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ORIGINAL ARTICLE

## Sex-based differences in pain distribution in a cohort of patients with persistent post-traumatic neck pain

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### ABSTRACT

**Objectives:** To analyze a cohort of 745 consecutive patients referred to a regional specialist clinic for evaluation of post-traumatic neck pain during a five-year period.

**Methods:** A cross-sectional observational study of baseline assessments performed by multi-professional rehabilitation teams according to a standardized checklist.

**Results:** The cohort contained nearly twice as many females as males (64% versus 36%). The type of injury did not differ between sexes. Of the entire cohort, 38% were diagnosed with widespread pain, 50% with regional pain, and 12% with local pain. The pain distribution among the females was 43% widespread, 48% regional, and 9% local, and corresponding figures among males were 29%, 53%, and 18%. Longer time between trauma and assessment did not affect pain distribution among the men, but a tendency towards more widespread pain was observed among the women.

**Discussion:** The importance of "female sex" as risk factor for the development of persistent pain after neck trauma needs to be discussed further. The high frequency of regional and widespread pain among patients with persistent neck pain after trauma calls for both multidisciplinary assessments and treatment strategies. The relationships between different pain distribution patterns, disability, activity, and psychological factors need to be studied further.

### ARTICLE HISTORY

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### KEYWORDS

Whiplash trauma; persistent pain; pain distribution; sex characteristics; gender differences

### ► IMPLICATIONS FOR REHABILITATION

- Patients suffering from pain and disability after neck trauma constitute a significant proportion of patients with persistent pain.
- The importance of the risk factor "female sex" should be further discussed in the development of persistent pain after neck trauma.
- The high frequency of regional and widespread pain among patients with persistent neck pain after trauma calls both for multidisciplinary assessments and treatment strategies.
- The relationships between different pain distribution patterns, disability, activity, and psychological factors need to be studied further.

## Introduction

Persistent pain after neck trauma, especially whiplash trauma, has burdened motorized societies since train travel came into common use in the 19th century [1]. The incidence of neck injuries in Sweden is currently estimated at 235/100,000/year [2]. In a recent Swedish study over 10% of all car occupants in car crashes sustained permanent medical impairment [3] and the risk for permanent disability after car crashes and whiplash trauma was reported to be 3–4 times higher for females in an earlier study [4].

Although not all traumas to the neck can strictly be regarded as whiplash trauma, it is a common neck injury mechanism, and the term is used in both the clinic and the literature to indicate a multitude of neck injury mechanisms. However, it is most commonly used to refer to an indirect trauma mechanism caused by acceleration–deceleration forces acting on the head and neck in a rear impact collision [5]. The result is an extra-physiologic movement in the cervical spine, which can cause injury to a variety of

structures [6] including the zygapophyseal joints [7,8], stabilizing muscles [9–11], nerve structures [12], vertebral disks, and bones [13]. Beyond physical injury, whiplash trauma and its sequelae can cause psychological [14], cognitive [15], and social consequences [16]. This multitude of mechanisms, in combination with varied social situations and physical responses to the initial trauma, creates heterogeneity in the resulting clinical presentation.

Long-term outcome measures following whiplash trauma typically indicate failed recovery rate in 50% of cases and about 30% report moderate or severe disability [17].

Several articles and reviews have examined and addressed a high number of prognostic factors during the last 15 years [18,19], identifying high initial neck pain intensity, neck-related disability and psychological distress factors such as post-traumatic stress symptoms and pain catastrophizing to be prognostic for poor recovery and to a lesser extent, low self-efficacy, and cold hyperalgesia.

The processes leading to recovery or development into persistent pain states were addressed at the IASP Research Symposium in Aarhus 2014 [20], recommending further research in this area. Previous prospective follow-up studies have had difficulties due to logistic problems [21,22] and high drop-out rates [23] and there is a lack of population-based studies on persistent pain after neck trauma.

One mechanism in the process of the development into persistent pain states is sensitization [24]. The sensitization process seems to be more frequent in patients with post-traumatic neck pain than in patients with non-traumatic neck pain [25,26]. The description of sensitization has been closely related to the diagnostic criteria for fibromyalgia defined by the American College of Rheumatology in 1990 [27] and 2010 [28,29]. The use of the latter criteria seems to level out the sex differences among the patients diagnosed with fibromyalgia. Alternative ways to describe sensitization have also been introduced, categorizing pain distribution as local, regional, or widespread [30,31]. Recently, a new taxonomy has been proposed by Kosek et al. [32], naming pain sensitization in terms of “nociplastic, algopathic, or nocipathic” pain.

The female–male proportion of patients who are exposed to whiplash trauma has been described in a number of studies. Stycke et al. reported a distribution of 48.1% female patients and 51.9% male patients in the acute phase of whiplash trauma [2]. We previously reported a retrospective analysis of patients receiving an ICD-10 diagnosis indicating sprain or strain of the cervical spine (ICD-S13.4), with a sex distribution of 54% women and 46% men [33]. Stigson et al. reported 50.7% female patients among 36,743 occupants injured in car crashes [3]. In contrast, Carstensen et al. reported a 64% versus 36% distribution of females to males among 740 patients assessed in emergency departments following acute whiplash trauma [34]. While there are a number of studies describing sex differences in acute and subacute post-traumatic neck pain, few have covered the transition into persistent pain.

Between 2010 and 2014, we gathered data on patients from Southern Sweden with persistent pain after neck trauma; we are now using this to examine the consistency of the baseline presentation of these patients with what has been previously described in the literature. The present study describes consecutive patients referred to and assessed at a specialist neck pain clinic with a focus on sex distribution, pain distribution patterns, and types of trauma.

## Materials and methods

In 2010, the Department of Pain Rehabilitation in Lund, Sweden was tasked by the regional government with starting a regional specialist clinic for post-traumatic neck pain and disability. Once set up, this was the only such clinic in the region during the study period. Skåne Region, which is located in the southernmost part of Sweden, has a population of approximately 1.2 million people and spans both rural and urban areas. Between 2010 and 2014, the department received more than 1000 new patients each year, with a sex distribution of approximately 2/3 female and 1/3 male.

This is a cross-sectional observational study of data from medical records of 745 consecutive patients referred to and assessed at the clinic from 2010 to 2014. The study design and protocol were reviewed by the Regional Ethical Review Board in Lund, Sweden (ref: 2014/34 and 2016/484).

The patients were firstly identified in the department’s common patient database, using the ICD-10 codes M53.0, M53.1, S13.4, and T91.8. Each patient record was then reviewed, by a designated nurse, who collected the necessary required data, taking special care that the patients reported symptoms that they

themselves related to trauma. Thus, the inclusion criteria for all patients in the cohort were exposure to neck trauma and symptoms persisting more than 6 months.

The medical records for the initial assessment were originally documented according to a standardized checklist. Most of the patients (80%) were assessed by a team consisting of a pain physician, a physical therapist specializing in orthopedic manual therapy (OMT 2), and a pain psychologist. In the remaining 20% of cases, the patients were assessed by a pain physician and a physical therapist specializing in OMT 2, and, if needed, by a psychologist. All team members were well experienced in the assessment of patients with persistent pain and pain after neck trauma.

The following data were collected from the medical records:

- Year of the assessment
- Sex
- Age at the time of the initial assessment
- Type of trauma
- Time, in months, elapsed between trauma and the initial assessment at the department, as reported by the patient
- Pain distribution at the initial assessment
- Interventions administered as a result of the assessment

### Trauma characteristics

Trauma was classified into car crashes and other neck traumas. The patients in the car crash group were further categorized as occupants of either the struck or the striking vehicle. Cases where information about the type of car crash could not be found in the medical records were registered as having unknown vehicle status. Of the entire cohort, 105 patients (14%) had been exposed to more than one trauma. In these cases, we recorded the trauma that the patient considered to have initiated their symptoms.

### Pain distribution

The determination of the category of each patient’s pain distribution was established jointly by the assessment team as local, regional, or widespread. All patients had neck pain.

- Local pain was defined as pain in a specific body area (i.e., part of the neck/shoulder area), including muscle and joint pain, with no referred or radiating pain.
- Regional pain was defined as pain in a larger area, including pain in the neck, upper extremities, shoulders, and head, allowing for trigger points, referred pain, and radiating pain.
- Widespread pain was defined as pain in all quadrants of the body with at least 11/18 tender points in accordance with the 1990 ACR criteria for fibromyalgia [27].

### Interventions administered as a result of the initial assessments

- Patients who currently received adequate treatment at the referring institution were referred back with recommendations.
- In cases where psychological distress was identified as having a major impact on the patient’s health, for example major depression or PTSD, the patients were referred for psychiatric treatment before further in-house interventions.
- Patients who were treated in-house could be referred to a single-service pain rehabilitation physiotherapy program, a multi-professional pain rehabilitation program based on cognitive behavioral therapy, or a combination of the two.

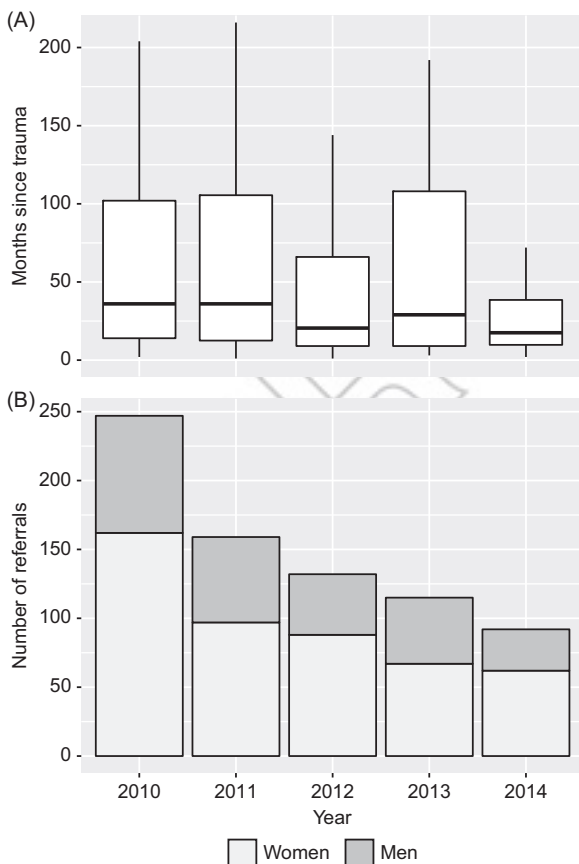
- Pharmacological treatment was also considered, using medications such as NSAIDs or Cox2 inhibitors, paracetamol, SSRIs or SNRIs, and in some selected cases low-dose opioids.
- Of the 745 patients assessed, 542 were treated in-house whilst 203 were either referred to other specialties or referred back to the referring unit with recommendations.

### Statistics

An ordinal logistic regression was fitted with *pain distribution* as the dependent variable and *months since the trauma*, *sex*, *age*, and *type of accident* (with *in struck vehicle* as reference category) as independent variables; no higher-order or interaction effects were investigated. Otherwise, the data and model were investigated for every relevant statistical assumption. R (R Core Team, Vienna, Austria) was used in all analyses, and the family-wise error rate ( $\alpha$ ) was set at  $p < 0.05$ . Percentile bootstrapped confidence intervals are given within square brackets.

### Results

Between 2010 and 2014, the annual number of patients referred to and assessed at the department declined from 247 to 92, and the median time between trauma and assessment decreased from 36 months to 17.5 months (Figure 1). The sex distribution for the whole cohort was 476 (64%) females and 269 (36%) males.

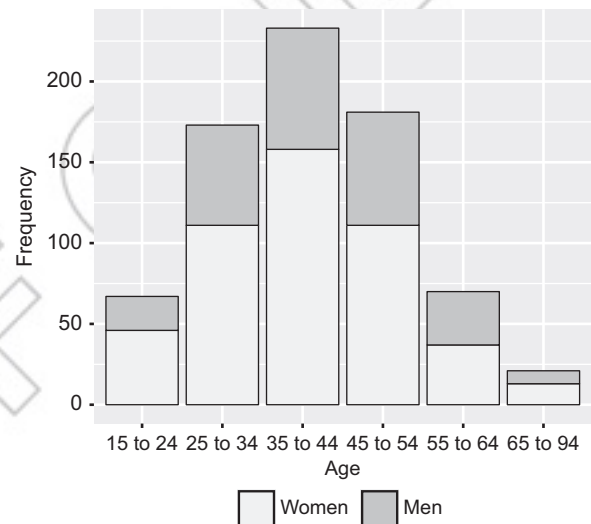


**Figure 1.** A. Tukey boxplots of months between trauma and assessment, as stated by the patients ( $n = 745$ ). The horizontal bars of the boxes represent the first quartile, median, and third quartiles, respectively, while whiskers represent 1.5 times the interquartile range. Outliers are omitted from the plot. B. Number of patients referred and assessed between 2010 and 2014.

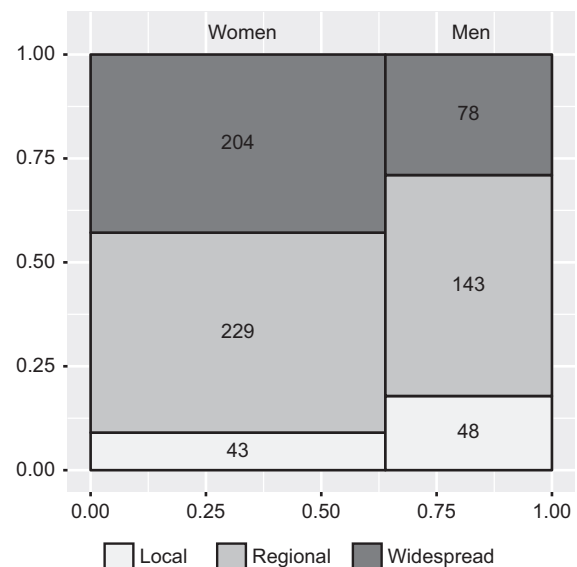
The greatest sex distribution difference was seen around the age of 45 (Figure 2).

In the entire cohort, 38% of the patients were diagnosed with widespread pain, 50% with regional pain, and 12% with local pain. Among females, the pain distribution was 43% widespread, 48% regional, and 9% local, while among males the corresponding figures were 29%, 53%, and 18% (Figure 3). Regional pain distribution was proportionally the most common pattern within all age groups (females and males), except for females aged 45–54, where widespread pain (48%) was proportionally most common (Table 1).

Analysis of the different types of trauma showed that 78% of the patients had been involved in car crashes, with about 33% being occupants of the striking vehicle and 62% of the struck vehicle; in 5%, the type of car crash could not be determined from the medical records. The sex distribution for the types of car crashes and the other types of trauma was comparable to the sex distribution in the entire cohort (Table 2). No differences in pain distribution were apparent with regard to type of trauma (i.e., car



**Figure 2.** Age at assessment, divided by sex.



**Figure 3.** Pain distribution (local, regional, or widespread) among females ( $n = 476$ ) and males ( $n = 269$ ). Each block is annotated with the corresponding number of patients.

**Table 1.** Pain distribution (local, regional, or widespread) grouped by age and sex.

Age	Pain distribution	Females	Males	All
15–24	Widespread	16	8	24
	Regional	27	12	39
	Local	3	1	4
25–34	Widespread	50	12	62
	Regional	50	39	89
	Local	11	11	22
35–44	Widespread	64	23	87
	Regional	82	37	119
	Local	12	15	27
45–54	Widespread	53	28	81
	Regional	47	32	79
	Local	11	10	21
55–64	Widespread	16	6	22
	Regional	18	18	36
	Local	3	9	12
65–94	Widespread	5	1	6
	Regional	5	5	10
	Local	3	2	5
	All	476	269	745

**Table 2.** Description of types of traumas. In cases involving multiple traumatic events, only the event which the patient considered to have produced the symptoms is displayed.

Type of trauma	Females	Males	All
Car crashes			
In striking vehicle	125	69	194
In struck vehicle	223	139	362
Vehicle status unknown	20	6	26
			582
Other neck traumas			
Bike accidents	14	5	19
Other traffic accidents	14	7	21
Sports-related accidents	19	7	26
Falls	31	13	44
Direct head or neck traumas	12	8	20
Miscellaneous accidents	18	15	33
			163
Total	476	269	745

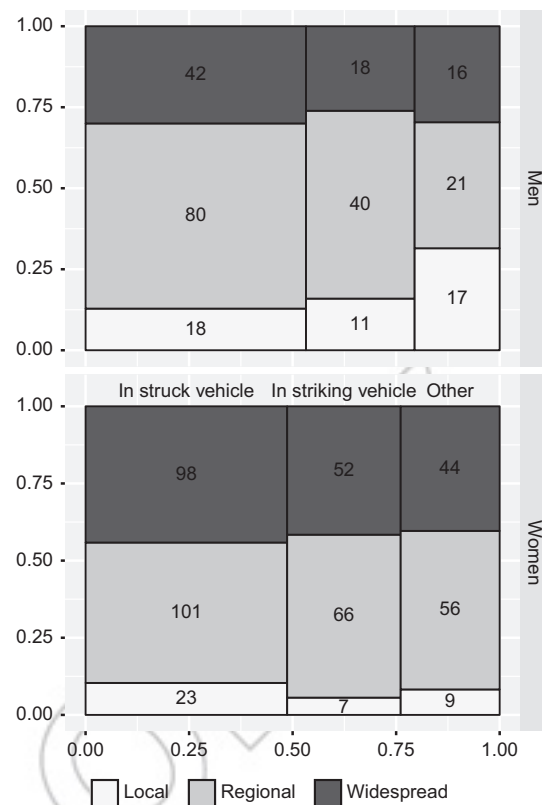
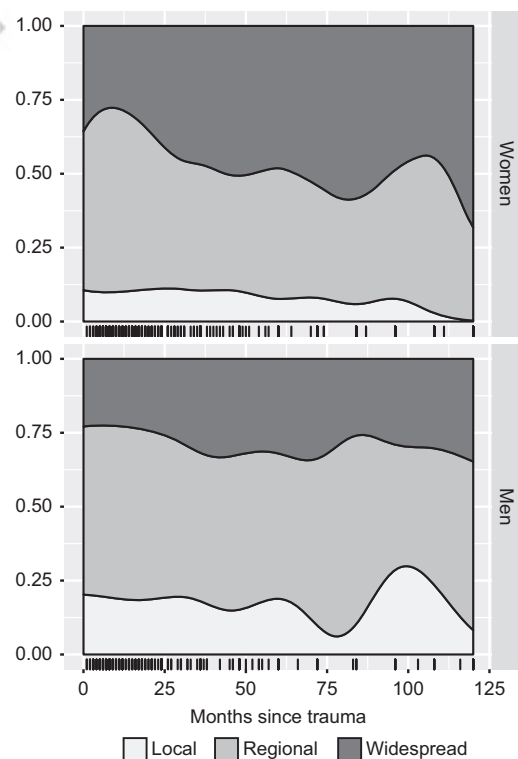
crashes compared with other traumas) or to whether the patient was occupying the striking or struck vehicle (Figure 4).

For females, but not for males, time since trauma at assessment at the department coincided with a shift in pain distribution from local to widespread. However, the proportion of patients with regional pain distributions remained similar over time (Figure 5).

The odds ratio (OR) of either regional or widespread pain compared with local pain, or of widespread pain compared with either local or regional pain was 1.88 [1.40; 2.53] for females ( $p < 0.001$ ). The OR for those with 84 months between trauma and assessment (third quartile) compared to those with 11 months between trauma and assessment was 1.33 [1.14; 1.54] ( $p < 0.001$ ). Neither age (first quartile vs. third quartile: OR = 0.84 [0.69; 1.02],  $p = 0.081$ ) nor type of trauma (struck vs. striking: OR = 0.85 [0.61; 1.18],  $p = 0.335$  and other vs. struck: OR = 0.75 [0.52; 1.07],  $p = 0.114$ ) were significantly associated with the chance of being diagnosed with either local, regional or, widespread pain distributions.

## Discussion

Twice as many females as males were referred to and assessed for persistent pain after neck trauma at a multidisciplinary clinic specialized in post-traumatic neck pain, serving a population of about 1.2 million inhabitants. The majority of both male and especially

**Figure 4.** Pain distribution according to sex and type of trauma in 719 of the 745 patients (in 26 cases, the type of car crash could not be determined). Each block is annotated with the number of patients belonging to that category.**Figure 5.** Conditional density plot of pain distribution and time (in months) since the trauma. Cases exceeding 120 months (16% of the total sample) are omitted, since they were too few to provide accurate estimates. Sample frequency is given at the bottom of each facet by a rug plot, and density estimates are given on the y axis; these were computed using a Gaussian kernel (the normal distribution function).

female patients had regional or widespread pain distribution, local pain was present more often in males.

Previous Swedish studies on exposure to neck trauma have not reported any major sex differences [2,33], but the risk of developing persistent symptoms has been reported to be much higher for females up to the age of 44, compared with males in the same age group [3]. The limitations of this study are that we do not have information from the acute stage about initial pain, disability and psychological distress or about the proportion of all patients with persistent neck pain after trauma that actually was referred. However, there was no other specialist unit in the catchment area during the study period, so we assume that the referral pattern reflects the fact that females are at higher risk of developing persistent pain after neck trauma. The actual figures for sex and pain distribution in patients with persistent neck pain after trauma have to our knowledge not been reported in a geographically defined population before.

Any analysis of persistent pain and disability after trauma must take into consideration not only the initial trauma or injury, but also possible pain-generating mechanisms, healing mechanisms, and factors that could affect these processes. We did not see any differences in types of trauma that could explain the sex differences in number of patients.

The first two established prognostic factors for poor recovery (high initial pain intensity and high baseline disability), both relate to tissue damage and structural factors. There are anatomical differences between the sexes in the cervical spine that may explain a higher vulnerability for females exposed to neck trauma. For example, cervical vertebrae differ between females and males, in that female's vertebrae are smaller even after compensating for head size [35,36]; this means that the segmental support area, including the disk and facet joints, is relatively smaller [37]. In addition, females have significantly less muscle strength in the neck, compared with males [36,38]. Consistent trends (albeit non-significant ones) have been identified for female's cervical spine ligaments to have less stiffness and a lower failure force than those in males [39]. All these factors may contribute to a decreased spinal stability in females, which may partly explain their greater range of motion during static [40] and dynamic [41,42] loading as well as their considerably lower tolerance limit for lower neck shear force (females: 384 N; males: 636 N) [43]. In addition, female's neck muscles react faster, which may cause greater tissue strain and increase the injury potential [44]. Recent research based on 50th percentile male and female human body numerical simulation models suggests that the sex difference in head and cervical spine kinematics during simulated rear impacts is primarily due to anatomical differences rather than differences in muscular force [43]. It has also been reported that existing whiplash protection concepts are generally less effective for females than males, with a 31% risk reduction of permanent medical impairment for females and 52% for males, according to Swedish insurance claims records [45]. Moreover, substantial differences were found when analyzing different whiplash protection concepts separately. Seats designed to absorb energy in the seat-back had equal or even somewhat higher effectiveness for females compared with males, while seats with reactive head restraints showed very high reduction effects for men (60–70%) and very low or no reduction for females [47]. One reason may be that existing whiplash protection concepts are primarily adapted to an average-sized male, and so only the extremes of the female population are accounted for by the existing crash test dummies available for rear impact crash testing; that is, the 50th percentile male rear impact dummy, or possibly the 5th percentile female frontal impact dummy. Females of average stature are associated

with the highest whiplash injury frequency/incidence in rear impacts [46,47].

The third and fourth established prognostic factors for poor recovery (pain catastrophizing and PTSD), are both related to psychological distress. In Scandinavia, depression is reported to be twice as common for females as for males [48], thus indicating sex differences for these risk factors as well.

Another risk factor for poor recovery after neck trauma, reported by Scott et al., is hypersensitivity [25]. The prevalence of widespread pain in Swedish population studies has been estimated at 15–34% for women and 8–22% for men [49,50], while the prevalence within those with persistent pain conditions is estimated to be 17.5–35.3% [49]. The presence of central sensitization is a well-known in "chronic whiplash" although population-based figures are sparsely reported [24]. Higher incidence of widespread pain has though been reported in patients exposed to whiplash trauma than in patients with idiopathic neck pain, although sex differences were not presented [26,27]. Our results show a higher proportion of individuals with widespread pain than in other Swedish population studies [47,48], but are in accordance with studies of populations with persistent pain [51].

In general, the prevalence of most common forms of pain conditions is higher in females, possibly because of underlying mechanisms such as differences in hormones, endogenous opioids, neurotransmitters, and receptors, as well as differences in the diffuse noxious inhibitory control system [52]. In this study, the greatest magnitude in the female–male ratio was seen during the pre-menopausal age, indicating hormonal differences as another risk factor for poor recovery in females. This has also been reported in patients with knee injuries [53].

Development of persistent pain can also be discussed in the context of gender differences. Although gender equality has garnered attention in the society and politics of Sweden, epidemiological analysis [54] and analysis of women living in relationships and working at least half-time [55] reveal several areas where women still face higher workloads and social distress than men. Even if the role of these factors must be further studied, they imply less favorable conditions for women to recover after trauma.

In summary, this cross-sectional study of data from baseline assessments in a cohort of patients with persistent pain after neck trauma found twice as many females as males. We conclude that mechanisms related to higher vulnerability to neck trauma, higher risk for psychological distress, the pain sensitization process, and possibly social factors together may explain the overrepresentation of females among patients with persistent pain after trauma. We therefore recommend that the importance of the risk factor "female sex" should be further discussed in the development of persistent pain after neck trauma.

The high frequency of both regional and widespread pain found in this study calls for both multidisciplinary assessments and treatment strategies, in line with the recommendations from the European League Against Rheumatism for fibromyalgia [56].

The relationships between different pain distribution patterns, disability, activity, and psychological factors need to be studied further.

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### Disclosure statement

The authors report no conflicts of interest.

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### References

- [1] Erichsen JE. On railway and other injuries of the nervous system. Philadelphia: Henry C Lea; 1867.
- [2] Styrke J, Ståhltnacke B-M, Bylund PO, et al. A 10-year incidence of acute whiplash injuries after road traffic crashes in a defined population in Northern Sweden. *Pmr*. 2012;4:739–747.
- [3] Stigson H, Gustafsson M, Sunnevång C, et al. Differences in long-term medical consequences depending on impact direction involving passenger cars. *Traffic Inj Prev*. 2015;16(Suppl 1):S133–S139.
- [4] Krafft M, Kullgren A, Lie A, et al. The risk of whiplash injury in the rear seat compared to the front seat in rear impacts. *Traffic Inj Prev*. 2003;4:136–140.
- [5] Stemper BD, Yoganandan N, Pintar FA. Kinetics of the head-neck complex in low-speed rear impact. *Biomed Sci Instrum*. 2003;39:245–250.
- [6] Siegmund GP, Winkelstein BA, Ivancic PC, et al. The anatomy and biomechanics of acute and chronic whiplash injury. *Traffic Inj Prev*. 2009;10:101–112.
- [7] Bogduk N. On cervical zygapophysial joint pain after whiplash. *Spine*. 2011;36(Suppl 25):S194–S199.
- [8] Winkelstein BA, Nightingale RW, Richardson WJ, et al. The cervical facet capsule and its role in whiplash injury: a biomechanical investigation. *Spine*. 2000;25:1238–1246.
- [9] Brault JR, Siegmund GP, Wheeler JB. Cervical muscle response during whiplash: evidence of a lengthening muscle contraction. *Clin Biomech*. 2000;15:426–435.
- [10] Elliott J, Pedler A, Kenardy J, et al. The temporal development of fatty infiltrates in the neck muscles following whiplash injury: an association with pain and posttraumatic stress. *PLoS One*. 2011;6:e21194.
- [11] Siegmund GP, Blouin JS, Carpenter MG, et al. Are cervical multifidus muscles active during whiplash and startle? An initial experimental study. *BMC Musculoskelet Disord*. 2008;9:80.
- [12] Svensson M, Aldman B, Boström O, et al. Nerve cell damages in whiplash injuries. *Animal experimental studies*. *Orthopade*. 1998;27:820–826.
- [13] Freeman MD. Medicolegal causation analysis of a lumbar spine fracture following a low speed rear impact traffic crash. *BMC Musculoskelet Disord*. 2015;3:23–29.
- [14] Sullivan MJ, Adams H, Martel MO, et al. Catastrophizing and perceived injustice: risk factors for the transition to chronicity after whiplash injury. *Spine*. 2011;36(Suppl 25):S244–S249.
- [15] Coppieters I, Ickmans K, Cagnie B, et al. Cognitive performance is related to central sensitization and health-related quality of life in patients with chronic whiplash-associated disorders and fibromyalgia. *BMC Musculoskelet Disord*. 2015;18:E389–E401.
- [16] Holm LW, Carroll LJ, Cassidy JD, et al. The burden and determinants of neck pain in whiplash-associated disorders after traffic collisions: results of the bone and joint decade 2000-2010 task force on neck pain and its associated disorders. *BMC Musculoskelet Disord*. 2009;32(Suppl 2):S61–S69.
- [17] Carroll LJ, Holm LW, Hogg-Johnson S, et al. Course and prognostic factors for neck in whiplash-associated disorders (WAD): results of the bone and joint decade 2000-2010 task force on neck pain and its associated disorders. *Spine*. 2008;33:S83–S92.
- [18] Walton DM, Carroll LJ, Kasch H, et al. An overview of systematic reviews on prognostic factors in neck pain: results from the international collaboration on neck pain (icon) project. *The Open Orthop J*. 2013;7(Suppl 4: M9):495–505.
- [19] Ritchie C, Sterling M. Recovery pathways and prognosis after whiplash injury. *J Orthop Sports Phys Ther*. 2016;46:851–861.
- [20] Kasch H, Turk CD, Jensen TS. Whiplash injury: perspectives on the development of chronic pain. 1st ed. Philadelphia: Wolters Kluwer Health; 2016.
- [21] Rosenfeld M, Seferiadis A, Carlsson J, et al. Active intervention in patients with whiplash-associated disorders improves long-term prognosis: a randomized controlled clinical trial. *Spine*. 2003;28:2491–2498.
- [22] Seferiadis A, Rosenfeld M, Gunnarsson R. A review of treatment interventions in whiplash-associated disorders. *Eur Spine J*. 2004;13:387–397.
- [23] Lamb SE, Williams MA, Williamson EM, et al. Managing injuries of the neck trial (MINT): a randomised controlled trial of treatments for whiplash injuries. *Health Technol Assess*. 2012;16:1–141.
- [24] Van Oosterwijck J, Nijs J, Meeus M, et al. Evidence for central sensitization in chronic whiplash: a systematic literature review. *Eur J Pain*. 2013;17:299–312.
- [25] Scott D, Jull G, Sterling M. Widespread sensory hypersensitivity is a feature of chronic whiplash-associated disorder but not chronic idiopathic neck pain. *Clin J Pain*. 2005;21:175–181.
- [26] Malfliet A, Kregel J, Cagnie B, et al. Lack of evidence for central sensitization in idiopathic, non-traumatic neck pain: a systematic review. *Pain Physician*. 2015;18:223–236.
- [27] Wolfe F, Smythe HA, Yunus MB, et al. The American College of Rheumatology 1990 criteria for the classification of fibromyalgia. Report of the multicenter criteria committee. *Arthritis Rheum*. 1990;33:160–172.
- [28] Wolfe F, Clauw DJ, Fitzcharles MA, et al. The American College of Rheumatology preliminary diagnostic criteria for fibromyalgia and measurement of symptom severity. *Arthritis Care Res (Hoboken)*. 2010;62:600–610.
- [29] Wolfe F. The status of fibromyalgia criteria. *Arthritis Rheumatol*. 2014;67:330–333.
- [30] Grimby-Ekman A, Gerdle B, Björk J, et al. Comorbidities, intensity, frequency and duration of pain, daily functioning and health care seeking in local, regional, and widespread pain - a descriptive population-based survey (SwePain). *BMC Musculoskelet Disord*. 2015;16:165.

- [31] Bortsov AV, Platts-Mills TF, Peak DA, et al. Pain distribution and predictors of widespread pain in the immediate aftermath of motor vehicle collision. *Eur J Pain*. 2013; 17:1243–1251.
- [32] Kosek E, Cohen M, Baron R, et al. Do we need a third mechanistic descriptor for chronic pain states? *Pain*. 2016;157:1382–1386.
- [33] Joud A, Stjerna J, Malmström EM, et al. Healthcare consultation and sick leave before and after neck injury: a cohort study with matched population-based references. *BMJ Open*. 2013;3:003172.
- [34] Carstensen TB, Frostholm L, Oernboel E, et al. Post-trauma ratings of pre-collision pain and psychological distress predict poor outcome following acute whiplash trauma: a 12-month follow-up study. *Pain*. 2008;139:248–259.
- [35] Stemper BD, Marawar SV, Yoganandan N, et al. Quantitative anatomy of subaxial cervical lateral mass: an analysis of safe screw lengths for Roy-Camille and Magerl techniques. *Spine*. 2008;33:893–897.
- [36] Vasavada AN, Danaraj J, Siegmund GP. Head and neck anthropometry, vertebral geometry and neck strength in height-matched men and women. *J Biomech*. 2008; 41:114–121.
- [37] Stemper BD, Yoganandan N, Pintar FA, et al. Anatomical gender differences in cervical vertebrae of size-matched volunteers. *Spine*. 2008;33:E44–E49.
- [38] Vasavada AN, Li S, Delp SL. Three-dimensional isometric strength of neck muscles in humans. *Spine*. 2001;26: 1904–1909.
- [39] Mattucci SF, Moulton JA, Chandrashekar N, et al. Strain rate dependent properties of younger human cervical spine ligaments. *J Mech Behav Biomed Mater*. 2012;10:216–226.
- [40] Malmström E-M, Karlberg M, Fransson PA, et al. Primary and coupled cervical movements: the effect of age, gender, and body mass index. A 3-dimensional movement analysis of a population without symptoms of neck disorders. *Spine*. 2006;31:E44–E50.
- [41] Ono K, Ejima S, Suzuki Y, et al. Prediction of neck injury risk based on the analysis of localized cervical vertebral motion of human volunteers during low-speed rear impacts. *Proc IRCOBI Conf, Madrid (Spain)*. 2006;103–113.
- [42] Stemper BD, Yoganandan N, Pintar FA. Gender dependent cervical spine segmental kinematics during whiplash. *J Biomech*. 2003;36:1281–1289.
- [43] Stemper BD, Yoganandan Y, Gennarelli TA, et al. Toward a lower rear impact injury criterion – correlation of lower neck loads with spinal kinematics. *Proc IRCOBI Conf, Maastricht (the Netherlands)*. 2007;249–262.
- [44] Siegmund GP, Sanderson DJ, Myers BS, et al. Awareness affects the response of human subjects exposed to a single whiplash-like perturbation. *Spine*. 2003;28:671–679.
- [45] Kitagawa Y, Yamada K, Motojima H, et al. Consideration on gender difference of whiplash associated disorder in low speed rear impact. *Proc IRCOBI Conf, Lyon (France)*. 2015;37. Available at: [http://www.ircobi.org/downloads/irc15/pdf\\_files/37.pdf](http://www.ircobi.org/downloads/irc15/pdf_files/37.pdf).
- [46] Kullgren AS, Stigson H, Krafft M. Development of whiplash associated disorders for male and female car occupants in cars launched since the 80s in different impact directions. *Proc IRCOBI Conf, Gothenburg (Sweden)*. 2013;14. Available at: [http://www.ircobi.org/downloads/irc13/pdf\\_files/14.pdf](http://www.ircobi.org/downloads/irc13/pdf_files/14.pdf).
- [47] Carlsson A, Chang F, Lemmen P, et al. Anthropometric specifications, development, and evaluation of evarid – a 50th percentile female rear impact finite element dummy model. *Traffic Inj Prev*. 2014;15:855–865.
- [48] Lehtinen V, Joukama M. Epidemiology of depression; prevalence, risk factors and treatment situation. *Acta Psychiatr Scand Suppl*. 1994;377:7–10.
- [49] Bergman S, Herrström P, Högström K, et al. Chronic musculoskeletal pain, prevalence rates, and sociodemographic associations in a Swedish population study. *J Rheumatol*. 2001;28:1369–1377.
- [50] Gerdle B, Björk J, Cöster L, et al. Prevalence of widespread pain and associations with work status: a population study. *BMC Musculoskelet Disord*. 2008;9:102.
- [51] Schliessbach J, Siegenthaler A, Streitberger K, et al. The prevalence of widespread central hypersensitivity in chronic pain patients. *Eur J Pain*. 2013;17:1502–1510.
- [52] Fillingim RB, King CD, Ribeiro-Dasilva MC, et al. Sex, gender, and pain: a review of recent clinical and experimental findings. *J Pain*. 2009;10:447–485.
- [53] Zazulak BT, Paterna M, Myer GD, et al. The effects of the menstrual cycle on anterior knee laxity: a systematic review. *Sports Med*. 2006;36:847–862.
- [54] Bernhardt L. Women and men in Sweden 2014: facts and figures. *Statistics in Sweden 2014*;1–104. Available at: [http://www.scb.se/Statistik/\\_Publikationer/LE0201\\_2013B14\\_BR\\_X10BR1401ENG.pdf](http://www.scb.se/Statistik/_Publikationer/LE0201_2013B14_BR_X10BR1401ENG.pdf).
- [55] Eek F, Axmon A. Gender inequality at home is associated with poorer health for women. *Scand J Public Health*. 2015;43:176–182.
- [56] Macfarlane GJ, Kronisch C, Dean LE, et al. Eular recommendations for the management of fibromyalgia. *Ann Rheum Dis*. 2016;0:1–11.