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REVIEW ARTICLE



# The course and factors associated with recovery of whiplash-associated disorders: an updated systematic review by the Ontario protocol for traffic injury management (OPTIMa) collaboration

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**ABSTRACT**

**Purpose:** To update the findings of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders (Neck Pain Task Force) on prognostic factors for whiplash-associated disorder (WAD) outcomes.

**Materials and methods:** We conducted a systematic review and best-evidence synthesis. We systematically searched MEDLINE, EMBASE, CINAHL and PsycINFO from 2000–2017. Random pairs of reviewers critically appraised eligible studies using the Scottish Intercollegiate Guidelines Network criteria.

**Results:** We retrieved 10,081 articles. Of those, 100 met inclusion criteria. After critical appraisal, 74 were judged to have low risk of bias. This adds to the 47 admissible studies found by the Neck Pain Task Force. Twenty-two related to course of recovery; 59 to prognostic factors in recovery; and 16 reported other WADs outcomes. Some studies related to more than one category. Findings suggest that half of those with WADs will experience substantial improvement within three months and cessation of symptoms within six months. Among factors associated with recovery are post-crash psychological factors, including expectations for recovery and coping.

**Conclusions:** Our review adds to the Neck Pain Task Force by clarifying the role of prognostic factors. Evidence supports the important role of post-crash psychological factors in WADs recovery.

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## Introduction

Whiplash injuries are common, with increasing frequency of visits to emergency rooms in the western world [1]. Recent estimates suggest that in North America and Western Europe, at least 300 per 100,000 inhabitants seek health care in emergency departments each year because of such injuries [1]. This figure does not capture those who do not attend emergency departments, and some estimates place the actual incidence at up to 600 per 100,000 inhabitants [2].

Whiplash is an acceleration-deceleration mechanism of injury to the neck that results in whiplash-associated disorders (WADs) [3]. In 1995, the Québec Task Force on Whiplash-Associated Disorders proposed that WAD includes neck pain and other symptoms such as dizziness, headache, memory loss, and temporomandibular joint pain [3]. Subsequent studies have added other common symptoms such as low back pain, difficulty concentrating, depressive symptomatology and widespread pain to the list of WAD-related symptoms [4–7]. Because of limited evidence available at that time on prognostic factors for WAD recovery, the Québec Task Force could only hypothesise that initial severity of injury predicted symptom persistence [3].

Since the Québec Task Force report, there have been several systematic reviews of WAD prognosis, including the

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Supplemental data for this article can be accessed here.

2008 best evidence synthesis from the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorder (Neck Pain Task Force) [8]. In that review, Carroll et al. provided an estimate that 50% of persons with WAD continue to experience symptoms one year post-collision, although fewer (approximately 10%) report daily neck pain or significant health impairment at that time [8]. In addition to the Neck Pain Task Force (NPTF) report, there have been several meta-analyses of risk factors for poor outcomes [9–11]. In the most recent updated meta-analysis, Walton et al. cited 12 significant factors, including prior pain, initial neck pain, catastrophizing and female sex, among other factors [11]. However, their inclusion/exclusion criteria were necessarily driven by the needs of the meta-analysis, and only nine studies representing four distinct cohorts were retained for their analysis. Thus, a systematic review (best evidence synthesis), designed to update the 2008 findings of the NPTF, was undertaken. In 2008, the current evidence suggested that initial symptom severity, psychological factors and type of compensation system/legal factors predicted poorer recovery [8]. However, even with the increased number of WAD studies available at the time of that review, the NPTF indicated that fundamental questions remained about prognostic factors for recovery [8].

The aim of this systematic review was to update the findings of the NPTF on prognostic factors for WAD outcomes by identifying new evidence and integrating it with the evidence previously synthesised by the NPTF.

## Materials and methods

### Registration

The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on 17 May 2013 (CRD42013004610).

### Eligibility criteria

#### Study characteristics

Eligible studies met the following criteria during citation and full text screening: (1) English language; (2) published between 1st January 2000 to 14th February 2017; (3) longitudinal design; and (4) $\geq$30 adults or children with WAD Grades I–III, using the Québec Task Force classification (Table 1) [3].

We excluded: (1) letters, editorials, commentaries, unpublished manuscripts, dissertations, government reports, books and book chapters, conference proceedings, meeting abstracts, lectures and addresses, consensus development statements, or guideline statements; (2) cross-sectional studies, case reports, qualitative studies, reviews, practice guidelines, biomechanical studies, or laboratory studies; (3) studies primarily about intervention effectiveness; or (4) cadaveric or animal studies. In addition, for course of recovery, we included those studies which tracked recovery with at least one follow-up point in the first six months post-injury, and which followed the participants at least until approximately half were recovered.

Table 1. The Québec Task Force Classification of Grades of Whiplash-associated Disorders.

| Grade | Definition |
|---|---|
| I | Subjects with neck pain and associated symptoms in the absence of objective physical signs |
| II | Subjects with neck pain and associated symptoms in the presence of objective physical signs and without evidence of neurological involvement |
| III | Subjects with neck pain and associated symptoms with evidence of neurological involvement including decreased or absent reflexes, decreased or limited sensation, or muscular weakness |
| IV | Subjects with neck pain and associated symptoms with evidence of fracture or dislocation |

#### Information sources

We developed our search strategy with a health sciences librarian and a second librarian peer reviewed the strategy using the Peer Review of Electronic Search Strategies (PRESS) Checklist [12,13]. We searched MEDLINE, EMBASE, CINAHL and PsycINFO. The search strategy was developed in MEDLINE (Supplementary Appendix 1) and adapted to the other bibliographic databases. Search terms included subject headings and free text words relevant to WAD prognosis or recovery. We downloaded the search results into reference managing software.

#### Study selection

We used a two-stage screening process (title/abstracts and full text) with randomly assigned pairs of independent reviewers. We stratified reviewers by level of experience with the systematic review/critical appraisal experience (senior vs. junior), and drew one name, blindly, from each group. The two individuals were paired for a set of reviews. We repeated this process to yield a different pairing for the next set of reviews. Disagreements were resolved by discussion. A third reviewer was used to resolve disagreements if consensus could not be reached.

#### Risk of bias assessment

Relevant studies were critically appraised by random pairs of trained, independent reviewers, using the Scottish Intercollegiate Guidelines Network criteria for cohort and case control studies [14]. Where consensus between reviewers could not be reached, a third reviewer was employed. Authors were contacted for further information when necessary. Those studies judged to have adequate internal validity (low-to-moderate risk of bias) were included in our synthesis [15].

#### Data extraction and synthesis of results

The lead author extracted data from all scientifically admissible studies into evidence tables, which were independently checked by a second reviewer. Findings are reported in three

main sections: course of recovery, factors associated with recovery, and other outcomes. For course of recovery, we combined those findings from studies reported by the NPTF and new studies that met our inclusion criteria. We classified the criteria used to define recovery as stringent, less stringent and other. We considered stringent criteria for recovery to include: no or almost no neck pain (self-report of no neck pain/symptoms or pain intensity of $\leq$1/10 on Numeric Rating Scale or $\leq$10/100 on Visual Analogue Scale); Neck Disability Index Score of $\leq$5/50 (classified as no disability) [16] and 'yes' to 'have you recovered?' We classified criteria as less stringent where cut-off scores were 3/10 on Numeric Rating Scale or 30/100 on Visual Analogue Scale (since scores up to 3/10 Numeric Rating Scale and 30/100 on Visual Analogue Scale have been shown to reflect 'mild pain') [17,18]; 30% (15/50) on Neck Disability Index (which includes mild disability) [16], and self-report of 'all better' or 'quite a bit improved' (shown to reflect an average pain intensity score of 2–3/10 on Numeric Rating Scale) [19].

In best evidence synthesis, more weight is given to studies whose designs make them least vulnerable to bias and confounding. Thus, for the synthesis of factors associated with recovery, we used a hierarchical classification system with three levels of evidence, Phases I, II or III (Table 2) [8,20–22].

Where the findings across studies were discordant, we used scientific judgment, based on methodological quality, to weigh the evidence, and gave the most weight to Phase-III studies, followed by Phase-II studies and the least weight to Phase-I studies. This decision framework was adapted from work previously reported by the NPTF [8] and by Altman and Lyman [23]. Terminology used to report the summary of evidence is as follows:

- *Evidence*: at least one Phase-III study
- *Preliminary evidence:* Phase-I and Phase-II studies only
- *Consistent:* all studies agree on the association
- *Preponderance:* findings are variable, but there is agreement among the stronger studies or among the majority of studies of similar strength
- *Varies:* no agreement among studies of similar strength
- *Limited:* three or fewer studies on the topic are available

We present reviewer agreement for the screening of the titles/abstracts and for critical appraisals using kappa statistic (k) with 95% confidence interval (CI) [24].

**Table 2.** Levels of evidence of cohort and case–control studies.

| Study Phase | Description |
|---|---|
| Phase I Exploratory | Associations between potential prognostic factors and health outcomes explored in a descriptive way. Only crude (univariable) associations are reported |
| Phase II Exploratory | Includes use of well-formulated comparison groups, stratified analyses or multivariable analyses to identify *sets* of predictors |
| Phase III Confirmatory | Goal is to test a specific hypothesis in order to confirm or disconfirm an independent relationship between an identified prognostic factor and a health outcome, while explicitly identifying and controlling for confounding |

### *Reporting*

The systematic review was organised and reported based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement [25]

## Results

### *Results of the search and screening*

Our search yielded 10,081 articles. We removed 1194 duplicates and screened 8887 articles for eligibility (Figure 1). One hundred articles were relevant and had not been reviewed by the NPTF. After critical appraisal, 74 studies were judged to have low to moderate risk of bias and were included in our synthesis (Supplementary Appendix 2, Tables 1 and 2). Twenty-two studies related to course of recovery (Supplementary Appendix 3), 59 studies reported factors associated with WAD recovery (Supplementary Appendix 4)

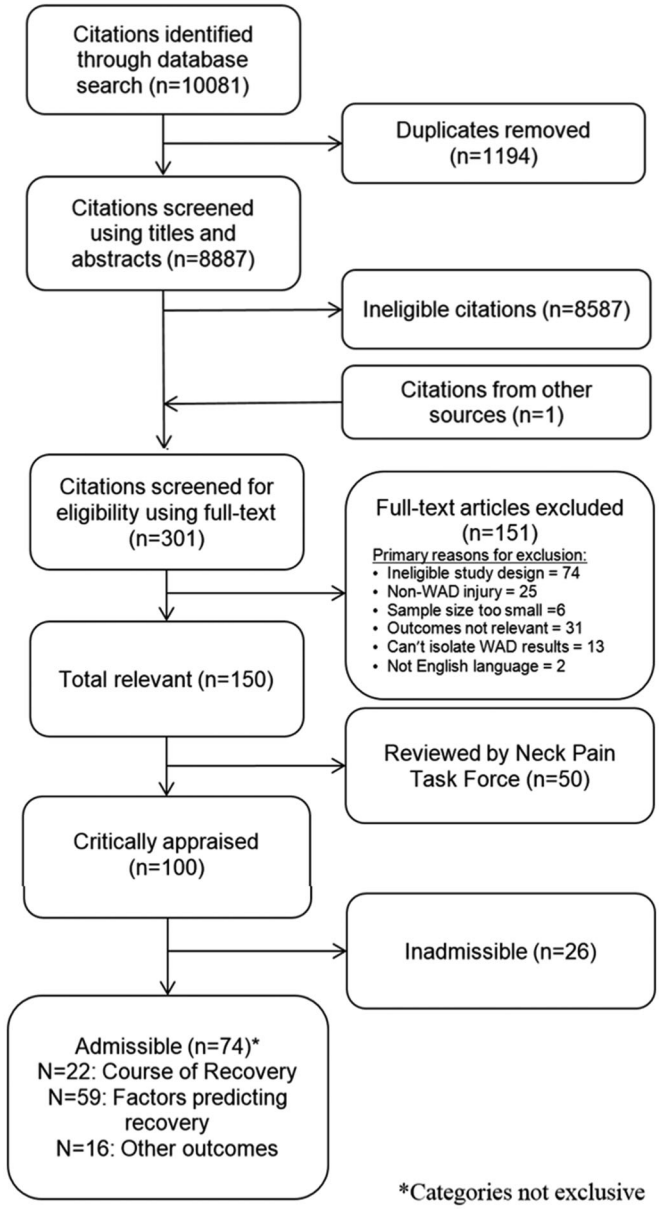


**Figure 1.** Identification and selection of articles.

Table 3. Number of included studies on course of Whiplash-associated disorder (WAD) recovery from the neck pain task force (NPTF) and the current review.

| Variable | NPTF | Current Review | Total |
|---|---|---|---|
| WAD in Children | | | |
| WAD recovery in children | 1 [26] | | 1 |
| WAD recovery in Adults | | | |
| Stringent criteria to define recovery | 2 [30,31] | 12 [34–45] | 14 |
| Less stringent indices of recovery | 3 [27,29,32] | 8 [46–53] | 11 |
| Insurance claim closure | 3 [2,28,33] | 1 [53] | 4 |
| Neck pain at one year | | 1 [55] | 1 |

Values refer to number of studies [references].

and 16 studies reported on WAD outcomes other than recovery (Supplementary Appendix 5). Some studies related to more than one topic and are therefore included in more than one evidence table. This adds to the eight studies on course of recovery reported by the NPTF and which meet the above criteria; to the 29 studies on factors associated with WAD recovery reported by the NPTF and to the nine studies of other outcomes reported by the NPTF [8]. All new studies were cohort studies and related to adults with WAD.

Inter-rater agreement for article screening was $k = 0.93$ (95% CI 0.91, 0.96) and percentage agreement (prior to consensus discussions) for critical appraisals of articles was 81.6%. We did not perform a meta-analysis due to heterogeneity of studies with respect to patient populations, predictors and outcomes. A non-quantitative synthesis of findings from the studies with low to moderate risk of bias was performed according to principles of best evidence synthesis by combining evidence from the NPTF and our update [8,15]. The findings were summarised and organised by type of criterion used to define recovery (course of recovery) and type of factor studied (factors predicting recovery). For detailed findings, see Supplementary Appendix 6. Tables 3–5 show the number of studies included from the NPTF and this update, as well as phase and type of factor studied.

## Findings: course of WAD recovery

Please refer to Supplementary Appendix 3, Table 1 for additional detail.

### WAD recovery in children

Only one study from the NPTF reported on WAD recovery in children, and this study found rapid recovery, with a mean of 8.8 days to symptom cessation [26]. No study on WAD recovery in children was found in the update.

### WAD recovery in adults

The NPTF concluded that one year after the injury event, 50% of adults have neck symptoms which they attribute to WAD. However, confidence in these findings was limited by a number of factors including: variability in definitions of recovery and a paucity of studies with sufficient and early enough follow-up points to accurately track recovery. Only eight of the 20 studies reported by the NPTF tracked recovery within the first six months and followed participants long enough for at least half to have recovered (our current inclusion criteria) [2,27–33]. In addition, the NPTF pointed out that neck pain is endemic in the general population and therefore in some cases, neck symptoms attributed to WAD may in fact reflect the background prevalence of neck pain [8].

In addition to these eight studies found by the NPTF, the update found 22 studies consisting of 20 distinct cohorts [34–54]. In combining findings from the NPTF and the update, recovery rate depended largely on the definition used for recovery. Fourteen studies (two from the NPTF and 12 studies of 11 distinct cohorts from the update) used a stringent criterion to define recovery [30,31,34–45]. The preponderance of these studies found that approximately 50% of study participants reached that criterion at or about the six month mark [34–42]. One of the preceding studies included two cohorts, one of which recovered more slowly [42], as did one other new study [43]. In contrast, four studies (two from the NPTF and two new studies, both from the same source population [44,45]) found faster recovery. Source population did not seem to be related to discrepancies.

Three studies reported in the NPTF and eight studies of seven distinct cohorts from the update [27,29,32,46–53] used *less stringent* indices of recovery. The preponderance of these studies found that median time to recovery was less than six months. These studies included persons seeking health care, including those presenting to emergency departments, with and without insurance claims. In contrast, two new studies using less stringent indices of recovery, both studying insurance claimants, reported average recovery times of one year or longer [52,53].

Four studies (three from the NPTF and one new study) reported insurance injury claim closure as an index of recovery, with median time to claim closure varying from one month to more than two years [2,28,33,53]. Whether there is a relationship between claim closure and other indices of recovery appears to vary by jurisdiction. Two of the studies reported by the NPTF found median time to claim closure varied from one month to one year; however, neither study related claim closure to other indices of recovery [33,54]. A third study from the NPTF found that median time to claim closure varied from six months for no fault claims to one year for tort claims [2]. In that cohort, claim closure was associated with other indices of recovery [2,28]. In contrast, the study found in the update that used claim closure as an outcome found little difference in pain intensity between those who did and did not settle their claims; however, only 30% had closed their claims at two years despite an average pain intensity of $<$ 16/100 on Visual Analogue Scale [53].

Finally, one new study reported that 36% of those with WAD reported neck pain at one year. However, the authors noted that not all individuals should be classified as having persistent pain since only 21% had reported symptoms at all three follow-ups (i.e. one-, three- and 12-month follow-up points) [55].

## Findings: factors associated with WAD recovery

Please refer to Supplementary Appendix 4, Table 1 for additional detail.

**Table 4.** Studies included from the neck pain task force (NPTF) and current review by phase and factors associated with recovery.

| Variable | NPTF | Current Review | Total |
|---|---|---|---|
| Sociodemographic Factors | | | |
| Sex | 4 Phase I [26,33,56,57]<br>7 Phase II [2,58–61, 76,78] | 4 Phase I [62–64,77]<br>17 Phase II [41,43,44,49,52,55,64–75] | 32 |
| Age | 8 Phase II [2,57–61,78] | 3 Phase I [62–64]<br>16 Phase II [35,41,43,44,47,49,52,55,65–67, 72,74,75,79,80] | 27 |
| Employment | No studies | 2 Phase I [62,63]<br>7 Phase II [35,41,52,55,65,67,79] | 9 |
| Education | 1 Phase I [57]<br>2 Phase 2 [2,58] | 2 Phase I [62,63]<br>8 Phase II [35,41,52,65–67,73,79] | 13 |
| Pre-Crash Health Factors | | | |
| Prior Health or Pain or Comorbidities | 2 Phase I [56,81]<br>4 Phase 2 [2,59,60,78] | 2 Phase I [62,63]<br>6 Phase II [34,47,55,65,72,73] | 14 |
| History of WAD | Prior WAD and recovered from subsequent WAD: No studies<br>Prior WAD and future reports of neck pain: 2 Phase II [26,58] | Prior WAD and recovered from subsequent WAD: 2 Phase II [52,74]<br>Prior WAD and future reports of neck pain: 1 Phase III [83] | 2 |
| Body Max Index, Smoking | No studies | Body Mass Index<br>1 Phase I [64]<br>1 Phase II [52]<br>1 Phase III [84]<br>Smoking<br>1 Phase I [63]<br>1 Phase II [74] | 3 |
| Physical and Psychological | 1 phase II [2] | Physical: 2 Phase I [62,63]<br>4 Phase II [55,65,69,73]<br>1 Phase III [85]<br>Psychological:<br>2 Phase I [62,86]<br>3 Phase II [65,67,69] | 8 |
| Collision Factors | | | |
| Collision Factors | 3 Phase I [26,87,88]<br>8 Phase II [2,33,57–61,76] | 2 Phase I [62,63]<br>4 Phase II [8,55,65,67] | 17 |
| Initial Post-Crash Pain, Disability, WAD Grade and Symptoms | | | |
| Initial Neck Pain Intensity | 3 Phase I [81,90,91]<br>6 Phase II [2,58,60,61,92,93] | 3 Phase I [62,63,77]<br>11 Phase II [43,47,49,66,69,70,72, 73,75,79,89] | 23 |
| Initial Self-Perceived Disability | 2 Phase I [90,91] | 1 Phase I [64]<br>10 Phase II [52,55,71,72,74,75,79,80,89,94] | 13 |
| WAD grade | 2 Phase I [57,97]<br>2 Phase II [58,60] | 3 Phase I [62,95,96]<br>3 Phase II [52,55,72] | 10 |
| Other post-crash symptoms and number of post-crash symptoms | | 2 Phase I [62,98]<br>5 Phase II [34,35,43,55,72] | 7 |
| Radiographic Imaging and Physical Findings | | | |
| Magnetic resonance imaging findings | 1 Phase I [76] | 5 Phase I [64,77,99–101]<br>1 Phase II [102] | 7 |
| Neck Range of Motion | 2 Phase I [81,103]<br>2 Phase II [61,76] | 1 Phase I [98]<br>2 Phase II [72,80] | 8 |
| Pain threshold, sympathetic vasoconstrictor response | 1 Phase II [105] | 4 Phase II [49,71,80,104] | 5 |
| Inflammatory biomarkers | | 1 Phase I [106] | 5 |
| Eye movement | | 1 Phase II [107] | 5 |
| Post-Crash Psychological Factors and Whiplash-associated Disorder Recovery | | | |
| Acute stress disorder/Post-traumatic stress disorder | | 2 Phase I [64,77]<br>7 Phase II [34,41,69,71,72,80,89] | 9 |
| Anxiety and Fear | 2 Phase II [76,91] | 2 Phase I [62,63]<br>8 Phase II [41,47,68,70,72,79,89,108]<br>1 Phase III [38] | 13 |
| General Psychological Health/Distress, Anger, Frustration | 1 Phase II [61] | 1 Phase I [63]<br>5 Phase II [52,55,72,74,75] | 7 |
| Pain-related Beliefs, Self-efficacy; Perceived Injustice | | 2 Phase I [45,110]<br>2 Phase II [72,89]<br>1 Phase III [109] | 5 |
| Depressive symptomatology | 1 Phase II [111] | 1 Phase I [63]<br>2 Phase II [41,47]<br>1 Phase III[38] | 5 |
| Expectations for Recovery | | 2 Phase I [63,77]<br>3 Phase II [44,66,72]<br>4 Phase III [37,109,112,113] | 9 |
| Pain Coping (excludes catastrophizing) | 1 Phase II [78]<br>1 Phase III [111] | 1 Phase I [110]<br>3 Phase II [67,72,115]<br>1 Phase III [114] | 7 |
| Catastrophizing | 1 Phase I [91]<br>1 Phase II [78] | | |

(*continued*)

Table 4. Continued.

| Variable | NPTF | Current Review | Total |
|---|---|---|---|
| | | 1 Phase I [63]<br>6 Phase II [52,72,74,75,79,89]<br>1 Phase III [109] | |
| Compensation and legal factors | | | |
| Compensation and Legal Factors | 2 Phase II [2,61] | 2 Phase I [48,63]<br>4 Phase II [52,53,74,75] | 6 |
| Post-Collision Health Care Factors | | | |
| Post-Collision Health Care Factors | 2 Phase III [116,117] | 1 Phase I [46]<br>1 Phase II [47]<br>1 Phase III [118] | 5 |
| Risk Scores/Prediction Rules | | | |
| Risk scores, prediction models, or prediction rules | | 2 Phase I [98,119]<br>4 Phase II [42,63,71,80] | 6 |

Table 5. Studies included from the neck pain task force (NPTF) and current review by phase and Whiplash-associated disorder (WAD) outcomes other than recovery.

| Variable | NPTF | Current Review | Total |
|---|---|---|---|
| WAD outcomes other than recovery | | | |
| WAD and Fibromyalgia | 1 Phase I [121] | 2 Phase I [122,123] | 3 |
| WAD and Widespread Pain | 1 Phase I [4]<br>1 Phase II [124] | 1 Phase II [63] | 3 |
| WAD and Jaw Pain | | 1 Phase I [40]<br>2 Phase II [125,126] | 3 |
| WAD and Psychological Outcomes | 2 Phase I [7,121]<br>1 Phase II [76] | 1 Phase I [38]<br>2 Phase II [49,127] | 6 |
| WAD and Health Care Utilisation | | 1 Phase I [128]<br>1 Phase II [129] | 2 |
| WAD and Lawyer Involvement | | 1 Phase II [52] | 1 |
| WAD and Muscle Activation, Spinal Cord Hyperexcitability, Modic Changes. | 1 Phase I [90] | 1 Phase I [130]<br>2 Phase II [39,104] | 3 |
| WAD and headaches | | 1 Phase II [131] | 1 |

Detailed results of the factors associated with WAD recovery are provided in Supplementary Appendix 6 of the online supplemental material. We present a summary of these findings below and in Table 6.

## Sociodemographic factors

### Sex

The combined preliminary evidence varies on the association between sex and *pain* recovery [2,26,33,41,43,44,49,52,55,56–77]. There is consistent preliminary evidence of no association between sex and *disability* recovery, although there is limited preliminary evidence that women report poorer physical health-related quality of life at one year.

### Age

The preponderance of combined preliminary evidence suggests that older age is not associated with pain recovery, but the preliminary evidence on the association between age and work capacity or self-perceived disability varies [2,35,41,43,44,47,49,52,55,57–67,72,74,75,78–80].

### Employment factors

The preponderance of preliminary evidence suggests that employment factors are not associated with WAD recovery [35,41,52,55,62,63,65,67,79].

### Education

The preponderance of preliminary evidence now suggests that education is not associated with recovery [2,35,41,52,57,58,62,63,65–67,73,79].

## Pre-crash health factors

### Prior pain

The preliminary evidence about the association of prior neck and other pain and WAD recovery now varies [2,34,47,55,56–59,62,63,65,72,73,81]. However, most of the studies utilised post-injury self-reports of pre-injury pain, which has been shown to have limited validity [82]. However, one study assessing the role of documented pain-related work absence prior to the injury found it to be associated with poorer recovery [56].

### History of WAD

There is limited preliminary evidence that having a prior compensation claim (possibly a proxy for prior WAD) is associated with poorer disability recovery and longer time to claim closure [52,74]. There is also limited evidence that a history of WAD increases the risk of future prevalent and incident episodes of neck pain [26,58,83].

**Table 6.** Summary table of prognostic factors associated with WAD recovery.

| Prognostic Factor | Level of Evidence[a] | Conclusion[b] | Citation | Notes |
|---|---|---|---|---|
| Sex – Pain | Preliminary – varying | Inconclusive | [2,26,33,41,43,44,49,52,55,56–77] | |
| Sex – Disability | Preliminary – consistent | No association | | |
| Age – Pain | Preliminary – preponderance of combined evidence | No association | [2,35,41,43,44,47,49,52,55, 57–67,72,74,75,78–80] | Disability measured as work capacity or self-perceived disability |
| Age – Disability | Preliminary – varying | Inconclusive | | |
| Employment factors | Preliminary – preponderance of evidence | No association | [35,41,52,55,62,63,65,67,79] | |
| Education | Preliminary – preponderance of evidence | No association | [2,35,41,52,57,58,62,63,65–67,73,79] | |
| Pre-crash health factors | | | | |
| Prior pain | Preliminary – varying | Inconclusive | [2,34,47,55,56–59,62,63,65,72,73,81] | |
| History of WAD | Preliminary | (−) Association | [52,74] [26,58,83] | Prior compensation claim association with disability recovery and claim closure |
| BMI | Preliminary – limited | No association | [52,64,84] | |
| Smoking | Preliminary – consistent limited | No association | [63,74] | |
| Physical health | Preliminary -preponderance of combined evidence | No association for 3-12 month follow-up period | [2,55,62,63,65,69,73,85] | Cautious interpretation due to challenges in determining prior health |
| i) Extended prior sick benefits | Preliminary – limited | (−) Association | [73] | |
| Psychological health | | | | |
| i) Prior somatic symptoms | Preliminary – limited | (−) Association | [63] | Cautious interpretation due to challenges in determining prior health |
| ii) Prior psychological health & personality | Preliminary – consistent | No association | [62,65,67,69,86] | Association for prior somatic symptoms is related litigants |
| Collision factors | | | | |
| Self-reported factors – WAD recovery:<br>i. Road type<br>ii. Reasons for travel<br>iii. Collision direction<br>iv. Speed<br>v. Perceived severity of collision/damage<br>vi. Vehicle position<br>vii. Airbags use<br>viii. Seatbelt/headrest<br>ix. Awareness of impending collision | Preliminary – preponderance of combined evidence | No association | [2,8,26,33,55,57–63,65,67,76,87,88] | |
| Injured in car (vs. other vehicles) | Preliminary – limited | (+) Association | [33,55] | |
| Vehicle with tow bars | Preliminary – limited | (−) Association | [87,88] | |
| Collision with greater mean acceleration | Preliminary – limited | (−) Association | [87,88] | |
| Post-crash factors | | | | |
| Initial neck pain intensity | Preliminary – preponderance of evidence | (−) Association | [2,43,47,49,58,60–63,66,69,70,72, 73,75,77,79,81,89–93] | |
| Initial self-perceived disability | | | [52,55,64,71,72,74,75,79,80,89–91,94] | |
| i) Greater initial neck disability – disability recovery | Preliminary – preponderance of evidence | (−) Association | | |
| ii) Initial disability – pain recovery | Preliminary – limited, varying | Inconclusive | | |
| WAD grade | Preliminary – preponderance of evidence | (−) Association | [52,55,57,58,60,62,72,95–97] | |
| Other symptoms | | | [34,35,43,55,62,72,98] | |
| i) Initial poor concentration | Preliminary – limited | (−) Association | | |
| ii) Dizziness | Preliminary – limited | No association | | |
| iii) Higher number of symptoms | Preliminary – limited | (−) Association | | |
| Radiographic and physical findings | | | | |
| MRI findings | | | | |
| i) Disc degeneration, protrusion, narrowing, foraminal stenosis, lordosis, kyphosis, alar or transverse ligament changes | Preliminary – consistent | No association | [76,77,99–102] | |

(*continued*)

Table 6. Continued.

| Prognostic Factor | Level of Evidence[a] | Conclusion[b] | Citation | Notes |
|---|---|---|---|---|
| ii) Cervical fatty infiltration | Preliminary – limited | (−) Association | [64] | |
| Neck ROM | Preliminary – varying | Inconclusive | [61,72,76,80,81,98,103] | No difference in recovery between WAD I and WAD II |
| Pain thresholds/vasoconstrictor response | | | [71,80,104,105] | |
| i) Time to peak pain threshold, post-crash pain threshold | Preliminary – limited | (−) Association | | |
| ii) Pressure pain threshold, sympathetic vasoconstrictor response | Preliminary – limited | No association | | |
| Inflammatory biomarkers | | | [106] | |
| i) TNF-α | Preliminary – limited | (+) Association | | |
| ii) CRP | Preliminary – limited | (−) Association | | |
| iii) IL-1β | Preliminary – limited | No association | | |
| Eye movement | Preliminary – limited | No association | [107] | |
| Post-crash psychological factors | | | | |
| ASD/PTSD | Preliminary – preponderance of evidence | (−) Association | [34,41,64,69,71,72,77,80,89] | Based on self-report questionnaires vs. formal diagnoses |
| Anxiety and fear | Confirmatory – preponderance of evidence | (−) Association | [38,41,47,62,63,68,70,72, 76,79,89,91,108] | |
| General psychological health | Preliminary – varying | Inconclusive | [52,55,61,63,72,74,75] | |
| Pain-related anger and frustration | Confirmatory – limited | (−) Association | | |
| Pain-related beliefs | Confirmatory – limited | (−) Association | [45,72,89,109,110] | |
| Self-efficacy | Preliminary – varying | Inconclusive | | |
| Perceived injustice | Preliminary – limited | No association | [45] | |
| Depressive symptomatology | Confirmatory - preponderance of evidence | (−) Association | [38,41,47,63,111] | |
| Expectations for recovery | Confirmatory – consistent | (−) Association | [37,44,63,66,72,77,109,112,113] | |
| Pain coping | Confirmatory – consistent | (−) Association | [67,72,78,110,111,114,115] | Assessed coping constructs not consistent |
| Catastrophizing | Preliminary – varying | Inconclusive | [52,63,72,74,75,78,79,89,109] | |
| Other | | | | |
| Compensation and legal factors | | | | |
| i) Claiming in Tort system | Preliminary – limited | (−) Association | [2,48,52,53,61,63] | |
| ii) Hiring a lawyer | Preliminary – varying | Inconclusive | [2,52,63,74,75] | |
| Post-collision health care factors | | | | |
| i) High initial health care utilisation | Confirmatory – preponderance of evidence | (−) Association | [47,116–118] | |
| ii) Seniority of first treating physician | Preliminary – limited | No association | [46] | |

ASD: acute stress disorder; BMI: body mass index; MRI: magnetic resonance imaging; PTSD: post-traumatic stress disorder; ROM: range of motion; WAD: whiplash-associated disorders; +: better recovery/lower pain; −: poorer recovery/higher pain.
[a]When the evidence is preliminary, associations need to be confirmed in Phase-III studies.
[b]Inconclusive results are likely dependent upon heterogeneous study populations, measurement of prognostic factor and outcome or effect modification.

### *Body mass index, smoking*

There is limited evidence that body mass index (BMI) is not associated with recovery and consistent limited preliminary evidence that smoking is not associated with recovery [52,63,64,74,84].

### *Pre-injury health: physical and psychological*

The preponderance of combined preliminary evidence indicates that pre-crash physical health is not associated with recovery for the longer term (i.e. three to 12 month follow-up) [2,55,62,63,65,69,73,85]. However, there is now also limited preliminary evidence that prior somatic symptoms may be associated with greater pain in the first six weeks after injury for those who are litigating (but not for non-litigants) [63]. There is also limited preliminary evidence that being on extended sick benefits in the five years prior to the injury is associated with negative change in work/employment status one year post-injury [73].

The preliminary evidence is consistent in suggesting that prior *psychological* health and personality are not associated with WAD recovery [62,65,67,69,86]. However, findings on the association between prior physical and psychological health should be interpreted cautiously because of difficulty in accurately ascertaining prior health.

## *Collision factors*

Self-reported collision factors include type of road and reason for travel; front, rear or side collision; speed at the time of collision or speed of colliding vehicles (self-reported); perceived severity of the collision/damage to the vehicle; position in the vehicle; use of airbags, seatbelts and/or

headrests; and awareness of impending collision [2,8,26,33,55,57–63,65,67,76,87,88]. The preponderance of combined preliminary evidence related to self-reported collision factors indicates no association with WAD recovery [2,8,26,57–63,65,67,76]. However, there is limited preliminary evidence that: being injured in a car (as opposed to other types of vehicles) is associated with *better* recovery [33,55]; while being injured in a vehicle with tow bars and being injured in a collision involving greater mean acceleration measured by a crash recorder are associated with *poorer* recovery [87,88].

## Initial post-crash pain, disability, WAD grade and symptoms

### Initial neck pain intensity

The preponderance of preliminary evidence indicates that greater initial post-WAD neck pain intensity is associated with poorer recovery of pain, self-reported disability and work ability [2,43,47,49,58,60–63,66,69,70,72,73,75,77,79,81,89–93].

### Initial self-perceived disability

The preponderance of preliminary evidence suggests that greater initial neck disability is associated with poorer disability recovery, but the limited preliminary evidence on the association between initial disability and *pain* recovery varies [52,55,64,71,72,74,75,79,80,89–91,94].

### WAD grade

In combining the evidence, the preponderance of preliminary evidence suggests that WAD Grade III was associated with poorer recovery but there is no clear evidence of a difference in recovery between Grades I and II [52,55,57,58,60,62,72,95–97].

### Other post-crash symptoms and number of post-crash symptoms

The preponderance of limited and preliminary evidence suggests that initial poor concentration but not dizziness is associated with poorer WAD recovery; and there is limited preliminary evidence that greater numbers of symptoms predict poorer WAD recovery [34,35,43,55,62,72,98].

## Radiographic imaging and physical findings

### Magnetic resonance imaging findings

There is consistent preliminary evidence of no association between the following post-collision magnetic resonance imaging findings and WAD recovery: abnormal findings related to disc degeneration, protrusion, narrowing, foraminal stenosis; lordosis; kyphosis or straight cervical spine, alar and transverse ligament changes [76,77,99–102]. There is limited, preliminary evidence that cervical fatty infiltration measured two weeks after a whiplash injury is associated with self-perceived disability [64].

### Neck range of motion

It should be noted that decreased range of motion is one of the key criteria in distinguishing between WAD Grade I and II [3]. The preliminary evidence varies on the association between initial range of motion and recovery [61,72,76,80,81,98,103]. However, the preponderance of preliminary evidence (reported above) suggests no significant difference in recovery between WAD I and WAD II.

### Pain threshold, sympathetic vasoconstrictor response

The preponderance of limited preliminary evidence suggests that initial reduced time to peak pain threshold and post-crash cold pain threshold, but not pressure pain threshold or sympathetic vasoconstrictor response, are associated with poorer disability recovery [71,80,104,105].

### Inflammatory biomarkers

There is limited, preliminary evidence that TNF-$\alpha$ (tumour necrosis factor-alpha) and CRP (C-reactive protein) are associated with disability recovery, while IL-1$\beta$ (interleukin-1beta) is not [106].

### Eye movement

Limited, preliminary evidence indicates no association between smooth pursuit eye movement and recovery [107].

## Post-crash psychological factors and WAD recovery

### Acute stress disorder/post-traumatic stress disorder

The preponderance of preliminary evidence suggests that early symptoms of acute stress disorder/post-traumatic stress disorder are associated with delayed recovery, and there is limited preliminary evidence that catastrophizing and fear avoidance may serve as mediators in this relationship [34,41,64,69,71,72,77,80,89]. All used self-report questionnaires rather than formal diagnoses of acute stress disorder or post-traumatic stress disorder.

### Anxiety and fear

The preponderance of evidence indicates that post-crash anxiety and fear (pain-related fear/anxiety/worry/kinesiophobia) are associated with poorer recovery [38,41,47,62,63,68,70,72,76,79,89,91,108].

### General psychological health/distress, anger, frustration

The preliminary evidence on the role of post-crash *general* psychological health/general distress varies and there is limited evidence that pain-related anger and frustration are associated with poorer recovery [52,55,61,63,72,74,75].

### Pain-related beliefs, self-efficacy, perceived injustice

The studies provided limited evidence that certain pain beliefs (that pain can be medically cured and that pain is mysterious) are associated with poorer recovery, while the

evidence on the role of perceived control over pain and self-efficacy varies [45,72,89,109,110]. Limited preliminary evidence suggests that perceived injustice does not predict delayed recovery, although delayed recovery appears to predict increases in perceptions of injustice [45].

### *Depressive symptomatology*

The preponderance of evidence indicates that early post-crash depressive symptoms are associated with poorer recovery [38,41,47,63,111].

### *Expectations for recovery*

There is consistent evidence that poorer expectations for recovery are associated with poorer recovery [37,44,63,66,72,77,109,112,113].

### *Pain coping (excluding catastrophizing)*

There is consistent evidence of an association between coping and WAD recovery, although studies were not uniform in what coping constructs they assessed [67,72,78,110,111,114,115].

### *Catastrophizing*

The preliminary evidence on the role of early post-injury catastrophizing on WAD recovery varies [52,63,72,74,75,78,79,89,109].

## *Compensation and legal factors*

There was limited, preliminary evidence that claiming under a tort system was associated with slower recovery and that claim closure *followed* health recovery and limited, preliminary evidence that health recovery *did not follow* claim closure [2,48,52,53,61,63].

The preliminary evidence on the association between hiring a lawyer and poorer recovery varies [2,52,63,74,75]. Hiring a lawyer may be related to differing compensation systems and initial symptom severity [2]. Further, there is limited preliminary evidence that the impact of making a claim may be dependent on the severity of the injury [48].

## *Post-collision health care factors*

The preponderance of evidence indicates that high levels of initial health care utilisation are associated with poorer WAD recovery [47,116–118]; and there is also limited, preliminary evidence that seniority of first treating physician is not associated with recovery [46].

## *Risk scores/prediction rules*

Five risk scores or prediction rules were found. One Phase-II study reported a parsimonious group of factors associated with moderate-to-severe neck pain at 6 weeks post-injury using Lasso regression techniques, but without external validation [63]. For those not engaged in litigation, a combination of female sex, severe neck and overall pain predicted greater pain at six weeks; while for those litigating, a combination of female sex, having moderate or severe neck pain or severe overall pain, not being employed full time, having no health insurance, having had a rear-end collision, being a passenger rather than a driver, higher levels of peritraumatic distress, a predisposition to anger and higher age predicted greater pain [63].

In two Phase I studies from the same cohort (and no external validation), a *risk score* was developed to predict WAD recovery; the risk score consisted of cervical range of motion, neck/head pain intensity, sex, number of non-pain symptoms and pain on palpation predicted WAD recovery outcomes [98,119].

In the update, one new Phase II study provided external validation that a set of factors (which had been identified in an earlier study [120]), consisting of high initial Neck Disability Index score, cold hyperalgesia, older age and symptoms of acute post-traumatic stress were associated with moderate/severe disability at 12 months [80].

Ritchie *et al.* derived a clinical prediction rule in a Phase-II study [71] and conducted an external validation study on a different cohort [94]. A prediction rule of the combination of initial NDI score, older age and hyperarousal (on the PDS) had good specificity and positive predictive values, but only moderate sensitivity to predict recovery.

Finally, a prediction model was derived using a cohort of ER attendees, and subjected to external validation in a separate cohort of insurance claimants. The set of factors found to predict self-rated recovery in the model building study did not, as a set, adequately predict self-rated recovery in the validation study [42].

## *Findings: WAD outcomes other than recovery*

### *WAD and fibromyalgia*

The limited and preliminary evidence varies on the association between WAD and onset of fibromyalgia [121–123] (Supplementary Appendix 5, Table 1).

### *WAD and widespread pain*

There is limited preliminary evidence that the risk of widespread pain is similar after WAD and after non-WAD traffic injuries [4,63,124]. No factor predicting the onset of widespread pain after WAD was found to be common across these studies; factors included being female, having poorer health, greater pain, more symptoms, and more initial depressive symptoms.

### *WAD and jaw pain*

There is limited preliminary evidence from three studies of two distinct cohorts that those with WAD are at greater risk of new onset of jaw pain than those with non-WAD injuries, either immediately after the injury or with onset during the year following the injury [40,125,126].

### *WAD and psychological outcomes*

There is limited preliminary evidence that WAD was associated with greater post-injury onset of depressive symptoms than non-WAD injuries [76]. There is now consistent but still limited preliminary evidence that poor prior mental health/depression is associated with greater post-collision depression [7,38].

There is limited preliminary evidence that initial dizziness is associated with persistent or recurrent post-collision depression [127]; and limited, preliminary evidence that prior anxiety, fear, anger and frustration are each associated with greater intensity of the corresponding pain-related anxiety, fear, anger and frustration at 6 weeks post-collision [38].

There is also limited, preliminary evidence that lower initial cold pain thresholds, greater initial pain intensity and older age are associated with greater severity of post-traumatic stress symptoms during the year following the crash [49].

### *WAD and health care utilisation*

There is limited preliminary evidence that those using passive pain coping strategies within 7 days of injury are more likely to use prescription pain medication at three weeks post-injury, and that those using few active and many passive pain coping strategies are less likely to comply with referral to an active rehabilitation programme [128].

There is limited preliminary evidence that in comparison with an injured non-WAD group, those with WAD have greater health care utilisation both prior to and after the injury and are more likely to transition from low to high health care utilisation levels (primarily through visiting physical therapists) [129].

### *Factors associated with lawyer involvement and WAD*

There is limited preliminary evidence that having greater initial self-perceived functional or work disability, speaking a language other than English at home and having poorer initial mental health, were associated with hiring a lawyer within 12 months of the injury [52]. In that study, age, sex, profession, admission to hospital after the collision, socioeconomic status, income, and catastrophization, were not associated with hiring a lawyer within 12 months of the injury.

### *WAD and muscle activation, spinal cord hyperexcitability, modic changes*

There is limited preliminary evidence that those with WAD have no elevated muscle reactivity in the *three months* following the injury and that greater initial self-perceived disability is associated with reduction in recruitment of trapezius muscle during isometric exercise [90]. There is also limited preliminary evidence that throughout the first 24 weeks post-injury, greater pain and fear of movement are associated with reduction in trapezius muscle recruitment during exercise, and that higher levels of pain intensity strengthen the association between fear of movement and decreased muscle activity on electromyography [39].

There is limited preliminary evidence that greater initial self-perceived neck disability is associated with spinal cord hyperexcitability at 3 months post-injury [104].

Limited, preliminary evidence found no association between WAD and modic changes of the cervical spine (at C2-3 to C7-T1) in long term follow-up [130].

### *WAD and headaches*

There is limited preliminary evidence that headaches experienced after a collision are similar in those with and without WAD, and that the frequency of headaches in those with WAD is similar to individuals without WAD [131].

## Discussion

The current review adds 74 studies to the 47 WAD prognosis studies reported in the 2008 publication by the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. The course of recovery has become clearer, and the evidence suggests that median time to recovery is three to six months, depending on the stringency of one's criteria for having recovered. Although our update identified more studies with follow-up points during the first six months post-crash, the synthesis of the data remains challenging for several reasons. First, there is much variability in the frequency and timing of follow-up and the study samples are heterogeneous (population-based WAD studies, compensation claim samples, emergency department sampling frames, hospital admissions or referrals to specialists, and those referred to research centres or RCTs). Therefore, it is difficult to identify clear and consistent patterns with time to recovery (e.g. recovery in six months or less, median time to claim closure, etc.) because of the heterogeneous nature of the studies.

Secondly, there is no predominant or standardised definition of recovery for this population. This has been discussed in previous work but little progress has been made in developing a standard list of outcomes [11,132]. The current literature typically reports on neck pain and/or disability/functional outcomes as indices of recovery; however, there is variability in the criterion used to distinguish recovered from non-recovered. Additional definitions of recovery include self-ratings of global recovery, WAD symptoms other than neck pain (e.g. headache) and personal injury insurance claim closure. A qualitative study exploring what persons with *recent* musculoskeletal injuries (not limited to neck) considered "recovered" to mean found that there were two main definitions: either total pain/symptom cessation accompanied by pain-free function, or the ability to function despite some residual pain [133]. In contrast, another qualitative study examining how those with *chronic* trauma-related neck pain (including WAD) defined recovery found five main criteria: absent or manageable symptoms, ability to participate in life roles, having the physical capability one 'ought to have', feeling positive emotions, and feeling like oneself again [134]. It seems likely that for those with musculoskeletal conditions,

their criteria for what constitutes 'recovery' changes as pain problems fail to resolve.

Thirdly, a lack of WAD-grade stratified findings makes it difficult to determine usual course of recovery in those with WAD III. WAD III with confirmed radiculopathy is relatively uncommon, and although many studies in our update included WAD I–III in their inclusion criteria, they rarely reported the number of each grade in their studies.

With the increased body of literature, the prognostic role of many factors is clearer, although uncertainty remains for some, such as range of motion. In particular, new findings since the NPTF highlight the importance of post-collision psychological factors in WAD recovery. Pain coping and depression were identified as prognostic factors in the previous report. The update strengthens these conclusions and adds: poor expectations for recovery, symptoms of acute stress disorder or post-traumatic stress disorder, anxiety, fear and anger. Below, we report summary statements that integrate the main findings from the NPTF and the update, according to the strength of evidence for these findings.

Variables associated with poor recovery, based on strong evidence (from confirmatory studies) are: expecting a poor recovery; having pain-related depression, anxiety, fear, frustration or anger; poor coping; and high frequency of health care utilisation in the first weeks after an injury. In addition, prior WAD is a risk factor for future neck pain. Where these findings come from a single confirmatory study, we recommend replication in other samples.

Variables associated with poor recovery, based on preliminary evidence (from exploratory but not confirmatory studies) may include: greater initial pain intensity, greater initial self-reported disability, more symptoms or more severe symptoms, Grade III WAD, post-crash low cold pain threshold, symptoms of acute stress disorder/post-traumatic stress disorder, and kinesiophobia. However, confirmatory studies (Phase III) should be conducted to validate their prognostic value.

Variables not associated with pain recovery, based on preliminary evidence (from exploratory but not confirmatory studies) may include: older age (for pain recovery), sex (for disability recovery), education, employment factors, pre-collision physical and psychological health, self-reported collision characteristics, smoking, post-collision pressure pain threshold, sympathetic vasoconstrictor response, smooth pursuit eye movement, and several types of magnetic resonance imaging findings (degenerative spine changes, alar and transverse ligament changes, kyphosis, lordosis and straight cervical spine). These findings should also be confirmed in Phase III studies.

Finally, there is strong evidence that BMI is not associated with recovery. As above, this should be replicated in other samples.

Several findings in this review are similar to those by Walton et al. [11]. These include the associations between initial post-WAD self-reported neck pain intensity and disability and WAD grade III injuries in poorer recovery and lack of association for certain collision factors. A recent meta-review qualitatively synthesised the results of 12 systematic reviews of prognostic factors for outcomes in acute WAD injury [135]. Again, there were consistent findings suggesting an association between initial post-injury pain and disability with ongoing pain and disability. Disparities in some results between reviews may be attributed to methodological differences between the reviews. Differences in eligibility criteria, indices of recovery, best-evidence synthesis using a hierarchical classification system with three levels of evidence, and no statistical pooling in our review (and thus the ability to include studies not reporting their findings in a way that meets the needs of a meta-analysis) may help explain the variances in reported prognostic factors of recovery.

The small number of studies of some prognostic factors means that uncertainty remains about their role in recovery. In addition, no new research study addressed prognostic factors for WAD recovery in children, and there was only one such study reported by the NPTF. It should also be noted that the role of prior physical and psychological health, and prior pain in recovery should still be considered uncertain because of the difficulty in accurately classifying prior health. These are generally assessed through self-report after the crash, and it has, for example, been shown that asking participants with WAD about prior neck pain results in systematic misclassification [82]. Thus, retrospective self-reports of prior health and prior pain should be viewed with caution.

Our review has several strengths. First, our literature search was comprehensive and methodologically rigorous. We broadened the scope of the NPTF search by using five electronic databases. A second, independent librarian reviewed the search strategy to minimise errors. We outlined detailed criteria to identify relevant citations from the searched literature. Second, we used pairs of independent reviewers to screen and critically appraise the literature. Third, we used the Scottish Intercollegiate Guidelines Network (SIGN) criteria to ensure standardisation of the critical appraisal process. Fourth, a standardised methodology was used and all reviewers were trained prior to initiation of this work. Finally, the risk of bias associated with using low quality studies was eliminated by using the best-evidence synthesis method to form our conclusions [15].

Our review has limitations. First, potentially admissible studies may have been excluded because our literature search was restricted to the English language. However, previous systematic reviews have investigated the impact of language restriction and found that it does not lead to bias as the majority of studies and reviews are published in English [136–140]. Second, it is possible that our search missed potentially relevant studies. Finally, the critical appraisal of articles may vary among reviewers. We minimised this potential bias by using standardised appraisal forms, conducting critical appraisal training sessions for reviewers, and using a consensus process to determine study admissibility.

## Conclusion

The current best evidence synthesis updates findings published by the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders with respect to

prognostic factors in WAD. This update provides a substantial body of evidence supporting the important prognostic role of post-collision psychological factors in WAD recovery.

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