**SUPPLEMENTAL MATERIAL**

**Appendix 1: MEDLINE through OVID search strategy**

**Course and Prognosis of Whiplash Associated Disorders**

1. Prognosis/

2. precipitating factors/

3. exp Causality/

4. Prevalence/

5. "Predictive Value of Tests"/

6. "Quality of Life"/

7. exp Risk/

8. "Recovery of Function"/

9. Work Capacity Evaluation/

10. exp "Outcome and Process Assessment (Health Care)"/

11. exp Disability Evaluation/

12. Attitude to Health/

13. or/1-12

14. Adaptation, Psychological/

15. Anger/

16. Anxiety/

17. Catastrophization/

18. "Compensation and Redress"/

19. Depression/

20. Dizziness/

21. Fatigue/

22. Fear/

23. Hearing Loss/

24. Helplessness, Learned/

25. Hyperalgesia/

26. Insurance, Accident/

27. Irritable Mood/

28. Lawyers/

29. Noise/ae [Adverse Effects]

30. Obesity/

31. Personal Satisfaction/

32. Personality/

33. Photophobia/

34. Range of Motion, Articular/

35. Recovery of Function/

36. Scoliosis/

37. Seat Belts/

38. Self Efficacy/

39. Shoulder Pain/

40. Social Support/

41. Somatoform Disorders/

42. Stress Disorders, Post-Traumatic/

43. Stress, Psychological/

44. Vision Disorders/

45. or/14-44

46. (prognosis or prognostic).ab,ti.

47. "predicti\*".ab,ti.

48. ((preinjury or pre-injury) and pain\*).ab,ti.

49. "risk\* factor\*".ab,ti.

50. "catastrophi\*".ab,ti.

51. "poor outcome\*".ab,ti.

52. hyperalgesia.ab,ti.

53. "recovery perception\*".ab,ti.

54. functional recovery.ab,ti.

55. self-reported recovery.ab,ti.

56. self reported pain.ab,ti.

57. self-perceived recovery.ab,ti.

58. "high NDI score\*".ab,ti.

59. (expectation\* and (recovery or work)).ab,ti.

60. beliefs.ab,ti.

61. (cope or coping).ab,ti.

62. head position\*.ab,ti.

63. impact direction.ab,ti.

64. seating position.ab,ti.

65. (vehicle and (stationary or moving)).ab,ti.

66. (aware\* and collision).ab,ti.

67. "seat belt\*".ab,ti.

68. (headrest\* or head rest\*).ab,ti.

69. (design and (car or vehicle or automobile)).ab,ti.

70. (speed and collision).ab,ti.

71. (anxiety or depression or stress or helplessness or ptsd or personality).ab,ti.

72. fear.ab,ti.

73. (catastrophising or catastrophizing).ab,ti.

74. Quality of life.ab,ti.

75. "precipitating factor\*".ab,ti.

76. causality.ab,ti.

77. prevalence.ab,ti.

78. (recovery adj3 function).ab,ti.

79. work capacity evaluation.ab,ti.

80. disability evaluation.ab,ti.

81. or/46-80

82. 13 or 45 or 81

83. Whiplash Injuries/

84. Neck Injuries/

85. Neck Pain/

86. exp Neck Muscles/in [Injuries]

87. exp Cervical Vertebrae/in [Injuries]

88. Radiculopathy/

89. exp Brachial Plexus Neuropathies/

90. Torticollis/

91. whiplash.ab,ti.

92. "neck injur\*".ab,ti.

93. "neck pain\*".ab,ti.

94. "cervical pain\*".ab,ti.

95. (neck ache\* or neckache\*).ab,ti.

96. "cervicalgia\*".ab,ti.

97. "cervicodynia\*".ab,ti.

98. "radiculopath\*".ab,ti.

99. "brachial plexus neuropath\*".ab,ti.

100. torticollis.ab,ti.

101. (headache\* and (whiplash or WAD or neck pain)).ab,ti.

102. or/83-101

103. exp Randomized Controlled Trials as Topic/

104. exp Controlled Clinical Trials as Topic/

105. exp Case-Control Studies/

106. exp Cohort Studies/

107. Double-Blind Method/

108. single-blind method/

109. Placebos/

110. randomized controlled trial.pt.

111. controlled clinical trial.pt.

112. (meta analys\* or meta-analys\* or metaanalys\*).ab,ti.

113. (cohort adj4 (study or studies or analys\*)).ab,ti.

114. (random\* adj4 (control\* or clinical or allocat\*)).ab,ti.

115. (case adj control\*).ab,ti.

116. ((double or single) adj3 blind\*).ab,ti.

117. "placebo\*".ab,ti.

118. or/103-117

119. 82 and 102 and 118

120. limit 119 to (english language and humans and yr="2000 -Current")

**Appendix 2: Table 1. Risk of Bias Table of Admissible Studies (n=74)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Author, year** | **1.1** | **1.2 a)** | **1.2 b)** | **1.3** | **1.4** | **1.5** | **1.6** | **1.7** | **1.8** | **1.9** | **1.10** | **1.11** | **1.12** | **1.13** | **1.14** |
| Andersen et al., 2016 [1] | Y | Y | N/A | Y | N/A | 39.4% | Y | Y | N/A | N/A | Y | Y | Y | Y | Y |
| Asenlof et al., 2013 [2] | Y | Y | N/A | Y | N/A | 3M: 16.3%  6M: 21.4%  12M: 25.5% | N/A | Y | N/A | N/A | Y | Y | N/A | N/A | N |
| Atherton et al., 2006 [3] | Y | Y | N/A | Y | Y | 1M: 28%  3M: 30%  12M: 37% | N/A | Y | N/A | N/A | Y | N | N/A | CS | Y |
| Bohman et al., 2012 [4] | Y | Y | N/A | N | Y | 6W: 4.7%  3M: 7.9%  6M: 12% | N/A | Y | N/A | N/A | Y | Y | N/A | N | Y |
| Borenstein et al., 2009  [5] | Y | Y | N/A | Y | CS | 6M: 9.27%  3Y: 32.0% | N/A | Y | N/A | N/A | Y | N | Y | Y | Y |
| Bostick et al., 2012 [6] | Y | Y | N/A | N/A | N/A | 3M: 24 %  6M: 33% | Y | Y | N/A | N/A | N/A | Y | N/A | N | Y |
| Bostick et al., 2013 [7] | Y | CS | N/A | N | Y | 3M: 23.6%  6M: 33.3% | N/A | Y | N/A | Y | Y | Y | Y | Y | Y |
| Buitenhuis et al., 2006 [8] | Y | Y | Y | Y | N/A | 20.8% | Y | CS | Y | N/A | Y | CS | Y | Y | Y |
| Buitenhuis et al., 2006 [9] | Y | N | Y | Y | N/A | 12% | N | Y | N/A | N | Y | N | N/A | Y | Y |
| Buitenhuis et al., 2008 [10] | Y | N | N/A | Y | Y | 29% | N/A | CS | N/A | N/A | CS | Y | N/A | CS | Y |
| Buitenhuis et al., 2009 [11] | Y | N | N/A | Y | Y | Questionnaire 2: 8.0%  Questionnaire 3: 5.3% | N/A | Y | N/A | N/A | N/A | N | N/A | N/A | Y |
| Carroll et al., 2007 [12] | Y | Y | N/A | N/A | Y | 55.9% | Y | Y | N/A | N/A | Y | CS | N/A | Y | Y |
| Carroll et al., 2009 [13] | Y | Y | Y | N/A | Y | 16.2% | N | Y | Y | CS | Y | Y | N | Y | Y |
| Carroll et al., 2011 [14] | Y | Y | N/A | Y | N/A | Over 50% | N/A | Y | N/A | N/A | Y | Y | N/A | Y | Y |
| Carroll et al., 2014 [15] | Y | Y | N/A | N/A | Y | 38.2% | N/A | Y | N/A | Y | Y | Y | N/A | Y | Y |
| Carstensen et al., 2009 [16] | Y | Y | N/A | Y | Y | 9.2% | N/A | Y | N/A | N/A | CS | Y | N/A | CS | Y |
| Carstensen et al., 2012 [17] | Y | Y | N/A | N/A | Y | 7.4% | N/A | Y | N/A | N/A | Y | Y | N | N/A | Y |
| Carstensen et al., 2015 [18] | Y | Y | Y | Y | N/A | 10.2% | Y | Y | N/A | Y | Y | Y | N/A | Y | N/A |
| Casey et al., 2015 [19] | Y | Y | N/A | Y | Y | 14% | N/A | Y | N/A | N/A | Y | Y | N/A | N | Y |
| Casey et al., 2015 [20] | Y | Y | N/A | Y | N/A | 2M: 14%  24M: 20% | Y | Y | N/A | N/A | Y | CS | N/A | CS | Y |
| Casey et al., 2015 [21] | Y | Y | N/A | Y | N/A | 2M: 14%  24M: 20% | Y | Y | N/A | N/A | Y | Y | N/A | N/A | Y |
| Cobo et al., 2010 [22] | Y | N | N/A | N | Y | 28% | N/A | Y | N/A | CS | Y | Y | N/A | CS | N |
| Crutebo et al., 2010 [23] | Y | Y | N/A | N/A | Y | ~15% | Y | Y | CS | Y | CS | Y | N/A | N | N |
| Elliott et al., 2015 [24] | Y | Y | Y | Y | N/A | 56.1% | N | Y | N/A | Y | Y | Y | Y | Y | N |
| Ferrari et al., 2011 [25] | Y | Y | Y | Y | N/A |  | N/A | Y | CS | CS | Y | N | N/A | Y | Y |
| Ferrari et al., 2014 [26] | Y | N | Y | Y | Y | 4.1% | N/A | Y | Y | N/A | Y | Y | N/A | Y | Y |
| Ferrari et al., 2015 [27] | Y | Y | Y | N/A | N/A | 3M: 3%  6M: 7.5% | Y | Y | Y | N/A | Y | Y | N/A | CS | N |
| Gehrt et al., 2015 [28] | Y | Y | N/A | Y | N | Neck pain :78.7%  Working ability:96.9% | N | Y | N/A | Y | Y | Y | Y | N | Y |
| Holm et al., 2008 [29] | Y | Y | Y | Y | CS | 17.5% | Y | Y | Y | CS | CS | Y | N | Y | Y |
| Hours et al., 2014 [30] | y | y | y | N | N/A | Whiplash: 32%  Other: 29% | Y | Y | Y | N/A | CS | Y | N/A | N | Y |
| Johansson et al., 2011 [31] | Y | Y | Y | N | N/A | 104/107: 61% | Y | Y | CS | Y | Y | Y | N/A | Y | Y |
| Joud et al., 2013 [32] | Y | Y | N/A | N/A | Y | Cases: 3.12%  Controls: 4.54% | N/A | Y | N/A | N/A | CS | N | N/A | N | Y |
| Kamper et al., 2011 [33] | Y | N | N/A | N | Y | 3M: 21% | Y | Y | N/A | CS | Y | N | Y | CS | Y |
| Kamper et. al, 2012 [34] | Y | Y | N/A | N | N/A | Baseline (89-97%)  3M: 72-88%  6M (35-38%) | N/A | Y | N/A | N/A | Y | Y | Y | Y | Y |
| Kasch et al., 2008 [35] | CS | Y | N/A | N/A | N/A | 6-10% | N/A | Y | N/A | N | N/A | Y | N | N | Y |
| Kasch et al., 2013 [36] | Y | Y | Y | Y | Y | 3M: 28.2%  6M: 28.2%  12M: 10.5% | N | Y | N | N | CS | Y | N/A | CS | N |
| Kivioja et al., 2008 [37] | Y | N | Y | N | Y | Group 1: 5 people  Group 2L 11 people | N | Y | N | N | CS | Y | N/A | CS | Y |
| Kongsted et al., 2008 [38] | Y | N | Y | Y | N | 7.3% | N | Y | CS | CS | Y | N | N/A | N | Y |
| Kongsted et al., 2008 [39] | Y | CS | N/A | Y | Y | 3.3% | CS | Y | Y | N/A | Y | Y | N | CS | Y |
| Kongsted et al., 2008 [40] | Y | Y | N/A | Y | Y | 9.4% | N | Y | Y | N/A | CS | Y | N | N | Y |
| Matsumoto et al., 2010 [41] | Y | Y | N | N | Y |  | N | Y | Y | N/A | Y | N | N/A | CS | Y |
| Matsumoto et al., 2012 [42] | Y | Y | N | N | Y | WAD: 73.7%  Control: 55.1% | N | Y | Y | Y | Y | CS | N/A | N | N |
| McLean et al., 2014 [43] | Y | Y | Y | Y | Y | 9.4% | N | Y | N/A | N/A | Y | Y | N | Y | Y |
| Myrtveit et al., 2015 [44] | Y | Y | Y | Y | Y |  | N | Y | N/A | N/A | CS | N | N/A | Y | Y |
| Nederhand et al., 2006 [45] | Y | N | Y | N | N/A | 8% | N | Y | CS | N | Y | Y | Y | Y | N |
| Nieto et al., 2013 [46] | Y | Y | N/A | Y | Y | 16.3% | N/A | Y | N/A | N/A | Y | Y | N/A | Y | N |
| Nolet et al., 2010 [47] | Y | Y | Y | N/A | Y | Exposed  6M 36.9%  12 M: 50%  Unexposed  12M: 33% | Y | Y | Y | Y | CS | Y | N/A | Y | Y |
| Ozegovic et al., 2009 [48] | Y | Y | Y | N | N | 4.6% | N | Y | Y | N | Y | Y | N | Y | Y |
| Palmlöf et al., 2015 [49] | Y | Y | Y | Y | Y | Cumulative drop-out: 16.2% | N | Y | Y | N/A | Y | Y | N/A | Y | Y |
| Pedler et al., 2011 [50] | Y | N | N/A | N | Y | 19.4 % | N/A | Y | NA | N/A | Y | Y | Y | CS | N |
| Pettersson et al., 2004 [51] | Y | Y | N | Y | Y | 2.5% | N/A | Y | N/A | N/A | N/A | Y | N/A | N | N |
| Phillips et al., 2010 [52] | y | Y | N/A | Y | Y | 39% did not complete 5 follow-ups | N/A | Y | Y | N | Y | Y | N/A | N | Y |
| Pieske et al., 2010 [53] | Y | N | N/A | N | Y | 17.3% | CS | Y | Y | CS | CS | Y | N | CS | N |
| Ritchie et al., 2013 [54] | Y | N | N/A | Y | N/A | Study1 12M: 13.3%  Study2 12 m: 26.0% | N/A | Y | N/A | N | Y | Y | Y | CS | Y |
| Ritchie et al., 2015 [55] | Y | N | N/A | N | N/A | - | N/A | Y | N/A | N | Y | Y | Y | N | Y |
| Rydman et al., 2017 [56] | Y | Y | Y | N | Y | MSK cohort: 11.1%  Insurance cohort: 19.7% | N | Y | Y | N/A | Y | N | N/A | N/A | Y |
| Sale et al, 2014 [57] | Y | Y | Y | Y | Y | Whiplash: 5%  Control: 5.7% | Y | Y | Y | N/A | Y | Y | N/A | N | Y |
| Sale al., 2007 [58] | Y | N | Y | N | Y | Subjects: 1.7%  Control: 0% | N | Y | N | N/A | Y | N | N | Y | Y |
| Skillgate et al., 2016 [59] | Y | Y | N/A | N | Y | 12M: 12% | N | Y | CS | N/A | CS | Y | N/A | Y | Y |
| Söderland et al., 2002 [60] | Y | N | N/A | N | N/A | 3W: 10.2%  6M: 15.3%  1Y:13.6% | N/A | Y | N/A | N/A | Y | Y | Y | N | N |
| Spearing et al., 2012 [61] | CS | N | Y | Y | Y | - | N | Y | N/A | N/A | Y | Y | Y | N | Y |
| Sterling et al., 2010 [62] | Y | N | CS | N | Y | 7.5% | NA | Y | Y | N/A | N/A | CS | N/A | N | N |
| Sterling et al., 2010 [63] | Y | Y | N/A | N/A | N/A | NDI:39%  PDS: 41% | N/A | Y | N/A | N | Y | Y | N/A | N | Y |
| Sterling et al., 2011 [64] | Y | N | N/A | N/A | N/A | NDI: 39%  PDS: 41% | N/A | Y | N/A | N | Y | Y | N/A | N | Y |
| Sterling et al., 2012 [65] | Y | Y | N/A | Y | Y | 10% | N/A | Y | Y | Y | Y | Y | N/A | N | N |
| Sterling et al., 2013 [66] | Y | N | N/A | N | N/A | Participants: 9.1%  Comparison: 0% | CS | Y | N/A | Y | Y | Y | Y | N | N |
| Stovner et al., 2008 [67] | Y | Y | Y | N | Y |  | N | Y | N/A | N/A | CS | N | N/A | Y | N |
| Tishler et al., 2006 [68] | Y | Y | Y | Y | CS |  | N | Y | N | N | Y | Y | N/A | N | N |
| Tishler et al., 2011 [69] | Y | Y | Y | Y | CS | WAD: 18%  Control: 31% | N | Y | N | N | Y | CS | NA | N | N |
| Tournier et al., 2016 [70] | Y | Y | Y | Y | N/A | WAD 5Y: 33% | Y | Y | N/A | N/A | Y | Y | N | Y | Y |
| Vetti et al., 2010 [71] | Y | Y | Y | N | Y | 2.6% | N | Y | Y | N/A | Y | Y | N/A | Y | Y |
| Vetti et al., 2011 | Y | Y | CS | Y | Y |  | Y | Y | CS | N/A | Y | Y | N/A | Y | Y |
| Williamson et al., 2014 | Y | Y | N/A | N/A | N/A | 12M: 23.4% | N/A | Y | N/A | N/A | Y | Y | Y | Y | Y |
| Yang et al., 2007 | Y | Y | Y | Y | N/A | N/A | N/A | Y | Y | N/A | Y | Y | N/A | Y | Y |

Heading descriptions: 1.1: appropriate and clearly focused question; 1.2a: source population well described; 1.2b: exposed/non-exposed from same population if exposure/outcome tested; 1.3: # asked to participate; 1.4: outcome at enrollment assessed; 1.5: % drop-out/group; 1.6: comparison of loss-to-follow-up by group; 1.7: outcomes clearly defined; 1.8: outcome assessment is blinded; 1.9: recognition that lack of blinding could influence outcome; 1.10: reliable exposure/prognostic factor assessment; 1.11: evidence from other sources that outcome assessment method is valid and reliable; 1.12: (time varying) exposure level/prognostic factor assessed more than once; 1.13: potential confounders identified and accounted for; 1.14: confidence intervals provided.

Abbreviations: CS: Can’t say; M: months; N: No; N/A: Not applicable; NDI: neck disability index; PDS: post-traumatic stress diagnostic scale; W: weeks; WAD: whiplash associated disorders; Y:Yes

**Table 2: Risk of Bias Table of Inadmissible Studies (n=26)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Author, year** | **1.1** | **1.2 a)** | **1.2 b)** | **1.3** | **1.4** | **1.5** | **1.6** | **1.7** | **1.8** | **1.9** | **1.10** | **1.11** | **1.12** | **1.13** | **1.14** |
| Bunketorp & Elisson, 2012  [72] | Y | N | N/A | N/A | N | No discussion | N | Y | N/A | N/A | N | N | N/A | N/A | Y |
| Bunketorp-Kall et al., 2008  [73] | Y | N | N/A | Y | C/S | 22.4% | N | Y | C/S | C/S | N | Y | Y | N | Y |
| Bunketorp-Kall et al., 2007 [74] | Y | N | C/S | N | N/A | Exposed=0%  Control=47% | N | Y | N | N | C/S | Y | N/A | N | N |
| Bunketorp et al., 2006 [75] | N | N | N/A | N/A | N | 14.9% | N/A | Y | N/A | N | Y | C/S | Y | C/S | N |
| Crouch et al., 2006 [76] | Y | Y | Y | Y | N | 15.0% | N & N/A | Y | N & N/A | C/S | C/S | Y | N/A | C/S | Y |
| Ferrari, 2010 [77] | Y | Y | Y | N | N | 2.8% | N | N | C/S | N/A | C/S | N | N/A | N | N |
| Geldman et al., 2008 [78] | Y | N | N/A | N | N | 18% | N | Y | Y | C/S | N | Y | N | N | N |
| Gun et al., 2005 [79] | Y | N | N/A | Y | N | 8.2% | N | Y | Y | Y | Y | Y | N | C/S | N |
| Hauser et al., 2010 [80] | Y | N | C/S | N/A | N | N/A | N/A | N | N/A | N | C/S | N | N/A | N | N |
| Ichihara et al., 2009 [81] | Y | N | N/A | Y | Y | N/A | N/A | N | C/S | C/S | Y | N | N/A | N | Y |
| Joslin et al., 2004 [82] | N | C/S | C/S | N | N | N/A – Retrospective Study | N/A | N | C/S | C/S | N | Y | N/A | N | N |
| Kall, 2008 [83] | Y | Y | N/A | Y | N | 15% | N/A | Y | N/A | C/S | Y | Y | N/A | C/S | N |
| Karnezis, 2007 [84] | Y | N | N/A | N/A | N/A | None | N/A | N | N/A | N | C/S | N | N | N | N |
| Kasch et al., 2008 [85] | N | N | N/A | N | N | 32.5% | N | N | N/A | C/S | Y | N | N/A | N | N |
| Lankester, 2006 [86] | C/S | N | N/A | N/A | N/A | N/A | N/A | Y | N/A | N | C/S | Y | C/S | Y | N |
| Mykletun et al., 2011 [87] | Y | Y | Y | N | Y | N/A | N/A | Y | N/A | C/S | C/S | N | N/A | N | Y |
| Oddsdottir & Kristjansson, 2012 [88] | Y | Y | C/S & N/A | N | N/A | 36.5% | N/A | Y | N/A | N | N | Y | Y | N | Y |
| Rebbeck et al., 2006 [89] | Y | Y | N/A | Y | N/A | 6 month=21%  2 year=41% | N/A | Y | N/A | C/S | Y | Y | N/A | C/S | N |
| Represas et al., 2008 [90] | Y | N | N | N | N | N/A | N | N | C/S | C/S | Y | N | N/A | N | N |
| Severinsson et al, 2010 [91] | Y | Y | N/A | N & N/A | N/A | 18.5% | N/A | Y | N/A | C/S | C/S | C/S | N | C/S | Y |
| Söderlund & Lindberg, 2001 [60] | Y | N | Y | Y | Y | Not Reported | N/A | Y | N/A | C/S | Y | Y | N/A | N | N |
| Sterling & Kenardy., 2006 [92] | Y | C/S | N/A | N/A | N/A | 5% | N/A | Y | Y | N | Y | N | Y | N | N |
| Stewart et al., 2008 [93] | Y | N | N/A | Y | Y | 1% | N/A | Y | Y | C/S | C/S | Y | N/A | N | Y |
| Uremovic, 2007 [94] | Y | Y | C/S | N | N | 0% | N/A | Y | C/S | N | Y | Y | N | N | N |
| Walton et al., 2011 [95] | Y | N | Y | N | N | 30.8% | N | N | N/A | N | Y | Y | N | N | Y |
| Wiles et al., 2005 [96] | Y | Y | Y | Y | 56.2% participation | N | Y | Y | Y | Y | C/S | Y | N/A | N/A | N/A |

Heading descriptions: 1.1: appropriate and clearly focused question; 1.2a: source population well described; 1.2b: exposed/non-exposed from same population if exposure/outcome tested; 1.3: # asked to participate; 1.4: outcome at enrollment assessed; 1.5: % drop-out/group; 1.6: comparison of loss-to-follow-up by group; 1.7: outcomes clearly defined; 1.8: outcome assessment is blinded; 1.9: recognition that lack of blinding could influence outcome; 1.10: reliable exposure/prognostic factor assessment; 1.11: evidence from other sources that outcome assessment method is valid and reliable; 1.12: (time varying) exposure level/prognostic factor assessed more than once; 1.13: potential confounders identified and accounted for; 1.14: confidence intervals provided.

Abbreviations: CS: Can’t say; N: No; N/A: Not applicable; Y:Yes

**Appendix 3: Table 1. Evidence Table for Course of Recovery of Whiplash Associated Disorders (WAD) (N=22)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Author(s), Year, Country of Study** | **Setting and Subjects, Number (N) Enrolled** | **Follow-up Points, Number (N) of Subjects at Follow-up** | **Outcomes Assessed** | **Key Findings** |
| Andersen et al., 2016 [1]  Denmark | WAD I-III patients 18 years or older, attending an ER in Denmark; July 2009-July 2011; contacted by mail within 3 weeks of injury. Excluded those with head injury or unconsciousness. N=327 responses to the letter. | Follow-up at 3 and 6 months for recovery trajectory.  N=198 with data at all time points | Neck pain recovery (average neck pain < 1/10) | Course of recovery: at 6 months, 64.6% were recovered (average pain < 1/10). 12.1% had moderate pain that remained moderate (averaged at 3.5/10-4/10); 18.7% had high pain that remained high (averaged just less than 6/10 to 5.5/10) and 4.5% had very high pain that remained high (at about 8/10) |
| Atherton et al. 2006 [3]  Great Britain | Patients attending one of 4 EDs\* in Greater Manchester with neck pain after MVC†; Feb 2002-Jun 2003; aged 17-70; Excluded those with cervical fracture or dislocation; distracting injury; suspected alcohol or drug intoxication; episode of neck pain in the month prior to collision. N=765 | Follow-up at 1, 3 and 12 months. N=480 with complete data. | Neck pain lasting one day or longer during the past week, weighted for non-participation. Persistent symptoms defined as neck pain at all follow-up points. | 21% had persistent symptoms (neck pain at all follow-up points).  36% had neck pain at 12 months (with or without neck pain at 1 and 3 months). |
| Bohman et al. 2012 [4]  Canada | Adults making a traffic injury claim after early consultation with physical therapist; injury occurred between December 1997 and November 1999; self-reported post-collision neck pain. Excluded those hospitalized > 2 days and those with baseline data > 42 days post-crash. N=680. Subcohort of Carroll et al. 2009. | Follow-up at 6 weeks, 3 and 6 months. N at 6 weeks = 648; N at 3 months = 626 and N at 6 months = 599. | Self-rated global recovery (recovered =first report of all better or quite a bit of improvement; unrecovered=some improvement, no improvement, a little worse and a lot worse). | Median time to recovery was 97 days.  By 6 months, 71.2% had recovered. |
| Bostick et al. 2012 [6]  Canada | Convenience sample of volunteers; WAD injury within the past 6 weeks; recruited through physical therapy and chiropractic clinics; aged 18 or over; excluded those with no neck pain at the time of recruitment. N=72 (Findings reported separately for the 59 survey only, and the 13 with additional interview). | Follow-up at 3 and 6 months. N=55 at 3 months and 46 at 6 months. | Pain intensity (11-point NRS§); Whiplash Disability Questionnaire (WDQ); Survey of Pain Attitudes (SOPA – 7 subscales: control, disability, harm, emotion, medication, solicitude, medical cure); Pain Beliefs and Perceptions Inventory (PBPI – 4 subscales: mystery, permanence, constancy, self-blame); Pain Catastrophizing Scale (PCS). | Pain intensity and disability (WDQ) decreased during the first 3 months (pain 5.2 for survey participants and 5.2 in those with additional interview to 2.9 and 2.5, respectively; and disability 59.8 for survey participants/55.9 for those with additional interview to 34.5 and 32.5, respectively) but no statistically significant differences between 3 and 6 months. Beliefs about pain were stable across time except for pain permanence and pain constancy which decreased during the first 3 months. |
| Buitenjuis et al. 2006 [9]  The Netherlands | Persons initiating personal injury insurance compensation claims at a Dutch insurance company; neck complaints after a MVC†; aged 18-65; neck complaints and soft tissue injuries only. Excluded those with history of chronic pain, LOC¶ > 1 minute. N=367 | Baseline at median 32 days post-crash. Follow-up at 6 and 12 months. N at follow-up not reported. | Presence of post whiplash syndrome (as determined by self-reported neck pain: yes/no). | Median duration of neck pain was 180 days and at 1 year, 47% (S.E. 2.7) reported neck pain presence. |
| Buitenhuis et al. 2008 [10]  The Netherlands | Persons initiating personal injury insurance compensation claims at a Dutch insurance company; neck complaints after a MVC†; aged 18-65; neck complaints and soft tissue injuries only. Excluded those with history of chronic pain, LOC¶ > 1 minute. N=140 | Baseline at median 25 days post injury. Follow-up at 6 and 12 months. N=122 at 6 months and 110 at 12 months. | Presence of post whiplash syndrome (as determined by self-reported neck pain: yes/no). | At 25 days, 100% reported post whiplash syndrome; at 6 months, 66.4% reported post whiplash syndrome; at 12 months 56.4% reported post whiplash syndrome. |
| Buitenhuis et al. 2009 [11]  The Netherlands | Persons initiating personal injury insurance compensation claims at a Dutch insurance company; neck complaints after a MVC†; aged 18-65; neck complaints and soft tissue injuries only. Excluded those with history of chronic pain, self-reported LOC¶ > 1 minute. N=879. | Some data available at point of accident; baseline questionnaire at median 21 days post-crash. Follow-up at 6 months and 12 months. N=809 at 6 months and 832 at 12 months. | Self-reported neck complaints as determined by score of > 0 on 0-10 point scale (pain intensity, neck stiffness, restricted neck movements, radiating pain in arms, paresthesia, concentration complaints, headache intensity; presence of dizziness or use of pain medication (both yes/no)). Work disability/working fewer hours (yes/no). | Of 879 with neck complaints after the MVC†, 728 (82.8%) had neck complaints at 21 days; 448 (51.0%) at 6 months and 384 (43.7%) at 12 months. Of the 733 who were involved in paid work (paid employment or self-employed), 392 (53.5%) did not have work disability. 141/733 (19.2%) had initial work disability but had no work disability by 21 days (1st questionnaire). 33.7% were work disabled at 21 days, 18.9% at 6 months and 12.6% at 12 months. |
| Carroll et al., 2009 [13]  Canada | Adults making a traffic injury claim or treated for traffic injuries; injury occurred between December 1997 and November 1999; self-reported post-collision neck pain. Excluded those hospitalized > 2 days and those with baseline data > 42 days post-crash. | Baseline at median of 11-days post-injury. Follow-up at 6 weeks, 3, 6, 9 and 12 months. N=5698 with at least one follow-up data point. | Pain recovery (0 - 1 on 11-point NRS§); disability recovery (0 on Pain Disability Index) | Recovery took an average of 4 months for those believing they would recover quickly and 11 months for those believing they would never recover. Median time to recovery for cohort as a whole was 6 months [personal communication]. |
| Carroll et al. 2007 [12]  Canada | Persons making a personal injury claim or being treated for neck pain after MVC-related injury and reporting post-crash jaw pain; aged 18 and above; injury occurred between July 1994 and Dec 1995; excluded those hospitalized for > 2 days; serious associated or unassociated health problem; inability to understand English; injured as pedestrian, bicyclist or motorcyclist and those reporting pre-crash jaw pain. N=1128 reporting new post-crash jaw pain. Subcohort of Carroll et al., 2011. | Baseline at median of 10 days post-crash. Follow-up at 6 weeks, 4, 8 and 12 months. Of 1128 WAD participants with incident jaw pain, 497 participated in at least one follow-up. | Resolution of jaw pain. | Median time to resolution of jaw pain was 120 days (95% CI 113, 128). |
| Carroll et al. 2011 [14]  Canada | Persons making a personal injury claim or being treated after MVC†-related injury; WAD (neck pain after collision); aged 18 and above; between July 1994 and Dec 1995; excluded those hospitalized for > 2 days; serious associated or unassociated health problem; inability to understand English; injured as pedestrian, bicyclist or motorcyclist; those who had recovered at 6 weeks (neck pain ≤ 10mm on VAS\*\*). N=2019. | Baseline at median 10 days post-crash; follow-up at 4 and 12 months. N=1639 at 4 months and 1456 at 12 months. | Pain intensity: Recovery defined as 0-10 mm on VAS\*\*. | Baseline neck pain was 55.6mm (VAS\*\*) and neck pain at six weeks was 41.1mm (VAS\*\*). At 4 months, 23% had pain recovery and at 12 months, 42% had pain recovery. When those who had recovered at 6 weeks were not excluded, 42% had recovered at 4 months and 63% had recovered at 8 months [Personal communication with author] |
| Casey et al. 2015 [19]  Australia | Traffic-related WAD injury claim for compensation (fault-based insurance system); injury had occurred no longer than 3 months previously; 18 years or older; no concurrent workers compensation claim; did not require the services of an interpreter (n=246). | Follow-up at 3 and 12 months (n=212) | Functional Rating Index (FRI). Recovery classified as FRI ≤ 25/100 | 23% had recovered by 3 months, 47% had recovered by 12 months. |
| Cobo et al., 2010 [22]  Spain | Patients seen at Department of Orthopedics of Mataró Hospital (Spain) and then referred to the Department of Physical Medicine and Rehabilitation (DPMR) for medical evaluation and treatment; October 2005 to June 2007; aged 18-75; WAD I or II from a road traffic accident; symptoms within 48 hours of injury. Excluded were WAD III and IV; fractures of upper or lower extremities; brain injury; prior cervical spine surgery, oncologic or rheumatic pathology. N=682 | Baseline at mean of 29 days post-crash. Follow-up at 6 months. N at follow-up was 557 | Neck VAS score; Goldberg Depression and Anxiety Scale; Northwick Park Neck Pain Questionnaire. | Mean neck pain VAS was 61 (s.d. 16) at baseline and 35 (s.d. 2) at 6 months. Mean depression score was 3.1 (s.d. 2.5) at baseline and 2.2(s.d. 2.2) at 6 months; anxiety was 5.2 (s.d. 3.1) at baseline and 3.3 (s.d. 2.9) at 6 months; NPH was 47.8 (s.d. 17.5) at baseline and 27.9 (s.d. 17.9) at six months. All differences statistically significant but depression and anxiety of doubtful clinical importance (all scores below published clinically important thresholds). |
| Crutebo et al. 2010 [23]  Sweden | Personal injury claimants to Trygg-Hansa or Aktsam (2 traffic insurers who have 20% of market share in Sweden); MVC† injuries occurred from Jan 15, 2004 to Jan 12, 2005; ages 18-74; answered questionnaire within 30 days of collision; neck pain or reduced neck movement as a result of the accident. Excluded those with WAD IV; other fractures, hospitalized more than 2 days; more than one injury during study period. N=1191with WAD. | Baseline assessment at median 18 days post-crash. At baseline, participants were asked about current symptoms and whether or not they had symptoms after the crash. Follow-up at 6 months. N at follow-up was 1005 | Symptoms (neck pain, headache, low back pain, reduced neck range of motion, numbness/tingling in arms/hands or legs/feet, ringing in ears, memory problems concentration problems, dizziness) each assessed as yes/no. Neck pain intensity, headache, low back pain intensity measured on NRS§; intensity of the other symptoms measured on 5-point Likert scale. Impact of Event Scale (IES), Hospital Anxiety and Depression Scale (HADS). | Baseline neck pain was 2.89 (s.d. 2.40) for men and 3.15 (s.d. 2.43) for women; headache 1.65 (s.d. 2.42) for men and 2.06 (s.d. 2.56) for women and low back pain was 1.21 (s.d. 2.24) for men and 1.23 (s.d. 2.25) for women. 86.8% of men and 80.3% of women had no post-traumatic stress (as assessed by IES); 83.0% of men and 74.6% of women had no post-crash anxiety and 86.8% of men and 87.5% of women had no post-crash depression. Course of symptoms: 98.3% of men and 99.3% of women reported neck pain after the crash, with 81.4% and 84.7% reporting continued neck pain at baseline (median 18 days post-crash) and 44.0% of men and 45.0% of women reported neck pain at 6 months. Headache reported by men and women, respectively: 61.0% and 69.3% after the crash; 44.6% and 53.9% at baseline; and 26.5% and 28.6% at 6 months. For low back pain reported by men and women, respectively: 35.9% and 36.1% after the crash; 31.9% and 30.7% at baseline; 20.2% and 18.2% at 6 months. For reduced neck range of motion reported by men and women, respectively: 83.9% and 86.2% after the crash; 71.2% and 73.2% at baseline; 38.2% and 40.8% at 6 months. Neck pain, headache, low back pain and range of motion all showed statistically significant recovery at 6 months. Prevalence of numbness/tingling, ringing in ears, memory problems, concentration problems and dizziness did not show statistically significant improvement except for memory problems in men, which increased from 6.7 at baseline to 12.6 at 6 months. At six months, men and women reported the following symptoms: Numbness/tingling in arm/hand: 21.0% and 24.0%; numbness/tingling in leg/foot: 9.4 and 7.2%; ringing in ears: 13.3% and 11.9%; memory problems 12.6% and 13.8%; concentration problems 17.8% and 18.5%; dizziness 13.1% and 19.9% (significantly higher in women than men). Majority of reported symptoms were mild or moderate. |
| Ferrari 2014 [26]  Canada | Patients aged 18 or over attending a walk-in primary care centre with 7 days of their injury; WAD grade I or II; injured in a motor vehicle; no loss of consciousness. Excluded those with fracture or neurological injury (Grade III of IV WAD); prior whiplash injury or spine pain requiring treatment; no fixed address or current contact information; unable to communicate in English; non-traumatic pain; had been admitted to hospital after injury.  N=116 | Follow-up at 3 months post-injury by telephone or in person | Self-perceived recovery as assessed by “Do you feel that you have recovered from your injuries?” (response options: yes or no/unsure) | At 3 months, 64% reported having recovered (calculated from published findings). |
| Ferrari, 2015 [27]  Phase I cohort  Canada | Patients aged 18 or over attending a walk-in primary care centre with 14 days of their injury; WAD grade I or II; injured in a motor vehicle; no loss of consciousness. Excluded those with fracture or neurological injury (Grade III or IV WAD); prior whiplash injury or spine pain requiring treatment; no fixed address or current contact information; unable to communicate in English; non-traumatic pain; admission to hospital after injury, sustained another collision-related injury during follow-up.  N=134 (n=4 WAD I and 130 WAD II) | Follow-up at 3, 6 and 12 months post-injury by telephone or in person. N=130 at 3 months, 124 at 6 months | Self-perceived recovery as assessed by “Do you feel that you have recovered from your injuries?” (response options: yes or no/unsure) | At 3 months, 62% recovered and 80% recovered at 6 months. There was no further recovery at 12 months. |
| Kamper et al. 2011 [33]  Australia | Convenience sample of patients with WAD grades I-III; recruited from hospital ED\*, newspaper ads and referral from physiotherapy practices; neck pain as a result of MVC†, 18-65 years; excluded if a history of major psychiatric illness, prior WAD or LOC¶, concussion or head injury due to MVC†. N=100 | Baseline measures within 4 weeks of injury. Follow-up at 3 months. N=79 | Neck pain intensity on VAS; pressure pain thresholds (PPT); Neck Disability Index (NDI); Depression, Anxiety and Stress scale (DASS42); Coping Strategy Questionnaire C - Catastrophizing; Tampa Scale of Kinesiophobia (TSK); analgesic medication; pressure point threshold (PPT cervical and tibialis anterior). | Over the three month period, NDI score decreased from 36.2 to 23.4; DASS decreased from 28.0 to 23.3; Catastrophizing decreased from 6.6 to 6.0; TSK from 40.8 to 35.9; % taking analgesics decreased from 69 to 48; Neck pain score decreased from 42 (s.d. 23) to 25 (s.d. 23); cervical PPT increased from 131.6 (s.d. 86.4) to 148 (s.d. 76.1) and tibialis anterior PPT decreased from 266.1 (s.d. 151.6) to 263 (s.d. 161.7). Weak correlation between change in pain and in cervical PPT (r=-0.33, p=.004); No correlation between change in pain and in tibialis anterior PPT (r=-0.01, p=0.94). This suggests that either PPTs are poor markers for peripheral and central sensitivity or that PPTs are only weakly associated with day to day pain. |
| Nederhand et al. 2006 [45]  The Netherlands | Patients admitted to ED of a Dutch general hospital after MVC; July 1999-December 2001; age 18-70 years; pain in neck or head starting within 48 hours of a collision; WAD grade I or II; excluded those with concussion, amnesia, serious injuries or neurological signs. N=100. | Follow-up at 4, 8, 12 and 24 weeks post MVC. Follow-up until recovered as defined by Neck Disability Score (NDI). N=92. | NDI score (recovery defined as NDI ≤ 5); pain intensity on VAS; Tampa Scale of Kinesiophobia (TSK). | By 24 weeks, 43/92 (46.7%) recovered; 5.4% recovered by 4 weeks; 30.4% recovered between 4 and 12 weeks and 10.9% recovered between 12 and 24 weeks. In those who failed to recover by 24 weeks, mean pain decreased from 53.7 (s.d. 21.4) to 38.8 (s.d. 21.0); TSK score showed little change. Baseline EMG readings increased: 147.7 (s.d. 77.8) vs 106.9 (s.d. 50.5) and pain intensity decreased (30.6, s.d. 20.3 vs. 53.7, s.d.21.4) in those who recovered by 24 weeks. |
| Pieske et al. 2010 [53]  Germany | Persons with WAD I-II, presenting to ED\* and treated as outpatients; aged 18-75; German speaking. Excluded those arriving at ED\* > 48 hours post-collision; those who consulted another physician before ED\* presentation; AIS 2‡‡ or greater injury; unconsciousness or amnesia; severe disease or prior chronic pain. N=98 | Baseline at ED\* presentation. Follow-up at 1, 3 and 6 months post collision. N=81 with complete data. | Neck pain intensity (NRS§); (failure to recover = NRS§ > 2 at least once per week and hinders normal activities of life); analgesic use at least 1/week for neck pain; inability to work because of WAD for at least half the time between trauma and interview. | At 3 months, 9% had not experienced neck pain recovery. |
| Rydman et al., 2016 [56]  Sweden | Participants were from 2 studies. Study 1 consisted of WAD patients presenting to ER within 24 hours of MVC; aged 15-65; Swedish speaking; recruited for a previous study of recovery after musculoskeletal injuries. Study 2 consisted of WAD claimants to one of 3 insurance companies; age 18-65; within 2 weeks of injury. Excluded those who no longer had daily neck pain, those with persistent symptoms from a prior injury; those with neck/shoulder pain prior to the MVC.  N=130 in ER cohort; N=142 in insurance cohort | Follow-up at 6 months. N=130 in ER cohort and 114 in insurance cohort | Self-rated recovery (Do you feel recovered after your injury: yes/no) at 6 months | At 6 months, 48.4% of the ER cohort failed to recover; 70.2% of the insurance cohort failed to recover. |
| Spearing et al., 2012 [61]  U.K. | Persons reporting WAD from a rear end collision to police over a 1 year period in Devon and Cornwall; aged 18 and older; WAD defined as neck pain lasting > 7 days from crash; sought compensation at some point during the 2 years post-injury; fault-based insurance scheme. Excludes those not participating in 2-year follow-up (since exposure status assessed at follow-up). N=265. | Baseline within 2 weeks of injury. Follow-up at 6 months, 12 months and 24 months. | Claim settlement; neck pain (VAS\*\*). | By 24 months, 30% had settled their claim. Pain intensity in those who settled vs. did not settle claims was 41.12 vs. 42.15 at baseline; 35 vs. 34.55 at 6 months; 29.25 vs. 25.50 at 12 months and 15.48 vs. 15.66 at 24 months. |
| Sterling et al. 2010;[63]  Sterling et al. 2011 [64]  Australia | Convenience sample of patients in Queensland, Australia (fault-based system); with WAD I-III, recruited from ED\* and GP†† practices; WAD < 1 month duration. Excluded were those with WAD IV; concussion or head injury; prior WAD, neck pain or headaches requiring treatment; those with a prior or current psychiatric or psychological condition. N=155 | Baseline at < 1 month; follow-up at 3, 6 and 12 months. 59% (n=91) had complete data and 61% (n=94) participated in at least 1 follow-up. | Neck disability (NDI: 0-8% no pain/disability; 10-28% mild pain/disability; 30-48% moderate pain/disability; 50% or more severe pain/disability). PDS (Posttraumatic Stress Diagnostic Scale: 0 no rating; 1-10 mild; 11-20 moderate; 21-35 moderate to severe; 36 and above severe); lodging a claim for insurance compensation. | There was general decline in pain/disability levels over the 12 month period regardless of baseline severity.  Three identified trajectories of recovery of NDI, based on initial NDI scores. (1) Resilient: mild/negligible pain/disability at 1 month, decreasing to 3 months, (n=45%); (2) moderate pain/disability at 1 month, mild by 3 months (n=39%); (3) chronic-severe for 6 months, moderate thereafter (n=16%). Similar trajectories of recovery of PDS, based on initial PDS scores. (1) Resilient: mild symptoms throughout (40%), (2) Recovering: initial moderate symptoms declining to mild levels by 3 months (43%) and (3) Chronic moderate-severe: persistent moderate/severe symptoms throughout 12 months (17%). For the mild and moderate trajectories, self-reported claim lodging within the past 1 month was associated with poorer NDI and PDS recovery. No such effect for those with initial severe pain/disability or initial moderate or severe PDS.  Joint trajectory membership estimates indicate that 34% of those with WAD will experience only mild symptoms of disability and PTSD§§ during the year following the injury; 26% will experience moderate, recovering disability and moderate and recovering PTSD§§ symptoms, and 9% will experience chronic moderate or severe trajectories of both disability and PTSD§§. Another 31% are likely to experience higher symptom level trajectories for one outcome but more moderate or mild symptoms trajectories in the other. |

\* ED refers to Emergency Department

† MVC refers to motor vehicle collision

‡ ROM refers to range of motion

§ NRS refers to 11-point numerical rating scale

¶ LOC refers to loss of consciousness

\*\* VAS refers to 100 mm visual analogue scale

†† GP refers to general medical practitioner

‡‡ AIS refers to Abbreviated Injury Score

§§ PTSD refers to Post-Traumatic Stress Disorder

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**Appendix 4: Table 1. Factors Associated with Whiplash Associated Disorders (WAD) Recovery (n=59)**

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| Author(s), Year, Phase and Study Design, Location of Study | Setting and Subjects Number (n) Enrolled | Prognostic Factors/ Exposures | Follow-up point(s) and Number (n) Subjects at Follow-up(s) | Outcomes Assessed | Key Findings |
| Andersen et al., 2016 [1]  Phase II Cohort  Denmark | WAD I-III patients 18 years or older, attending an ER in Denmark; July 2009-July 2011; contacted by mail within 3 weeks of injury. Excluded those with head injury or unconsciousness. N=327 responses to the letter. | PTSD symptoms, pain catastrophizing, fear avoidance beliefs, depression, age, gender, education, occupation, marital status | Follow-up at 6 months for recovery  N=198 with data at all time points | Neck pain recovery (recovered = average neck pain < 1/10; failure to recover = average neck pain >3/10) | Failure to recover predicted by: fear avoidance (OR for each 1/30 point increase = 1.09, 1.04 to 1.15) catastrophizing (OR for each 1/48 point increase 1.08, 1.02 to 1.14); depression (OR for each 1/21 point increase = 1.09, 0.96 to1.25, n.s.). Catastrophizing and fear avoidance mediated the effect of post-traumatic stress symptoms on pain intensity. |
| Asenlof et al., 2013 [2]  Phase II cohort  Sweden | Patients attending one of 2 EDs in Uppsala and Vasteras, Sweden; aged 18-65; WAD 1 and II; Swedish language skills; subjective report of not needing treatment at 2-4 weeks post-injury due to low pain and disability. N=98 | Prognostic factors: disability (Swedish version of the Pain Disability Index); pain intensity (11-point NRS); functional self-efficacy (Swedish version of the Self-Efficacy Scale); fear of movement and re-injury (Swedish version of Tampa Scale of Kinesiophobia); catastrophizing (Swedish version of Catastrophizing subscale of Coping Strategies Questionnaire); PTSD symptoms (Impact of Event Scale) | Follow-up at 12 months. (n=73) | Pain Related Disability (Swedish version of the Pain Disability Index) | In multivariable analyses, only baseline PDI predicted 12 month PDI (R2 =0.67). |
| Atherton et al. 2006 [3]  Phase II cohort  Great Britain | Patients attending one of 4 EDs in Greater Manchester with neck pain after MVC; Feb 2002-Jun 2003; aged 17-70; Excluded those with fracture or dislocation of neck; distracting injury; suspected alcohol or drug intoxication; episode of neck pain in the month prior to collision. N=765 | Prognostic factors: Age; gender; prior health (excellent to poor); number of GP consults in the past year; lifetime experience of prior neck pain (pain lasting 1 day or longer); other bodily pain; psychosocial aspects of work place environment; speed and direction of vehicles; severity of collision (100 mm VAS); position in vehicle, use of airbag, seatbelt and headrest; awareness of impending collision; post-crash psychological status (GHQ and Modified Somatic Perceptions Questionnaire); perceived severity of injury (100 mm VAS); NDI; WAD symptoms; WAD grade. | Follow-up at 1, 3 and 12 months. N=480 with data at every time point | Neck pain lasting one day or longer during the past week. Persistent symptoms defined as neck pain at all follow-up points. | After adjusting for age and sex, 5 variables predicted persistent symptoms: prior widespread pain (yes/no); non-car; 5 or more WAD symptoms; NDI of 19 or greater; and post-crash psychological status. The greater the number of these factors, the greater the risk for persistent symptoms (χ2 for trend=39.5, P<.001) |
| Bohman et al 2012 [97]  Phase II cohort  Canada | Adults making a traffic injury claim or treated for traffic injuries; injury occurred between December 1997 and November 1999; self-reported post-collision neck pain; consulted a physical therapist prior to baseline. Excluded those hospitalized > 2 days and those with baseline data > 42 days post-crash. N=680 | Prognostic factors: age, sex; days between collision and baseline questionnaire; neck, low back and headache, other pain intensity (11-point NRS, categorized into 0=no pain, 1-4=mild, 5-7=moderate, 8-10=severe); post-crash symptoms; prior pain; post-crash activity restrictions; number of visits to physical therapists and medical doctors; expectations for recovery; pre- and post-collision health; worry or anxiety; depression (CES-D) | Follow-up at 6 weeks, 3 and 6 months. N at 6 weeks = 648; N at 3 months = 626 and N at 6 months = 599. | Self-rated global recovery (recovered =all better or quite a bit of improvement, unrecovered=some improvement, no improvement, a little worse and a lot worse) | HRR and 95% CI for final multivariable prediction model for recovery included HRR: age (for each year, HRR=0.99, 0.98, 1.00); days to report collision (HRR=0.98, 0.97, 0.99); moderate, severe neck pain (HRR=0.65, 0.50, 0.85; HRR=0.61, 0.45, 0.82); severe back pain (-0.66, 0.49-0.89); other pain (yes HRR=0.71, 0.57, 0.88); mild prior headaches (HRR=1.32, 1.07, 1.63); poor expectations, don’t know (HRR=0.51, 0.41, 0.65; HRR=0.34, 0.26, 0.44) |
| Bostick et al. 2013 [7]  Phase III cohort  Canada | Patients attending 18 physiotherapy and chiropractic clinics in urban and rural Alberta and Saskatchewan with acute WAD--complaints of neck pain of < 6 weeks duration as a result of MVC; Dec 2008 to May 2010; Excluded those <18 years of age and inability to speak or read English. N=72 | Prognostic factors (6 weeks post MVC): SOPA, PBPI, PCS. Analyses controlled for the following confounders: age, sex, history of WAD, baseline pain intensity (where pain was the outcome) and baseline disability (where disability was the outcome). | Follow-up at 3 (n=55) and 6 months post-MVC (n=48) | Pain intensity (11 point NRS) and disability (Whiplash Disability Questionnaire). | In adjusted analyses: Greater control beliefs predicted less pain and less disability at 6 months (but not 3 months). Belief in a medical cure was associated with more pain and more disability at 6 months (but not 3 months). Greater belief that pain is permanent predicted greater pain and disability at 3 and 6 months. Greater catastrophization predicted greater pain at 3 and 6 months and greater disability at 3 months. Greater belief that pain is mysterious was associated with greater disability at six months, but not three months. |
| Buitenhuis et al. 2006 [8]  Phase II cohort  The Netherlands | Persons initiating personal injury insurance compensation claims at a Dutch insurance company; aged 18-65; soft tissue injuries only; injuries occurred in a car. Excluded those with history of chronic pain, LOC and those with no physical complaints. N=240. | Prognostic factors: PTSD (ascertained by Self-Rating Scale for PTSD: SRS-PTSD: dichotomized to yes/no); gender, age, neck pain, dizziness. | Baseline at median 21 days post-collision. Follow-up at 6 and 12 months. N=208 (79 with post-whiplash syndrome) at 6 months and 190 (62 with post-whiplash syndrome) at 12 months | Post-whiplash syndrome, as defined as persistent neck pain. | At each assessment point, PTSD was more prevalent in those with persistent neck pain than those without. After adjusting for neck pain, PTSD (yes/no) at baseline did not predict persistent neck pain. However, without adjusting for neck pain (if neck pain is on causal pathway), presence of PTSD did predict persistent neck pain (OR=13.94, 95 % CI 1.76, 110.6 and OR=7.52, 95% CI 1.58, 35.72 at 6 and 12 months). When looking at subscale scores of the SRS-PTSD, baseline # hyperarousal symptoms (OR=1.99, 95% CI 1.13, 3.50), neck pain (OR=1.50, 95% CI 1.14, 1.87) and gender (OR=0.21, 95% CI 0.06, 0.75) predicted persistent neck pain at 6 months and # of hyperarousal symptoms (OR=2.25, 95% CI 1.28, 3.95), and neck pain (OR=1.55, 95% CI 1.18, 2.03) predicted persistent neck pain at 12 months. |
| Buitenhuis et al. 2006 [9]  Phase II cohort  The Netherlands | Persons initiating personal injury insurance compensation claims at a Dutch insurance company; neck complaints after a MVC; aged 18-65; neck complaints and soft tissue injuries only. Excluded those with history of chronic pain, LOC. N=367, of whom N=211 had neck complaints at time of completing baseline questionnaire and were eligible to complete the TSK | Prognostic factors: Tampa Scale of Kinesiophobia (TSK – Dutch version); age, gender; head restraints; collision anticipated; seat in car; seatbelt use; symptoms, all on 0-10 scale: neck and headache pain intensity neck stiffness, restricted neck movement, radiating pain in arms, concentration problems, difficulty reading, difficulty conversing, dizziness; use of medication; sleep disturbance; daily duration of pain (1-5); onset of neck pain (hours after collision); collision occurred in first three months of study. | Baseline at median 32 days post-crash. Follow-up at 6 and 12 months. N at follow-up not reported. | Self-reported neck pain (yes/no) | TSK predicted neck pain duration only when symptoms not included in the multivariable model. |
| Buitenhuis et al. 2008 [10]  Phase II cohort  The Netherlands | Persons initiating personal injury insurance compensation claims at a Dutch insurance company; neck complaints after a MVC; aged 18-65; neck complaints and soft tissue injuries only. Excluded those with history of chronic pain, LOC > 1 minute. N=140 met inclusion/exclusion criteria. | Prognostic factors: Pain Catastrophizing Scale (PCS); Causal Beliefs Questionnaire-Whiplash (4 scales: attribution of symptoms to psychological factors, to having had a severe injury, to vertebral origins, to muscular origins) plus one item attributing symptoms to whiplash; age; gender. Baseline measures at median of 25 days post-crash. | Follow-up at 6 and 12 months. N=122 at 6 months and 110 at 12 months. | Presence of post whiplash syndrome (as determined by self-reported presence of neck pain: yes/no); Neck Disability Index scores. | At 6 months, post-whiplash syndrome (neck pain) was predicted by the following baseline measures (ORs and 95% CIs): NDI (OR=1.20, 1.08, 1.32), CBQ-W psychological (OR=4.34, 1.56, 12.03), vertebral (OR=3.69, 1.47, 9.26) and whiplash (OR=3.43, 1.62, 7.27), and PCS (OR=.89, .81, .96). At 23 months, post-whiplash syndrome was predicted by: baseline NDI (OR=1.16, 1.06, 1.26), CBQ-W psychological (OR=2.67, 1.09, 6.53) and whiplash (OR=2.66, 1.33, 5.31) |
| Buitenhuis et al.2009 [11]  Phase II cohort  The Netherlands | Persons initiating personal injury insurance compensation claims at a Dutch insurance company; neck complaints after a MVC; aged 18-65; neck complaints and soft tissue injuries only. Excluded those with history of chronic pain, self-reported LOC > 1 minute. (Included some participants from Buitenhuis et al. [8-10]). N=879 met inclusion/exclusion criteria. | Prognostic factors: At point of accident: Age, gender, employment, minimal education required for described work. Initial questionnaire data at median of 21 days: neck pain intensity, neck stiffness, restricted neck movements, radiating pain in arms, paresthesia, concentration complaints headache intensity (all of 0-10 scale); presence of dizziness, use of pain medication (both yes/no). Work disability/working fewer hours (yes/no). | Follow-up at 6 months and 12 months. N=809 at 6 months and 832 at 12 months. | Self-reported neck pain intensity, neck stiffness, restricted neck movements, radiating pain in arms, paresthesia, concentration complaints headache intensity (all of 0-10 scale); presence of dizziness, use of pain medication (both yes/no). Work disability/working fewer hours (yes/no). | Multivariable model of complaints at 21 days which predicted work disability at 6 months: greater concentration complaints (β=0.22, 95% CI 1.15, 1.36). Higher age and greater headache were of borderline significance (β=0.02, 95% CI 0.999-1.04 and 0.09, 95% CI 0.99, 1.21). Multivariable model of complaints at 21 days which predicted work disability at 12 months: older age (β=0.03, 95% CI 1.004, 1.05); greater concentration complaints (β=0.22, 95% CI 1.13, 1.37). |
| Carroll et al., 2009 [13]  Phase III cohort  Canada | Adults making a traffic injury claim or treated for traffic injuries; injury occurred between December 1997 and November 1999; self-reported post-collision neck pain; excluded those hospitalized > 2 days and those with baseline data > 42 days post-crash. N=6,021 | Prognostic factor: Expectations for recovery: expect to get better quickly, get better slowly, never get better, don’t know. Adjusted for socio-demographic factors, self-reported prior health/injuries; direction of impact; pain extent and intensity after the crash; other injuries besides WAD; hospitalization after crash; health care received and post-crash symptoms. | Baseline at median of 11 days post-crash. Follow-up at 6 weeks, 3, 6, 9 and 12 months (followed until recovery occurred). N=5698 with at least one follow-up data point. | Recovery, assessed in three ways: self-reported global recovery (all better or quite a bit of improvement vs. some improvement, no improvement or getting worse); pain resolution (self-rated neck pain intensity of 0-1 vs. 2-10 on 11-point NRS); disability resolution (Pain Disability Index score of 0 vs. 1-70). | Better expectation was independently associated with faster recovery. Reference group expect to never get better. For self-reported global recovery: adjusted HRR for get better soon = 3.62, 95% CI 2.55, 5.13); get better slowly HRR=2.66 (95% CI 1.88, 3.75); don’t know HRR=1.95 (95% CI 1.38, 2.76). For neck pain resolution: adjusted HRR for get better soon=1.81 (95% CI) 1.34, 2.44); better slowly HRR=1.49 (95% CI 1.11, 2.01); don’t know HRR=1.27 (95% CI 0.94, 1.71). For disability resolution: adjusted HRR for better soon=3.01 (95% CI 2.05, 4.43); better slowly HRR=2.38 (95% CI 1.62, 3.48); don’t know HRR=1.93 (95% CI 1.32, 2.84) |
| Carroll et al. 2011 [14]  Phase III cohort  Canada | Persons making a personal injury claim or being treated after MVC-related injury; WAD (neck pain after collision); aged 18 and above; between July 1994 and Dec 1995.  Excluded those hospitalized for > 2 days; serious associated or unassociated health problem; inability to understand English; injured as pedestrian, bicyclist or  Motorcyclist; recovered at 6 weeks (defined by neck pain ≤ 10 on 100 mm VAS). Also excluded those not completing the pain-related emotions items at 6 weeks. N=2019. | Exposures: pain-related depression, anxiety, fear, anger and frustration (100 mm VAS) at 6 weeks post-collision. Adjusted for confounding: age, sex, education, family income, work status, position in vehicle, impact direction, head position, having consulted a lawyer, assignment of fault for collision, tort vs. no fault claim, initial health care provider, prior general health, prior depression, anxiety, fear, anger or frustration, % of body in pain at 6 weeks, pain intensity at 6 weeks, still off work at 6 weeks, disability (Pain Disability Index: PDI) at 6 weeks, coping (Pain Management Inventory: PMI) at 6 weeks. | Baseline at 6 weeks; follow-up at 4 (N=1639) and 12 months (N=1456). | Failure to achieve neck pain recovery as defined as ≤ 10 on 100 mm VAS. | Adjusted associations between emotions and recovery at 4 months (OR and 95% CI for each 1 point increment on 100-point emotion scale): depression (OR=1.014, 95% CI 1.01, 1.02); anxiety (OR=1.02, 95% CI 1.01, 1.02); fear (OR=1.01, 95% CI 1.01, 1.02); anger (OR=1.01, 95% CI 1.01, 1.02); frustration (OR=1.01, 95% CI 1.01, 1.02). Associations lower for recovery at 12 months, but all statistically significant. |
| Carroll et al. 2014 [15]  Phase III Cohort  Canada | Same as Carroll et al., 2011 [14] except for last exclusion criteria. This study excluded those with only mild pain at 6 weeks post-injury.  N=2428. | Prognostic factors: active and passive pain coping strategies measured with Vanderbilt Pain Management Inventory (VPMI: scores categorized into high, medium and low, based on a tertile split). Models adjusted for the following confounders: baseline values of age, sex, marital status, education level, and income, at fault for the collision, direction of impact, head position at the time of the collision,  seatbelt use, and fixed or adjustable head restraint, whether or not the vehicle was drivable after the collision, admission to hospital, time lost from work due to the collision, whether they had consulted with a lawyer, whether they claimed under the tort or no fault system, self-rated precollision health (excellent, very good, good, fair, and poor), postcollision depressive symptomatology, percentage of body in pain, neck pain intensity, headache and other pain intensity. | Follow-up to recovery (assessment points were 4, 8, 12 months post collision) | Time to neck pain recovery: neck pain intensity (VAS, 0-100 mm) of 0-10 mm  Time to pain disability recovery: Pain Disability Index (PDI, 0-70) of 0-4 | In adjusted analyses, those reporting a passive coping style at 6 weeks after onset of WAD exhibit a slower rate of recovery from neck pain (HRRs, 95% CIs) for medium passive and high passive copers were HRR=0.82; 0.71, 0.97 and HRR=0.72, 0.59, 0.88, respectively) and neck pain disability (HRRs for medium passive and high passive copers were HRR=0.74, 0.59, 0.94 and HRR=0.57, 0.41, 0.78, respectively) as compared with those with WAD who are less likely to engage a passive coping style. Active coping was not associated with pain recovery or disability recovery. |
| Carstensen et al. 2009 [16]  Phase II cohort  Denmark | Consecutive patients referred to Danish Pain Research Center and Back Research Center from ED or GP after MVC injuries in 4 counties in Denmark from April 2001 to June 2003. Included ages 18-70; rear end or frontal car collisions; WAD symptoms within 72 hours. Excluded those not examined within 10 days of injury; WAD IV; amnesia/LOC; injuries in addition to WAD; prior physical or psychiatric condition or drug or alcohol abuse; prior neck pain >5 (0-10 scale). Same cohort as Kongsted et al.’s 2-centre study [98]. N=740 enrolled. | Prognostic factors: Prior psychological distress, assessed with the Whiteley-7 (illness worrying); SCL-90 (somatisation, obsessive-compulsiveness, hostility, SCL-8 mental illness, SCL-DEP6 depression and SCL-ANX4 anxiety scales) – using these measures in latent class analysis, patients were classified as class 1 = non-distressed, class 2 = medium distressed and class 3 = highly distressed; Prior persistent illness; prior non-specified pain condition; prior neck pain; age; gender; education; occupation; 30 km/h or greater speed difference in vehicles; 50% or more damage to vehicles | Baseline at < 10 days post-injury. Follow-up at 12 months. N at follow-up was 672: 651 for work capability and 529 for neck pain | Work capability as self-assessed by calendar recording during last month of follow-up (unaffected = no days with sick leave or reduced work capability due to accident; affected = any sick leave or reduced work capability because of accident; absent due to illness = stopped working due to accident); neck pain (11-point box scale: 0-3 = minimal pain; 4-10 = considerable pain) | In final, comprehensive multivariable models, prior unspecified pain (OR=2.4, 95% CI 1.4, 4.2) was associated with affected work capability. Prior unspecified pain (OR=3.5, 95% CI 2.0, 5.9), high prior psychological distress (OR=2.1, 95% CI 1.1, 4.2). |
| Carstensen et al. 2012 [17]  Phase II cohort  Denmark | Same as Carstensen et al., 2009. [16] | Prognostic factors; Coping (Coping Strategies Questionnaire – CSQ – administered at 3 months post injury – subscales distraction, ignoring, reinterpreting, catastrophizing and praying and hoping); age; gender; education; occupation; living conditions; self-reported collision severity; prior psychological distress (SCL-90) | Follow-up at 12 months. N=529 with outcome data | Neck pain intensity during the past week on 11-point box scale (0-3 = mild; 4-10 = considerable) | There were no differences in coping scores across gender. Coping strategies were modelled separately.  (1) Considerable neck pain was predicted by distraction (OR=1.03, 95% CI 1.01, 1.05) and female gender (OR=2.04, 95% CI 1.26, 3.29).  (2) Ignoring pain did not predict considerable neck pain, but female gender did (OR=1.95, 95% CI 1.22, 3.12).  (3) Considerable neck pain was predicted by Reinterpreting (OR=1.03, 95% CI 1.01, 1.06) and female gender (OR=2.12, 95% CI 1.31, 3.43). (4) Considerable neck pain predicted by Catastrophizing (OR=1.14, 95% CI 1.10, 1.18) and female gender (OR=2.38, 95% CI 1.41, 4.03). (5) Considerable neck pain predicted by Praying and Hoping (OR=1.09, 95% CI 1.05, 1.13) and female gender (OR=2.19, 95% CI 1.34, 3.58). |
| Carstensen et al. 2015 [18]  Phase II cohort  Denmark | WAD: same as Carstensen et al., 2009 [16]  Comparison Group: randomly selected from Danish Civil Registration System, matched to gender, age and region of residence; excluded those in the WAD cohort.  N=719 (WAD) and 3595 (Comparison) | Prognostic factors: WAD, age, gender, prior unemployment benefits (1-52 weeks; > 52 weeks), past social assistance, prior sickness benefit (1-12 weeks, > 12 weeks). For neck pain outcome, also education, self-reported pre-collision pain condition resulting in work absence in the past 5 years and neck pain intensity at start of study | Follow-up at 12 months. For provisional situation, n=716 WAD and n=3566 comparison group. For neck pain, n=517. | Negative change in health-related provisional situation (movement from self-supporting or labour-marked-related benefits to temporary health benefits; self-supporting or labour-marked related benefits or temporary health related benefits to permanent health related benefits).  For WAD group, neck pain intensity over the past week on 11-point NRS; 0-3 minimal pain and >3 considerable pain | More negative change in provisional situation for those with WAD (10% vs 3%). In multivariable analysis, negative change in provisional situation was predicted by WAD (adjusted OR=3.13, 2.25, 4.35) after controlling for other factors.  In multivariable analysis of WAD group, negative change in provisional situation was predicted by: being on sickness benefit > 12 weeks in the past 5 years prior to the collision (adjusted OR=3.81; 95% CI 2.05, 7.06).  In multivariable analysis of WAD group, neck pain at 1 year was predicted by: Female gender (OR=2.11; 95% CI 1.28, 3.49), sickness benefit > 12 weeks in 5 years prior to collision (OR=3.34; 95% CI 1.77, 6.32); self-reported pre-collision pain condition resulting in work absence in the past 5 years (OR=2.43; 95% CI 1.43, 4.12); and neck pain intensity at study start (OR=1.48; 95% CI 1.31, 1.67) |
| Casey et al. 2015 [19]  Phase II cohort  Australia | Traffic-related WAD injury claim for compensation (fault-based insurance system); injury had occurred no longer than 3 months previously; 18 years or older; no concurrent workers compensation claim; did not require the services of an interpreter (n=246). | Age, gender, employment status, type of work, claim status, prior claim, education, language, income, SES (Index of Relative Social Disadvantage), lawyer involvement, days from injury to questionnaire, BMI, WAD Grade II or III, attended hospital, baseline disability (Functional Rating Index), Catastrophizing (PCS; overall, rumination, magnification and helplessness scales); SF-36 (MCS, PCS). Prognostic factors measured a median of 72 days post-collision. | 12 months (n=212) | Disability measured by Functional Rating Index | Functional disability (FRI score) at 12 months predicted by: prior compensation claim (β = 12.19, p = 0.001), the Pain Catastrophising helplessness subscale score (β = 2.16, p < 0.001), and older age (β = 0.32, p < 0.001). |
| Casey et al., 2015 [21]  Phase II cohort  Australia | Same as Casey et al. 2015 [19] | Prognostic factors: age, gender, initial pain (BP scale on SF-36), pain catastrophizing, lawyer involvement, prior claim, mental health, work disability, initial disability, general health. Prognostic factors measured a median of 72 days post-collision. | 12 and 24 months. N=212 at 12 months and 197 at 24 months. | Trajectory of disability recovery (Functional Rating Index: mild disability with scores decreasing from 26 at baseline to 15 at 24 months; moderate disability with scores decreasing from 50 to 41; severe disability with scores decreasing from 70 to 67) | Compared with mild disability trajectory, moderate disability predicted by baseline measures of older age (OR=1.04, 95% CI 1.01-1.07), more bodily pain (OR= 0.87, 95% CI 0.81-0.94), higher pain catastrophizing (OR=1.05, 95% CI 1.01-1.10) and fair/poor general health (OR=0.15, 95% CI 0.03-0.66).  Compared with mild disability trajectory, severe disability predicted by baseline measures of greater bodily pain (OR=0.73, 95% CI 0.64-0.82), more catastrophizing (OR=1.11, 95% CI 1.06-1.17) and fair/poor general health (OR=0.18, 95% CI 0.04-0.78). |
| Casey et al., 2015 [20]  Phase II Cohort  Australia | Same as Casey et al. 2015 [19] | Prognostic factors: mental health (SF-36 Mental Component Scale); general health (SF-36 General Health Scale); disability (FRI), catastrophization, time to notify claim, work disability, lawyer involvement, prior claim, attendance at hospital, age, gender, smoking status, SES, income. Prognostic factors measured a median of 72 days post injury. | Continuous follow-up for time to claim closure, up to 3 years. N=211 | Days to insurance claim closure  Association between recovery and claim closure: At 12 months, of those recovered (FRI < 25), 78% had closed their claims. At 24 months, of those recovered, 93% had closed their claim. | Longer time to claim closure was predicted by: baseline FRI > 25 (HRR=1.92, 95% CI 1.32, 2.77); worse mental health (HRR=0.97, 95% CI 0.96, 0.99): lawyer involvement (HRR=1.91, 1.17, 3.12); and prior claim (HRR=1.52, 95% CI 1.06, 2.20). |
| Cobo et al., 2010 [22]  Phase I Cohort  Spain | Patients seen at Department of Orthopedic of Mataró Hospital (Spain) and then referred to the Department of Physical Medicine and Rehabilitation (DPMR) for medical evaluation and treatment; October 2005 to June 2007; aged 18-75; WAD I or II from a road traffic accident; symptoms within 48 hours of injury. Excluded were WAD III and IV; fractures of upper or lower extremities; TBI; prior cervical spine surgery, oncologic or rheumatic pathology. N=682 | Prognostic factors: Gender, age; education;, working status before accident; work disability after accident; prior health problems; prior neck, dorsal or low back pain; medication use prior to accident (sedatives or anti-depressants); crash characteristics (location of impact, location in vehicle); symptoms (WAD classification – 11% were WAD I and 89% were WAD II, headache, dizziness, dorsal pain, low back pain, shoulder pain, TMJ pain, assessed by VAS, split into mild: 0-30, moderate: 31-59, and severe: 60-100); time between crash and getting to emergency room; time in days between crash and arrival at DPMR; days of cervical column immobilization; Goldberg Depression and Anxiety Scale; Northwick Park Neck Pain Questionnaire (NPH). | Baseline at mean of 29 days post-crash. Follow-up at 6 months. N at follow-up was 557 (82%). | Neck VAS score | Greater neck pain at 6 months was seen in those with older age, female gender, more days of neck immobilization, higher baseline VAS, NPH, depression, and anxiety scores, not being self-employed, not being a student, being a housewife or a pensioner, prior neck pain, post-crash headache, post-crash dizziness (unadjusted analyses). |
| Crutebo et al. 2010 [23]  Phase I cohort study  Sweden | Personal injury claimants to Trygg-Hansa or Aktsam (2 traffic insurers who have 20% of market share in Sweden); MVC† injuries occurred from Jan 15, 2004 to Jan 12, 2005; ages 18-74; answered questionnaire within 30 days of collision; neck pain or reduced neck movement as a result of the accident. Excluded those with WAD IV; other fractures, hospitalized more than 2 days; more than one injury during study period. N=1191with WAD. | Presentation to ED after injury; sex; symptoms (consisting of neck pain, headache, low back pain, reduced neck range of motion, numbness/tingling in arms/hands or legs/feet, ringing in ears, memory problems concentration problems, dizziness) each assessed as yes/no. | Baseline assessment at median 18 days post-crash. At baseline, participants were asked about current symptoms and whether or not they had symptoms after the crash. Follow-up at 6 months. N at follow-up was 1005 | Recovery as assessed by presence of any symptoms (yes or no); individual symptoms. | Those presenting to ED after the collision had more symptoms at baseline and at follow-up. No sex difference in symptom recovery. |
| Elliott et al., 2015 [24]  Phase I cohort  USA | Patients aged 18-55 attending an emergency department (level 1 trauma designation); neck pain from MVC; Grade II WAD; no previous MVC’s; no treatment for neck pain in the past 10 years; no nervous system or metabolic disorders; not deemed to be at risk for multi-system trauma. N=56 | Muscle fatty infiltration (MFI) in the cervical multifidi, as detected by water-fat MRI and measured at 1 week post-injury and 2 weeks post-injury; age, gender; initial neck disability (Neck Disability Index: NDI); body mass index (BMI); hyperarousal symptoms (hyperarousal scale on Posttraumatic Stress Diagnostic Scale: PDS); days from MVC to assessment | Follow-up at 3 months. N=36. | Neck pain disability: 0-28% were mild/recovered; >30% were moderate/severe. | At 1 week, higher NDI and, higher PDS associated with poorer outcome at 3 months. At 2 weeks, higher MFI, NDI and PDS at 2 weeks both associated with poorer outcome at 3 months. (mean 2-week MFI was 13.9%, s.d.4% in mild recovered vs 25.1% s.d.10.6% in moderate/severe). |
| Ferrari et al., 2014 [26]  Phase II cohort  Canada | Patients aged 18 or over attending a walk-in primary care centre within 7 days of their injury; WAD grade I or II; injured in a motor vehicle; no loss of consciousness. Excluded those with fracture or neurological injury (Grade III or IV WAD); prior whiplash injury or spine pain requiring treatment; no fixed address or current contact information; unable to communicate in English; non-traumatic pain; admission to hospital after injury.  N=116 | Exposure: Expectation for recovery (get better soon, get better slowly, never get better, don’t know). Potential confounders were: Whiplash Disability Questionnaire (WDQ); age; sex | Follow-up at 3 months post-injury by telephone or in person. N=116 | Self-perceived recovery (Do you feel that you have recovered from your injuries: yes or no/unsure) | Compared to those endorsing “never get better” or “don’t know” (proportion recovered at 3 months was similar for these groups), RR of recovery for “get better soon” was 2.59 (95% CI 1.72, 3.88) and RR for “better slowly” was 1.87 (95% CI 1.12, 3.11) (recalculated from published data). Sex, age and WDQ were not associated with recovery so did not confound the association. |
| Ferrari, 2015 [27]  Phase I cohort  Canada | Patients aged 18 or over attending a walk-in primary care centre with 14 days of their injury; WAD grade I or II; injured in a motor vehicle; no loss of consciousness. Excluded those with fracture or neurological injury (Grade III or IV WAD); prior whiplash injury or spine pain requiring treatment; no fixed address or current contact information; unable to communicate in English; non-traumatic pain; admission to hospital after injury, sustained another collision-related injury during follow-up.  N=134 | Perceived injustice, measured by the Injustice Experience Questionnaire | Follow-up at 6 months. N=124 | Self-perceived recovery (Do you feel that you have recovered from your injuries: yes or no/unsure) | Perceived injustice at baseline was not associated with recovery. |
| Gehrt et al., 2015 [28]  Phase II cohort  Denmark | Same cohort as Carstensen [16, 17] and Kongsted et al. [98] | Prognostic factors: Illness perceptions, assessed by Illness Perceptions Index at baseline and 3 months (subscales: emotional representation, consequence, and timeline perspective subscales), categorized into no pessimism (no subscale score in top 20th %ile); some pessimism (top 20th %ile on one subscale) and high pessimism (top 20th %ile on 2 or 3 subscales); age; sex; education (> 10 years); baseline neck pain. For the work capacity analysis, prognostic factors also included baseline expectation to return to work (as determined by: How likely do you think it is that you will be working/in school in 6 weeks?) | Follow-up at 12 months. N at follow-up was 672: 651 for work capability and 529 for neck pain | Neck pain (11-point box scale: 0-3 = low neck pain intensity; 4-10 = high neck pain intensity).  Self-assessed work capability during the past month: dichotomized into unaffected = no days with sick leave or reduced work capability due to accident; affected = any sick leave or reduced work capability because of accident or stopped working due to accident. | High neck pain at 12 months was predicted by pessimistic illness perceptions (adjusted OR=1.71, 95% CI 1.03, 2.83 and OR=3.41, 95% CI 1.48, 7.84 for moderate and high pessimism, respectively), female sex, lower education and greater baseline neck pain, but not age.  Reduced working capacity at 12 months was predicted by: poor baseline expectations for working ability (OR=3.18, 95% CI 1.50, 6.77) and education (OR=0.55, 95% CI 0.34, 0.90), but not with age, sex, illness perceptions, or baseline neck pain. |
| Holm et al. 2008 [99]  Phase III cohort  Sweden | Injury claimants to two Swedish traffic insurers; WAD; between Jan 15 2004 and Jan 12 2005; aged 18-74; car occupants filing a claim within 30 days of collision. N=1,571 WAD claimants enrolled | Exposure: Expectations for recovery measured on 0-10 NRS (categorized into low expectations = less likely to make full recovery; intermediate expectations; and high expectations = very likely to make a full recovery); Adjusted for confounders (post collision symptoms and pain, anxiety, depression (HADS), collision related stress (IES), coping, sociodemographic factors, prior health and injuries) | Follow-up at 6 months post-collision. N=1,032 | Disability, assessed with Pain Disability Index; trichotomized with cut-off scores at the median and the 75th percentile (low, moderate and high disability). | Expectation for recovery predicted disability six months later. Compared to “very likely to make a full recovery”, adjusted OR of having *moderate disability* at 6 months for those with intermediate expectations was 1.5 (95% CI 1.0, 2.3) for those with intermediate expectations and OR=2.0 (95% CI 1.0, 3.8) for those stating they were less likely to make a full recovery. The OR of having *high disability* at 6 months was 2.0 (95% CI 1.2, 3.2) for those with intermediate expectations and OR=4.2 (95% CI 2.1, 8.5) for those with low expectations. |
| Hours et al., 2014 [30]  Phase I cohort for relevant findings  France | Patients registered with Rhône administrative area Registry of Road Traffic Casualties; October 2004-December 2005; aged 16 or over; whiplash injury as coded by AIS codes 310402 or 640278 or other injury; mild injury (defined as MAIS 1). Excluded those with AIS≥2 (which would exclude WAD III-IV). N=255 with WAD | Prognostic factors: WAD 1 vs. WAD 2 | Initial assessment at the time of the accident. Follow-up at 1 year. N=62 with WAD I and 109 with WAD II | Health-Related Quality of life (HRQoL: the World Health Organization Quality of Life tool: WHOQOL-BREF); time off work; posttraumatic stress disorder (PTSD), assessed on the PTSD Checklist Scale (score ≥ 44 indicating probable PTSD); self-reported medical status (totally recovered or not); debilitating physical pain (item 3 of the WHOQOL-BREF); disturbed occupational and leisure activities; financial repercussions, effect on family life, effect on sexual life, effect on leisure, feeling run down, feeling nervous, negative feelings (e.g., depression). | No association between WAD grade and HRQoL Those with WAD I had more negative feelings than those with WAD II (16.1% of WAD I and 27.5 of those with WAD II never had negative feelings) |
| Johansson et al. 2011 [31]  Phase II cohort  Denmark | Patients enrolled from 2 centre WAD intervention RCT (Subcohort of Kongsted et al.,[38, 98] and Carstensen et al., [16]); recruited from EDs and general practitioners in 4 Danish Counties; WAD I-III after a rear or frontal car collision; aged 18-70; symptoms began within 3 days of MVC; MVC occurred within 10 days of enrollment; excluded fractural or dislocations of cervical spine, amnesia or LOC associated with the injury; presence of injuries other than WAD; prior neck pain > 5 on 11-point box scale; prior somatic or psychiatric disease. N=213 enrolled in longitudinal study, with baseline MRI data on 171. | Prognostic Factors: MRI scan (lordosis, kyphosis or straight); adjusted for gender and age. | Follow-up at 1 year. N=104. | Outcomes: self-reported neck pain and headache intensity (each on 11-point box scale) | No significant associations between postures at baseline and pain intensity at one year |
| Kamper et al. 2012 [34]  Phase II cohort  Australia | Recruitment from Sydney and Brisbane; recruited from ED admissions (55%), primary care physiotherapy clinics and GP referral (17%) and newspaper ads (28%); Neck pain from MVC in past 4 weeks; ages 18 – 65; fluent in English; Excluded those with prior WAD requiring treatment; cervical fracture or dislocation; LOC, concussion or head injury; major psychiatric history. N=205 enrolled. | Prognostic factors: Pain intensity over past 24 hours (10 cm VAS); Neck Disability Index (NDI); Tampa Scale of Kinesiophobia (TSK); Pictorial Fear of Activity Scale (PFActS); Coping Strategies Questionnaire – Catastrophizing subscale. | Baseline < 4 weeks from injury. Follow-up at 3 and 6 months. Data completeness was 89-97% at baseline, 70-75% at 3 months and 69-80% at 6 months (no exact numbers given by authors). | Neck Disability Index (NDI) | Fear avoidance had a limited role as mediator of the association between baseline pain and subsequent neck disability (accounting for 20-40% of the association). Series of cross-sectional analyses at baseline, 3 and 6 months did not conclude that the influence of fear avoidance increases. Fear avoidance measured by TSK had a slightly stronger role than the PFActS. |
| Kasch et al. 2008 [35]  Phase I cohort  Denmark | Subcohort of Kongsted et al. 2007 2-centre RCT.[40] and Carstensen et al., [16] Recruited from EDs and general practitioners in 4 Danish Counties 2001-2003; WAD I-III after a rear or frontal car collision; aged 18-70; symptoms began within 3 days of MVC; MVC occurred within 10 days of enrollment; excluded fractural or dislocations of cervical spine, amnesia or LOC associated with the injury; presence of injuries other than WAD; prior moderate or greater neck pain; prior somatic or psychiatric disease.  N=688 enrolled | Prognostic factors for Study 1: High vs. low risk status, as in Kongsted et al. 2007 [98]. High risk: risk score ≥4; low risk score <4. Risk score a combination of cervical range of motion scored 0-10; neck pain/headache intensity scored 0-10; female gender; # of non-painful symptoms; pain on palpation. | Baseline within 10 days of collision. Follow-up at 12 months. N=625 | Handicap, as defined as more than 3 months sick leave in the past 6 months; work inability during the last month; or not working anymore because of the injury. Neck and headache pain intensity (minimal = 0-4, considerable = 5-10). Neck disability, as determined by the Copenhagen Neck Disability Scale (minimal = 0-6; considerable = 7-30) | At one year follow-up, 19.3% (95% CI 17.1-21.8) of high risk patients had handicap compared with 2.4% (1.9-2.9) of low risk patients. High risk patients had greater handicap, neck pain, headache and disability at 12 months.  H*andicap* predicted by: initial high neck pain (RR=3.5, 95% CI 2.2, 5.5); headache intensity (RR=3.7, 95% CI 2.4, 5.7); reduced ROM (RR=4.6, no CI provided); palpation tenderness (RR=4.0, 95% CI 1.9, 8.5); larger # of non-pain symptoms (RR=4, no CI reported).  *Severe neck pain* predicted by initial neck pain and gender but not headache. *Severe headache* predicted by initial severe headache and gender but not neck pain.  *Neck disability* predicted by female gender (RR=1.3, 95% CI 1.0, 1.7). |
| Kasch et al. 2013 [36]  Phase I cohort  Denmark | Subcohort of Kongsted et al. 2007 2-centre RCT,[100] and same cohort as Kasch et al., 2008.[35]  N=688 enrolled. N=648 for work outcomes (includes only those previously employed). | Prognostic Factors: Risk status (7 strata). | Baseline within 10 days of collision. Follow-up at 12 months. N=625 | 1-year work disability (called handicap in Kasch 2008); diarized days on sick leave; expected work difficulties, post-traumatic stress (Impact of Event Scale: IES); pressure pain detection and pain tolerance thresholds; pain on palpation; neck disability (Copenhagen Neck Disability Index); McGill Pain Questionnaire; shoulder-arm neck pain, headache and global pain (11-point box scores) | 96% of those in lowest risk strata and 32% in highest risk strata had returned to work at one year. All outcomes were differentially distributed across the risk strata. |
| Kivioja et al. 2008 [37]  Phase I cohort  Sweden | Consecutive patients seen in a Swedish ED\* and then referred to an orthopedic surgeon’s clinic; November 1996 to June 1997; MVC†-related WAD < 1 week prior to being seen; age 18-65. Excluded those with previous neck injury, other obvious simultaneous injuries or neurological disease.  N=186: | WAD grade | Baseline measures within 1 week of injury, follow-up at 1 year. N=170 at follow-up. | Neck pain measured on VAS\*\*, split into ≤ 30mm and > 30mm. | At 1 year, 7% (1 of 15) of those with WAD Grade I had neck pain >30; 19% (26 of 139) of those with WAD Grade II had neck pain > 30; 25% (4 of 16) of those with Grade III had neck pain > 30; findings not statistically significant. |
| Kongsted et al. 2008 [40]  Phase II cohort  Denmark | Subcohort of patients enrolled in 2-centre WAD intervention RCT (Kongsted et al., [40]); Also see Kasch et al., 2008 [35] and Carstensen et al., 2009 [16].  N=740 enrolled. | Prognostic factors: post-traumatic stress (Impact of Event Scale - IES total, intrusion and avoidance subscales) – dichotomized into mild and distinct stress; SF-36 MCS and PCS prior to the injury; prior neck, headache pain (11-point box scale); neck pain and headache intensity (11-point box scale); sociodemographic factors. | Baseline < 10 days post-collision. Follow-up at 3, 6 and 12 months. N=668 at 12 months (511 questionnaires – full outcome data and 157 interviews – partial outcome data). | Self-reported neck pain and headache (11-point box scale) over the past week; neck disability (Copenhagen Neck Functional Disability – 0-30 point scale); general health from SF-36; calendarized. work ability during the 12 month after the injury (unaffected, reduced working hours, off sick) | In multivariable models, Pain > 3 at follow-up was predicted by distinct stress (OR=2.1, 95% CI 1.1, 4.1), female (OR=1.9, 95% CI 1.3, 2.9) and baseline pain intensity (OR=1.4, 95% CI 1.3, 1.6). Reduced working ability was predicted only by baseline pain (OR=1.4, 95% CI 1.2, 1.5; gender and stress n.s.). Disability >6 was predicted by distinct stress (OR=2.1, 95% CI 1.1, 4.2) and pain intensity (OR=1.4, 95% CI 1.2, 1.5).  Stratified analyses: Distinct stress was strongly associated with pain > 3 and reduced working ability at 1 year in those with initial pain of 0-3 (pain OR=7.1, 95% CI 2.3, 21.8; work ability OR=7.2, 95% CI 1.6, 32.8) but not in those with initial pain intensity of 6-10. |
| Kongsted et al. 2008 [39]  Phase II cohort  Denmark | Subcohort of patients enrolled from 2 centre WAD intervention RCT (Kongsted et al., 2007.[40] See Kasch et al. 2008 [35] and Carstensen et al., 2009 [16] and excluding those with no eye movement tests at baseline.  N= 261. | Prognostic factors: smooth pursuit eye movements tested with electrooculography; adjusted for baseline neck pain intensity (11-point box scale); intervention group; age; gender; active cervical range of motion. | Follow-up at 3 and 12 months. N=237. | Copenhagen Neck Functional Disability Scale (CNFDS); neck, headache intensity; calendarized sick days or reduced working hours. | No associations between eye movement tests at baseline and outcomes of pain intensity, neck disability or reduced work capacity |
| Kongsted et al. 2008 [38]  Phase I cohort  Denmark | Subcohort of patients enrolled from 2 centre WAD intervention RCT (Kongsted et al., 2007.[40] See Kasch et al. 2008 [35] and Carstensen et al., 2009 [16]and excluding those with no MRI at baseline.  N=213 enrolled, with baseline MRI data on 278. | Prognostic factor: MRI findings (no abnormal findings; mild pre-existing disc degeneration; moderate/severe pre-existing degeneration; traumatic findings). | Follow-up at 3 months and 1 year. N=165 | Neck pain intensity and headache intensity (categorized as mild=0-4 and considerable=5-10); Copenhagen Neck Functional Disability scale (categorized as minimal=0-6 and considerable>6); calendarized work disability (categorized as unaffected= no sick listing or reduced hours and affected= sick listing, reduced hours or no longer working) | No statistically significant association between traumatic MRI findings and outcome. Pre-existing findings not associated with outcome after adjusting for baseline pain. However, number with traumatic findings was small (n=7) which would lead to unstable estimates. |
| Matsumoto et al. 2010 [41]  Phase I cohort  Japan | Recruited from patients attending hospital after a car crash injury; WAD; between 1995 and 1997; seen within 2 weeks of injury; no prior history of cervical spinal disease or trauma; excluded those with fracture/dislocation of cervical spine or other severe injuries. Controls were volunteers recruited 1993-1996, (acquaintances of investigators, medical students, high school students). N=506 with WAD and 497 controls at baseline. | Prognostic factor: change in MRI over the 10 year follow-up period (degenerative changes, defined as decrease in signal intensity of intervertebral discs, progressive posterior disc protrusion, progressive disc space narrowing, foraminal stenosis). | Follow-up at 10 years. N=133 WAD and 223 controls. | Symptoms at follow-up: neck pain, shoulder stiffness, headache, arm pain/numbness | No associations between progression of any of the degenerative changes on MRI and symptoms at 10 years in either controls or WAD participants. |
| McLean et al., 2014 [43]  Phase I cohort for predictors; Phase II cohort for prediction rule.  USA | Patients presenting with WAD within 24 hours of MVC, to one of 8 EDs in 4 no-fault states; February 2009-October 2011, aged 18-65; unlikely to require hospitalization; non-Hispanic whites. Excluded those with fractures other than phalangeal, have > 4 lacerations requiring sutures or single laceration > 20 cm, intracranial or spinal injuries.  N=948 | Age, gender, income, height, weight, education, employment status, smoking status, health insurance coverage, collision characteristics (seat belt, air bag, location in vehicle, vehicle speed, direction of impact, extent of vehicle damage), perceived fault for collision, prior pain, pain at presentation, pain extent, pain catastrophizing (PCS), distress, dissociation, depressive symptoms, physical and mental health status (PCS, MCS of SF-12), generalized optimism, trait and state anxiety, confidence (expectations) in recovery, symptoms, litigation status. | Follow-up at 6 weeks. N=859 | Moderate to severe neck pain (≥4/10 on NRS). | In those not hiring a lawyer: female gender, older age, greater vehicle damage, being in a stopped vehicle at the time of collision, moderate and severe neck pain, moderate and severe overall pain, any regional pain, any widespread pain, more somatic symptoms, belief that the collision was someone’s fault, belief that the collision was not the participant’s fault, peritraumatic distress and dissociation, expectations that it will take longer to recover physically and emotionally, catastrophizing all predicted moderate to severe neck pain at 6 weeks.  In those hiring a lawyer: not being in full time employment, not having health insurance, being a passenger, catastrophizing predicted moderate/severe pain at 6 weeks.  Prediction rule: Using Lasso regression, variables were included if they maximized the area under the ROC curve, whether or not they were statistically significant predictors of this outcome. For those not engaged in litigation, a combination of female sex, severe neck and overall pain, as assessed in the ED, yielded AUROCC of 0.73. For those litigating, a combination of female sex, having moderate or severe neck pain or severe overall pain as assessed in the ED, 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 yielded AUROCC of 0.73 |
| Myrtveit et al., 2015 [44]  Phase II cohort  Denmark | Same as Kongsted et al.,[38, 98] and Carstensen et al., [16]  N=740 | Coping/healthcare preferences: coping/healthcare options participants believed would help them get better. Assessed within 10 days of injury. Adjusted for age, gender, education, baseline neck pain and collision severity. | Follow-up at 12 months.  N=529 for neck pain outcome and 651 for work capability outcome | Neck pain (11-point box scale) and reduced capability to work. | Neck pain at 12 months predicted by: not endorsing "keep living as usual" as only coping preference (mean neck pain was -1.62 lower than those endorsing the item (95% CI -2.39 to -0.84); preference of coping by sickness absence (mean neck pain 1.18 points higher, 95% CI 0.53 to 1.82); preference of coping by taking medications (mean neck pain 1.24 points higher, 95% CI 0.67 to 1.82) and preference of being referred to a physical therapist/chiropractor (0.65 points higher, 95% CI 0.03 to 1.28). Authors did not mention clinical relevance of these findings.  Reduced working capability predicted by: not preferring coping by changing lifestyle (OR=0.11, 0.01-0.78); not endorsing "keeping living as usual" (OR=0.09, 0.01-0.64); sickness absence (OR=3.05, 1.80-5.17); taking medications (OR=3.53, 2.13-5.86); being referred to a specialist (OR=1.98, 1.15-3.41), being referred to a physical therapist/chiropractor (OR=3.03, 1.33-6.91). |
| Nieto et al., 2013 [46]  Phase II cohort  Spain | Consecutive patients seeking treatment for WAD from one of 10 rehabilitation services in Tarragona, Spain from April 2006 – July 2007, injury in motor vehicle in past 3 months, between 18-65 years. Excluded those where were illiterate, had fracture, dislocations or neurological injuries or self-reported chronic neck pain prior to the accident.  N=147 | Pain catastrophization (PCS); kinesiophobia (TSK); age, gender, education, occupation, days since injury, neck pain intensity (11-point NRS), neck disability (NDI) | Follow-up at 6 months  N=123 | Neck disability (NDI), neck pain (11-point NRS). | Greater initial pain intensity, greater initial neck disability and greater kinesiophobia predicted disability at 6 months. Greater pain intensity, longer time since injury at baseline and greater kinesiophobia (“nearly significant” trend) predicted greater pain intensity at 6 months. |
| Nolet et al. 2010 [101]  Phase III cohort  Canada | Random survey of adult population in Saskatchewan, Canada; 1995-1996; no pain or only mild neck pain at baseline. N=919 | Exposure: self-reported history of neck injury in motor vehicle collision. Adjusted for baseline confounders: demographic and socioeconomic characteristics, health status (SF-36), comorbid health conditions, depression, smoking, body mass index, exercise. | Follow-up 6 and 12 months after index survey. N=676 at 6 months and 580 at 12 months | Intense and/or disabling neck pain, as defined by Grade II-IV on Chronic Neck Questionnaire. | History of neck injury was associated with onset of severe pain: Adjusted HRR=2.14, (95% CI 1.12, 4.10). |
| Ozegovic et al. 2009 [48]  Phase III cohort  Canada | Subgroup analysis of Carroll et al.;[13] excluding those not employed at time of injury and those who had already returned to their employment by the time of completing baseline questionnaire. N=2335 | Exposure: Expectations to return to work (yes; no/don’t know). Adjusted for: baseline confounding: sociodemographic factors, prior health, initial symptoms and pain intensity, post-crash depression, pre-crash job satisfaction, employment status, collision characteristics, time from injury to baseline questionnaire. | Follow-up at 6 weeks, 3, 6, 9 and 12 months post injury. Participants followed to recovery, to end of study or to drop-out from study. N=2050 with follow-up information. | Time to self-assessed recovery with no relapse in subsequent follow-ups. Response options: recovered = all better – cured or feeling quite a bit of improvement vs. not recovered - some improvement; no improvement; a little worse; much worse. | Sixty-six percent expected to return to usual job; 32.2% did not know; 1.8% expected not to return to their usual job. Those expecting to return to usual job recovered faster (adjusted HRR=1.42, 95% CI 1.26, 1.60). |
| Palmlöf et al. 2015 [49]  Phase III cohort  Canada | Same as Carroll et al.[13] | Self-reported cardiovascular disease (CVD) assessed at baseline (no CVD; yes but no or mild effect on health,; or yes and moderate to severe effect on health). Adjusted for age, education, prior musculoskeletal problems, prior mental health problems; findings stratified by sex. | Time to self-reported recovery with assessment periods of 6 weeks, and 3, 6, 9 and 12 months post injury (n=5046) | Self-reported global recovery (all better or quite a bit of improvement vs. some improvement, no improvement or getting worse); | Presence and severity of CVD are not associated with recovery. |
| Pedler et al. 2011 [50]  Phase II cohort  Australia | Convenience sample of adults aged 18-65 with acute (< 1 month) WAD from MVC; volunteers from ads, referrals from primary care physicians and from EDs of 2 large hospitals; WAD I-III; excluded those with prior neck pain requiring treatment, concussion or head injury from MVC. N=98 | Potential prognostic factors: Neck Disability Index (NDI); Pictorial Fear of Activity Scale – Cervical (PFActS-C); Tampa Scale of Kinesiophobia (TSK-17); pain intensity (10 cm VAS); sex. | Baseline at < 1 month post-injury; follow-up at 3 and 6 months. N=80. | Neck Disability Index score at 6 months. | Initial neck pain alone explained 29.4% of the variance of NDI at six months. Adding TSK-17 to the model increased this to 38.7% (in multivariable model, VAS β=0.39, SE=0.92; TSK-17 β=0.34, SE=0.21; PFACtS-C and sex were not associated. |
| Petterson et al. 2004 [51]  Phase I cohort  Sweden | Consecutive traffic-related WAD II or III patients admitted to the Department of Orthopedic Surgery at a University Hospital; admitted within 8 hours of injury; age 18-64. Excluded those with loss of consciousness; head injury; WAD I and IV; prior neck injury. N=40 | Personality (assessed by the Dimensions of Temperament and Character Inventory) | Baseline at < 8 hours post-injury; follow-up at 2 years. N=39 | Recovery status, classified as: good (no symptoms), mild (mild symptoms, mostly intermittent neck pain and headache), severe (severe symptoms, e.g., daily neck pain or headache, radiating pain, cognitive disturbances). | No association between personality indices as measured less than 8 hours after injury (i.e., pre-injury personality) and recovery status. |
| Pieske et al. 2010 [53]  Phase I cohort  Germany | Persons with WAD 1-2, presenting to ED and treated as outpatients; aged 18-75; German speaking. Excluded those arriving at ED > 48 hours post-collision; those who consulted another physician before ED presentation; AIS2 or greater injury; unconsciousness or amnesia; severe disease or prior chronic pain. N=98 | Seniority of physician; | Baseline at ED presentation. Follow-up at 1, 3 and 6 months post collision. N=81 with complete data. | Neck pain intensity (11-point NRS; NRS > 2 means that at least once per week, the neck pain is > 2 and hinders normal activities of life); analgesic usage at least 1/week for neck pain; inability to work because of WAD for at least half the time between trauma and interview; need for further intervention; SF-36. | No association between physician seniority and any of the outcomes. |
| Ritchie et al. 2013 [54]  Phase II Cohort  Australia | Participants were from 2 studies (1 cohort study and control group from RCT). Patients recruited from emergency departments, primary care and general advertisement; with Grade I, II, III WAD following MVA (<1 month duration); 2006-2010; Excluded those with WAD IV; concussion or head injury as a result of MVA; prior whiplash, neck pain, or headaches requiring treatment; past or present diagnosis or treatment for psychiatric or psychological condition. N=336 | Prognostic factors at < 1 month post-injury: NDI; cold pain threshold (mid-cervical spine); age; post-traumatic stress (Posttraumatic Diagnostic Scale (PDS): hyperarousal subscale); neck pain (VAS 0-10); sex; presence of headache at time of assessment; neck ROM | Follow-up at 12 months post-injury (n=262) | Neck Disability Index (NDI): NDI ≥30%: indicates moderate to severe pain-related disability. NDI ≤10%: indicates full recovery | Proposed clinical prediction rule for moderate/severe disability: with the combination of initial NDI ≥40; Age ≥35; hyperarousal scale (PDS) ≥6, sensitivity was 43.5 – 58.8% and specificity was 86.9 - 93.8%.  Proposed clinical prediction rule for recovery: initial NDI ≤32; Age ≤35. Sensitivity of 45.3% and specificity of 84.5%. |
| Ritchie et al. 2015 [55]  Phase II Cohort  Australia | Participants were from 2 studies (1 cohort study and control group from RCT). Recruited from: accident and emergency departments; referred by primary care practitioners; volunteers to media advertisements; 18-65 years old; acute MVC-related WAD II <4 weeks; fluent in English. Excluded those with prior whiplash or treatment neck pain. 2 cohorts: prospective longitudinal study; control intervention of RCT. N=101 | External validity of CPR for WAD recovery [54]: Proposed clinical prediction rule for failure to recover was: initial NDI ≥40; Age ≥35; hyperarousal scale (PDS) ≥6. Proposed clinical prediction rule for recovery: initial NDI ≤32; Age <35. | Follow-up at 6 months. | Disability measured by Neck Disability Index. Full recovery defined as NDI of 10% or less; mild/moderate disability defined as NDI of 11%-29%); moderate/severe disability defined as NDI 30% or greater. | For predicting full recovery, CPR sensitivity = 54.9 (95% CI 40.5, 68.6); specificity = 86.0 (95% CI 72.6, 93.7); PLR = 3.9 (95% CI 1.9, 8.1); NLR = 0.5 (95% CI 0.4, 0.7); PPV = 80.0 (95% CI 62.5, 91.7). NPV not provided. For predicting moderate/severe disability, CPR sensitivity = 43.5 (95% CI 22.9, 65.1); specificity = 98.7 (95% CI 92.9, 99.9); PLR = 33.9, (95% CI 4.6, 251.2); PPV = 90.9 (95% CI 58.7, 98.5). |
| Rydman et al., 2016 [56]  Phase II Cohort  (Phase I for the expectations question)  Sweden | Participants were from 2 studies. Study 1 (model-building set) consisted of WAD patients presenting to ER within 24 hours of MVC; aged 15-65; Swedish speaking; recruited for a previous study of recovery after musculoskeletal injuries. Study 2 (model validation set) consisted of WAD claimants to one of 3 insurance companies; age 18-65; within 2 weeks of injury. Excluded those who no longer had daily neck pain, those with persistent symptoms from a prior injury; those with neck/shoulder pain prior to the MVC.  N=130 in ER cohort (model development)  N=142 in insurance cohort (model validation) | Clinical prediction rule: Employment status; education level; pain intensity on 100 MM VAS; mental status (anxiety, depression) on 100 mm VAS.  Additional question in insurance cohort (not part of clinical prediction rule) on expectations for recovery on 100 mm VAS. | Follow-up at 6 months. N=130 in ER cohort and 114 in insurance cohort | Self-rated recovery (Do you feel recovered after your injury: yes/no) at 6 months | In ER cohort, failure to recover was predicted by: older age and greater mental distress (compared to score of <5/100, 5-51 OR = 3.25, 95% CI 1.16, 8.20 and > 51 OR = 8.53, 95% CI 1.93, 37.57).  In model-building cohort, algorithm had area under the curve (AUC) at 82% .AUC for validation cohort was 59% (47%-72%)  In insurance cohort, 44% expected to fully recover and 42% of these had recovered at 6 months. 21% of those not expecting to recover had recovered at 6 months. |
| Skillgate et al. 2016 [59]  Phase III  Canada | Same as Carroll et al., 2009 [13] except included only those responding to 6-week follow-up.  N=5204 | Exposures were health care intensity across care patterns and health care intensity within care patterns at 6 weeks post-injury. Potential confounders were: demographic and socioeconomic factors, prior health, prior chiropractic and physiotherapy treatments in past 5 years, injury-related symptoms and pain, depressive symptoms, expectations of recovery, off job due to collision, job satisfaction, expectation to return to work, self-reported injury-related disability, comorbid health conditions | Time to recovery (1 year follow-up) | Self-reported global recovery (all better or quite a bit of improvement vs. some improvement, no improvement or getting worse) | In adjusted analysis, those with higher health care utilization recovered more slowly than those with low health care utilization. Reference group was low utilization of physician only. Those with slowed recovery included: high physician only utilization; any physician + high physiotherapy utilization; any physician + high chiropractor utilization; any physician + high massage; any physician = any massage + high physiotherapy; any physician + any massage + high chiropractic; high chiropractic usage alone.  Within categories of health care utilization listed above, those with high health care utilization recovered more slowly than those with low health care utilization. |
| Söderlund et al. 2002 [60]  Phase II cohort  Sweden | Convenience sample of patients with acute whiplash visiting the orthopaedic clinic at a University hospital; most injuries from MVC. N=59 enrolled | Potential prognostic factors: self-efficacy (Self-Efficacy Scale: SES); coping (Coping Strategies Questionnaire: CSQ) | Baseline at mean of 20 days post-injury; follow-up at 6 and 12 months. N=53 at three weeks, 50 at 6 months and 51 at 12 months. | Disability (Pain Disability Index: PDI) | Effect of self-efficacy and coping on concurrent disability increased over the study period. The crucial type of coping strategy changes over time, with pain behaviors being the only significant coping strategy at 3 weeks, and at one year, catastrophizing was the only significant coping strategy at 1 year. The direct effect of self-efficacy was greatest at baseline and decreased over the year (direct effect was 97%, 93% and 67% of total (direct plus indirect) effect of self-efficacy at 3 weeks, and 6 and 12 months, respectively. The indirect effect of coping on disability increased from 3%, 7% to 33% during the first year after the accident. Self-efficacy may predict the use of different coping strategies, which may predict the extent to which persons with WAD become disabled. |
| Spearing et al., 2012 [61]  Phase I cohort  U.K. | Persons reporting WAD from a rear end collision over a 1 year period to police in Devon and Cornwall; aged 18 and older; WAD defined as neck pain lasting > 7 days from crash; sought compensation at some point during the 2 years post-injury; fault-based insurance scheme. Excludes those not participating in 2-year follow-up (since exposure status assessed at follow-up). N=265 | Potential prognostic factor: claim closure (yes/no), assessed at 12 and 24 months. | Baseline within 2 weeks of injury. Follow-up at 6 months, 12 months and 24 months. | Neck pain (100 mm VAS) | Claim settlement in the study period prior to follow-up point did not predict lower neck pain. |
| Sterling et al., 2010 [63]  Sterling et al., 2011 [64]  Phase II cohort  Australia | Convenience sample of patients in Queensland, Australia (fault-based system); with WAD I-III, recruited from ED and GP practices; WAD < 1 month duration. Excluded were those with WAD IV; concussion or head injury; prior WAD, neck pain or headaches requiring treatment; those with a prior or current psychiatric or psychological condition. N=155 enrolled. | Potential prognostic factors: lodging a claim (for Sterling 2010) and age, gender, initial pain (11-point VAS), pressure pain thresholds (PPT), cold pain thresholds (CPT), sympathetic vasoconstrictor response (SVR: sympathetic reflex – SRF and quotient of integrals – QI) for Sterling 2010 | Baseline at < 1 month. Follow-up at 3, 6 and 12 months. N=155 with at least one data point and 94 with complete NDI and 91 with complete PDS) | Identification of Neck Disability Index recovery trajectories for Sterling 2010 ; and disability trajectories as outcomes for Sterling 2011 | There were 3 post-WAD trajectories of disability: mild - mild throughout (45% of the cases), Moderate - initially moderate decreasing to mild (39% of the cases), and chronic moderate/severe – severe pain/disability persisting at moderate/severe for 12 months (16% of the cases). Submitting a compensation claim had a detrimental effect on mild and moderate trajectories, but not on chronic-severe.  Both disability and PTSD are predicted by similar factors. In multivariable analyses, and with mild trajectory as reference category, membership in moderate and chronic severe NDI trajectory were predicted by CPT ≥ 13 degrees (OR=3.63, 95% CI 1.35, 9.98 and OR=26.32, 95% CI 4.98, 139.09); initial pain intensity (OR=1.99, 95% CI 1.42, 2.79 and OR=4.31, 95% CI 2.55, 7.28) and age (OR=1.06, 95% CI 1.02, 1.10 and 1.11, 95% CI 1.04, 1.18). |
| Sterling et al. 2012 [65]  Phase II cohort  Australia, Canada and Iceland | Recruitment at Brisbane, Melbourne, Montreal, Reykjavik; Convenience sample of attendees at a university research laboratory (recruited from primary care practices, EDs, advertisements); 2005-2008; WAD I, II or III < 3 weeks duration. Excluded those with concussion, LOC or head injury, history of whiplash, neck pain or headaches requiring treatment. N=286 enrolled | Prognostic factors: cervical range of motion to the left (ROML); cold pain thresholds at mid cervical spine (CPT); sympathetic vasoconstrictor response (quotient of integrals: QI); stress (Impact of Events Scale: IES); initial NDI; age. These were the factors significant in a disability prediction model by Sterling et al. 2005. | Follow-up at 12 months. N=257. | Neck Disability Index (NDI), dichotomized into mild or no disability (scores 0-28) or moderate to severe disability (30-100) | Goal was to test a disability prediction model. In the current model, initial NDI and CPT predicted disability at 2 months (Area under the ROC curve was 0.89, 95% CI 0.84, 0.94). When site was adjusted for, IES and age also predicted disability |
| Sterling et al. 2013 [66]  Phase I cohort  Australia | Volunteers recruited from local ED, primary care practices and print media advertisement; WAD II; injured in MVA within past three weeks. Excluded those WAD III/IV; concussion or TBI, prior WAD, neck pain or headaches requiring treatment; prior diagnosis of tension-type headache or migraine. (n=44).  Asymptomatic control group; volunteers recruited from general community via print media advertisement; no prior cervical pain or trauma, head or upper quadrant requiring treatment. (n=18) | Prognostic factors at baseline (<3 weeks post-injury): inflammatory biomarkers: IL-1β, TNF-α, CRP | Follow-up at 3 months post injury (WAD II, n=40; Controls, n=18) | Disability at 3 months post-injury, classified as: Recovered/mild disability (≤ 8-28% NDI); ongoing moderate/severe pain (≥ 30% NDI). | Higher level of serum TNF-α at baseline was associated with better recovery at 3 months.  Higher baseline level of serum CRP was associated with failure to recover at 3 months.  IL-1β at baseline was not associated with recovery status at three months and not associated with WAD vs control status. |
| Tournier et al., 2016 [70]  Phase I Cohort (for relevant findings)  France | Same as Hours et al., 2014 [30]  N=255 with WAD | WAD I vs. WAD II | Follow-up at 1 and 5 years post-injury. N=63 for WAD I and 104 for WAD II for pain outcomes and 50 and 83, respectively, for HRQoL outcomes | At 1 year: PTSD. At 5 years: Health-related quality of life (HRQoL: WHOQoL-Bref – physical, psychological, social and environmental domains), satisfaction with neck pain presence, non-neck spinal pain presence and headache presence | At 1 year, no association between WAD grade and PTSD  5-year follow-up: WAD grade I vs grade II predicted neck pain (22.7% vs. 33.7%), non-neck spinal pain (12.7% vs 20.2%), satisfactory health status (76.0% vs. 62.7%). No association between WAD grade and HRQoL at 1 and 5 years. |
| Vetti et al. 2010 [71]  Vetti et al. 2011 [102]  Phase I cohort  Norway | Consecutive WAD 1-2 patients from ED and from a hospital clinic; May 2007-March 2009; Norwegian speaking drivers or passengers; aged 18-80; injury < 7 days with pain onset within 48 hours. Controls with chronic neck pain recruited from outpatient clinic. Excluded: prior neck injury or WAD, prior neck pain lasting more than 30 days or requiring treatment; prior severe head injury; prior cervical spine surgery; rheumatic disease, cancer or other serious somatic or psychiatric conditions, pregnancy. N=114 WAD and 52 controls | For Vetti et al. 2010: High signal changes of the alar ligaments (on high-resolution proton-weight MRI; graded 0-3); post-traumatic stress (Impact of Event Scale: IES, dichotomized at score of 26); expectations for recovery (high/low). For Vetti et al. 2011: High signal changes of alar ligaments; WAD vs. control | Baseline at 0-13 days; follow-up at 12 months. N=111 for Vetti et al. 2010 and N=91 for Vetti et al. 2011. Controls tested once. | Neck Disability Index (NDI); neck pain intensity (11-point NRS); High signal changes of alar ligaments. | Predictors of NDI >8:  initial neck pain (OR=1.27, p=0.02);  post-traumatic stress (OR=1.53 for each 10 point increment, p=0.001); low expectations for recovery (OR=5.53, p=0.001).  Predictors of neck pain > 4: Female gender (OR=3.44, p=0.02);  initial pain (OR=1.50, p=0.001);  post-traumatic stress (OR=1.65 per 10 point increment, p=0.001);  low expectation for recovery (OR=4.07, p=0.01), Grades 2-3 and transverse ligaments predicted pain >4 (OR=2.07, p=0.12). No change in high signal alar ligament changes over 1 year; no difference in signal intensity between WAD and chronic neck pain. |
| Williamson et al. 2015 [103]  Phase II Cohort  United Kingdom | Participants attending NHS emergency departments following whiplash injury and self-referred to PT as part of an RCT, had acute whiplash injury and were experiencing pain at least 3 weeks after injury; January 2006 to November 2007. Participants with WAD grade I-III within last 6 weeks; neck symptoms within previous 24 hours; age ≥18. Excluded those with fractures or loss of consciousness at time of injury/ED presentation, hospitalised, contraindications to PT. N=599 | Prognostic factors: Neck Disability Index (NDI); pain intensity (single score reflecting current, average and worst pain in past week); physical symptoms subscale of the cervical spine outcome questionnaire; neck range of movement (cervical ROM device); active vs. passive coping strategies questionnaire (by combining CPQ subscales); pain catastrophizing scale (PCS); Fear Avoidance Beliefs Questionnaire (Physical Functioning); Impact of Events Scale (IES); WAD grade at ED; WAD grade at randomisation; endorsement of neck exercises following neck injury; self-efficacy; predicted time to recovery; expected benefit of treatment; treatment preferences; psychological distress (GHQ-12); age; gender; history of neck pain; history of chronic widespread pain; social support; treatment allocation | Follow-up at 12 months after ED attendance (n=459) | Chronic disability defined as Neck Disability Index (NDI) (0-100); NDI ≥30% | In adjusted analysis, baseline disability, predicted time to recovery (expectations), psychological distress, use of passive coping strategies and number of symptoms were associated with developing a chronic disability at 12 months. |
| Yang et al. 2007 [104]  Phase III cohort  Canada | Adults making a traffic injury claim or treated for traffic injuries; injury occurred between July 1, 1994 and December 31, 1995; aged 18 and older; self-reported post-collision neck pain; reported height and weight. Excluded those hospitalized > 2 days and those with baseline data > 30 days post-crash; those who reopened their claims. N=4,395 | Exposure: body mass index (BMI: underweight BMI<18.5 kg/m2; normal BMI 18.5-24.9; overweight BMI25-29.9; obese BMI≥30). Adjusted for sociodemographic variables; early post-collision health care utilization; prior general health; post collision pain intensity; post-collision injury severity (corresponding to WAD grades); % of body in pain. | Follow-up to November 1, 1997. N=4,395 | Recovery as indicated by claim closure (validated as a marker of recovery through its relationship with clinically important levels of improvement in neck pain, physical functioning and depressive symptoms). | Median days and 95% CI to recovery was highest for underweight group (315, 95% CI 222, 354); then obese (270, 95% CI 244, 304); overweight (250, 95% CI 229, 278) and normal BMI (244, 95% CI 229, 266).  Adjusted HRR suggest no association between BMI and recovery. Compared with normal BMI, HRR and 95% CI for:  Underweight: HRR=0.88, 0.73, 1.06;  Overweight: HRR=1.01, 0.94, 1.09;  Obese: HRR=0.99, 0.90, 1.08.  Results were similar when reopened cases were included. |

Acronyms: BMI-Body Mass Index; CI- Confidence Interval; ED-Emergency Department; HRR- WAD-Whiplash Associated Disorder

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**Appendix 5: Table 1. Evidence Table of Studies Relating to WAD Outcomes Other Than Recovery (n=16)**

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| --- | --- | --- | --- | --- | --- |
| Author(s), Year, Phase of Study and Study Design, Location of Study | Setting and Subjects Number (N) Enrolled | Prognostic Factors/ Exposures | Follow-up point(s) and Number (N) Subjects at Follow-up(s) | Outcomes Assessed | Key Findings |
| Borenstein et al. 2010[5]  Phase I  Sweden | Patients in southwest Sweden (Elfsborg County) with acute WAD seen in primary care units, emergency wards and private clinics; referred for enrollment in an intervention trial; WAD I and II. N=97. |  | Baseline within 96 hours of injury (pre-collision cognitive symptoms assessed at this point). Follow-up at 6 months (n=88) and 3 years (n=71) | Self-reported cognitive symptoms (fatigue, forgetfulness, irritability, excessive emotionality and distractibility; yes/no responses) | Cognitive symptoms at: pre-crash; within 96 hours; 6 months and 3 years as follows (% reporting symptoms): fatigue (8.6, 42, 31 and 27); forgetfulness (5.4, 13, 24 and 28); easily irritated (8.6, 28, 33 and 27); emotional (13, 33, 24, 18); and distractibility (4.3, 15, 23, 19). |
| Carroll et al. 2007[12]  Phase II cohort study  Canada | Persons making a personal injury claim or being treated for neck pain after MVC-related injury aged 18 and above; between July 1994 and Dec 1995; excluded those hospitalized for > 2 days; serious associated or unassociated health problem; inability to understand English; injured as pedestrian, bicyclist or motorcyclist. All injuries: N=8109; 7763 with no self-reported prior jaw pain. WAD: N=7452; 7127 with self-reported prior jaw pain | Prognostic factors: WAD vs. non-WAD; prior jaw pain; demographics; prior health; post-crash pain intensity; post-crash symptoms; crash characteristics. | Follow-up at 6 weeks, 4, 8 and 12 months. Of 1128 WAD participants with incident jaw pain, 497 participated in at least one follow-up. | Self-reported jaw pain; time to resolution of incident jaw pain. | In all injuries with no prior jaw pain, post-crash incidence of jaw pain was 14.9 % (95% CI 14.1, 15.7). Incidence in women was 17.2% and 11.6% in men. In WAD with no prior jaw pain, incidence was 15.8% (95% CI 15.0, 16.7%); 18.4% in women and 12.4% in men. RR in WAD was 3.36 (95% CI 2.36, 4.78).  Factors associated with incidence jaw pain in WAD were (adjusted ORs and 95% CI presented):  Female sex (OR=1.46, 1.25, 1.70); age over 50 (OR=0.65, 0.51, 0.83); hit head in collision (uncertain: OR=1.44, 1.17, 1.76; yes: OR=1.38, 1.17, 1.62); prior bodily discomfort sometimes (OR=1.26, 1.04, 1.54); post-crash numbness, tingling in arms, hands, (OR=1.18, 1.01, 1.37) dizziness (OR=1.22, 1.03, 1.44), nausea (OR=1.25, 1.07, 1.47), difficulty swallowing (OR=3.75, 3.10, 4.54), ringing in ears (OR=2.00, 1.70, 2.36), visual difficulties (OR=1.47, 1.21, 1.78); % of body in pain (OR= 1.02, 1.01, 1.02); neck pain intensity (OR=1.004, 1.000-1.01); headache intensity (OR=1.01, 1.004, 1.01). |
| Carroll et al. 2011[14]  Phase I cohort study  Canada | Persons making a personal injury claim or being treated after MVC-related injury; WAD (neck pain after collision); aged 18 and above; between July 1994 and Dec 1995; excluded those hospitalized for > 2 days; serious associated or unassociated health problem; inability to understand English; injured as pedestrian, bicyclist or Motorcyclist. N=7462. Same cohort as Carroll et al. 2007 [12] | Prognostic factors: pre-collision depression, anxiety, fear, anger and frustration (never/almost never; sometimes; very often; every day); neck pain intensity (100 mm VAS). | Follow-up at 6 weeks post-collision. N=2986. | Pain-related depression, anxiety, fear, anger and frustration (100 mm VAS). | Each pain-related emotion at 6 weeks was associated with its corresponding prior emotion. Mean pain-related emotion intensity for never/every day prior to collision: depression from 30.1/66.9; anxiety 36.1/54.4; fear 31.4/73.8; anger 40.5/70.2; frustration 49.8/82.0. Correlation between baseline neck pain intensity and depression r=0.32; anxiety r=0.37; fear r=0.31; anger r=0.35 and frustration r=0.36. |
| Casey et al. 2015[19]  Phase II cohort study  Australia | Traffic-related WAD injury claim for compensation (fault-based insurance system); injury had occurred no longer than 3 months previously; 18 years or older; no concurrent workers compensation claim; did not require the services of an interpreter (n=246). | Age, gender, employment status, type of work, claim status, prior claim, education, language, income, SES (Index of Relative Social Disadvantage), lawyer involvement, days from injury to questionnaire, BMI, WAD Grade II or III, attended hospital, baseline health (Functional Rating Index), Catastrophizing (PCS; overall, rumination, magnification and helplessness scales); SF-36 (MCS, PCS); | 12 months (n=212) | Lawyer involvement (defined as participant with legal representation) | Baseline predictors of lawyer involvement at 12 months were: greater disability (OR for each point on FRI score, 1.38, 95% CI, 1.13, 1.68); work disability (OR=4.93, 95% CI 2.00, 12.17); speaking a language other than English at home (OR=1.12, 95% CI 1.12, 4.74); having poorer levels of mental health (OR for each point on MCS =0.96, 95% CI 0.94, 1.00) (age, gender, profession, hospital admission, IRSD score, income, PCS, catastrophization not associated with lawyer involvement). |
| Ferrari et al. 2011[25]  Phase I cohort study  Canada | Routine referrals to a specialist consultant from GPs at an urban walk in clinic; WAD I-II injured in a motor vehicle; aged > 18; no LOC; presented within 7 days of crash. Excluded if WAD III; objective neurological signs; prior WAD; prior spine pain requiring treatment; admitted to hospital. N=60 | Prognostic factor: coping style (high active/low passive; high active/high passive; low active/high passive; low active/low passive; using the Vanderbilt Pain Management Inventory) | Follow-up at 3 weeks either in person or by telephone. (48 in person and 12 by telephone). | Self-reported attendance at an active rehabilitation program; use of prescription medications for the injury | One quarter (15/60) were non-compliant with referral to treatment; 29/60 used prescription medications for pain.  Reanalysis of crude findings using high active/low passive as the reference group (theoretically most likely to be compliant and least likely to use prescription meds). For compliance: RR for high active/high passive =0.59, 95% CI 0.39, 0.92; RR for low active/low passive = 0.95, 95% CI 0.73, 1.24; RR for low active/high passive=0.48, 95% CI 0.28, 0.81. For medication use: RR for high active/high passive=1.5, 95% CI 0.64, 3.5; RR for low active/low passive = 0.33, 95% CI 0.05, 2.42; RR for low active/high passive=2.67, 1.28, 5.56. |
| Jöud et al. 2013[32]  Phase II Cohort study  Sweden | Patients included in Skåne Healthcare Register; aged 18 or older; coded with neck injury, Whiplash, ICD-10-SE code S13.4\*, by a physician in an acute setting (emergency ward, acute non-planned visit to physician in either specialist or primary care) between 2007 and 2008. Excluded those with records of head/neck injury between 1998 and 2007. N=1443. Age, sex and area of residence matched each WAD patient with 4 reference participants randomly selected from the Swedish population N=5772. Reference cohort 2: additionally matched for education. N=5772. Reference 3: additionally required participant to have had at least one healthcare consultation in the same year as the case had neck-injury diagnosis. N=5770 | WAD vs. Reference (control) population; Pre-injury health care consultations, pre-injury sick days, pre-injury disability pension | 6 year study period, 3 years before injury and three years after injury.  3 year follow-up:  Cases: 45, of which 3.12% died or relocated  Reference (controls) 1: 262, 4.54% died or relocated | Healthcare consultations (Skåne Healthcare Register, overall and number to physician and physiotherapist). Categorized into low-frequent (≤ 1 consultation), frequent (2-8 consultations) and high-frequent (≥ 9 consultations).  Specific consultations for: musculoskeletal disorders, headache, dizziness and tinnitus. | Pre-injury health care use predicted post-injury health care use. On average those with WAD had more pre- and post-injury consultations, were more likely to be on disability pension (for musculoskeletal and mental disorders) at the time of injury, to have more sick days both before and after the injury. WAD group was more likely to change from low to high consultation frequency (RR=2.27, 95% CI 1.63, 3.15). Risk attributable to WAD injury for increasing from low or frequent to high frequent consulter was 16% (most of the increase in consultation was to physical therapists). The low to high frequency cases experienced the greatest increase in sick days. |
| Matsumoto et al. 2013[42]  Phase I cohort study  Japan | Recruited from patients attending hospital after a car crash injury; WAD between 1993 and 1996; seen within 2 weeks of injury; no prior history of cervical spinal disease or trauma; excluded those with fracture/dislocation of cervical spine or other severe injuries. Controls were volunteers recruited 1993-1996, (acquaintances of investigators, medical students, high school students). N=506 with WAD and 497 controls at baseline | Prognostic factors for Modic changes of the cervical spine: whiplash injury, details of collision (vehicle collision points, seat location, extent of damage to the vehicle, seatbelt use) age, gender, regular participation in sports, smoking occupation, BMI, degenerative changes at initial investigation. | Follow-up at 10 years. N=133 WAD and 223 controls. | Modic changes of cervical spine (none, Type 1, 2 or 3) at C2-3 to C7-T1. | No difference in modic changes in WAD vs. controls. Age, heavy labour and pre-existing posterior disc protrusion were associated with development of modic changes of cervical spine. |
| McLean et al., 2014[43]  Phase II Cohort study  USA | Patients presenting with WAD within 24 hours of MVC, to one of 8 EDs in 4 no-fault states; February 2009-October 2011, aged 18-65; unlikely to require hospitalization; non-Hispanic whites. Excluded those with fractures other than phalangeal, have > 4 lacerations requiring sutures or single laceration > 20 cm, intracranial or spinal injuries. N=948 at baseline and 859 at follow-up. | Age, gender, income, height, weight, education, employment status, smoking status, health insurance coverage, collision characteristics (seat belt, air bag, location in vehicle, vehicle speed, direction of impact, extent of vehicle damage), perceived fault for collision, prior pain, pain at presentation, pain extent, pain catastrophizing (PCS), distress, dissociation, depressive symptoms, physical and mental health status, generalized optimism, trait and state anxiety, confidence (expectations) in recovery, symptoms, litigation status. | Follow-up at 6 weeks | Widespread pain (≥ 7 body regions of pain) | According to the Lasso analysis, in litigants, prior neck pain, prior widespread pain, widespread pain in the ED, rear-end collision and not having health insurance predicted widespread pain. In non-litigants, severe neck pain in ED, widespread pain in ED, expectation that it will take longer to recover and high pain catastrophizing predicted widespread pain at 6 weeks. |
| Nederhand et al. 2006[45]  Phase II cohort study  The Netherlands | Patients admitted to ER of a Dutch general hospital after MVC; July 1999-December 2001; aged 18-70; pain in neck or head starting within 48 hours of a collision; WAD grade 1 or 2; excluded those with concussion, amnesia; serious injuries or neurological signs. N=100 (from Nederhand 2003, included in NPTF) | Prognostic factors measured at 1 week: Tampa Scale of Kinesophobia (TSK) BMI; Neck Disability Index (NDI, scored as 0-50); pain intensity (VAS 100 mm) | Follow-up at 4, 8, 12 and 24 weeks post MVC. Follow-up until recovered (0=NDI ≤ 5; 1=NDI > 5). N=92. | Muscle activity (EMG) of trapezius muscle. | At any follow-up point, pain and fear of movement were both associated with level of muscle activation. Higher levels of pain intensity result in stronger effect of fear of movement on decreased muscle activity |
| Phillips et al. 2010[52]  Phase II cohort study  Canada | Population-based sample of persons claiming for or being treated for a MVC-related injury; WAD; aged 18 or older; injury between Dec 1, 1997 and Nov 30, 1999; Exclusions were > 2 days in hospital; serious associated or unassociated health condition; inability to understand English; N=5845 met inclusion criteria and completed baseline depression questionnaire. | Prognostic factors: demographic and socioeconomic characteristics (gender, age, marital status, income, education); prior health factors (general health, comorbid health conditions including prior mental health); crash-related factors (position in vehicle, direction of impact, whether head was struck in crash, fractures); post-crash pain symptoms (% of body in pain, pain intensity on 11-point NRS, numbness, tingling or pain in arms/hands or legs/feet, dizziness, memory problems, concentration problems, irritability, vision problems, sleep problems, fatigue, anxiety, painful or reduced neck movement sore jaw) | Follow-up: 6 weeks, 3, 6, 9 and 12 months. For course of depression analyses, only those responding at all follow-ups were included. N=3452 | Depression (CES-D ≥ 16 at baseline); course of depression (never depressed, depression which resolved, recurrent depression, persistent depression, later onset depression) | At baseline, 44.9% had depressive symptomatology (median 11 days post-crash). Course of depression: never depressed – 48.3%; initial depression with resolution – 25.9%; recurrent depression – 10.0%; persistent depression – 4.7%; onset of depression at some point during follow-up – 11.2%. Key baseline factors associated with course of depression (partial findings only reported here; never depressed was reference category): neck pain intensity – for resolved course OR=1.16 (95% CI 1.10, 1.22); recurrent OR=1.24, 95% CI 1.15, 1.33; persistent OR=1.30, 95% CI 1.17, 1.45; late onset OR=1.08, 95% CI 1.02, 1.15. Dizziness – for resolved course OR=1.92, 95% CI 1.57, 2.35; recurrent OR=1.63, 95% CI 1.23, 2.17; persistent OR=3.65, 95% CI 2.37, 5.61; late onset OR=1.31, 95% CI 1.01, 1.72. Prior severe mental health problems – for resolved OR=3.38, 95% CI 1.54, 7.42; recurrent OR=6.26, 95% CI 2.67, 14.69; persistent OR=16.78, 95% CI 6.73, 41.83; late onset OR=2.11, 95% CI 0.78, 5.70 n.s.) |
| Salé et al., 2007[58]  Salé et al., 2014[57]  Phase II cohort study  Sweden | Consecutive presentations to ER (Sundsvall); WAD I-III from rear-end car collision; no direct trauma to head or neck. N=60 enrolled. Controls; frequency age and sex matched volunteers from the same geographic region, no history of trauma to head or neck. N=53. | Prognostic factors: WAD vs. control. WAD grade (determined by orthopedic surgeon in ER); MR imaging; health and medication history, head and neck symptoms | Baseline at 3-15 days; follow-up at least 1 year post-examination (median 13 months). N=59 WAD and 53 controls.  For 15 year follow-up, N=57 WAD and 51 controls. | TMJ symptoms at baseline and delayed (not present during baseline but evolved during follow-up). | In the WAD group, 15% (9/59) had new TMJ symptom onset at baseline. In WAD group, another 34% (11/32) developed TMJ symptoms by 1 year; compared with 3/43 (7%) in controls. In WAD, 5% at baseline vs. 19% at 1-year follow-up had TMJ symptoms as main complaint (increase was in females, only). At 15 year follow-up, prevalence of TMJ symptoms and prevalence of TMJ pain decreased but was still above baseline and greater than controls. |
| Sterling et al., 2010[62]  Phase II cohort study  Australia | Volunteers; WAD II or III; recruited up to 3 weeks post-MVC; exclusions were concussion; prior WAD, neck pain or headaches requiring treatment. Controls were healthy community volunteers; exclusions were prior pain or cervical, head or upper quadrant trauma. N=62 WAD; 22 controls. | Exposure: WAD vs. healthy controls. Prognostic factors: NDI | Baseline at 3 weeks; follow-up at 3 months post-injury. N=64 at three months. | Spinal cord hyper-excitability at 3 months. | Greater baseline NDI predicted spinal cord hyper-excitability at 3 months (adjusted β= -0.11, p=.003) |
| Sterling et al., 2011[64]  Phase II study  Australia | Convenience sample of patients in Queensland, Australia (fault-based system); with WAD I-III, recruited from ER and GP practices; WAD < 1 month duration. Excluded were those with WAD IV; concussion or head injury; prior WAD, neck pain or headaches requiring treatment; those with a prior or current psychiatric or psychological condition. N=155 enrolled. | Potential prognostic factors: age, gender, initial pain (11-point VAS), pressure pain thresholds (PPT), cold pain thresholds (CPT), sympathetic vasoconstrictor response (SVR: sympathetic reflex – SRF and quotient of integrals – QI) | Baseline at < 1 month. Follow-up at 3, 6 and 12 months. N=155 with at least one data point and 94 with complete NDI and 91 with complete PDS) | Posttraumatic Stress (Posttraumatic Stress Diagnostic Scale: PDS). Trajectories as reported in Sterling 2010(a) (1) Resilient: mild symptoms throughout, (2) Recovering: initial moderate symptoms declining to mild levels by 3 months and (3) Chronic moderate-severe: persistent moderate/severe symptoms throughout 12 months | In multivariable analyses, and with resilient trajectory as reference category, membership in:  a) moderate PDS trajectory were predicted by: CPT ≥ 13 degrees (OR=3.54, 95% CI 1.22, 10.30); initial pain intensity (OR=1.84, 95% CI 1.32, 2.56), age (OR=1.05, 95% CI 1.01, 1.09), age2 (OR=1.00, 95% CI 0.99,1.00) and PPT neck (n.s. for recovery group and OR=0.99, 95% CI 0.98, 1.00).  b) chronic severe PDS trajectory were predicted by: CPT ≥ 13 degrees (OR=9.70, 95% CI 2.22, 42.44); initial pain intensity (OR=2.13, 95% CI 1.43, 3.17), age (OR= 1.07, 95% CI 1.01, 1.14), age2 (OR= 0.99, 95% CI 0.99, 1.00) and PPT neck (n.s. for recovery group and OR=0.99, 95% CI 0.98, 1.00). |
| Stovner et al. 2008[67]  Phase II cohort study  Lithuania | Persons in MVC hit from the rear; recorded by traffic police in Kaunas, Lithuania; no prior history of jaw, head, facial or neck injury; Controls were sex and age matched randomly drawn from the population register of the Kaunas region. Excluded from this group were any one who had previously been in an accident.  N=210 | Prognostic factors: Rear end collision vs. healthy control; WAD vs. healthy control | Follow-up at 2 and 12 months. N=208 WAD at 2 months and 200 WAD and 193 controls at 12 months. | Headache presence, diagnosis, frequency and features | Thirty-six percernt (75/210) of those in rear end collisions reported developing headaches (HA) within 7 days post-crash. Of these, 37/75 (49%) also reported having experienced neck pain (NP) after the crash. There were no differences between those with HA + NP and those with HA only at 2 or 12 months. At 2 weeks, more of those with both HA + NP had a history of prior NP than those with HA only. This difference was no longer present at 2 or 12 months. Those with prior HA had a 6-10 time increased risk for short and long-term HA after the crash. Being in a crash did not increase the risk of HA at 2 or 12 months. |
| Tishler et al. 2006[68]  Phase I cohort study  Israel | Patients seen in ER at Asaf-Harofe Medical Center (Israel); August 2003-Jan 2004; MVC-related WAD. Excluded those with fractures, dislocations, spinal subluxations on radiograph; concussion or head injury. Controls were hospitalized in orthopedic, surgery or neurosurgery wards due to MVC. N=153 WAD and 48 controls. | Prognostic factor: WAD vs. non-WAD traumatic injury | Follow-up by telephone after the 1st week and every 5 months thereafter for up to 18 months for WAD, up to 14 months for controls; only those self-reporting symptoms or signs suggestive of fibromyalgia were invited for further evaluation. In WAD group, N=153; in controls, N=48  Second follow-up at 3 years. Same process for follow-up. N=126 (WAD) and 33 (controls). | Physical exam including 18 tender points as per 1990 American College of Rheumatology (ACR) criteria for fibromyalgia | At first follow-up, 12 patients in all were recalled for examination. One WAD patient was diagnosed with fibromyalgia; no controls were diagnosed.  At 3 years, 12 WAD and 6 control participants were recalled for evaluation. Of these 3 WAD (2.4%) and 1 control (3%) participants diagnosed with fibromyalgia.  This does not support a link between WAD and onset of fibromyalgia. |

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**Appendix 6: Detailed Results on Prognostic Factors for Recovery from WAD**

**Sociodemographic Factors**

**Sex.** We combined evidence from 27 studies: 11 from the NPTF (4 Phase I and 7 Phase II) [105] and 21 (4 Phase I and 17 Phase II) from the update [1, 3, 9, 10, 16-22, 24, 26, 28, 40, 43, 50, 54, 64, 71, 103]. The NPTF found that the association between sex and WAD recovery varied across studies [105]. New evidence from 3 Phase II studies of the same cohort and 2 Phase I studies found slower pain recovery in women [17, 18, 22, 28, 71] and 1 Phase I study found that in those not litigating, women had slower pain recovery in the first 6 weeks, while in those litigating, there was no significant association [43]. Three Phase II studies found no significant association between sex and pain recovery [1, 3, 16]. One of these studies was a different analysis (using a different set of explanatory factors) of the same cohort where an association was found. Finally, 1 phase II study found that women had poorer pain recovery at 6 but not 12 months [9].

New evidence from 11 Phase II studies of 6 distinct cohorts and 3 Phase I studies of 2 distinct cohorts suggests that female sex is not associated with disability recovery, work capacity, return to work [10, 16, 19, 21, 24, 28, 40, 50, 54, 64, 71, 103] and self-reported global recovery [26]. One Phase II study found that sex is not associated with time to claim closure [20]. Finally, 1 Phase II study found that female sex predicted poorer physical but not poorer mental health-related quality of life at one year [40].

Overall, the combined preliminary evidence varies on the association between sex and pain recovery. There is consistent preliminary evidence of no association between sex and disability recovery, although there is limited preliminary evidence (from one study) that women have poorer physical health related quality of life at one year.

**Age.** Our review combined evidence from 27 studies: 8 Phase II studies from the NPTF and 19 (3 Phase I and 16 Phase II studies reflecting 12 distinct cohorts) from the update [1, 3, 4, 10, 11, 16, 17, 19-22, 24, 26, 28, 43, 46, 64, 65, 103]. Using evidence from 8 Phase II studies, the NPTF found that evidence varied [105]. New evidence from 6 Phase II studies of 4 distinct cohorts found no association between age and neck pain recovery [1, 3, 16, 17, 28, 46]. One Phase I study also found no association between age and neck pain recovery at 6 weeks post-injury in those who were litigating, although in non-litigators, older individuals had poorer pain recovery at 6 weeks [43]. A second Phase I study also found older age to predict poorer neck pain recovery [22]

Two Phase II studies of the same cohort found no association between age and work capacity at follow-up [16, 28], while 2 Phase II studies (partial participant overlap in the two studies) found an association between older age and poorer work capacity post-injury [10, 11]. Three Phase II studies found older age to predict poorer recovery of self-perceived neck disability and/or physical functioning [19, 64, 65], while 2 Phase II and 1 Phase I studies reported no association [24, 46, 103]. In a different analysis of one of the previously reported Phase II cohorts (which found no association between age and neck disability), the study found that older age was associated with a moderate but not a severe (poor) trajectory of disability recovery (in comparison with a good trajectory) [21]. Another study from that same cohort found that age was not associated with time to closure of insurance claims [20].

Finally, 1 Phase II study of persons seeking physical therapy found older age to be weakly associated with slowed self-reported global recovery [4]; however 1 Phase II study of persons seeking primary care found no such association [26].

Overall, 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.

**Employment Factors.** The NPTF found no studies examining employment factors and WAD recovery [105]. The current review adds 9 studies (2 Phase I and 7 Phase II) from 8 distinct cohorts [1, 3, 11, 16, 17, 19, 22, 43, 46]. One Phase II study found that pre-crash employment status was not associated with neck pain recovery [11] and 3 Phase II studies found that occupation [1, 46], pre-crash employment status and type of work [19] were not associated with disability recovery. Two phase II analyses of the same cohort found occupation was not associated with pain recovery or work capacity [16, 17]. Finally, 1 Phase II study reported that workplace psychosocial factors were not associated with neck pain at one year [3]. In contrast, 1 Phase I study found pre-crash employment status (i.e., not being employed) to predict poorer pain recovery [22], and 1 Phase I study found that, in persons who are litigating (but not in persons who are not litigating), not being employed full time was associated with greater pain at 6 weeks post-collision [43].

Overall, the preponderance of preliminary evidence suggests that employment factors are not associated with WAD recovery.

**Education.** Our update combines evidence from 13 studies. From 1 Phase I study and 2 Phase II studies, the NPTF found that the limited preliminary evidence varied [105]. The update adds 10 studies from 7 distinct cohorts: 2 Phase I studies [22, 43] and 8 Phase II studies from 5 distinct cohorts [1, 11, 16-19, 28, 46]. Six Phase II studies from 4 distinct cohorts and 2 Phase I studies reported no association between education and neck pain recovery [1, 11, 16-18, 22, 43, 46]; 1 Phase II study found education was not associated with work capacity [16]; and 2 Phase II studies found education was not associated with recovery of physical function/disability [19, 46]. In contrast, 1 Phase II study found lower education to be associated with both greater pain and reduced working capacity at 12 months [28]. That study utilized the same cohort but considered a different set of predictors as one of the studies above showing no such associations [16]. Overall, the preponderance of preliminary evidence suggests that education is not associated with recovery.

**Prior Health Factors**

**Prior Pain.** Our update combines evidence from 14 studies; 2 Phase I and 4 Phase II studies from the NPTF and 2 Phase I and 6 Phase II studies from the update [3, 4, 8, 16, 18, 22, 43, 103]. The NPTF found that the preponderance of preliminary evidence suggested an association between prior neck pain and poorer recovery [105]. New evidence from 4 Phase II studies and one Phase I study found that prior self-reported neck pain is not associated with neck pain ratings or self-rated recovery [3, 4, 16, 43, 103]. However, evidence from 1 Phase II study [8] and 1 Phase I study [22] found that prior neck pain was associated with greater neck pain at follow-up.

One Phase II study found that prior widespread pain was not associated with disability at 12 months [103]. However, we also found evidence from 1 Phase II study that prior widespread pain predicted greater neck pain at 12 months [3]. In addition, one Phase II study found that prior *unspecified* pain (not neck pain) predicted both greater neck pain and poorer work capacity at 12 months [16]. One Phase II study found that documented pain-related work absence in the 5 years preceding the whiplash injury was associated with poorer pain recover at one year follow-up [18].

Finally, 1 Phase II study found that prior mild headaches predicted *faster* self-rated global recovery in a sub-cohort of individuals seeking early post-crash physical therapy [4].

Overall, the preliminary evidence about the association of prior pain and WAD recovery varies. However, most of these studies utilized post-injury self-reports of pre-injury pain, which has been shown to have limited validity [106]. The one study assessing the role of documented pain-related work absence prior to the injury found an association.

**History of WAD.** The NPTF found no studies of the association between prior WAD and recovery from a subsequent WAD. The update found limited and preliminary evidence from 2 Phase II studies of the same cohort that having a prior compensation claim (possibly a proxy for prior WAD) is associated with poorer disability recovery [19] and longer time to claim closure [20].

On the slightly different question of the association between a prior WAD and future reports of neck pain, the update combines evidence from 3 studies: 2 Phase II studies from the NPTF and 1 Phase II study from our update). The NPTF reported limited and preliminary evidence that prior WAD is associated with future (prevalent or incident) neck pain and health complaints [105]. The current review adds evidence from 1 Phase III study that prior self-reported WAD which had resolved to a point of no or only mild neck pain is associated with new onset (incident) intense and/or disabling neck pain at a future point in time [47].

Thus, there is limited evidence that a history of WAD increases the risk of future (new onset) neck pain, and limited preliminary evidence suggests that prior WAD is associated with poorer recovery.

**Body Mass Index, Smoking.** The NPTF identified no studies of body mass index (BMI) and recovery [105]. Our update accepted evidence from 1 Phase III, 1 Phase II and 1 Phase I studies [19, 24, 107]. The Phase III study found BMI was not associated with claim closure [107], which had been shown to be a marker of health recovery in that cohort [108, 109], and 1 phase II and 1 Phase I study found BMI was not associated with self-perceived disability at 1 year [19, 24].

The NPTF identified no studies of smoking and WAD recovery [105]. Our update found two studies (1 Phase II and 1 Phase I) [20, 43], which found smoking was not associated with pain severity at 6 weeks post-injury [43] or time to claim closure [20].

Thus, there is limited evidence that BMI is not associated with WAD recovery and limited preliminary evidence suggesting no association between smoking and short-term pain recovery.

**Pre-Injury Health: Physical and Psychological**. With respect to pre-injury physical health, the update combines evidence from 8 studies: 1 Phase II study from the NPTF and 1 Phase III, 4 Phase II studies from 2 distinct cohorts and 2 Phase I studies from the update [3, 16, 18, 22, 40, 43, 49]. The NPTF previously reported limited preliminary evidence that pre-collision *physical* health was not associated with neck pain or work capacity at follow-up [105]. New evidence from 2 Phase I [22, 43], 3 Phase II [3, 16, 40] and 1 Phase III [49] studies support this through their finding that pre-crash physical health or general health [22, 40], number of physician visits in the year prior to the injury [3], pre-existing cardiovascular disease [49] and prior persistent illness [16] are not associated with WAD recovery.

However, 1 Phase I study found that high levels of pre-injury somatic (unspecified) symptoms were associated with greater pain at 6 weeks post-collision in litigants, but not non-litigants [43]. Finally, 1 Phase II study found that being on sickness benefits for more than 12 weeks in the 5 years prior to the whiplash injury was associated with negative change in work/employment status one year post-injury [18].

The preponderance of preliminary evidence suggests that pre-crash *physical* health is not associated with WAD recovery. However, most of these studies utilized post-injury self-reports of pre-injury health.

The NPTF found no studies on prior psychological health and WAD recovery. We found new evidence from 5 studies of 3 distinct cohorts: 1 Phase I [22] and 4 Phase II studies [16, 17, 40, 51]. One Phase I study found no association between prior use of sedatives or antidepressants (possible markers of mental health) and neck pain recovery [22] and 2 Phase II studies found no association between prior mental health and neck pain or disability at follow-up [40, 51]. Moreover, two articles on the same cohort (both Phase II studies) found that that an association initially reported by the authors between prior psychological health and neck pain and work capacity [16] was no longer present in another analysis (in that same cohort) which adjusted for baseline coping strategies [17]. However, in those studies, “prior” psychological health was assessed by standardized psychological measures administered *after* the crash; thus, there is potential for misclassification.

Therefore, although the preponderance of preliminary evidence suggests that prior *psychological* health does not predict WAD recovery, this should be interpreted cautiously because of the difficulty in accurately ascertaining prior psychological health.

**Collision Factors.**

Our update combines the evidence from 11 Phase I and II studies from the NPTF and 6 studies from the update, which consisted of 2 Phase I studies [22, 43] and 3 Phase II studies of 2 distinct cohorts [3, 16, 17, 105]. The NPTF found the preponderance of evidence showed no association between self-reported collision factors and WAD recovery, although there was limited preliminary evidence that: being injured in a vehicle with a tow bar (1 Phase I study); collisions involving greater mean acceleration measured by a crash recorder (1 Phase I study); and those injured in trucks or buses (1 Phase I study) had poorer recovery [105]. One new Phase II study also found that being injured in a vehicle other than a car was associated with poorer recovery [3]. In other studies published since the NPTF, the following factors were found to not be associated with recovery: direction of the motor vehicle collision [3, 22, 43]; speed/speed differential of collision [3, 16]; *perceived* severity of the collision [3, 16]; position in the vehicle [3, 22]; use of airbags, seatbelts, headrests [3, 43], awareness of the impending collision [3];speed of the colliding vehicles [16, 43]; or damage to the vehicle [16, 17, 43]. However, 1 Phase I study found that for those not litigating (but not non-litigants), greater vehicle damage and being in a stopped vehicle at the time of collision were associated with greater pain severity at 6 weeks post-collision; and for litigants (but not non-litigants), being a passenger was associated with greater pain severity at 6 weeks [43].

Thus, the preponderance of preliminary evidence indicates no association between most self-reported collision factors and recovery, although there is limited preliminary evidence that being injured in a car may be associated with better recovery, 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

**Initial Post-Collision Pain and Symptoms**

**Initial Neck Pain Intensity.** We combined the evidence from 23 studies: 9 studies from the NPTF (3 Phase I reflecting 2 distinct cohorts and 6 Phase II) from the NPTF [105] and 14 from our update: 3 Phase I [22, 43, 71] and 11 Phase II studies of 8 distinct cohorts [2, 4, 10, 18, 21, 28, 40, 46, 50, 64, 103]. The NPTF reported consistent preliminary evidence that initial neck pain intensity is associated with slower claim closure (3 Phase II studies) greater pain (1 Phase I and 1 Phase II), greater self-reported disability (2 Phase I studies of the same cohort) and poorer work ability at follow-up (1 Phase II study) [105]. From the update, in 3 Phase I and 6 Phase II studies of 4 distinct cohorts, greater initial post-crash neck pain intensity was consistently associated with greater *neck pain* at follow-up [18, 22, 28, 40, 43, 46, 64, 71] and poorer self-rated global recovery [4], although in one of these studies, the association with neck pain recovery was present only in those who were not litigating [43]. In contrast, one Phase II study found that early post-crash use of pain medication was not associated with neck pain presence at 12 months [10], although it is unclear whether this is a valid proxy for pain intensity.

One Phase I and 4 Phase II studies found initial neck pain severity to be associated with self-perceived *neck disability* at follow-up [40, 46, 50, 71] and poorer trajectory of disability recovery [21], but 2 Phase II studies found no such association [2, 103]. Similarly, 1 Phase II study found greater initial neck pain to be associated with reduced working ability [40] while 1 Phase II study which used the same cohort as the latter study, but explored a different set of predictors, found no such association [28].

Overall the preponderance of preliminary evidence indicates that greater post-WAD neck pain intensity predicts poorer recovery of pain, self-reported disability and work ability.

**Initial Self-Perceived Disability.** We combine the results from 13 studies: 2 Phase I studies of one distinct cohort from the NPTF and 1 Phase I study and 10 Phase II studies from 8 distinct cohorts from the update [2, 3, 19-21, 24, 46, 54, 55, 65, 103]. The NPTF previously found limited preliminary evidence from one distinct cohort that initial neck disability was associated with *disability* at follow-up [105]. From our update, 5 Phase II studies and 1 Phase I study found an association between initial neck disability (as assessed by self-report questionnaire) and *neck disability* at follow-up [2, 24, 46, 54, 55, 65] and one study also showed an association between initial neck disability and greater time to claim closure [20]. However, 3 Phase II studies of 2 distinct cohorts report no association between initial disability and disability at follow-up or trajectory of disability recovery [19, 21, 103]

One Phase II study found initial disability to be associated with greater *neck pain* at follow-up [3] while 1 Phase II study found no such association [46].

Thus, the preponderance of preliminary evidence suggests that initial self-perceived disability is associated with poor recovery from disability, but the limited preliminary evidence on the association between initial disability and pain recovery varies.

**WAD Grade.** Our update combines evidence from six studies: 4 from the NPTF (2 Phase I and 2 Phase II) and 6 studies from the update. The NPTF found consistent preliminary evidence that WAD Grade III was associated with poorer recovery but no clear evidence of a difference in recovery of Grades I and II WAD [105]. Our update adds 3 Phase II studies [3, 19, 103] and 3 Phase I studies of two distinct cohorts [22, 30, 70]. The 3 studies comparing WAD I and WAD II showed no association between WAD grade and pain intensity at 6 months [22]; and no association with quality of life or satisfaction with health and quality of life at 1 year, although those with WAD I reported more negative feelings (e.g., feelings of depression) at 1 year than those with WAD II [30]. At five years, the same cohort showed that those with WAD II had more neck pain, more non-neck pain and less self-reported satisfaction with health at 5 years, although no difference in health-related quality of life [70]. One study comparing outcomes of those with WAD I vs. a group combining WAD grades II and III found no differences in self-perceived disability at 12 months, although there was no examination of the effect of WAD III itself [103]. The 1 new study examining the prognostic effect of WAD III itself found no association with persistent neck pain at 12 months [3]; however, in that study, there was a very small number of participants with WAD Grade III, so power to detect a difference is unclear.

Thus, the preponderance of preliminary evidence suggests no difference in prognosis between WAD I and WAD II, while the preponderance of preliminary evidence suggests that WAD III is associated with poorer recovery.

**Other Post-Collision Symptoms, Number of Post-Collision Symptoms**. The NPTF did not identify studies on other post-crash symptoms [105]. The current review contributes findings from 7 studies from 5 distinct cohorts (2 Phase I and 5 Phase II) [3, 8, 10, 11, 22, 35, 103]. Two Phase II studies found no association between initial dizziness and recovery of neck pain [8] or work ability [10]; however, one, in contrast, 1 Phase I study found that initial post-crash dizziness was associated with greater neck pain at six months [22]. Two Phase II studies (with overlapping samples) suggested that poor post-crash *concentration* predicted poorer work ability at 12 months [10, 11].

Two Phase I studies found that greater numbers of symptoms predicted greater self-perceived disability [103] and greater work disability, but not headache or neck pain [35] at 12 months, while 1 phase II study found that having 5 or more WAD symptoms (but no particular groupings of symptoms) predicted persistent neck pain at 12 months [3].

Thus, 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.

**Radiographic Imaging and Physical Findings**

**MRI Findings.** We combined six studies: 1 Phase I study from the NPTF and 5 Phase I and 1 Phase II studies from 5 distinct cohorts from the update [24, 31, 38, 41, 71, 102]. The NPTF previously reported that MRI findings were not associated with WAD recovery [105]. New evidence from one Phase II study found that MRI findings of lordosis, kyphosis or straight post-WAD cervical spine were not associated with neck pain or headache at follow-up [31]. Similarly, two Phase I studies found no association between abnormal MRI findings and neck pain, headache, neck disability or working ability at follow-up [38, 41]. In addition, there was evidence from two Phase I studies of the same cohort that grade 2-3 alar ligament changes were not associated with neck pain or neck disability at one year, and no differences were found in signal intensity between those with WAD and those with chronic neck pain [71, 102].

One Phase I study found that greater muscle fatty infiltration in cervical multifidi at 2 weeks, but not at 1 week, was associated with greater disability at 3 months [24].

Overall there is consistent preliminary evidence of no association between the following post-crash MRI findings (abnormal findings, lordosis, kyphosis or straight cervical spine) and WAD recovery. There is limited, preliminary evidence that cervical fatty infiltration 2 weeks after a whiplash injury is associated with disability.

**Neck Range of Motion (ROM).** The NPTF found 2 Phase II and 2 Phase II studies and the current review adds 1 Phase I [35] and 2 Phase II studies [65, 103]. From the NPTF, 1 Phase I study found an association between decreased ROM and cervicogenic headaches at 1 year. In addition, 1 Phase I and 1 Phase II studies found an association between self-reported neck stiffness or decreased ROM and poorer WAD recovery. From the update, 1 Phase I study found that decreased neck ROM was associated with work disability [35] while the 2 Phase II studies found no association between ROM and self-perceived neck disability [65, 103].

Thus, the preliminary evidence varies on the association between initial ROM and recovery. However, the preponderance of preliminary evidence suggests no significant difference in prognosis between WAD I and WAD II (reported above). This finding is relevant because decreased ROM is one of the key criteria in distinguishing WAD Grades I and II.

**Pain Threshold, Sympathetic Vasoconstrictor Response.** Our update combines the evidence from 4 studies: 1 Phase II study from the NPTF and 4 Phase II studies of 3 distinct cohorts from the update [54, 64, 65]. The NPTF found limited preliminary evidence that reduced time to peak pain threshold in the first 6 months was associated with failure to recover by 1 year [105]. Two Phase II studies from the update found that post-crash *pressure* pain threshold [64] and sympathetic vasoconstrictor response [64, 65] do not predict neck disability, but that post-crash *cold* pain threshold was associated with neck disability at 12 months [64, 65]. In contrast, a third Phase II study found cold pain threshold (mid-cervical spine) was not associated with neck disability at 12 months [54].

Thus, 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.

**Inflammatory Biomarkers**. The NPTF did not identify any study on this association. Our update found 1 Phase I study which studied the role of IL-1β, TNF-α and CRP in disability recovery. This study showed that higher levels of serum TNF-α, and lower levels of serum CRP at baseline were associated with better recovery at 3 months; higher level of serum CRP was associated with failure to recover at 3 months. IL-1β at baseline was not associated with recovery status at three months and did not differ between those with WAD vs control status [66].

Thus, there is limited, preliminary evidence that TNF-α and CRP are associated with disability recovery, while IL-1β is not.

**Eye Movement.** The NPTF did not identify any study on this association. We found one Phase II study showing that smooth pursuit eye movement is not associated with neck pain or headache recovery, recovery of self-assessed neck disability or reduced working ability.[98].

Thus, limited, preliminary evidence suggests no association between smooth pursuit eye movement and recovery.

**Post-Collision Psychological Factors**

**Symptoms of Acute Stress Disorder (ASD)/ Post-Traumatic Stress Disorder (PTSD).** The NPTF did not identify studies on ASD or PTSD. We found new evidence from 2 Phase I studies [24, 71] and 7 Phase II studies [1, 2, 8, 40, 54, 65, 103]. In all studies, ASD and PTSD symptoms were ascertained using self-report measures rather than by clinical diagnosis. Two Phase II studies and one Phase I study found that presence of ASD or PTSD *symptoms* and/or number of hyperarousal symptoms predict greater *neck pain* at 12 months [8, 40, 71]. Three Phase II studies and two Phase I studies report that ASD symptoms at baseline predict greater *neck disability* at follow-up [24, 40, 54, 65, 71]. One Phase II study also reported that ASD symptoms were associated with *reduced working ability* at 12 months in those with lower initial pain but not in those with higher initial pain intensity [40]. In contrast, 2 Phase II studies found no association between these symptoms and disability at follow-up [2, 103]. However, both of the latter studies also included other self-report measures of psychological distress in their statistical models, and it is likely that these measures are highly correlated. One Phase II study which examined this idea found that while there was a crude (unadjusted) association between PTSD symptoms and subsequent pain recovery, the effect of these symptoms was completely mediated by catastrophizing and fear avoidance [1].

Overall, the preponderance of preliminary evidence suggests that early symptoms of ASD/PTSD are associated with delayed recovery, and there is limited preliminary evidence that the mechanism of this association may be through the mediators catastrophizing and fear avoidance.

**Anxiety and Fear.** Our update combined the evidence from 2 studies from the NPTF (Phase II) and 11 newly identified studies (1 Phase III, 9 Phase II and 1 Phase I) from the update [1, 2, 4, 9, 14, 22, 34, 43, 46, 50, 103]. The NPTF found limited preliminary evidence showing an association between anxiety and delayed recovery [105]. New evidence from 1 Phase III study, 3 Phase II studies and 1 Phase I study indicates that anxiety/kinesiophobia/fear avoidance/pain-related fear were associated with greater *neck pain* intensity follow-up [1, 9, 14, 22, 46]. Two Phase II studies reported an association between kinesiophobia and *neck disability* [46, 50]. In a Phase II series of cross-sectional analyses (same participants, analyzed at baseline, 3 and 6 months) fear avoidance mediated the relationship between initial pain and neck disability [34]. In contrast, in a Phase II study of individuals seeking early physical therapy treatment, post-crash worry/anxiety was not associated with global self-ratings of recovery [4]; in 1 Phase I and 2 Phase II studies (one of which involved a sample of very mildly affected participants), fear of re-injury or fear avoidance were not associated with disability [2, 103] and baseline anxiety was not associated with pain intensity at 6 weeks post-injury [43].

Thus, the preponderance of evidence from Phase I, II and III studies shows that post-crash anxiety/worry/kinesiophobia/fear avoidance and/or pain-related fear are associated with poorer recovery.

**General Psychological Health/Distress, Anger, Frustration.** Our update combines the evidence from 7 studies examining the role of post-crash general psychological health on recovery: 1 Phase I study from the NPTF, and 1 Phase I and 5 Phase II studies from 3 distinct cohorts from the update [3, 19-21, 43, 103]. The NPTF reported limited preliminary evidence that post-crash general psychological health was not associated with WAD recovery [105]. From the update, 1 Phase I study and 2 Phase II studies from the same cohort found no association between post-crash general mental health (from the SF-36 or SF-12) and pain intensity at 6 weeks [43], disability at 12 months or trajectory of disability recovery over a 2 year period (two studies from the same cohort [19, 21], although in that same cohort, poorer baseline mental health was associated with longer time to claim closure in those seeking injury compensation [20]. In contrast, 1 Phase I and 2 Phase II studies found that greater psychological distress at baseline predicted more pain at 6 weeks [43], greater disability at 12 months [103] and persistent neck pain [3]. Thus, evidence on post-crash general psychological health/general distress is still limited, preliminary and variable.

The NPTF did not find studies on anger, frustration or self-efficacy. We found new evidence from 1 Phase III, 2 Phase II and 1 Phase I studies [2, 14, 60, 103]. One Phase III study found evidence that pain-related anger and frustration are each associated with poorer neck pain recovery in WAD [14].

Thus, the preliminary evidence on the role of post-crash general psychological health/general distress is variable and there is limited evidence that pain-related anger and frustration are associated with poorer recovery.

**Pain-related Beliefs, Self-efficacy; Perceived Injustice.** The NPTF did not find studies specifically addressing pain beliefs, self-efficacy or perceived injustice. Our update found 1 Phase III study examining the role of pain beliefs on pain intensity and self-perceived disability at 3 and 6 months [7]. In that study, early post-injury beliefs that the cure for WAD-related neck pain will be medical (rather than up to the individual themself) was associated with less pain and disability at 6 months, and the belief that pain is mysterious was associated with greater disability at 3 and 6 months.

Our update found 4 studies related to perceived control over pain and self-efficacy. One was Phase III [7], 2 were Phase II [2, 103] and 1 was Phase I [60]. The Phase III study found that greater belief in one’s control over one’s pain was associated with less pain and disability at 6 months, but there was no association at 3 months [7]. The Phase I study, a series of cross-sectional analyses over time, found that the direct and indirect *concurrent* effect of self-efficacy on pain disability was stronger initially and decreased over a one-year period [60]. However, 2 Phase II studies found that initial self-efficacy was not related to pain disability at 1 year [2, 103]. These two studies, but not the Phase II study, also included other psychological factors in their multivariable analysis.

Finally, our update found one Phase I study which reported that early perceptions of injustice was not associated with self-perceived global recovery, although feelings of perceived injustice appeared to follow failure to recover by 3 months [27].

Thus, there is limited evidence from 1 study that certain pain beliefs (that the cure that pain can be medically cured and that pain is mysterious) are associated with recovery, and limited preliminary evidence from 1 study that perceived injustice follows but does not predict delayed recovery. However, the role of perceived control over pain and self-efficacy is still unclear since the evidence varies.

**Depressive Symptomatology.** This update combines evidence from 7 studies on post-crash depressive symptomatology: 1 from the NPTF (Phase II) and 4 from the update (1 Phase I, 2 Phase II and 1 Phase III) [1, 4, 14, 43]. The NPTF found limited preliminary evidence that post-crash depressive symptoms were associated with delayed recovery [105]. New evidence from 1 Phase III study found that higher levels of pain-related depression, measured 6 weeks after the injury, predicted greater neck pain intensity at four and 12 months [14], although in a Phase I study, depressive symptoms did not predict early pain outcomes (i.e., at 6 weeks) [43]. In contrast to an earlier study cited by the NPTF, which reported an association between depression and recovery [110], a sub-cohort analysis of that same study failed to find an association between depression and recovery in those seeking physical therapy within days of the injury [4]. It is possible that this discrepancy is because the latter study focused on a distinct population. Alternatively, the latter study adjusted for expectation for recovery. If poor expectation for recovery mediates the association between depression and recovery, that statistical adjustment might have introduced bias toward the null. In another Phase II study, the association showed a non-statistically significant trend (after adjusting for catastrophizing, fear-avoidance and PTSD symptoms) [1]

Thus, the preponderance of evidence suggests that early post-injury depression is associated with poorer recovery.

**Expectations for Recovery.** The NPTF found no studies on the prognostic role of expectations for recovery. New evidence from 10 studies of 9 distinct cohorts provides consistent evidence that early recovery expectations are associated with WAD recovery. There were 4 Phase III studies of 3 distinct cohorts [7, 13, 48, 99], 3 Phase II studies [26, 28, 103] and 3 Phase I studies [43, 56, 71] One Phase III study provides evidence that positive expectations for recovery are associated with faster pain, disability and self-rated global recovery [13]. Two sub-cohort analyses of that study, a Phase II study of those seeking early physical therapy interventions [4] and a Phase III study of expectations to return to work [48] also reported faster self-reported global recovery in those with positive expectations. A third Phase III study also found that positive expectations for recovery were associated with lower pain-related disability at six months [99] and a fourth Phase III study found that the belief that the WAD pain will be permanent (arguably a similar construct to poor expectation to recover) was associated with greater pain and disability at 3 and 6 months [7]. Two Phase I and 3 phase II studies reported that positive recovery expectations were associated with better self-reported global recovery at three months [26] and 6 months [56] and less neck pain [28, 71], less self-assessed disability [71, 103] and better work capacity [28] at 12 months. Finally, 1 Phase I study found that in non-litigants (but not in litigants), poor expectations for physical and mental recovery were associated with greater pain in the short term (6 weeks post-injury) [43].

Thus, there is consistent evidence indicating that expectations are associated with recovery.

**Pain Coping (Excluding Catastrophizing).** This update adds 5 studies (1 Phase I, 3 Phase II and 1 Phase III) [15, 17, 44, 60, 103] to the two studies on coping found by the NPTF (1 Phase II, 1 Phase III). The NPTF reported (limited) evidence that coping was associated with recovery [105]. New evidence from 1 Phase III study showed that passive coping is associated with slower recovery of neck pain and neck disability [15]. In that study, active coping was not associated with recovery. Similarly, new evidence from 3 Phase II studies found that coping strategies were associated with recovery. One of these studies found that coping strategies of distraction, re-interpreting and praying/hoping were associated with greater neck pain at 12 months [17] ; one study found that passive coping was associated with greater disability at 12 months [103] and one study showed that very early post-injury beliefs about what coping and healthcare strategies would help them recover were associated with neck pain recovery and working capacity at one year [44]. Specifically, those who did not believe that living as usual, who anticipated that taking sick time, taking medications and being referred to a physical therapist or chiropractor would help them get better had more neck pain at 12 months. Those who anticipated that not changing one’s lifestyle, not living life as usual, taking sick time, taking medications, being referred to a specialist, physical therapist and/or chiropractor were coping/healthcare options that would help them recover had reduced working capability at 12 months.[44]. Lastly, one Phase I study found that the indirect *concurrent* effect of coping on pain disability increased over time [60].

Therefore, there is consistent evidence of an association between coping and WAD recovery, although studies were not uniform in what coping constructs they assessed.

**Catastrophizing.**

The NPTF found 2 studies (1 Phase I and I Phase II) on the role of catastrophizing on recovery [105]. In that review, the limited preliminary evidence varied with the Phase I study showing an association while the Phase II study did not. This update adds 1 Phase III study [7], 6 Phase II studies of 4 distinct cohorts [2, 19, 20Nieto, 2013 #6765, 21, 103] and 1 Phase I study [43]. Associations between catastrophizing and recovery were found by 1 Phase III, 1 Phase II and 1 Phase I study: catastrophizing in the early (acute or subacute) phase of WAD recovery was associated with greater pain at 6 weeks [43] and at 6 months [1], greater pain disability at 3 and 6 months [7] and greater disability at 12 months [19]. That same cohort showed that catastrophizing was associated with a worse disability-recovery trajectory within the first 2 years [21], although there was no association with time to insurance claim closure [20]. In contrast, 3 Phase II studies found pain catastrophization to be unrelated to pain and disability outcomes when other psychological factors (such as kinesiophobia, coping and post-traumatic stress symptoms) were also included in the analysis [2, 46, 103].

In summary, the evidence about the role of early post-injury catastrophizing on recovery varies.

**Compensation and Legal Factors.**

The NPTF found two studies (Phase II) related to compensation and legal factors, and the update adds 4 additional studies: 2 Phase I studies [43, 61] and 2 Phase II studies [19, 63]. The NPTF reported limited, preliminary evidence that claiming under a tort system associated with slower recovery [105]. The outcome in that study was claim closure, which had been validated against indices of health recovery [108, 109]. In these 2 Phase II studies of the same cohort, it was found that health recovery preceded claim closure. The current review adds 1 Phase I study which asked the opposite question (i.e., does claim closure precede recovery) and found that claim closure does not predict *subsequent* pain recovery. This study took place in the Devon and Cornwall region of England (a tort based system, that is, those not at fault for the crash can sue for pain and suffering) [61]. In that study, 30% had settled their claim within two years of the crash, at which point, mean neck pain was approximately 15/100 (VAS: well within the “mild pain” range). Evidence on health recovery and claim closure from the NPTF and the update cannot be combined since the questions were too disparate.

The NPTF also reported limited preliminary evidence from two Phase II studies that lawyer involvement was associated with slower recovery [105]. The current review adds 4 new studies of 2 distinct cohorts on that topic. One Phase I study found that those hiring a lawyer had greater pain 6 weeks follow-up, but also had greater initial pain [43]. One Phase II study found lawyer involvement was not associated with self-reported functional disability at 12 months [19]. That same study showed no association between hiring a lawyer and the trajectory of disability recovery over a two year period [21], although it was associated with slower closure of the injury insurance claim [20].

Thus, the preponderance of evidence suggests an association between hiring a lawyer and poorer recovery, although hiring a lawyer may be a response to greater initial symptom severity and the association is likely highly dependent on the compensation system in place.

The question of lodging a compensation claim has also been studied in 1 new study from the update. One Phase II study found that the effect of lodging a compensation claim depended on the severity of the injury. For those with initially severe pain and disability and whose symptoms persisted at a moderate to severe level during the course of 12 months, lodging a compensation claim did not have a detrimental effect on recovery. However, for those with mild or moderate symptoms, lodging a compensation claim adversely affected recovery [63].

Thus, the limited, preliminary evidence on whether making a claim is associated with recovery varies, although the impact of making a claim may be dependent on the severity of the injury.

**Post-Collision Health Care Factors.**

The NPTF reported 2 Phase III studies on the association between post-collision health care and recovery. The update adds three additional studies (1 Phase III, 1 Phase II and 1 Phase I) [4, 53, 59]. The NPTF reported consistent evidence from a limited number of studies that higher frequency, type and combination of health care visits (specialist, general medical practitioner, chiropractor, as assessed using health databases) during the first *6 weeks* after a crash was associated with slower WAD recovery [105]. New evidence from one Phase III study similarly found that those with higher health care utilization in the *first 6 weeks* after the injury recovered more slowly than those with low health care utilization [59]. However, in examining a subcohort of that study, one Phase II study found that self-reported number of health care visits to a medical doctor and/or physical therapist in the *first 2 weeks* after the injury was not associated with self-rated global recovery [4].

One Phase I study found that seniority of the first treating physician is not associated with neck pain, use of analgesics, work disability, need for further intervention or health-related

Thus, the preponderance of the limited evidence indicates that high levels of initial health care utilization are associated with slower WAD recovery, and there is also limited, preliminary evidence that seniority of first treating physician is not associated with recovery.

**Risk Scores/Prediction Rules.**

The NPTF did not find studies reporting risk scores or prediction rules for recovery. The update reports 5 sets of risk scores, prediction models or prediction rules [35, 36, 43, 54, 56, 65], of which 2 have received external validation. 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. Variables were included if they maximized the area under the ROC curve, whether or not they were statistically significant predictors of this outcome. For those not engaged in litigation, a combination of female sex, severe neck and overall pain, as assessed in the ED, yielded area under the receiver operating characteristic curve (AUROCC) of 0.73. For those litigating, a combination of female sex, having moderate or severe neck pain or severe overall pain as assessed in the ED, 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 yielded a UROCC of 0.73 [43].

In 2 Phase I studies from the same cohort, Kasch and colleagues found that a *risk score* made of up cervical range of motion, neck/head pain intensity, sex, number of non-pain symptoms and pain on palpation predicts the following outcomes: work disability/sick leave from work, neck and headache pain recovery, recovery of self-perceived neck disability, expectations of work difficulties, post-traumatic stress symptoms; pressure pain thresholds and pain on palpation [35, 36].

Sterling and colleagues had earlier proposed a prediction rule for moderate/severe disability, consisting of higher initial Neck Disability Index (NDI) score, older age, cold hyperalgesia and symptoms of acute post-traumatic stress, decreased neck range of motion and diminished sympathetic reactivity [111]. In the update, we found 1 Phase II multicentre external validation study. After adjusting for study site, Sterling et al. found that four of the above factors, initial high NDI score, older age, cold hyperalgesia and symptoms of acute post-traumatic stress, were associated with moderate/severe disability at 12 months, with AUROCC was 0.89, 95% CI 0.84-0.94) [65].

Ritchie et al. derived a clinical prediction rule in one Phase II study [54] and conducted an external validation study using a different cohort [55]. In both the derivation set and the validation set, a combination of initial Neck Disability Index score ≥40, age ≥35 and hyperarousal scale (on the PDS) ≥6 had good specificity, but poor sensitivity to predict moderate/severe neck disability (as defined as NDI score of 30% or above) at 1 year. The proposed clinical prediction rule for recovery (defined as NDI score of 10% or less) was initial NDI ≤32 and age ≤35, which, again, had good specificity but poor sensitivity in both the derivation and the validation samples.

Finally, Rydman et al derived a prediction model using a cohort of ER attendees, and conducted a validation study using a 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 [56].

**Other Outcomes.**

**Is WAD a Risk Factor for Fibromyalgia?** The update combines evidence on fibromyalgia from three studies: 1 Phase I study from the NPTF and 2 Phase I studies of one cohort from the update [68, 69]. The NPTF reported limited preliminary evidence that WAD increased the risk of (diagnosed) fibromyalgia within 18 months post- crash [105]. Two new studies (one cohort) found that WAD did not increase the risk of fibromyalgia during the first three years post-crash [68, 69]. Thus, evidence on WAD as a risk factor for diagnosed fibromyalgia is still limited, preliminary and varies.

**Predictors of Widespread Pain in WAD.** This update combines two studies (1 Phase I and 1 Phase II) from the NPTF [105] and 1 new Phase II study [43]. From the NPTF, there was limited, preliminary evidence that WAD does not increase the risk of widespread pain (in comparison with non-WAD traffic injuries) and limited, preliminary evidence that in those with traffic-related WAD, being female, having poorer health, greater pain, more symptoms and more initial depressive symptoms was associated with the development of widespread pain, with this widespread pain resolving in most participants [105]. From the update, 1 Phase II study found that in both litigants and non-litigants, presence of widespread pain in the ED was associated with presence of widespread pain at 6 weeks [43]. In addition, prior neck pain, prior widespread pain, being in a rear-end collision and not having health insurance were associated with presence of widespread pain at 6 weeks in litigants. Severe neck pain in ED, poor recovery expectations and pain catastrophizing were associated with presence of widespread pain at 6 weeks in non-litigants [43]. The limited preliminary evidence on factors associated with the subsequent presence of widespread pain in WAD varies.

**Predictors of Lawyer Involvement.** The NPTF found no studies on predictors of lawyer involvement in WAD injury claims. From the update, 1 Phase II study provided preliminary and limited 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. Age, sex, profession, admission to hospital after the collision, socioeconomic status, income and catastrophization were not associated with hiring a lawyer [19].

**Predictors of Post-Collision Health Care Utilization.** The NPTF found no studies reporting factors associated with health care utilization in WAD. The update adds 1 Phase II study which provides preliminary and limited evidence that in comparison with a non-WAD matched comparison group, those with WAD had greater health care utilization both pre- and post-injury, were more likely to have been on a disability pension for musculoskeletal and mental health reasons at the time of injury, had more sick days both before and after injury, and were over twice as likely to change from low (pre-injury) levels of health care consultation to high consultation levels, with most of the increase in consultation being to physical therapists. High pre-injury health care utilization was associated with high post-injury utilization level and increase in health utilization was also associated with increases in number of post-injury sick days. [32].

**Jaw Pain.** No studies on WAD-related jaw pain were found by the NPTF. The update adds 3 new studies of 2 distinct cohorts [12, 57, 58]. Two Phase II studies provide limited preliminary evidence that approximately 15% of those with WAD developed jaw pain in the first days or weeks after the injury [12, 58]. One of these studies also found that the onset of new jaw pain was often delayed; those with WAD were at five times the risk of developing new jaw pain over a 1 year period than a non-injured comparison group [58]. Over a 15 year follow-up period, the prevalence of jaw symptoms and pain decreased in the group with WAD, but was still greater than the non-injured comparison group [57]

**Psychological Outcomes.** The NPTF reported 2 Phase I and 1 Phase II studies on factors associated with psychological outcomes in WAD. The update adds 1 Phase I analysis (nested within a Phase III study), and 2 Phase II studies [14, 52, 64]. The NPTF found limited preliminary evidence that compared with non-WAD injuries, WAD was associated with post-injury onset of depressive symptoms [105]. The update adds no studies on that topic.

The NPTF found limited and preliminary evidence from 1 study that that poor prior mental health was associated with presence and persistence of post-collision depressive symptoms [105]. The update adds one Phase I study which also reports that prior depression is associated with greater intensity of post-collision depression at 6 weeks [14]. Thus, there is consistent preliminary limited evidence that poor prior mental health/depression is associated with greater post-collision depression. The NPTF found limited preliminary evidence that greater initial pain was associated with greater post-collision depression [105]. The update adds 1 Phase I study supporting this [14]; thus the evidence is consistent but still limited and preliminary. In addition, the update also limited preliminary evidence from 1 Phase II study that initial dizziness is also associated with a persistent or recurring course of post-collision depression. [52].

The update adds limited and preliminary evidence from 1 Phase I study 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 [14]. No studies on this issue were found by the NPTF. Finally, the update adds 1 Phase II study that lower cold pain thresholds, greater initial pain intensity and older age predicted a greater severity of post-traumatic stress symptoms during the year following the crash [64].

**Compliance with Referral to Active Rehabilitation Program.** One Phase I study provides limited preliminary evidence that early passive pain coping style (within 7 days of injury) is associated with poorer compliance with being referred to an active rehabilitation program and increased use of prescription pain medications three weeks after the injury [25].

**Muscle Activation, Spinal Cord Hyperexcitability, Modic Changes.** The NPTF found limited preliminary from 1 Phase I study evidence that those with WAD had no elevated muscle reactivity in the three months following the injury; greater initial self-perceived disability was associated with reduction in recruitment of trapezius muscle during isometric exercise [105].From the update, 1 Phase II cohort study (from that same study sample) provides limited preliminary evidence that greater initial pain intensity and kinesiophobia are also associated with lower levels of muscle activation throughout the first 6 months of recovery. In that study, greater initial pain intensity increased the association between initial kinesiophobia and muscle activation [45].

The NPTF found no studies on hyperexcitability in WAD. The update found limited, preliminary evidence from one Phase II study that greater initial self-perceived neck disability is associated with spinal cord hyperexcitability at 3 months post-injury [62].

The NPTF found no studies on modic changes in WAD. The update found limited, preliminary evidence from 1 Phase I study that found no association between WAD and modic changes of the cervical spine (at C2-3 to C7-T1) in long term follow-up.

**Headaches/Headache Recovery.** The NPTF found no studies on WAD-related headache. The update adds limited, preliminary evidence from one Phase II study of individuals who had experienced a rear-end collision that neck pain presence (i.e., presence or absence of WAD) was not associated with subsequent headache diagnosis, headache characteristics or prognosis for headache recovery. In addition, those with WAD and uninjured controls had the same prevalence of headaches at 2 and 12 months [67].

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