1.0% | <0.0001 |
| C1 | 7 | 6.7% | |
| C2 | 25 | 24.0% | |
| C3 | 4 | 3.8% | |
| C4 | 4 | 3.8% | |
| C5 | 11 | 10.6% | |
| C6 | 15 | 14.4% | |
| C7 | 9 | 8.7% | |
| C3-C4 | 1 | 1.0% | |
| C4-C5 | 6 | 5.8% | |
| C5-C6 | 11 | 10.6% | |
| C6-C7 | 10 | 9.6% | |
| Total | 104 | 100.0% | 0.0003 |
| High cervical fractures | 33 | 31.7% | |
| Subaxial fractures | 71 | 68.3% | |
| Total | 104 | 100.0% | |

p-value < 0.05 (Chi-square Goodness of Fit Test); significance level $\alpha = 0.05$. Source: SAME do Hospital Mario Covas - Santo André.

DISCUSSION

Studies on the epidemiology of spinal cord injury have been extensively conducted in recent decades. In developing countries, it is essential to know and predict how to use limited resources in order to benefit the entire population.

It is already well established in the global literature that there is a higher prevalence of spinal fractures in males, especially among economically active individuals in the population.¹¹⁻²¹ We can attribute this unequal distribution between the sexes to the fact that men engage in activities with a higher risk of work-related accidents, the tendency to do manual work alone at home, and excessive alcohol consumption.²² The higher prevalence of spinal fractures in this age group has negative socioeconomic consequences for society, as it involves individuals in their prime productive age. Soon, the various injuries, temporary or permanent, as well as deaths, interrupt work activities, ceasing to generate income and production for the economic system, in addition to incurring high costs to the health system, with hospitalizations and rehabilitations.²³

A national study conducted in Norway with 3248 patients identified a higher prevalence of males, with an average age of 52 years for men and 63 years for women.¹² This data was also found in this study, as well as in others in the global literature.¹³⁻¹⁷

These facts may be associated with the high incidence of falls and traffic accidents as a mechanism of trauma associated with cervical spine fractures, with falls being the most common mechanism in elderly women and traffic accidents in young adults.

Moraes et al. conducted a study on the characteristics of falls in the elderly population, where they found the highest prevalence in elderly women.²⁴ This prevalence in elderly women is due to hormonal factors, highlighting menopause which can lead to greater loss of bone cells and, simultaneously, greater instability in walking, postural problems, thus being one of the risk factors for falls.²⁴⁻²⁶

The AO Spine classification is widely used in cervical spine fractures as a tool to identify the type of fractures and the likely forces acting on the fracture.⁸ In this study, type A0 was observed as the most predominant, minor fractures without structural injuries, such as an isolated fracture of the lamina or spinous process, with a lower incidence of neurological deficit and, therefore, more permissive to non-surgical treatment. Not in agreement with Kanna et al.¹⁵ who observed the most common type of AO spine classification being B (33.1%), and Negrelli et al.¹⁷ that type C was the most common.

A literature review conducted by Beeharry et al. identified that the most affected vertebrae in the cervical spine are C2 followed by C7, corroborating the findings in this study.²⁷ The greater involvement of the C2 vertebra may be associated with the higher prevalence of individuals without neurological deficit at their first consultation (Frankel E), as identified in this study, as well as in others in the literature.¹⁵⁻¹⁷ This finding is consistent with the literature and can be explained by the difference in the size of the spinal canal between the upper cervical and subaxial spine.²⁸⁻³¹

CONCLUSION

Traumatic injuries of the cervical spine were more frequent in adult males of productive age. In females, we identified a higher prevalence > 60 years. The most common mechanism of trauma was a fall from height. The vast majority of patients were classified as Frankel E. The most affected vertebra was C2, and in the subaxial cervical segment it was C6. The subaxial cervical segment was the most affected in the overall consolidation of traumatic injuries.

Traumatic injuries of the cervical spine represent a considerable problem with the potential to incur financial and social costs to the state, as they widely affect adults of working age who need to be treated as a priority by public health. Obtaining an understanding of the factors involved in this process and the consequences of injuries is of utmost importance for public health planning and strategies for the promotion and prevention of traumatic cervical spine injuries.

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REFERENCES

- Okereke I, Mmerer K, Balasubramanian D. The management of cervical spine injuries – a literature review. Vol. 13, Orthopedic Research and Reviews. Dove Medical Press Ltd; 2021. p. 151-62.
- Copley PC, Tadross D, Salloun N, Woodfield J, Edlmann E, Poon M, et al. A systematic review identifying outcome measures used in evaluating adults sustaining cervical spine fractures. *Eur Spine J.* 2022;31(12):3365-77.
- National Clinical Guideline Centre (UK). Spinal injury assessment: assessment and imaging for spinal injury. London: National Institute for Health and Care Excellence (NICE); 2016.
- Brito LMO, Chein MB da C, Marinho SC, Duarte TB. Avaliação epidemiológica dos pacientes vítimas de traumatismo raquimedular. *Rev Col Bras Cir.* 2011;38(5):304-9.
- Beschloss AM, Taghlabi KM, Rodriguez DA, Lee N, Gupta S, Bondar K, et al. Demographic and economic trends in vertebral fracture surgeries throughout the United States. *N Am Spine Soc J.* 2022;12:100175.
- Baaj AA, Uribe JS, Nichols TA, Theodore N, Crawford NR, Sonntag VKH, et al. Health care burden of cervical spine fractures in the United States: Analysis of a nationwide database over a 10-year period: Presented at the 2009 Joint AANS/CNS Spine Section Meeting - Clinical article. *J Neurosurg Spine.* 2010;13(1):61-6.
- Gonçalves AMT, Rosa LN, D'Ángelo CT, Savordelli CL, Bonin GL, Squarcino IM, et al. Aspectos epidemiológicos da lesão medular traumática na área de referência do Hospital Estadual Mário Covas. *Arq Méd ABC.* 2007;32(2):64-6.
- Divi SN, Schroeder GD, Oner FC, Kandziora F, Schnake KJ, Dvorak MF, et al. AOSpine—Spine Trauma Classification System: The Value of Modifiers: A Narrative Review with Commentary on Evolving Descriptive Principles. *Global Spine J.* 2019 ;9(1 Suppl):77S-88S.
- Maynard FM, Bracken MB, Creasey G, Jr JFD, Donovan WH, Ducker TB, et al. International Standards for Neurological and Functional Classification of Spinal Cord Injury. *Spinal Cord.* 1997;35(5):266-74.
- Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, et al. The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. *Spinal Cord.* 1969;7(3):179-92.
- Campos MF de, Ribeiro AT, Listik S, Pereira CA de B, Andrade Sobrinho J de, Rapoport A. Epidemiologia do traumatismo da coluna vertebral. *Rev Col Bras Cir.* 2008;35(2):88-93.
- Fredø HL, Bakken IJ, Lied B, Rønning P, Helseth E. Incidence of traumatic cervical spine fractures in the Norwegian population: A national registry study. *Scand J Trauma Resusc Emerg Med.* 2014;22:78.
- Khanpara S, Ruiz-Pardo D, Spence SC, West OC, Riascos R. Incidence of cervical spine fractures on CT: a study in a large level I trauma center. *Emerg Radiol.* 2020;27(1):1-8.
- Liu J, Liu HW, Gao F, Li J, Li JJ. Epidemiological features of traumatic spinal cord injury in Beijing, China. *J Spinal Cord Med.* 2022;45(2):214-20.
- Kanna RM, Peddireddy S, Shetty AP, Rajasekaran S. Patterns of Traumatic Spinal Injuries in the Developing World: A Five-Year Longitudinal Review. *Asian Spine J.* 2022;16(5):658-65.
- Costa GHR da, Bohana e Silva JV, Petersen PA, Marcon RM, Cristante AF. Epidemiology of Vertebral Spine Fractures in a Hospital in São Paulo in the Two-Year Period 2017-2018. *Coluna/Columna.* 2021;20(4):291-4.
- Negrelli MAC, De Oliveira RG, Da Rocha ID, Cristante AF, Marcon RM, Filho TEPDB. Traumatic injuries of the cervical spine: Current epidemiological panorama. *Acta Ortop Bras.* 2018;26(2):123-6.
- Kang Y, Ding H, Zhou H, Wei Z, Liu L, Pan D, et al. Epidemiology of worldwide spinal cord injury: a literature review. *J Neurorestoratology.* 2018;6:1-9.
- Fayez ES, Soliman AA, Awad A. Prevalence and Characteristics of Traumatic Spinal Cord Injuries for Educational Hospitals in Cairo. *Med J Cairo Univ.* 2019;87(9):3687-90.
- Scopel G, Jacob Júnior C, Brazolino M, Cardoso I, Batista Júnior J, Sogame L, et al. Epidemiology Profile of Traumatic Spine Injury of a Spinal Cord Service in the State of Espírito Santo. *Arq Bras Neurocir.* 2018;37(2):101-4.
- Yadollahi M, Paydar S, Ghaem H, Ghorbani M, Mousavi SM, Taheri Akerdi A, et al. Epidemiology of Cervical Spine Fractures. *Trauma Mon.* 2016;21(3):e33608.
- Arruda GO de, Marcon SS. Comportamentos de Riscos à Saúde de Homens da Região Sul do Brasil. *Texto Contexto - Enferm.* 2018;27(2):e2640014.
- Barbosa M, Abrantes K, Silva Júnior W, Casimiro G, Cavalcant A. Acidente Motociclístico: Caracterização das Vítimas Socorridas pelo Serviço de Atendimento Móvel de Urgência (SAMU). *RBCS.* 2014;18(1):3-10.
- Moraes SA de, Soares WJS, Lustosa LP, Bilton TL, Ferrioli E, Perracini MR. Characteristics of falls in elderly persons residing in the community: a population-based study. *Rev Bras Geriatr Gerontol.* 2017;20(5):691-701.
- Burns ER, Stevens JA, Lee R. The direct costs of fatal and non-fatal falls among older adults – United States. *J Safety Res.* 2016;58:99-103.
- Silva NV de O, Costa LMO, Medeiros ES, Viana ILR de S, Andrade ILXC, Santos DA dos, et al. Compreensão dos fatores agravantes de quedas em idosos no domicílio. *Res Soc Dev.* 2022;11(13):e533111335967.
- Beeharry MW, Moqem K, Rohilla MU. Management of Cervical Spine Fractures: A Literature Review. *Cureus.* 2021;13(4):e14418.
- Epstein N, Hollingsworth R. Diagnosis and management of traumatic cervical central spinal cord injury: A review. *Surg Neurol Int.* 2015;6(5):S140-53.
- Eismont FJ, Clifford S, Goldberg M, Green B. Cervical Sagittal Spinal Canal Size in Spine Injury. *Spine (Phila Pa 1976).* 1984;9(7):663-6.
- Morishita Y, Naito M, Hymanson H, Miyazaki M, Wu G, Wang JC. The relationship between the cervical spinal canal diameter and the pathological changes in the cervical spine. *Eur Spine J.* 2009;18(6):877-83.
- Lee SE, Chung CK. Risk Prediction for Development of Traumatic Cervical Spinal Cord Injury without Spinal Instability. *Global Spine J.* 2015;5(4):315-21.