Ron *et al.*
European Journal of Medical Research (2025) 30:377
https://doi.org/10.1186/s40001-025-02537-z

European Journal
of Medical Research

RESEARCH

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Injuries in the cervical craniomandibular complex after whiplash phenomenon

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Abstract

Background Traffic accidents worldwide are considered a public health problem and traumatic injuries due to the phenomenon of whiplash with clinical manifestations such as neck or head pain and temporomandibular joint pain are considered common.

Aims The aim was to determine the prevalence of lesions in the cervical craniomandibular complex after traffic accidents in Quito, Ecuador.

Methods This was an observational, cross-sectional study with data provided by the Fire Department of the Metropolitan District of Quito Emergency Department (911) for the years 2019, 2020, 2021, 2022, and the first semester of 2023. Five hospitals with maxillofacial surgery departments had a standard clinical history according to the Diagnostic Criteria for temporomandibular disorders. The treatment of temporomandibular disorders such as cervical pain, muscular palpation tenderness, difficulty opening the mouth, regular headache, joint crackles, and arthralgia was considered.

Results The results revealed that the muscle palpation tenderness had a considerably high prevalence (71.03%), followed by difficulty opening the mouth (14.33%), and regular headache (25.31%). Among the participants, the highest prevalence of muscle palpation tenderness (32.56%) and regular headache (30.23%) was found in older adults aged 55 years and older.

Conclusion Injuries to the cranio-cervico-mandibular complex because of traffic accidents found a prevalence of muscle pain (32.5/25%) and headaches (headaches 30/20%) in the entire population studied: children, adolescents, adults and older adults.

Keywords Prevalence, Temporomandibular disorders, Temporomandibular joint, Whiplash injuries

Introduction

Road traffic accidents are now considered a public health problem. The WHO indicates that each year, collisions claim the lives of approximately 1.19 million people and are the leading cause of death among children and young people aged 5–29, although approximately 60% of the world's vehicles are concentrated in low- and middle-income countries. Ninety-two percent of the road deaths are recorded in these countries [1]. More than half of the road traffic accident victims, such as pedestrians, cyclists, and motorcyclists, are

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vulnerable road users [2]. In Ecuador, an average of six people die every day as a result of traffic accidents. According to the National Traffic Agency, between January 1 and October 31, 2023, 1942 people died, and 17,257 traffic accidents occurred, causing 15,357 injuries [3].

Vehicle collision can damage soft and hard tissues of the concerned area with different clinical manifestations (Table 1) [4]. Prospective baseline studies on stomatognathic consequences have shown that the incidence of neck pain disorders is influenced by multiple risk factors, e.g., psychosocial status, job satisfaction, and carelessness, in addition to the more proximate role of occupational injuries [multiple factors in addition to motor vehicle collision (CVS)] contribute to CVS-based neck pain disorders [5]. Although much less is known about the etiologic significance of musculoskeletal "strains" and "sprains" in the cervical craniomandibular complex and tissue damage is not normally observed, dental evidence suggests that all types of injuries, with or without observable tissue damage, are equally challenging for the clinical management of nonodontogenic pain [6].

A consistent finding from the few perspective cohort studies available is that relatively few people who experience injury develop an acute pain disorder. Some individuals have preexisting traits that make it difficult for them to recover from an injury, malocclusion, an incorrect posture, or a high stress index, increasing the risk of chronic pain [7]. Based on extensive preclinical and human studies, a very likely neuronal mechanism that may amplify the effects of injury is central sensitization, defined as "the amplification of central nervous system (CNS) neuronal signaling that causes hypersensitivity to pain." However, we are not aware of any prospective cohort studies that have assessed the effects of a state of latent sensitization for its potential to amplify the effect of injury on the risk of developing nonodontogenic clinical pain [8]. Temporomandibular disorders (TMDs) result in significant pain and limited mandibular function, although characteristically, there is no apparent trauma or pathology to explain the symptoms [9]. The incidence of TMDs in the world population was 34%. The age group 18–60 years is the most exposed to TMDs [10].

Temporomandibular disorders (TMD) integrate at least 30 health disorders [11], within these muscular alterations, condyle disk complex and adjacent tissues [12] having a variety of causes, coexist with overlapping medium conditions such as headaches, fibromyalgia, migraine, back pain [13], irritable bowel syndrome, the drawback that appears is that they can be transient or permanent that can go from a simple jaw click and trigger in a golden facial pain [14]. Throughout the history of the disease, patients have often been asked to cite a preexisting lesion as a trigger for symptoms, and retrospective studies have reported strong associations between injury history and odds of TMDs. In addition to bias issues, retrospective studies generally inquire only about trauma injuries (cervix/cranial/mandibular, whiplash) [15], overlooking potential injuries to routine jaw function (e.g., prolonged mouth opening, subluxation, dislocation) [16]. Many studies of TMDs have other methodological limitations, such as the lack of adequate comparison groups, the use of comparison groups in which TMD misclassification is likely, and unvalidated methods for diagnosing TMDs and assessing lesions [17]. The hypothesis of the research proposed there is a relationship between the phenomenon of whiplash and temporomandibular disorders. The aim of the present study was to determine the prevalence of lesions in the cervical craniomandibular complex after traffic accidents in Quito, Ecuador.

Materials and methods

Study design

This is an observational, epidemiological, cross-sectional study of cervical craniomandibular complex lesions after traffic accidents in Quito, Ecuador from 2019 to 2023.

Setting

The study was carried out in the Metropolitan District of Quito located in the province of Pichica in Ecuador, it is located at 2850 m above sea level, it has an area of 4183 km^2 and according to data from the Instituto

Table 1 Detailed numerical presentation of the study population

Year	Age/years	Gender		Total	Excluded	Sample of the study	Total sample
		Man	Woman				
2019	0–17	208	248	456	1186	1290	2476
2020	18–34	196	186	382			
2021	35–54	289	313	602			
2022	55+	387	373	760			
2023		145	131	276			

Nacional de Estadísticas y Sensos (INEC), it has a population of 2,239,191 inhabitants.

Data source and description

The study used data from the Emergency Department of the Metropolitan District of Quito (911), years 2019, 2020, 2021, 2022 and the first half of 2023.Selection of emergencies was limited to traumatic emergencies, such as vehicle collisions, run overs, bicycles, and motorcycles; cervicalgia (M50); cervical trauma (S13 whiplash/cervical sprain syndrome) (S13 whiplash syndrome); and neck or neck trauma (blunt/blunt/whiplash). The total sample was 2476 patients, 1186 were excluded (they did not wish to participate, state of unconsciousness, relatives did not authorize their participation) (Table 1). Within the data provided, five hospitals within the metropolitan district of Quito that have a department of maxillofacial surgery with a standardized clinical history and Diagnostic Criteria for temporomandibular disorders (DC/TMD Axis II) were considered. The symptoms recorded during anamnesis for temporomandibular disorders are cervical pain, muscular palpation tenderness, difficulty opening the mouth, regular headache, joint crackles, and arthralgia.

Data analysis

The study analyzed the prevalence of post traffic accident disorders by year, age group and sex with the following formula $\frac{\text{number of cases present}}{\text{total cases examined}} \times 100$, we group the population into 4 groups: children and young adults (0–17 years old), Young adults (18–34 years old), adults (35–54 years old) and older adults (> 55 years old). ANOVA were utilized, to compare differences in post-traffic accident disorders for which the following formula was used

$$\text{SSentre} = \sum_{i=1}^{k} ni(\overline{yi} - \overline{y})^2 \quad \text{SSentre} = \sum_{i=1}^{k} \sum_{j=1}^{ni} (yij - \overline{yi})^2 \quad F = \frac{\text{MS entre}}{\text{MS dentro}}$$

The study did not exclusively use Excel or manual formulas. Python was used with statistical libraries such as numpy, pandas, SciPy. Stats and stats models, for statistical analysis. To assess whether the data follow a normal distribution, the Shapiro–Wilk test was applied: in a standard ANOVA, the typical threshold for statistical significance is $p < 0.05$. Bonferroni's correction is used when multiple comparisons are made to reduce the type error (false positives).

Ethical consideration

Authorization of the Bioethics Committee of the University of the Americas (UDLA) CBE170455A/234 approved the request for the provision of statistical data by the Fire Department of the Metropolitan District of Quito emergency department (911).

Results

Pathology analyzed

After the analysis it was possible to find: cervical pain in 2020, a peak of 25% was detected, and a notable decrease was observed in 2023 (2.76%). The muscular palpation tenderness increased significantly in 2023, with a prevalence of 71.03%. Difficulties in opening the mouth increased by a minimum of 14.33% in 2021, with similar rates in 2023 for the first semester at 8.97%. Regular headache had a prevalence of 25.31% in 2019 and 11.03% in 2023 until the first semester. Articular crackles exhibited a significant prevalence in 2022 (20.67%), with a marked reduction in 2023 (6.21%). The prevalence of arthralgia was highest in 2020 (15.31%) and was not reported in 2019 or 2023 (Fig. 1).

Population analyzed

After the analysis it was possible to find the prevalence of post-traffic accident disorders by age group, the most common in all groups was muscular palpation tenderness, with a prevalence of 25% in children and adolescents, 27.27% in young adults, 29.1% in adults, and 32.56% in older adults. In the group of young adults and older adults with post-traffic accident disorder, the least prevalent was cervical pain, with a prevalence of 12.5% and 16.28% respectively, while in the group of children and adolescents, the least prevalent were cervical pain and joint crepitus, both with 12.5%. Additionally, in the adult group, regular headaches and difficulties in opening the mouth had a prevalence of 12.4% (Table 2).

Gender analyzed

After the analysis, it was found a peak was observed in the relationship of Muscular Palpation Tenderness in the male population in the year 2023, while 'Regular Headache' shows a higher prevalence in women in most years. However, in 2022, the prevalence among men is slightly higher. In addition, the prevalence of joint crepitus is higher in women in 2020, as is the prevalence of arthralgias, which in 2020 and 2022 is higher in women. Although the prevalence is relatively low in general, this disorder does not show prevalence in 2019 or 2023 for both genders, which could indicate success in treatment and prevention, or changes in diagnostic methods (Fig. 2a–c).

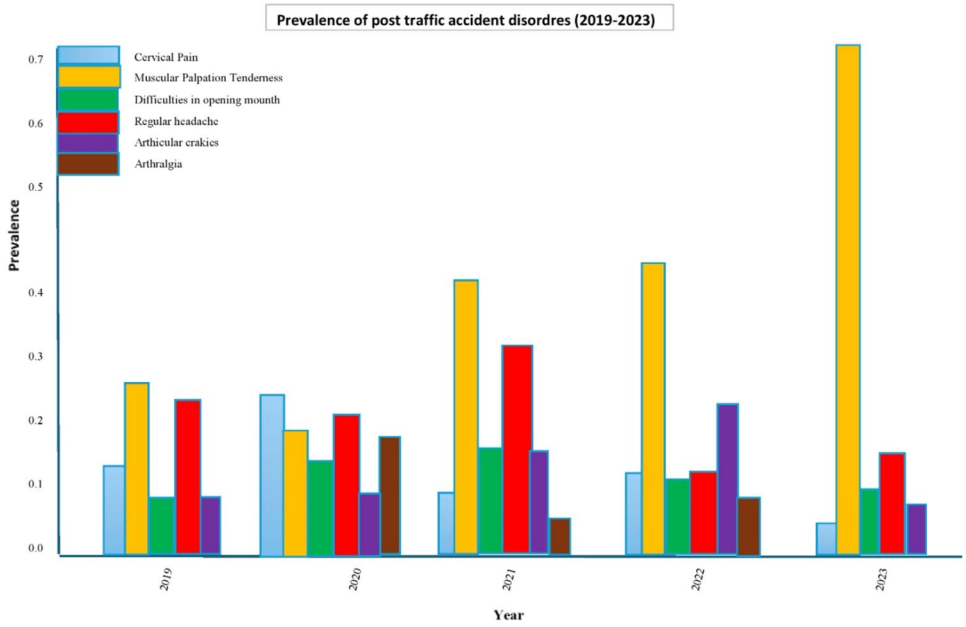

Fig. 1 Prevalence of post-traffic accidents disorders by year

Statistic test used

The ANOVA analyses used helped in the comparative analysis, which were complemented by the use of Bonferroni correction due to the multiple statistical in the study, reducing the risk of obtaining false positives (Type I error) [15]. We observed that cervical pain has a mean of 10.46 with a p value < 0.001, indicating statistically significant differences in the prevalence of this disorder over the years. The same occurs with Muscular Palpation Tenderness (F-statistic = 31.99, p value < 0.001), regular headache (F-statistic = 10.08, p value < 0.001), joint crepitus (F-statistic = 7.75, p value < 0.001), and arthralgias (F-statistic = 18.62, p value < 0.001, unlike difficulties in Opening Mouth (F-statistic = 2.06, p-value = 0.084), suggesting that there are no statistically significant differences between the years (Fig. 3).

In the studio it was possible to reveal significant associations between different post traffic accident disorders: cervical pain showed a strong association with years of study ($Chi^2 = 40.68$, $p < 0.001$); muscular palpation tenderness demonstrated a significant and robust relationship ($Chi^2 = 116.79$, $p < 0.001$) [16]; although difficulties in opening the mouth did not reach conventional significance ($Chi^2 = 8.22$, $p = 0.084$), they approached it; regular headaches and joint crepitus exhibited significant associations ($Chi^2 = 39.25$, $p < 0.001$; $Chi^2 = 30.40$, $p < 0.001$, respectively), while arthralgia also showed a strong correlation with the disorder ($Chi^2 = 70.65$, $p < 0.001$).

Discussion

The temporomandibular joint (TMJ) is a complex anatomical structure that allows the opening, closing, laterality, and protrusion movements of the jaw, being essential for functions such as chewing, swallowing, and speech [17]. Its functioning depends on the coordinated interaction between the articular disk, the mandibular condyles, the temporal glenoid cavity, the ligaments and the chewing muscles. Under physiological conditions, the TMJ maintains a biomechanical balance that allows a smooth movement of the disk over the condyle, minimizing joint wear [18]. However, when this balance is altered by factors such as bruxism, functional habits, malocclusion or stress, macro traumas (whiplash phenomenon) they can develop temporomandibular disorders (TMD). These alterations include disk displacements, muscle dysfunction and degenerative changes in the joint, which can generate orofacial pain, limitation of mouth opening and joint noises [19] (Table 3).

The close functional and biomechanical relationship between the temporomandibular joint (TMJ), the cervical spine and the masticatory musculature has been demonstrated in several studies [20], this connection between these structures is due to the continuity of the neuromuscular and fascial systems, which implies that dysfunctions in one of them can affect the others. For example, alterations in the TMJ, such as disc displacement or joint hypomobility, can generate compensatory changes in cervical posture, affecting the stability of the spine and causing symptoms such as neck pain, headaches, and

Table 2 Prevalence by age

Population	Age (years)	Pathology				%				
Children and adolescents	0–17	Muscular palpation tenderness	Regular headache	Cervical pain	Articular crackles tenderness)	25	21.43		12.5	12.5
Young adults	18–34	Muscular palpation tenderness	Regular headache	Cervical pain		27.27		26.14		12.5
Adults	35–54	Muscular palpation tenderness	Difficulties in opening mouth	Regular headache		29.31		24.14		24.14
Seniors	55+	Muscular palpation tenderness	Regular headache	Cervical pain		32.56		30.23		16.28

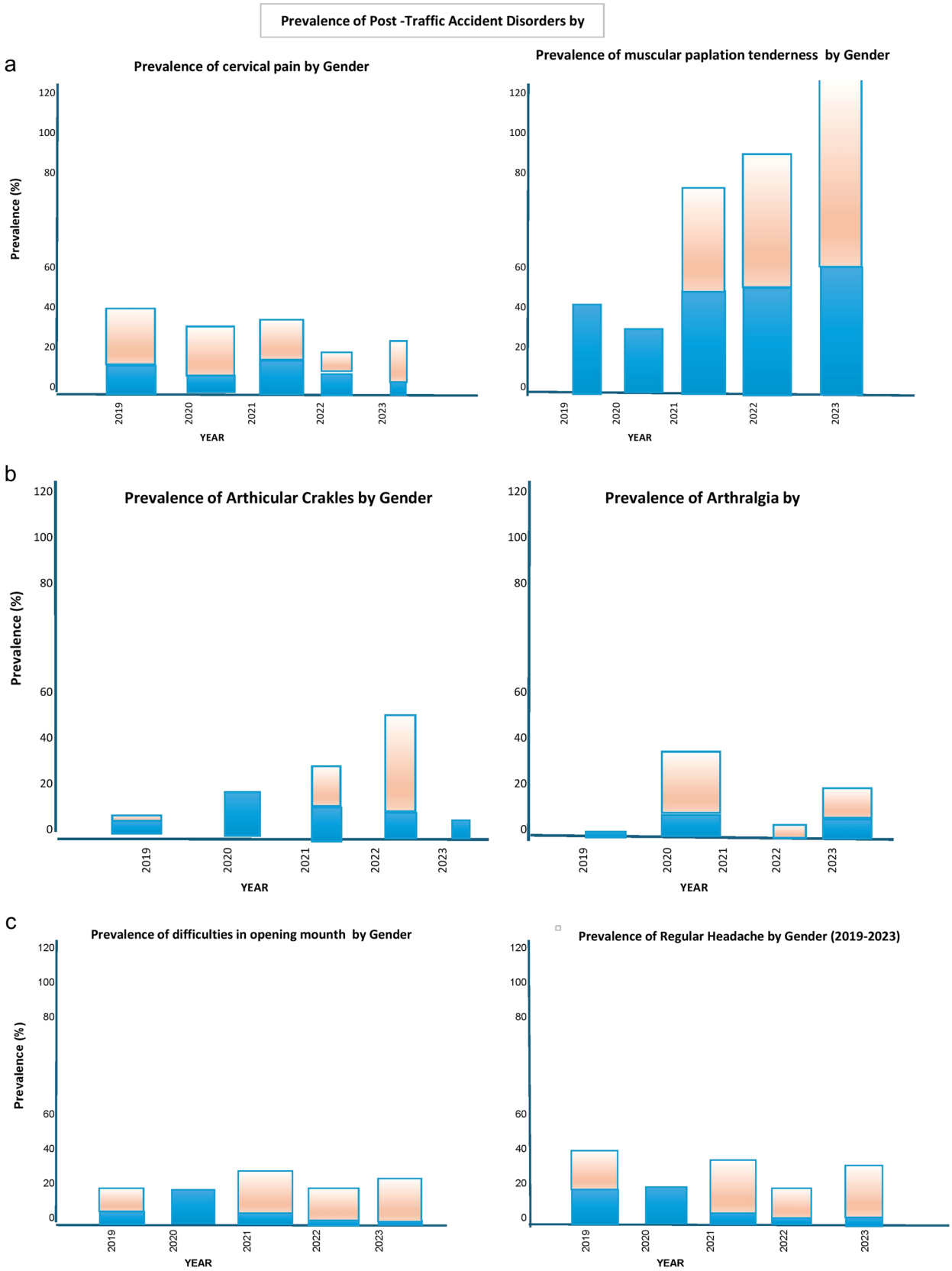

Fig. 2 Prevalence of post-traffic accidents disorders by sex

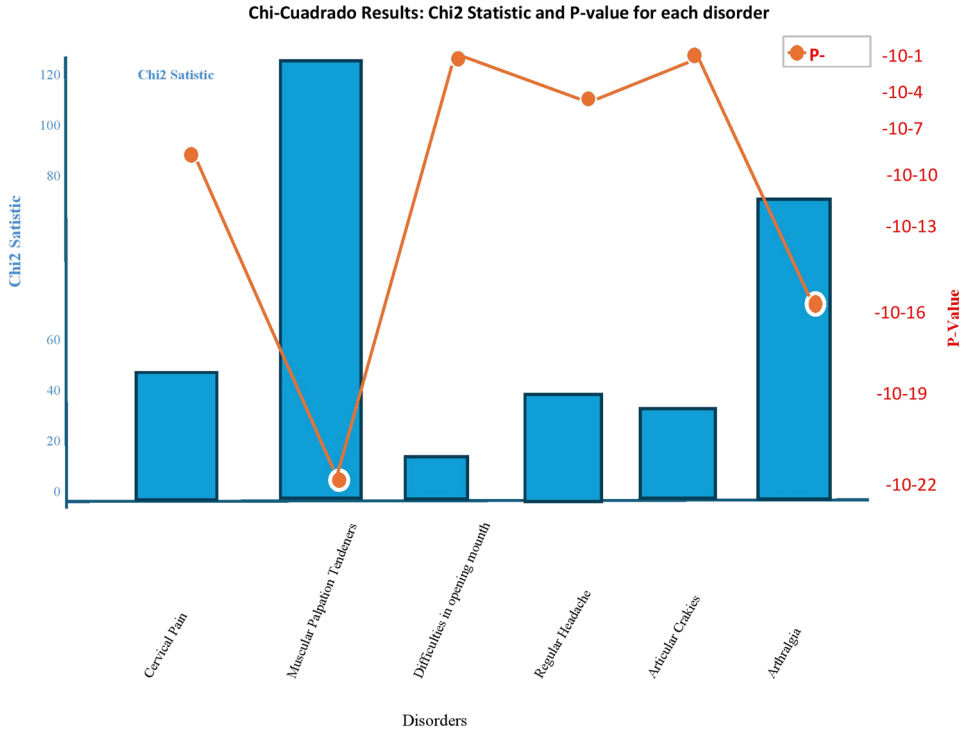

Fig. 3 ANOVA analysis

Table 3 Statistic analysis

Pathology	Anova F/*p*		Chi^2/p		Linear regression	Variation of coefficient %
Cervical pain	10.46	2.43e−08	40.68	3.13e−08	− 0.0343	259.97
Muscular palpation tenderness	31.99	1.94e−25	116.79	2.58e−24	0.1051	136.43
Difficulties in opening mouth	2.06	0.05	8.22	0.05	0.0045	286.34
Regular headache	10.8	4.90e−08	39.25	6.17e−08	− 0.0361	217.34
Joint crepitus	7.75	3.58e−06	30.40	4.06e−06	0.0054	250.52
Arthralgia	18.62	2.43e−08	70.65	1.65e−14	− 0.0055	396.57

restriction of movement [21]. Hyperactivity or dysfunction of the masticatory muscles such as masseter and pterygoid can generate an increase in tension in the cervical muscles, particularly in the sternocleidomastoid muscle and the suboccipitals, favoring the appearance of altered postural patterns [22].

Clinical manifestations associated with whiplash syndrome may appear after a variable period of time following trauma, and these manifestations are classified as whiplash syndrome or delayed whiplash syndrome [23]. The clinical scenario is extremely variable, with different signs and symptoms that can interact in different ways, complicating the diagnosis [24]. Headache, cervical pain and stiffness, shoulder pain, back pain, disorders in the cervical craniomandibular complex [25], paresthesia, vertigo, visual disturbances and dizziness are signs and symptoms that can occur after trauma [26]. Acute and chronic manifestations may develop variably. With regard to acute symptoms, patients can perceive little or no pain immediately after injury [27]. The symptoms gradually increase in the following days, probably due to the diffusion of edema within the soft tissues [28]. The limitations of cervical movements, cervical tension, muscle spasm, and/or swelling may be accentuated a few hours after trauma.

Disorders associated with whiplash are often self-limiting over time, with many patients only being observed in the first few months [29]. May et al. reported that symptoms of TMDs developed in the first week after a car accident in most patients, ranging from one month

to five years after the accident [30]. In their magnetic resonance imaging analysis, El-Shaheed et al. discovered TMJ abnormalities in 95% of whiplash patients who presented symptoms of TMJ; did not report direct trauma to the face, head or jaw; and were considered totally asymptomatic before the accident [31]. Some studies have shown that the collation of the cervical collar and physiotherapeutic traction potentiate the pathogenesis of temporomandibular disorders by forcing the superolateral and posterior super lateral positions, which allows anteromedial dislocation of the disc with compression of the retro disc tissue, causing retrociditis or posterior capsulitis [32].

The controversy that arises among the authors is that whiplash can cause more severe symptoms (especially in the short term) than in non-traumatized patients. Post-traumatic TMD patients are more likely to experience neck pain, headache, facial pain, and masticatory muscle pain than no traumatized patients [33]. Sollecito et al. reported that patients with posttraumatic TMD did not respond adequately to treatment and required additional methods than no traumatized patients [34]. Anarte et al. compared two groups of patients with TMDs: one with a history of traumatic brain injury and one with no history correlated with trauma [35]. The trauma group initially showed more noticeable symptoms, but both groups responded well to conservative treatment, as demonstrated a year later by applying anamnesis Diagnostic Criteria for temporo-mandibular disorders (DC/TMD Axis II) [27].

The factors for a negative prognosis in functional recovery as well as in the emergence of TMDs are as follows: high impact velocity (>60 km/h), high intensity of initial pain, position of the head during impact, absence of headrests, advanced age, female sex (genetic or behavioral factors could imply lower muscular and structural resistance of the female sex associated with greater dependent hormonal hyperlaxity and less adaptation to stress that favors central sensitization and the possibility of pain), cervical spine deformity and ongoing legal cases, factors that are not being considered in the anamnesis and subsequent treatment plan [36].

TMDs, as a consequence of whiplash, evolve into chronic pain due to neuroplasticity in different neuronal structures, which is responsible for the amplification of nociception and exaggerated response to pain, with a notable decrease in the pain threshold. Chronic pain is not related to the actual current damage to the joint structure, and the energy transmitted is insufficient to cause true permanent injuries. Control of the acute phase and multidisciplinary management resolve the condition in a short time, substantially limiting chronicity [37].

The residual symptoms may persist for a variety of reasons, such as the manifestation of a traumatic brain injury or a dislocation of the craniocaudal joint. The visual analog scale (VAS) score was 4 for patients who reported a traumatic brain injury, and the VAS score ranged from 3 to 5 for patients who experienced severe trauma. Preexisting craniomandibular dysfunction with a VAS score greater than 3 indicated functional impairment during the 6-month follow-up period [13, 19]. The patients with a residual VAS score greater than 3 were older than 38 years. The patients were referred for prolonged therapy and the use of myorelaxant plaque [38].

The pathophysiology of the development of TMDs and their complications by whiplash syndrome can be complicated if there are predisposing factors such as functional habits or microtrauma, functions or malocclusion [35, 38]; macro-trauma of variable intensity in the muscles, ligaments, and tendons of the cervical area as an adjunct involvement of the central nervous system as a consequence of diffuse axonal injury [39] or as a result of prolonged masticatory muscle pain. The frequent experience of emotional trauma from injury may further contribute to creating a complex neuropathology of pain exacerbation in patients with TMDs following whiplash syndrome.

Limitations

One of our limitations is that the information was collected from databases raises the possibility of biases in the data. It is also critical to remember that the researchers had no influence over how the data was input into the system. The potential for typographical errors, which make it difficult to receive accurate information, is a further consideration. Another of our limitations is that since this is a study carried out only in the city of Quito, we cannot generalize the results to other cities and provinces in which there is less vehicular control or have more or less vehicular circulation.

Observational studies, especially ecological ones, cannot conclude a cause-effect relationship, however, they are very valuable for identifying associations and relationships for further investigations.

Conclusion

Injuries to the cranio-cervico-mandibular complex because of traffic accidents found a prevalence of muscle pain (32.5/25%) and headaches (headaches 30/20%) in the entire population studied: children, adolescents, adults and older adults.

Abbreviations

CVS	Motor vehicle collision
CNS	Amplification of the central nervous system
INEC	Instituto Nacional de Estadisticas y Sensos

TMDs	Temporomandibular disorders
DC/TMD Axis II	Diagnostic criteria for temporomandibular disorders
TMJ	Temporo mandibular joint
VAS	Visual Scale Analog

Acknowledgements
The authors would like to thank the University of the Americas for providing the funds related to the publication fee.

Author contributions
BV-R contributed toward the conception and design of the whole project, obtained full access to the data, was primarily accountable for all aspects of work, and ensuring integrity and accuracy of the research as well as of the drafting of the manuscript. EO-P, JVG contributed with the revision of the available literature. BV-R, and EO-P contributed to the statistical analysis, internal validity of the study, and initial drafting of the manuscript. BV-R, EO-P,JV-G, and JSIC critically reviewed and edited the manuscript, and providing input toward the reporting of the data and its interpretation. All authors contributed to the article and approved the submitted version.

Funding
There were no funding sources for the development of this research.

Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Include appropriate approvals or waivers.

Informed consent
Bioethics Committee of the University CBE170455A/234 approved.

Competing interests
The authors declare no competing interests.

Received: 16 December 2024 Accepted: 30 March 2025
Published online: 12 May 2025

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