# Onset of Neck Pain After a Motor Vehicle Accident: A Case-Control Study

NICOLA J. WILES, GARETH T. JONES, ALAN J. SILMAN, and GARY J. MACFARLANE

*ABSTRACT.* ***Objective.*** To assess the relative contribution of constitutional (individual) factors, pre-accident health, psychological and workplace psychosocial factors, and accident related (mechanical) factors in the development of neck pain (whiplash) following a motor vehicle accident.

***Methods.*** We conducted a case-control study of drivers (ages 17–70 yrs) who reported a motor vehicle accident to their insurance company. A self-report mailed questionnaire retrospectively collected information on the driver's pre- and post-accident health, details of the accident, and other exposure data. Case/control status (post-accident neck pain) was ascertained using a preshaded manikin.

***Results.*** In total, 26% of drivers reported post-accident neck pain. Women, younger individuals, and those with a history of neck pain were more likely to report neck pain following their accident (OR 1.50, 95% CI 0.98, 2.28; OR 1.62, 95% CI 0.96, 2.74; OR 1.75, 95% CI 1.09, 2.81, respectively). In addition, a number of accident related and psychosocial factors were independently associated with reporting post-accident neck pain: collision from behind (OR 2.55, 95% CI 1.41, 4.62); vehicle stationary at impact (OR 1.93, 95% CI 1.12, 3.33); collision severity (upper vs lowest tertile: OR 16.1, 95% CI 8.64, 30.1); not being at fault (OR 2.61, 95% CI 1.49, 4.59); and monotonous work (OR 2.19, 95% CI 1.19, 4.04). Based on these 8 factors, the likelihood of having neck pain increased from 7% with ≤ 2 risk factors to 62% with ≥ 5.

***Conclusion.*** Development of neck pain after a motor vehicle accident is a complex phenomenon resulting from the combined effects of constitutional, mechanical, and psychosocial factors. Using 8 such variables it is possible to identify those at high risk of developing neck pain. (J Rheumatol 2005;32:1576–83)

*Key Indexing Terms:*
EPIDEMIOLOGY NECK PAIN WHIPLASH RISK FACTORS

New episodes of neck pain are very frequent in the general population, and a number of population based studies have investigated risk factors for its occurrence. A combination of constitutional (individual) and psychological factors have been shown to predict a new episode of neck pain[1]. The importance of psychological[2], psychosocial[3], and mechanical factors[3,4] has been confirmed by others.

In the UK, it has been estimated that roughly 250,000 cases of whiplash result from motor vehicle accidents each year[5]. Neck pain is the cardinal feature of this common problem. While the body of evidence on prognosis for individuals suffering whiplash has been growing in recent years, there remains a dearth of information about the factors associated with the onset of neck pain following such accidents.

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Studies examining the etiology of neck pain following vehicle trauma have suggested that female sex[6-9], rear-end collision[9,10], and a history of neck pain[7] are important risk factors. Age has also been implicated, although results are conflicting; some suggest that older age is a risk factor[6], while others report an increased risk among younger individuals[8,9]. The focus of earlier work has been the relationship between vehicle occupant and crash related factors and the onset of neck pain. Epidemiological investigations of the onset of a variety of regional pain syndromes have shown the multifactorial etiology of these syndromes, with constitutional, psychological, psychosocial and mechanical factors all being implicated[11-14]. However, the interplay of such factors has not been examined in relation to the onset of neck pain following trauma. We assessed the relative contribution of constitutional (individual) factors, prior health, psychological and workplace psychosocial factors, and accident related (mechanical) factors in the development of neck pain (whiplash) following a motor vehicle accident.

## MATERIALS AND METHODS

A case-control study design was adopted based on the recruitment of individuals reporting an accident to a national insurance company in the UK.

*Recruitment.* At the time of the initial post-accident telephone contact with the insurance company, consecutive driver-policyholders (ages 17–70 yrs) were asked for their consent for study participation. Recruitment commenced March 1, 2002, and continued for a 14 month period. Anonymized details (age, sex, and whether the driver was at fault for causing the acci-

dent) were recorded for those who refused to participate at the time of the initial telephone contact in order to assess the external validity of the study findings. The study was approved by the University of Manchester Committee on the Ethics of Research on Human Beings.

*Questionnaire data.* A questionnaire was mailed to all drivers who consented to contact from the university and retrospectively collected details of the accident itself and driver's pre- and post-accident health. Two reminders were mailed to subjects who failed to respond to the initial questionnaire mailing(s), with the option of completing a short questionnaire over the telephone or by post.

*Subject identification: cases and controls.* Drivers were asked to indicate whether they had experienced neck pain after the accident based on a shaded neck manikin (Figure 1). Specifically, drivers were asked, "Since the accident, have you had any ache or pain which lasted for one day or longer, in the area shaded below?". The duration of one day or longer was used in order to exclude any transient episodes of neck pain. Individuals who answered positively to this question were classified as cases and those without neck pain were designated controls.

Cases were asked whether they had consulted their general practitioner (GP) because of their neck pain and whether they had neck pain on the day of completing the questionnaire. Those positive for the latter were asked to rate the severity of, and distress caused by, their neck pain on the day of questionnaire completion using two 100 mm visual analog scales (VAS), and were also asked to complete the Neck Disability Index (NDI)[15].

The NDI is a validated 10 item questionnaire designed to ascertain the influence of neck pain on daily living (e.g., on personal care, reading, work or usual activities, sleeping, recreational activities). The subject is asked to rate the effect of their neck pain on the day of questionnaire completion on each of the 10 areas on a scale from zero (no impact or no difficulty related to neck pain) to 5 (worst possible scenario — unable to do). A "not applicable" option was added to 2 sections (lifting and driving), as pilot studies showed that some drivers indicated that they did not lift weights because of other health problems (e.g., back pain) or no longer had access to a car to drive. The total score for the 10 NDI items is then summed and multiplied by 2 to give a score from 0 to 100% (prorating where applicable).

*Exposure data collection.* Data on the following potential etiologic risk factors was recorded for both cases and controls on the self-questionnaire.

*Health before the accident.* Self-rating of general health; number of GP consultations in the year prior; pain in the month before the accident (subjects were asked to shade the area affected on blank body manikins); history of neck pain ever and in the month before the accident (using a preshaded neck manikin; Figure 1); Health Anxiety (HA) and Illness Behavior (IB) [derived from the Illness Attitude Scales (IAS)[16]]; psychological distress [using the 12 item General Health Questionnaire (GHQ)[17]]; and the number of somatic symptoms (using the Somatic Symptom Checklist[18]).

*Accident related data.* Type of vehicle; whether a seat belt was worn; position of the headrest; severity of the collision using a 100 mm VAS; direction of the collision; whether the driver anticipated the collision; and speed of the driver's vehicle at the time of the impact.

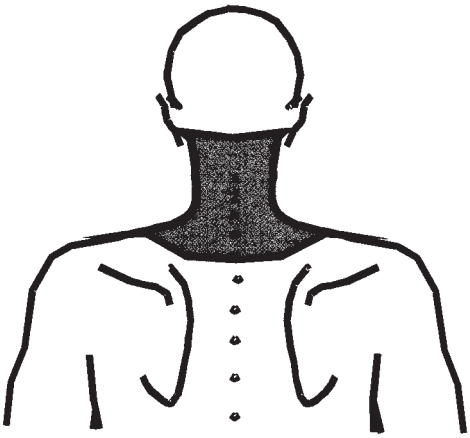

*Figure 1.* Manikin with neck region shaded.

*Work related data.* Those in paid employment (full or part-time) were asked to complete psychosocial work related questions[14].

Finally, all drivers were asked whether they had claimed compensation for any injuries resulting from the accident.

*Statistical analysis.* All analyses were conducted using Stata version 6[19].

The primary analysis focused on identifying predictors of neck pain using logistic regression. All variables significant at $p \leq 0.20$ univariately were entered into a multivariable model to permit identification of independent associations. This model was simplified using the likelihood-ratio test[20]. All variables significant at $p < 0.10$ were retained. Previously excluded variables (univariate; $p > 0.20$) were added to the multivariable model to determine whether they contributed significantly; any that were then significant at $p < 0.10$ were retained.

Compensation is an often controversial element in the development and persistence of neck pain (whiplash) following a motor vehicle accident. However, it may be postulated that the likelihood of initiating a claim for compensation is related to the severity of neck pain. This hypothesis was explored within this dataset. Differences between those who did and did not claim compensation were examined and predictors of compensation identified using logistic regression. Further analyses were conducted to identify predictors of neck pain among those individuals who had not claimed compensation. Statistical modeling techniques were employed as previously.

Differences between those invited to participate at the time of the first contact with the insurance company and those subjects included in the final dataset for analysis were identified. Final multivariable logistic models were adjusted for any differences using sampling (or probability) weights[21]. Unweighted and weighted results were then compared.

## RESULTS

*Recruitment and response to mailing.* During the 14 month recruitment period, 2723 drivers (ages 17–70 yrs) were invited to participate in the study (Figure 2). Of these, 1901 (69.8%) agreed to being sent a questionnaire by post.

Of the 1843 "appropriate" referrals, a questionnaire was completed by 1499 individuals (81.3%). In total, 1003 drivers completed the full-length questionnaire and 496 drivers completed the short version. The majority of these drivers (97%) reported being involved in a collision and were eligible for the study. To permit identification of factors associated with the onset of neck pain after a motor vehicle accident, those drivers (n = 154) who reported pain in the neck area (using a preshaded manikin) during the month before the accident were excluded. Further analysis was therefore conducted among the 847 drivers who completed full-length questionnaires and 448 drivers with short questionnaire data.

*Characteristics of participants.* Of the 847 drivers who were involved in a collision, who completed a full-length questionnaire, and who did not report pain in the area of the neck manikin in the month before the accident, 434 were female (51.2%). The median age at the time of the accident was 40.6 years [interquartile range (IQR) 33.1, 49.9]. Eighty-six percent of drivers (n = 726) were in paid employment (full or part-time). The median interval from the accident to questionnaire completion was 24 days (IQR 14, 40).

Twenty-six percent of drivers (n = 218) reported having

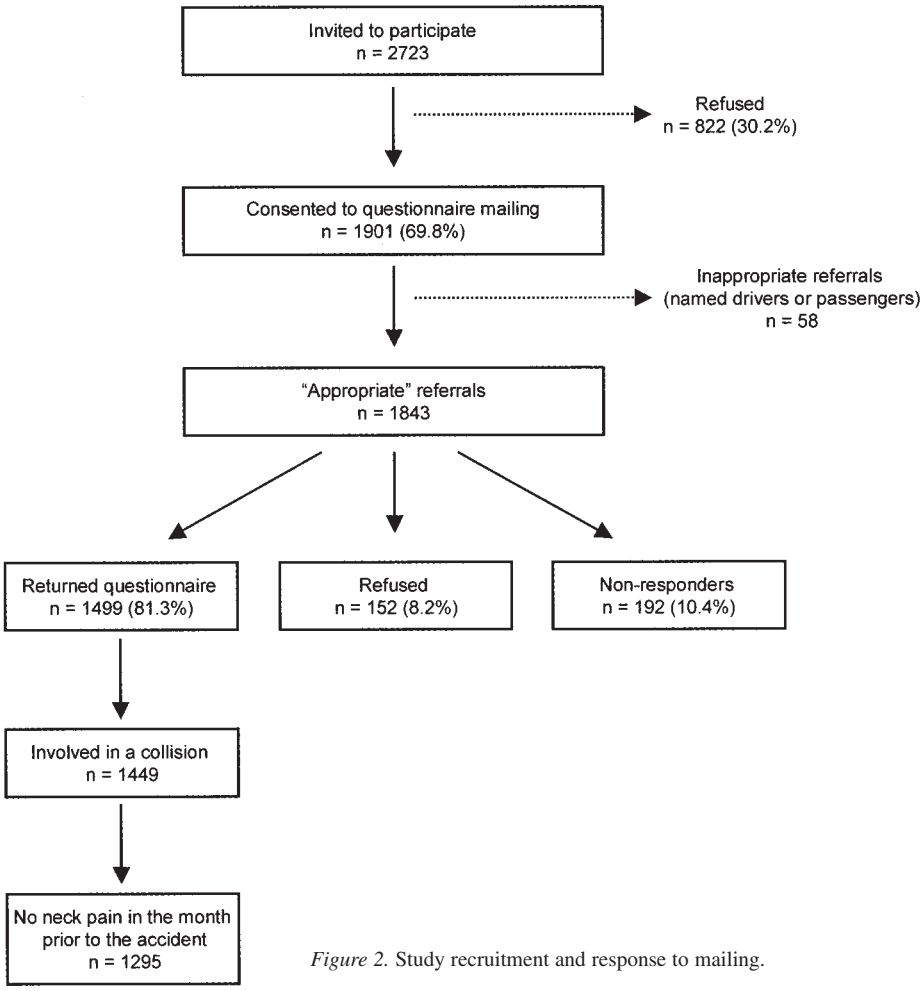


*Figure 2.* Study recruitment and response to mailing.

pain in the area of the neck manikin after their motor vehicle accident and were designated the cases. In the majority of cases the onset of this neck pain was within 24 hours of the accident (92%), had resulted in a consultation with a GP (64%), and was still present and reported on the day of questionnaire completion (69%). Overall, 11.3% of cases reported disabling neck pain (defined as NDI ≥ 20%) and 46% were seeking compensation. In total, 183 cases and 505 of those without neck pain (the controls) had complete data for further analyses.

*Predictors of neck pain.* Women and younger individuals had increased odds of reporting post-accident neck pain (Table 1). In addition, markers of health prior to the accident (number of GP consultations, history of neck pain, and higher scores on the Illness Behavior subscale of the IAS) and psychosocial factors (no-fault claim and monotonous work) were associated with increased odds of post-accident neck pain. A number of accident related factors (height of headrest, direction of collision, speed of vehicle at time of impact, severity of collision) were also univariately associated (Table 1).

On multivariable analysis, 8 factors were identified as being independently associated with post-accident neck pain (Table 2): female sex (OR 1.50), age < 36 years (OR 1.62), history of neck pain before the accident (OR 1.75), collision from behind (OR 2.55), being stationary at the time of impact (OR 1.93), collision severity (OR upper tertile 16.1), not being at fault (OR 2.61), and monotonous work (OR 2.19). Based on these 8 factors, the likelihood of having neck pain increased from 7% with ≤ 2 risk factors to 62% with ≥ 5 risk factors. Excluding perceived severity of collision (which may be particularly influenced by symptoms) from the list of predictors had little effect on model performance (increasing from 11% to 60%, respectively). Overall, the model had an accuracy of 81.3% in predicting those who would experience neck pain (positive predictive value 69%, negative predictive value 84%).

*Compensation.* Women were more likely to claim compensation, as were younger individuals, those who were regarded as not at fault for the accident, those in more severe collisions, those who were hit from behind, and those who were stationary at the time of the impact (Table 3). Those claiming compensation were significantly more likely to report neck pain on the day of questionnaire completion [84.7% vs 54.3%: per-

*Table 1.* Univariate predictors of neck pain.

| | Cases | Controls | OR | 95% CI |
|---|---|---|---|---|
| Sex | | | | |
| Male | 77 | 266 | 1.00 | |
| Female | 106 | 239 | 1.53 | 1.09, 2.16 |
| Age at time of accident, yrs | | | | |
| ≥ 46 | 44 | 160 | 1.00 | |
| 36–45 | 58 | 173 | 1.22 | 0.78, 1.91 |
| < 36 | 81 | 172 | 1.71 | 1.12, 2.62 |
| Self-rated health in year prior to accident | | | | |
| Excellent/very good | 147 | 395 | 1.00 | |
| Good/fair/poor | 36 | 110 | 0.88 | 0.58, 1.34 |
| No. of GP consultations in year prior to accident | | | | |
| 0–1 | 81 | 269 | 1.00 | |
| ≥ 2 | 102 | 236 | 1.44 | 1.02, 2.02 |
| History of neck pain | | | | |
| No | 128 | 410 | 1.00 | |
| Yes | 55 | 95 | 1.85 | 1.26, 2.73 |
| GHQ score | | | | |
| < 3 | 172 | 449 | 1.00 | |
| ≥ 3 | 11 | 56 | 0.51 | 0.26, 1.00 |
| Somatic Symptom Checklist | | | | |
| 0 | 124 | 318 | 1.00 | |
| ≥ 1 | 59 | 187 | 0.81 | 0.57, 1.16 |
| Health Anxiety (IAS) | | | | |
| 0–2 | 62 | 178 | 1.00 | |
| 3–7 | 61 | 164 | 1.07 | 0.71, 1.61 |
| ≥ 8 | 60 | 163 | 1.06 | 0.70, 1.60 |
| Illness Behavior (IAS) | | | | |
| 0–2 | 62 | 211 | 1.00 | |
| 3–5 | 64 | 175 | 1.24 | 0.83, 1.86 |
| ≥ 6 | 57 | 119 | 1.63 | 1.07, 2.49 |
| Headrest height | | | | |
| Correct height | 135 | 402 | 1.00 | |
| Too low | 48 | 103 | 1.39 | 0.94, 2.06 |
| Direction of collision | | | | |
| Other | 31 | 164 | 1.00 | |
| From front | 30 | 169 | 0.94 | 0.54, 1.62 |
| From behind | 122 | 172 | 3.75 | 2.40, 5.88 |
| Anticipated collision | | | | |
| No | 121 | 297 | 1.00 | |
| Yes | 62 | 208 | 0.73 | 0.51, 1.04 |
| Speed of vehicle | | | | |
| Moving | 67 | 347 | 1.00 | |
| Stationary | 116 | 158 | 3.80 | 2.67, 5.42 |
| Fault (insurance company) | | | | |
| At fault | 26 | 237 | 1.00 | |
| Not at fault | 157 | 268 | 5.33 | 3.40, 8.38 |
| Perceived severity of collision (100 mm VAS) | | | | |
| < 13 | 16 | 232 | 1.00 | |
| 13–28 | 51 | 162 | 4.56 | 2.51, 8.29 |
| ≥ 29 | 116 | 111 | 15.2 | 8.57, 26.8 |
| Satisfaction with job | | | | |
| Very/Satisfied | 136 | 387 | 1.00 | |
| Neither, Dissatisfied or Very dissatisfied | 47 | 118 | 1.13 | 0.77, 1.67 |
| Monotonous work | | | | |
| Never/Occasionally | 153 | 457 | 1.00 | |
| Half/Most of the time | 50 | 48 | 1.87 | 1.14, 3.05 |
| Hectic work | | | | |
| Never/Occasionally | 132 | 342 | 1.00 | |
| Half/Most of the time | 51 | 163 | 0.81 | 0.56, 1.18 |
| Stressful work | | | | |
| Never/Occasionally | 155 | 412 | 1.00 | |
| Half/Most of the time | 28 | 93 | 0.80 | 0.50, 1.27 |
| Job decision making | | | | |
| Very often/Often | 155 | 436 | 1.00 | |
| Sometimes/v/seldom | 28 | 69 | 1.14 | 0.71, 1.84 |
| Job learning | | | | |
| Very often/Often | 113 | 322 | 1.00 | |
| Sometimes/v/seldom | 70 | 183 | 1.09 | 0.77, 1.55 |

GP: general practitioner, GHQ: General Health Questionnaire, IAS: Illness Attitude Scales.

*Table 2.* Independent predictors of neck pain.

| Variable | OR | 95% CI |
|---|---|---|
| Sex | | |
| Male | 1.00 | |
| Female | 1.50 | 0.98, 2.28 |
| Age, yrs | | |
| ≥ 46 | 1.00 | |
| 36–45 | 0.97 | 0.56, 1.68 |
| < 36 | 1.62 | 0.96, 2.74 |
| History of neck pain | | |
| No | 1.00 | |
| Yes | 1.75 | 1.09, 2.81 |
| Direction of collision | | |
| Other | 1.00 | |
| From front | 1.03 | 0.55, 1.91 |
| From behind | 2.55 | 1.41, 4.62 |
| Vehicle stationary | | |
| No | 1.00 | |
| Yes | 1.93 | 1.12, 3.33 |
| At fault | | |
| Yes | 1.00 | |
| No | 2.61 | 1.49, 4.59 |
| Severity of collision (VAS) | | |
| < 13 | 1.00 | |
| 13–28 | 4.35 | 2.29, 8.26 |
| ≥ 29 | 16.1 | 8.64, 30.1 |
| Monotonous work | | |
| Never/Occasionally | 1.00 | |
| Half/Most of the time | 2.19 | 1.19, 4.04 |

centage difference 30.4% (95% CI 18.9, 41.9)]. Compensation claimants also reported more severe, disabling, and more distressing neck pain (Table 3). In addition, those claiming compensation reported a greater number of health related symptoms after the accident (median 3 vs 0; $p < 0.0001$, Mann-Whitney U test). Three factors were identified as independent predictors of compensation: female sex, not being at fault for the accident, and being hit from behind (Table 4).

Multivariable modeling identified 6 factors that were independently associated with the odds of reporting post-accident neck pain in those not claiming compensation (Table 5). Five of these factors were previously identified as predictors of neck pain in all subjects (Table 2).

*Comparison of predictors of post-accident neck pain in all subjects and in those not claiming compensation.* In order to compare the predictors of post-accident neck pain in all subjects and in those not claiming compensation, multivariable models were constructed containing all predictors identified in either group (Table 6). Five factors were identified as predictors of post-accident neck pain in both groups (history of neck pain, being in a stationary vehicle, not being at fault, rating the collision as more severe, and monotonous work). Women, younger individuals, and those hit from behind were more likely to report post-accident neck pain in the entire dataset. However, these factors did not reach statistical significance among non-compensation claimants. Those who anticipated the collision had decreased odds of reporting neck pain in those not claiming compensation; when included in the list of predictors for all subjects, a weaker effect was observed.

*External validity and adjustments for probability weights.* Those who completed the short questionnaire were younger and more likely to be male. However, there was no significant difference in onset of neck pain after the accident among respondents to the short (24.4%) and full-length (25.8%) questionnaire [difference, 1.4% (95% CI –3.6%, 6.3%)].

The age, sex, and claim-type profile of those included in the main analysis (n = 688) and the original 2665 (appropriately referred) participants invited by the insurance company were compared. Those included in the main dataset were more likely to be female [50.2% vs 42.8%, percentage difference 7.3% (95% CI 3.0, 11.6)] and were more likely to have been not at fault for the accident [61.8% vs 48.4%, percentage difference 13.4% (95% CI 9.1, 17.6)]. There was no difference in age at the time of the accident between those included in and excluded from the main dataset ($p = 0.41$, Mann-Whitney U test).

A weighted analysis using probability weights to account for the differences in sex and claim type reported above showed no substantial differences in the associations observed in the various multivariable logistic regression models (data not shown).

## DISCUSSION

*Principal findings.* This study has shown that the onset of neck pain after a motor vehicle accident has, in common with other regional pain syndromes, a multifactorial etiology. A combination of 8 constitutional, mechanical, and psychosocial factors could be used to identify those at high risk of developing neck pain. Specifically, younger individuals, women, and those with a history of neck pain had 50% to 80% increased odds of reporting post-accident neck pain. A 2- to 3-fold increased odds was seen for those whose vehicles were hit from behind and who were stationary at the time of impact. Greater severity of the collision was also associated with increased odds of post-accident neck pain. Those not at fault for the accident and those whose jobs were boring or monotonous also had 2- to 3-fold increased odds of reporting neck pain following their motor vehicle accident.

*Comparison with data from previous studies.* Female sex[6-9] and being involved in a rear-end collision[6,9,10] have emerged as the 2 most consistent predictors of the onset of neck pain after a motor vehicle accident. The balance of evidence[7-9] would suggest, in common with our findings, that younger individuals are more likely to experience post-accident neck pain, although opposing evidence exists[6]. One study also observed[7] that a history of neck pain is associated with an increased likelihood of reporting a new episode of neck pain following a motor vehicle accident.

Several studies have, in common with ours, been based

*Table 3.* Differences between those claiming and not claiming compensation.

| | Not Claiming Compensation, n = 596 | | Claiming Compensation, n = 87 | | Difference, % |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Sex | | | | | |
| Male | 305 | 51.2 | 37 | 42.5 | |
| Female | 291 | 48.8 | 50 | 57.5 | –8.6 (–19.8, 2.5) |
| Claim type | | | | | |
| Fault or 50:50 | 257 | 43.1 | 4 | 4.6 | |
| No fault | 339 | 56.9 | 83 | 95.4 | 38.5 (32.6, 44.4) |
| General health | | | | | |
| Excellent/v. good | 466 | 78.2 | 72 | 82.8 | |
| Good, fair, poor | 130 | 21.8 | 15 | 17.2 | –4.6 (–13.2, 4.0) |
| GP visits in year prior to accident | | | | | |
| 0–1 | 307 | 51.5 | 42 | 48.3 | |
| ≥ 2 | 289 | 48.5 | 45 | 51.7 | –4.6 (–13.2, 4.0) |
| History of neck pain | | | | | |
| No | 469 | 78.7 | 65 | 74.7 | |
| Yes | 127 | 21.3 | 22 | 25.3 | 4.0 (–5.7, 13.7) |
| GHQ score | | | | | |
| < 3 | 532 | 89.3 | 84 | 96.6 | |
| ≥ 3 | 64 | 10.7 | 3 | 3.5 | –7.3 (–2.7, –11.9) |
| Somatic Symptom Checklist | | | | | |
| 0 | 376 | 63.1 | 62 | 71.3 | |
| ≥ 1 | 220 | 36.9 | 25 | 28.7 | –8.2 (–18.4, 2.1) |
| Anticipated accident | | | | | |
| No | 361 | 60.6 | 56 | 64.4 | |
| Yes | 235 | 39.4 | 31 | 35.6 | –3.8 (–14.6, 7.0) |
| Head rest | | | | | |
| No | 469 | 78.7 | 64 | 73.6 | |
| Yes | 127 | 21.3 | 23 | 26.4 | 5.1 (–4.7, 15.0) |
| Direction of collision | | | | | |
| Other direction | 187 | 31.4 | 6 | 6.9 | |
| Front | 182 | 30.5 | 16 | 18.4 | |
| Behind | 227 | 38.1 | 65 | 74.7 | p < 0.001** |
| Speed of vehicle | | | | | |
| Stationary | 387 | 64.9 | 25 | 28.7 | |
| Moving | 209 | 35.1 | 62 | 71.3 | 36.2 (25.9, 46.4) |
| | Median | (IQR) | Median | (IQR) | p |
| Age, yrs | 40.0 | (32.8, 47.7) | 37.5 | (29.1, 44.5) | 0.05* |
| Health Anxiety score | 5 | (1, 9) | 5 | (1, 8) | 0.59* |
| Illness Behavior score | 3 | (1, 5.5) | 3 | (2, 6) | 0.25* |
| Severity of collision, VAS | 16 | (8, 30) | 48 | (28, 64) | < 0.0001* |
| Neck pain NDI score | 17.9 | (12, 28) | 33 | (23, 42) | < 0.0001* |
| Severity of neck pain, VAS | 18 | (9, 31) | 30 | (19, 44) | 0.0004* |
| Distress of neck pain, VAS | 12 | (5, 25) | 31.5 | (13, 49) | 0.0001* |

* Mann-Whitney U test for continuous non-normal variables. ** Chi-square test. GHQ: General Health Questionnaire, IQR: interquartile range, NDI: Neck Disability Index.

on data from insurance company claimants[9,10], but others have been restricted to hospital inpatients and outpatients[6,8], or to accidents reported to the police[7]. The generalizability of previous findings has also been debatable due to poor response rates[7]. Earlier studies have collected limited data on both the subject (age and/or sex) and the accident itself (most often, the direction of collision). Given the complex etiology of other regional pain syndromes, it is perhaps surprising that, with the exception of history of neck pain[7], none of the above studies collected data on prior health or psychosocial factors. Indeed, we have shown that a combination of constitutional, accident related, and psychosocial factors are associated with the onset of neck pain following a motor vehicle accident.

*Compensation.* The evolution of a "compensation culture" within society is often quoted in the media and indeed, as noted, compensation often forms a controversial aspect in discussions surrounding whiplash. However, our findings suggest that the initiation of a compensation claim is linked closely to the severity of the pain. Compensation claimants

*Table 4.* Independent predictors of claiming compensation.

| Variable | OR | 95% CI |
|---|---|---|
| Sex | | |
| Male | 1.00 | |
| Female | 1.58 | 0.97, 2.57 |
| Claim type | | |
| Fault | 1.00 | |
| No-fault | 13.5 | 4.74, 38.4 |
| Direction of collision | | |
| Other | 1.00 | |
| From front | 4.71 | 1.75, 12.7 |
| From behind | 7.35 | 3.08, 17.6 |

*Table 5.* Independent predictors of neck pain among those not claiming compensation.

| Variable | OR | 95% CI |
|---|---|---|
| Anticipated collision | | |
| No | 1.00 | |
| Yes | 0.56 | 0.34, 0.92 |
| History of neck pain | | |
| No | 1.00 | |
| Yes | 1.96 | 1.16, 3.33 |
| Vehicle stationary | | |
| No | 1.00 | |
| Yes | 2.58 | 1.49, 4.46 |
| At fault | | |
| Yes | 1.00 | |
| No | 1.89 | 1.03, 3.48 |
| Severity of collision, VAS | | |
| < 13 | 1.00 | |
| 13–28 | 3.02 | 1.53, 5.96 |
| ≥ 29 | 8.63 | 4.49, 16.6 |
| Monotonous work | | |
| Never/Occasionally | 1.00 | |
| Half/Most of the time | 2.24 | 1.14, 4.40 |

reported more severe, disabling, and distressing pain than nonclaimants. Others have also suggested that compensation is likely to be a consequence of severe pain rather than the cause[22]. True malingering is also regarded as uncommon[23]. However, we are unable to exclude the possibility that those who decide to claim compensation may then report more severe symptoms.

When we restricted our analyses to those subjects who had not claimed compensation, 5 out of the 8 predictors previously identified on multivariable analysis remained in the model. The independent associations with sex, age, and direction of collision weakened. Given the association between compensation and severity of neck pain, this subgroup analysis is likely to identify predictors of less severe neck pain rather than neck pain *per se*.

*Strengths and weaknesses of this study.* The case-control study design allowed us to investigate a wide range of potential etiological factors in the development of neck pain. Use of a self-questionnaire eliminated the potential for observer bias that may exist in interview based studies. Further, differential selection of cases and controls was avoided by the identification of case status from responses to the self-questionnaire.

The possibility of recall bias exists due to the retrospective nature of data collection. This is most likely to affect the individual's recall of their health before the accident and may explain the protective effect of prior psychological distress in predicting neck pain that was seen univariately. Similarly, rating the severity of collision is likely to be influenced by the consequences of the accident. However, when severity of collision was excluded from the final multivariable model, the performance of the model was not substantially affected. It could be argued that objective measures of the accident (for example, independent rating of vehicle damage) may be better than self-report data. However, it is likely that subjective health related outcomes, such as pain, will be more closely linked to the individual's perception of the accident rather than objective measures (which may in turn be related to unrelated factors such as vehicle monetary value). Finally, given that this study was conducted among drivers reporting a motor vehicle accident to their insurance company, it is possible that we have underestimated the incidence of neck pain.

As we restricted our main analyses to those with complete full-length questionnaire data, we explored the external validity of our study findings by using probability weights to adjust for the differences in sex and claim type between those included and excluded from the main dataset. No substantial differences were observed. Further evidence for the validity of our findings was provided by comparison of the incidence of neck pain among those who completed the short and the full-length questionnaires (24% vs 26%).

The development of neck pain following a motor vehicle accident is a complex phenomenon resulting from the combined effects of constitutional, mechanical, and psychosocial factors. Using 8 such variables it is possible to identify those at high risk of developing neck pain after a motor vehicle accident. The relationship between these etiological factors and markers of prognosis requires further investigation.

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*Table 6.* Comparison of independent predictors of neck pain in all subjects and those not claiming compensation.

| Variable | All Subjects, n = 688 | | Variable | Not Claiming Compensation, n = 596 | |
|---|---|---|---|---|---|
| | OR | 95% CI | | OR | 95% CI |
| Sex | | | Sex | | |
| Male | 1.00 | | Male | 1.00 | |
| Female | 1.49 | 0.98, 2.28 | Female | 1.38 | 0.84, 2.27 |
| Age, yrs | | | Age, yrs | | |
| ≥ 46 | 1.00 | | ≥ 46 | 1.00 | |
| 36–45 | 1.00 | 0.57, 1.73 | 36–45 | 0.90 | 0.47, 1.73 |
| < 36 | 1.68 | 0.99, 2.84 | < 36 | 1.55 | 0.84, 2.85 |
| Anticipated collision | | | Anticipated collision | | |
| No | 1.00 | | No | 1.00 | |
| Yes | 0.76 | 0.47, 1.22 | Yes | 0.65 | 0.37, 1.14 |
| History of neck pain | | | History of neck pain | | |
| No | 1.00 | | No | 1.00 | |
| Yes | 1.76 | 1.10, 2.82 | Yes | 1.98 | 1.16, 3.39 |
| Direction of collision | | | Direction of collision | | |
| Other | 1.00 | | Other | 1.00 | |
| From front | 1.15 | 0.60, 2.19 | From front | 0.77 | 0.36, 1.63 |
| From behind | 2.39 | 1.31, 4.38 | From behind | 1.67 | 0.87, 3.19 |
| Vehicle stationary | | | Vehicle stationary | | |
| No | 1.00 | | No | 1.00 | |
| Yes | 1.98 | 1.14, 3.42 | Yes | 1.84 | 0.99, 3.44 |
| At fault | | | At fault | | |
| Yes | 1.00 | | Yes | 1.00 | |
| No | 2.72 | 1.54, 4.81 | No | 1.81 | 0.96, 3.41 |
| Severity of collision, VAS | | | Severity of collision, VAS | | |
| < 13 | 1.00 | | < 13 | 1.00 | |
| 13–28 | 4.43 | 2.33, 8.45 | 13–28 | 2.90 | 1.45, 5.80 |
| ≥ 29 | 16.4 | 8.77, 30.6 | ≥ 29 | 8.43 | 4.34, 16.4 |
| Monotonous work | | | Monotonous work | | |
| Never/Occasionally | 1.00 | | Never/Occasionally | 1.00 | |
| Half/Most/All | 2.17 | 1.17, 4.01 | Half/Most/All | 2.17 | 1.09, 4.31 |


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