Whiplash-associated disorders: who gets depressed? Who stays depressed?

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Abstract Depression is common in whiplash-associated disorders (WAD). Our objectives were to identify factors associated with depressive symptomatology occurring in the initial stages of WAD, and to identify factors predicting the course of depressive symptoms. A population-based cohort of adults sustaining traffic-related WAD was followed at 6 weeks, 3, 6, 9, and 12 months. Baseline measures (assessed a median of 11 days post-crash) included demographic and collision-related factors, prior health, and initial post-crash pain and symptoms. Depressive symptomatology was assessed at baseline and at each follow-up using the Centre for Epidemiological Studies Depression Scale (CES-D). We included only those who participated at all follow-ups ($n = 3,452$; 59% of eligible participants).

Using logistic regression, we identified factors associated with initial (post-crash) depression. Using multinomial regression, we identified baseline factors predicting course of depression. Courses of depression were no depression; initial depression that resolves, recurs or persists, and later onset depression. Factors associated with initial depression included greater neck and low back pain severity, greater percentage of body in pain, numbness/tingling in arms/hand, dizziness, vision problems, post-crash anxiety, fracture, prior mental health problems, and poorer general health. Predictors of persistent depression included older age, greater initial neck and low back pain, post-crash dizziness, vision and hearing problems, numbness/tingling in arms/hands, anxiety, prior mental health problems, and poorer general health. Recognition of these underlying risk factors may assist health care providers to predict the course of psychological reactions and to provide effective interventions.

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Introduction

The biopsychosocial model of health posits that in addition to biomedical factors, psychological, and sociological factors play important roles in the diagnosis, treatment, and recovery from illness and disease [11]. According to the Quebec Task Force on whiplash-associated disorders, whiplash is defined as an acceleration–deceleration mechanism of energy transferred to the neck as a result of a motor vehicle collision, and the resulting injury or cluster of symptoms is referred to as whiplash-associated disorders (WAD) [20]. WAD is a disorder where the interplay

between biological and psychosocial factors appears to have an important effect on recovery [8].

Research into these various interactive factors and recovery from WAD is still in a preliminary state. Research findings are relatively consistent with respect to the roles that greater initial pain intensity and symptom severity play in prolonging WAD recovery [8]. The bulk of the evidence examining psychological factors suggests that these factors also play a role in WAD recovery. For example, psychological stress, emotional lability, and depression have all been shown to play a significant role in the natural history of WAD [2, 21]. However, the effect of such factors has yet to be fully teased out with respect to what factors are consistently present, how these factors are associated with baseline pre-crash factors, and how these psychological factors and their possible interactions affect diagnosis, treatment, and recovery in WAD [8].

The current study focuses on depressive symptomatology. Depressive symptomatology has been reported to be common in the early stage of WAD recovery, with an incidence of over 40% within the first few weeks after a traffic collision, and with another 20% of persons with WAD developing such symptomatology later in their course of recovery [6]. In the majority of cases these post-crash depressive symptoms resolve satisfactorily with no recurrence. However, many others with WAD do not experience good resolution of their post-crash depressive symptoms, instead experiencing a recurrent or persistent course [6]. In addition to the personal health burden of ongoing depressive symptoms, their importance is underscored by their association with poor WAD recovery [7].

Our goals in the current study were twofold: (1) to identify sociodemographic, health-related, collision-related, and injury-related factors associated with presence of depressive symptomatology within the first 6 weeks of traffic-related WAD; and (2) to identify baseline factors (demographic, socioeconomic, collision-related, prior health, initial pain intensity, percentage of body in pain, and other symptoms) that predict the course of depressive symptoms during the first year post-crash.

Materials and methods

Design and study population

The source population for this inception cohort study was residents of Saskatchewan, a Canadian province of approximately 1.1 million persons. Our study participants are described in more detail elsewhere [9], but briefly, the current study included all adults aged 18 or older who made a claim for a traffic-related injury sustained in Saskatchewan between 1 December 1997 and 31 November

1999. Saskatchewan has a single insurer for traffic injuries, Saskatchewan Government Insurance (SGI), and our study population includes all those seeking treatment for traffic injuries, since health care providers are mandated to report these to SGI. Entry into the cohort was the date of the collision. We excluded those who died as a result of their injuries and those unable to answer the baseline questionnaire (the application for benefits form) due to language barrier, serious injuries (such as coma), or serious unrelated illness. These data do not include those with traffic injuries sustained in the course of employment and covered by the workers' compensation system, since those individuals claimed for benefits under the WCB system.

From the 8,634 meeting the above eligibility criteria, we formed a subcohort of claimants with WAD. To form this group, we excluded 797 who were hospitalized for more than 2 days due to the collision (since these are likely to have been more serious injuries) and those not injured in a motor vehicle (pedestrians and bicyclists), since the mechanism of injury is likely different in these cases. Of the 7,837 remaining subjects, 6,021 met our operational case definition for WAD by reporting that the accident had caused neck pain and by making their claim within 42 days of the crash. Median time between the crash and completion of the claim form was 11 days [9].

Sources of data and follow-up

All information was self-reported. Claimants completed an extensive insurance application form (the Application for Benefits), which formed the baseline data for those meeting our inclusion criteria. This questionnaire included items on pre-crash health, demographic and socioeconomic characteristics, and post-crash pain symptoms, and depressive symptomatology. Baseline data were available on all eligible claimants through these administrative data. Consenting participants were then followed by structured telephone interviews at 6 weeks, and 3, 6, 9, and 12 months post-crash. The research ethics boards of the Universities of Saskatchewan and Alberta approved the study.

Outcome

The main outcome measure for these analyses was the Centre for Epidemiological Studies Depression Scale (CES-D), which is a self-report questionnaire assessing depressive symptomatology. The CES-D was administered on the initial application for benefits questionnaire and at each follow-up interview. The CES-D is a widely used, valid, and reliable measure, and a cut-off score of 16 suggests depression [3, 10, 16, 17, 19]. Early post-crash depressive symptomatology was determined by CES-D

Table 1 Course of depressive symptoms

Course of depressive symptoms	Description ^a
No depressive symptoms	No CES-D scores ≥ 16 (at baseline or at any follow-up point)
Early depressive symptoms which resolve	CES-D score ≥ 16 at baseline, but resolves to < 16 at a follow-up point with all subsequent scores < 16
Early depressive symptoms with recurrence	CES-D score ≥ 16 at baseline; resolves to < 16 at a follow-up point; subsequently increases to ≥ 16
Early depressive symptoms, persistent	CES-D score ≥ 16 at baseline, and all follow-up scores ≥ 16 (required 2 positive depression scores)
Later onset depressive symptoms	CES-D score < 16 at baseline, but ≥ 16 at one or more subsequent follow-up points

^a CES-D refers to the Centre for Epidemiological Studies Depression Scale. Baseline refers to time of the injury claim, and was within 6 weeks after the crash

score ≥ 16 at the time the individual filed their injury insurance claim. This questionnaire does not necessarily reflect major depressive disorders, as defined by the DSM IV [1]; rather it reflects self-reported depressive symptomatology during the preceding week. This would include sub-clinical depressive symptoms as well as major depression. The five “course of depressive symptomatology” categories are outlined in Table 1. This study is an extension of a previous report which outlined courses of depressive symptomatology, and a more detailed description of how these categories were formed is available in Carroll et al. [6]. The current study includes only those who completed the depression questionnaire at baseline and at all five follow-ups.

Potential explanatory/associated factors

The initial questionnaire included demographic and socioeconomic items (gender, age, marital status, annual family income, highest level of education); pre-crash health factors (self-report general health the month before the crash, pre-existing comorbid health conditions, including mental health problems in the 6 months prior to the crash); crash-related factors (position in the vehicle: driver, passenger, other; direction of main impact to the vehicle: frontal, rear, side impact; whether the head was struck in the collision; fractured bones, having struck one’s head), and pain/symptoms after the collision (percentage of body in pain and pain intensity, numbness, tingling or pain in arms/hands or legs/feet, dizziness or unsteadiness, memory problems or forgetfulness, concentration or attention problems, irritability, vision problems, hearing

problems, sleep problems, unusual fatigue or tiredness, anxiety or worry, painful neck movements, reduced neck movement, or sore jaw).

Pain intensity was measured using an 11-point numerical rating scale for each of neck, low back, and headache; and a pain drawing was used to calculate the percentage of body in pain [13, 15]. The presence and severity of previously existing musculoskeletal complaints, prior mental health problems, and other comorbid medical conditions were assessed using a 15-item self-report measure of health problems. These questions ask participants to report whether these health conditions are present, and, if so, how severely that condition impacts their overall health (that is, “health condition not present; health condition present with no effect or mild effect on health; health condition present with moderate or severe effect on health”).

Analysis

Assessment of response bias due to attrition

We built a multivariable logistic regression model to identify predictors of full participation throughout follow-up (that is, participation at all five follow-up points) versus any attrition. Potential predictors were age, gender, education, income, general health the month prior to the collision, mental health in the 6 months prior to the collision, and baseline measures of percentage of body in pain, neck pain intensity, presence of anxiety, and depressive symptomatology. All variables were entered into a multivariable logistic regression model simultaneously, and those factors whose confidence intervals crossed unity were removed from the model one at a time (replacing that variable when testing the next one) to assess the impact of this removal on the log likelihood and the estimates of the remaining factors. Where removal of that factor led to a non-trivial change in either the model’s overall log likelihood value or the estimates of the remaining factors, that factor was retained in the final model.

Main analyses

For our main analyses, we built two sets of multivariable models. The first model was developed to identify factors associated with initial depressive symptomatology (a cross-sectional analysis) and includes all those who completed the CES-D at baseline. The second model was developed to identify baseline factors associated with the subsequent course of depressive symptoms over the follow-up period (a longitudinal analysis), and includes all those who completed the CES-D at baseline and participated at all five follow-up points.

Factors associated with initial depressive symptomatology

To identify factors for inclusion in the multivariable model, we first examined the crude associations between the explanatory factors (listed above) and initial post-crash depressive symptomatology. Initial depressive symptomatology was dichotomized using the validated cut-off score of 16 [17]. Those factors whose Wald statistic in the crude logistic regression models had a p value of <0.10 were retained for inclusion in a multivariable model and were entered into the model together [18]. In order to improve the precision of our estimates by decreasing the number of factors in our model, we removed those factors which were not contributing to the model. We did so by removing, one at a time (with replacement when testing the next factor), those factors with a Wald statistic p value of ≥ 0.05 . If removal of that variable resulted in a decrease in the negative log likelihood value of the model or changed the point estimates of the remaining factors in any but a non-trivial manner, we re-entered that factor and retained it in the final model.

Factors associated with course of depressive symptomatology

We used multivariable multinomial logistic regression to identify factors associated with the course of depressive symptomatology over the follow-up period. In a multinomial logistic regression model, each outcome category is compared with the reference group, much the same as in binary logistic regression; however, all outcome categories are modeled simultaneously. The five levels of outcome (course of depressive symptomatology) are listed in Table 1. The category of “no depressive symptomatology at any point” was used as the reference category. Our selection of variables for the multinomial model followed the same procedures as for the above model describing initial depressive symptomatology. All factors were entered simultaneously into the multivariable model.

Results

Of the 6,021 eligible subjects, 5,845 completed the CES-D on the initial questionnaire. Of these, 3,221 (55.1%) did not have initial depressive symptomatology, that is, their CES-D score on the initial post-crash questionnaire was <16 . The remaining 2,624 (44.9%) had depressive symptomatology (CES-D ≥ 16) as assessed within 42 days (6 weeks) of the crash.

Of the 5,845 with baseline depression data, 3,452 (59% completed all five follow-ups). Of these, 48.3% ($n = 1,667$) did not have depressive symptomatology at any point; 25.9% ($n = 894$) had initial depressive symptoms that resolved

during the course of follow-up; 10.0% ($n = 344$) had early depressive symptomatology that resolved, then recurred at some point during follow-up; 4.7% ($n = 162$) had early depressive symptoms that persisted throughout the follow-up period; and 11.2% ($n = 385$) had no depressive symptoms at baseline, but developed these at some point during the course of follow-up. These participants are described in Table 2 of this report.

Assessment of response bias due to attrition

Our multivariable analysis comparing full participation with no or partial participation suggests that women and those over the age of 24 were more likely to have participated at all follow-up points, as were those with higher income and at least high school education. Those with greater initial neck pain intensity, greater initial post-crash anxiety, and greater initial depressive symptomatology were more likely to have missed at least one follow-up interview.

Factors associated with initial depressive symptomatology

Factors associated with initial depressive symptomatology are listed in Table 3. In our multivariable model, those over age 50 years and those with a higher family income had less depressive symptomatology within the first 6 weeks of the collision. Several indices of injury severity were associated with higher risk of initial post-crash-depressive symptomatology. These include greater pain intensity (neck and low back), greater % of body in pain, numbness or tingling in the arms and hands, dizziness and vision problems after the collision, and sustaining a fractured bone in the collision. Additionally, those who reported feeling anxious after the collision had over three times the odds of also experiencing depressive symptomatology.

In our multivariable model, gender was not associated with post-crash depressive symptomatology, nor were presence of severe pre-crash bodily pain or severe pre-crash headaches. Both prior *mild* bodily pain and prior *mild* headaches showed small negative associations with presence of post-crash depressive symptomatology. Although there was a suggestion that those with fair or poor prior health had a greater risk of post-crash depressive symptoms, the effect size was small and confidence intervals include unity. For this multivariable logistic model the Pseudo R^2 was 0.19, indicating that 19% of the variance in depressive symptomatology is explained by this model.

Factors associated with course of depressive symptomatology

Factors associated with the *course* of depressive symptomatology over the 1-year follow-up period are listed in

Table 2 Characteristics of claimants in each course of depressive symptoms

Factor	Never depressed (<i>n</i> = 1,667)	Depressive symptoms with resolution (<i>n</i> = 894)	Recurrent depressive symptoms (<i>n</i> = 344)	Persistent depressive symptoms (<i>n</i> = 162)	Late onset of depressive symptoms (<i>n</i> = 385)
Age: mean (SD) ^a	396 (15.1)	37.7 (15.3)	40.2 (14.0)	45.2 (15.6)	43.3 (15.8)
Sex: <i>n</i> (%)					
Male	844 (32.6)	244 (27.3)	94 (27.3)	58 (35.8)	122 (31.2)
Female	1,123 (67.4)	650 (72.7)	250 (72.7)	104 (64.2)	263 (68.3)
% Body in pain ^b mean (SD)	18.7 (13.0)	26.2 (16.1)	27.2 (17.8)	31.9 (19.4)	22.0 (14.7)
Pain intensity ^c mean (SD)					
Neck/shoulder	5.8 (2.0)	6.7 (2.0)	7.1 (2.1)	7.6 (1.8)	6.4 (2.0)
Low back	2.8 (3.1)	3.9 (3.5)	4.5 (3.6)	5.7 (3.4)	5.0 (3.1)
Headache	4.1 (3.2)	5.4 (3.2)	6.2 (3.1)	7.0 (2.7)	5.0 (3.1)
CES-D score at baseline: mean (SD)	6.7 (4.5)	25.0 (7.4)	26.9 (8.9)	33.1 (9.9)	9.0 (4.5)
Education: <i>n</i> (%)					
Less than high school	266 (16.0)	182 (20.4)	82 (23.9)	58 (35.8)	101 (26.2)
High school	266 (16.0)	182 (20.2)	82 (23.9)	58 (35.8)	101 (26.2)
Technical school or some university	720 (44.4)	385 (43.1)	123 (27.0)	49 (30.2)	137 (35.6)
University graduate	263 (15.8)	91 (10.2)	42 (12.2)	17 (10.5)	56 (14.5)
Marital status: <i>n</i> (%)					
Single	456 (27.4)	317 (35.5)	90 (26.2)	39 (24.1)	87 (22.6)
Married/common law	1,039 (62.3)	484 (54.2)	203 (59.0)	83 (51.2)	229 (59.5)
Widowed	44 (2.6)	22 (2.5)	8 (2.3)	5 (3.1)	25 (6.5)
Separated/divorced	128 (7.7)	70 (7.8)	43 (12.5)	35 (21.6)	44 (11.4)
Family income: <i>n</i> (%)					
\$0–20,000	322 (19.7)	260 (29.7)	105 (31.4)	70 (43.8)	105 (28.0)
\$20,001–40,000	506 (31.0)	297 (33.9)	113 (33.8)	51 (31.9)	137 (36.5)
\$40,001–60,000	429 (26.3)	182 (20.8)	71 (21.3)	26 (16.3)	79 (21.1)
+\$60,000	375 (23.0)	137 (15.6)	45 (13.5)	13 (8.1)	54 (14.4)

N = 3,452 participating in all five follow-ups

^a SD refers to standard deviation

^b Percentage of body in pain measured on a pain drawing

^c Pain intensity measured on an 11-point numerical rating scale

Table 4. In this multinomial model, the estimates of the effect refer to the comparison of factors in each course of depressive symptomatology with the reference group. For all four courses of depressive symptomatology (resolved, no recurrence; resolved but recurred; persistent; and late onset), the reference group is those with no depressive symptomatology at any time point throughout the study period.

Initial depressive symptomatology with resolution, no recurrence

In the multivariable model, gender was not an important factor; however, those aged 50 years or more were less likely than the youngest age group to develop depressive symptomatology that resolves, as were university graduates

(in comparison with those of lower education) and those with higher family income (in comparison with lower income). Those with prior bodily pain (mild) and those who were injured in a rear end collision, were also less likely to have depression that resolves (than no depression at all). Having a greater percentage of body in pain, greater neck pain intensity (each increase of 1 point on the 11-point scale increased the odds of resolving depression by 16%), post-crash symptoms of dizziness and vision problems, fractured bones, prior mild or severe mental health problems, and good prior health (as opposed to excellent health) increased the risk of this course of depression compared with no depression at all. Those who reported post-crash anxiety were also much more likely to experience this course of depression (OR = 3.92, 95% CI 3.22–4.76).

Table 3 Factors associated with initial post-crash depressive symptomatology

Factor	Univariable odds ratios (95% CI) <i>N</i> = 5,845	Multivariable odds ratios ^a (95% CI) <i>N</i> = 5,531
Age group		
18–23 (years)	1.00	1.00
24–29 (years)	1.01 (0.85–1.21)	1.09 (0.88–1.35)
30–39	0.96 (0.82–1.11)	1.00 (0.83–1.21)
40–49	0.82 (0.70–0.96)	0.92 (0.74–1.12)
50 and older	0.80 (0.69–0.94)	0.80 (0.64–0.99)
Female gender	1.21 (1.08–1.34)	1.13 (0.99–1.30)
Annual family income ^b		
Less than \$20,000	1.00	1.00
\$20,000–39,999	0.68 (0.59–0.77)	0.77 (0.53–0.77)
\$40,000–59,999	0.50 (0.43–0.58)	0.64 (0.53–0.77)
\$60,000 or more	0.42 (0.36–0.50)	0.62 (0.51–0.76)
Education		
<High school	1.00	1.00
High school	0.82 (0.70–0.95)	0.92 (0.77–1.11)
Technical school or some university	0.77 (0.67–0.88)	0.84 (0.71–1.002)
University degree	0.55 (0.46–0.66)	0.70 (0.56–0.88)
Direction of impact		
Frontal impact	1.00	1.00
Rear impact	0.62 (0.55–0.71)	0.74 (0.63–0.86)
Side impact	1.05 (0.92–1.21)	0.99 (0.84–1.16)
Other	1.18 (0.92–1.52)	1.09 (0.81–1.47)
% of body in pain ^c	1.03 (1.03–1.04)	1.01 (1.00–1.01)
Neck pain intensity ^d	1.29 (1.25–1.32)	1.16 (1.12–1.20)
Low back pain intensity ^d	1.13 (1.11–1.15)	1.05 (1.03–1.07)
Numbness, tingling in arms and hands ^e	1.92 (1.73–2.14)	1.16 (1.02–1.33)
Felt dizzy after collision ^e	2.93 (2.63–3.26)	1.61 (1.41–1.83)
Vision problems after collision ^e	3.07 (2.58–3.65)	1.56 (1.26–1.93)
Hearing problems after collision ^e	3.08 (2.40–3.95)	1.24 (0.92–1.68)
Felt anxious after collision ^e	4.58 (4.10–5.12)	3.32 (2.93–3.76)
Fractured bone in collision		
No	1.00	1.00
Yes	1.75 (1.34–2.29)	1.65 (1.19–2.29)
Uncertain	2.01 (1.50–2.71)	1.23 (0.87–1.75)
Prior musculoskeletal pain		
No	1.00	1.00
Yes, mild	0.83 (0.73–0.93)	0.77 (0.66–0.90)
Yes, moderate to severe	1.23 (1.05–1.43)	0.92 (0.75–1.13)
Prior headaches		
No	1.00	1.00
Yes, mild	0.95 (0.84–1.07)	0.86 (0.74–0.99)
Yes, moderate to severe	1.34 (1.13–1.58)	0.94 (0.76–1.17)
Prior GI problems		
No	1.00	1.00
Yes, mild	1.19 (1.00–1.42)	1.13 (0.91–1.39)
Yes, moderate to severe	1.79 (1.41–2.28)	1.32 (0.99–1.78)

Table 3 continued

Factor	Univariable odds ratios (95% CI) <i>N</i> = 5,845	Multivariable odds ratios ^a (95% CI) <i>N</i> = 5,531
Prior mental health problems		
No	1.00	1.00
Yes, mild	2.09 (1.71–2.55)	1.50 (1.19–1.90)
Yes, moderate to severe	5.61 (3.90–8.07)	3.99 (2.58–6.19)
Prior general health		
Excellent	1.00	1.00
Very good	1.08 (0.95–1.22)	1.17 (1.01–1.36)
Good	1.29 (1.12–1.48)	1.34 (1.11–1.61)
Fair or poor ^f	1.86 (1.50–2.32)	1.32 (0.99–1.78)

Bolded ORs are significant at $p < 0.05$

^a Depressive symptomatology as assessed by the CES-D within 6 weeks after the crash. “Depressed” refers to CES-D score of 16 or above

^b Log likelihood of the multivariable model = $-3,072.14$. Pseudo $R^2 = 0.19$. $N = 5,531$ in the multivariable analysis because of missing data for some factors

^c Annual family income in Canadian dollars

^d Percent of body in pain calculated using a pain drawing. Estimate of effect is reported for each percentage point increase

^e Neck and low back pain intensity measured on an 11-point numerical rating scale. Estimate of effect is reported for each one point increase in this scale

^f Self-reported symptoms with response options of “yes” or “no”

^g Categories “fair” and “poor” prior health combined because of small cell sizes

Table 4 Personal, pre-crash, and crash-related factors associated with course of depressive symptomatology during the year post-crash

Factor	Course of depressive symptoms			
	Resolution of depressive symptoms OR (95% CI)	Resolution with recurrence OR (95% CI)	Persistent depressive symptoms OR (95% CI)	Later onset of depressive symptoms OR (95% CI)
Age group (years)				
18–23	1.00	1.00	1.00	1.00
24–29	1.01 (0.73–1.41)	1.13 (0.67–1.88)	2.45 (1.11–5.42)	1.40 (0.85–2.31)
30–39	0.96 (0.71–1.30)	1.70 (1.09–2.64)	2.41 (1.17–3.98)	2.19 (1.41–3.40)
40–49	0.89 (0.65–1.23)	1.94 (1.23–3.05)	2.80 (1.33–5.88)	2.46 (1.57–3.84)
≥50	0.71 (0.52–0.98)	1.17 (0.73–1.88)	1.99 (1.47–6.11)	1.95 (1.25–3.06)
Female gender	1.15 (0.93–1.42)	1.05 (0.78–1.42)	0.63 (0.42–0.95)	0.85 (0.66–1.11)
Education				
<Grade 12	1.00	1.00	1.00	1.00
High School	0.85 (0.63–1.14)	0.78 (0.53–1.15)	0.69 (0.41–1.18)	0.70 (0.49–1.01)
Technical college or some university	0.77 (0.58–1.01)	0.55 (0.38–0.80)	0.42 (0.25–0.70)	0.59 (0.42–0.83)
University graduate	0.59 (0.41–0.85)	0.63 (0.39–1.02)	0.49 (0.24–0.99)	0.74 (0.49–1.12)
Income				
<\$20K	1.00	1.00	1.00	1.00
\$20–39K	0.78 (0.61–1.00)	0.62 (0.44–.87)	0.46 (0.29–0.73)	0.71 (0.52–0.98)
\$40–59K	0.60 (0.45–0.79)	0.48 (0.33–0.71)	0.35 (0.20–0.62)	0.48 (0.33–0.78)
\$60K and above	0.59 (0.43–0.80)	0.41 (0.26–0.64)	0.22 (0.11–0.45)	0.40 (0.26–0.60)
Direction of impact				
Frontal	1.00	1.00	1.00	1.00
Rear	0.65 (0.51–0.82)	0.78 (0.56–1.07)	0.74 (0.46–1.19)	1.01 (0.75–1.36)
Side	0.84 (0.66–1.08)	0.85 (0.60–1.20)	0.84 (0.51–1.39)	0.80 (0.57–1.13)
Other	1.00 (0.64–1.56)	0.75 (0.38–1.50)	1.03 (0.42–2.51)	0.73 (0.36–1.49)
% of body in pain ^a	1.01 (1.01–1.02)	1.01 (1.00–1.02)	1.02 (1.00–1.03)	1.01 (1.00–1.012)

Table 4 continued

Factor	Course of depressive symptoms			
	Resolution of depressive symptoms OR (95% CI)	Resolution with recurrence OR (95% CI)	Persistent depressive symptoms OR (95% CI)	Later onset of depressive symptoms OR (95% CI)
Neck pain intensity ^b	1.16 (1.10–1.22)	1.24 (1.15–1.33)	1.30 (1.17–1.45)	1.08 (1.02–1.15)
Low back pain intensity ^b	1.03 (1.00–1.06)	1.08 (1.04–1.13)	1.15 (1.08–1.22)	1.06 (1.02–1.10)
Dizziness	1.92 (1.57–2.35)	1.63 (1.23–2.17)	3.65 (2.37–5.61)	1.31 (1.01–1.72)
Vision problems	1.49 (1.06–2.10)	1.75 (1.43–2.67)	1.32 (0.76–2.29)	1.23 (0.78–1.94)
Hearing problems	1.54 (0.93–2.57)	1.88 (1.03–3.42)	2.89 (1.47–5.67)	1.99 (1.08–3.67)
Numbness, tingling in arms and hands	1.10 (0.90–1.36)	1.71 (1.29–2.26)	1.37 (0.91–2.06)	0.91 (0.70–1.19)
Anxiety	3.92 (3.22–4.76)	3.57 (2.71–4.70)	3.17 (2.12–4.75)	1.66 (1.28–2.15)
Fracture				
No	1.00	1.00	1.00	1.00
Yes	2.31 (1.44–3.69)	1.33 (0.65–2.73)	1.42 (0.56–3.62)	1.19 (0.57–2.50)
Uncertain	1.16 (0.66–2.04)	1.20 (0.60–2.41)	1.47 (0.60–3.60)	1.31 (0.66–2.62)
Prior MSK pain				
No	1.00	1.00	1.00	1.00
Mild	0.76 (0.60–0.96)	0.67 (0.48–0.92)	0.73 (0.46–1.17)	0.98 (0.74–1.30)
Severe	0.94 (0.68–1.30)	0.93 (0.61–1.42)	1.18 (0.69–2.04)	1.21 (0.84–1.76)
Prior headaches				
No	1.00	1.00	1.00	1.00
Mild	1.02 (0.82–1.27)	1.01 (0.81–1.50)	0.90 (0.57–1.41)	1.25 (0.95–1.65)
Severe	1.16 (0.82–1.63)	1.66 (1.09–2.53)	1.16 (0.63–2.13)	1.66 (1.11–2.47)
Prior GI problems				
No	1.00	1.00	1.00	1.00
Mild	1.15 (0.84–1.59)	1.17 (0.77–1.80)	1.32 (0.74–2.38)	1.06 (0.71–1.56)
Severe	0.87 (0.53–1.41)	1.55 (0.90–2.68)	1.74 (0.89–3.41)	0.80 (0.44–1.44)
Prior mental health problems				
No				
Mild	1.62 (1.22–2.34)	2.27 (1.45–3.57)	3.28 (1.85–5.82)	1.78 (1.15–2.75)
Severe	3.38 (1.54–7.42)	6.26 (2.67–14.69)	16.78 (6.73–41.83)	2.11 (0.78–5.70)
Prior general health				
Excellent	1.00	1.00	1.00	1.00
Very good	0.98 (0.78–1.22)	1.30 (0.94–1.80)	1.61 (0.93–2.80)	1.29 (0.95–1.75)
Good	1.44 (1.09–1.91)	1.49 (1.00–2.23)	3.81 (2.14–6.80)	2.01 (1.41–2.87)
Fair to poor	1.16 (0.71–1.89)	1.60 (0.88–2.91)	2.44 (1.09–5.47)	1.90 (1.09–3.30)

Reference group is “no depressive symptomatology” during the 1-year study period. Depressive symptoms measured by the CES-D, using a cut-off score of 16 or above to indicate depressive symptomatology. Resolution refers to initial depressive symptoms (measured on the baseline questionnaire administered within 6 weeks of crash) which resolve without recurrence. Recurrent refers to initial depressive symptoms which resolve but recur at some point during the study period. Persistent refers to initial depressive symptoms which are persistent (never resolve). Late onset refers to depressive symptomatology at follow-up in those with no initial depressive symptomatology

All odds ratios and confidence intervals reflect the results of the multivariable model. Number included in the multivariable model was 3,314 rather than 3,452 due to missing data in factors included in the model. Log-likelihood of the multivariable model was $-3,700.7904$; pseudo $R^2 = 0.1516$

Bolded ORs are significant at $p < 0.05$

^a Percentage of body pain as determined from a pain drawing

^b Neck pain and low back pain intensity assessed using an 11-point numerical rating scale

Initial depressive symptoms which resolve but recur

In our final model, those aged 30–49 years were more likely to experience recurrent depressive symptoms

(compared with no depressive symptomatology at any point), and those with technical college or some university education were less likely than those with low education to experience recurrent depression. Recurrent depression was

also less likely among those with higher family income (compared with those with the lowest category of annual income). Post-crash pain intensity (neck and low back pain) and symptoms of dizziness, vision and hearing problems, arm/hand numbness and tingling, and post-crash anxiety were positively associated with increased risk of subsequent recurrent depressive symptoms. An increase of each point (on an 11-point scale) of neck pain was associated with 24% higher odds of recurrent depression. Again, initial post-crash anxiety was also highly associated with experiencing recurrent depressive symptoms (OR = 3.57, 95% CI 2.71–4.70). Pre-crash mild (self-reported) musculoskeletal pain was associated with a lower risk of recurrent depressive symptomatology and pre-crash mental health problems were associated with a greater risk of recurrent depression (OR for mild problems = 2.27, 95% CI 1.45–3.57; OR for severe problems = 6.26, 95% CI 2.67–14.69). Prior severe headaches also increased the risk of this course of depressive symptoms. Although there was a trend for those with less than excellent prior health to experience a greater risk of recurrent depression, these findings were not statistically significant. Direction of the collision was not associated with risk of experiencing recurrent depressive symptoms.

Persistent depressive symptoms

This group was the least similar to those without depressive symptoms at any point during the study. Men and individuals over 24 years of age were at greater risk for experiencing persistent depressive symptoms. Those with greater than high school education and those with family income level over \$20,000 (CND) per year (compared with less than high school and the lowest income category, respectively) were less likely to experience persistent depressive symptoms.

Again, direction of the collision was not associated with persistent depression; however, as in the resolved and the recurrent groups, higher intensity of neck pain was associated with a higher risk of persistent depressive symptoms. In this group, each one-point increase on the 11-point neck and back pain intensity scales was associated with a 30 and 15% (respectively) increase in the odds of persistent depressive symptoms. Post-crash dizziness and hearing problems were also associated with greater risk of persistent depression. As in the other courses of depression, initial anxiety was strongly associated with persistent depression (OR = 3.17, 95% CI 2.12–4.75), as were prior mental health problems (OR for mild problems = 3.28, 95% CI 1.85–5.82; OR for severe problems = 16.78, 95% CI 6.73–41.83). Those with fair to poor or good self-reported general health were also more likely than those with excellent health to experience this course of depression.

Later onset of depressive symptoms

In this particular course, age over 30 years increased the risk of a later onset of depression (after the first 6 weeks after the crash); and having technical college or some university (in comparison with less than high school) and higher family income (in comparison with the lowest income category) decreased the risk of a later onset of depression. Like recurrent and persistent courses of depression, greater initial intensity of pain was associated with experiencing late onset of depression (vs. no depression at all). Each one point increase on the 11-point neck and back pain scales increased the odds of late onset of depression by 8 and 6%, respectively. Those who reported post-crash dizziness, hearing problems, and anxiety were also more likely to experience late onset depression than no depression at all, although the association between anxiety and this course of depression was smaller than with the other courses (OR = 1.66, 95% CI 1.28–2.15). Mild pre-crash mental health problems were associated with greater risk of experiencing this course of depression, as was reporting good or fair to poor prior general health (as opposed to excellent general health).

For this multinomial logistic model the Pseudo R^2 was 0.15, indicating that 15% of the variance in the courses of depressive symptomatology are explained by this model.

Discussion

Although as a mechanism of injury, whiplash is a biomechanical event, the health sequelae are clearly consistent with the biopsychosocial conceptualization of health. Depressive symptomatology has been shown to be common after such an event, and the determinants of depressive symptoms and the course of post-crash depressive symptoms are multifactorial [5, 6]. Depressive symptomatology may now be considered an important component in the cluster of WAD symptoms.

Our first research objective was to identify factors associated with initial post-crash depressive symptomatology. Indeed, we found that sociodemographic factors were important. We noted that as age, income, and education increased, the frequency of post-crash depression decreased. Not surprisingly, as crash-related symptoms, pain intensity, and proportion of the body in pain increased, post-crash depression also increased. For example, for every one point increase in neck pain on the 11-point VAS scale, the odds of initial depression increased 16%. In fact, neck pain intensity was associated with each course of depression, and the associations were especially strong in the two less-benign courses of depression, recurrent and persistent depression. These findings are consistent with

the extensive existing literature showing a strong association between pain and depression. For example, Carroll et al. [5] found that back and/or neck pain was associated with onset of a new episode of depression 6–12 months later, and Magni et al. [14] demonstrated that the presence of pain at baseline was associated with the development of depression up to 8 years later.

Interestingly, fewer of those who were struck from behind had post-crash depressive symptoms than those with side or frontal collisions, although the association was modest. This is an interesting finding, especially given that direction of the collision has no clear implications for recovery [8]. It is possible that the current findings relate to being “at fault” or blamed for the collision since drivers who are struck from behind are the least likely to be declared “at fault” for the collision. It may be that that being blamed for the collision is a risk factor for developing depressive symptoms in the early stages of recovery. Interestingly, this study was done in a “no-fault” jurisdiction, so being “at fault” would have had fewer implications for insurance coverage than in other jurisdictions, although there would still have been repercussions in the form of possible traffic violation charges. It is unlikely that these findings were related to severity of the injury itself, since the multivariable model adjusts for crash-related pain and symptoms.

Psychological variables were also highly associated with increased presence of post-crash depressive symptomatology in the initial stages of recovery. Both prior (self-reported) mental health problems and feelings of anxiety and worry after the collision were highly associated with presence of post-crash depressive symptomatology. This finding is very important in that recognition of these psychological factors at the initial assessment may allow clinicians to make better and more efficient treatment decisions for those individuals with a history of mental health problems.

Course of depression

We tracked the course of depressive symptomatology over the follow-up period. There were five courses. To reiterate, resolution with no recurrence refers to initial depressive symptomatology (initial CES-D ≥ 16) that resolves (to CES-D < 16) during the course of follow-up with no subsequent CES-D score above 16. Resolution with recurrence refers to initial depressive symptoms that resolve during follow-up but subsequently recur. Persistent depressive symptomatology refers to initial depressive symptomatology (CES-D ≥ 16) that fails to resolve at any point during follow-up, that is, where CES-D scores remain at 16 or above. Late onset refers to those cases with initial CES-D scores < 16 , but who attain scores of 16 or above at any follow-up [6]. Each of the four courses was compared with

the group of participants with no depressive symptomatology at any point during the study.

There were some interesting similarities and differences among the four courses of depression. For example, despite the well-known fact that women report more depression and more depressive symptomatology in general, gender does not appear to play an important role in either the development of post-crash depression or the course of depressive symptoms. The one exception to this was that women were less likely than men to experience persistent depression rather than no depression at all. The effect of age was relatively consistent, but was also generally modest, although those aged 24 and older were two or more times as likely as those in the 18- to 23-year-old age group (reference category) to experience a persistent course. Greater income was a protective factor for each of the courses of depressive symptomatology. Most notably, the highest income group was 78% less likely to experience persistent depression (compared to no depression at all) than those in the lowest income group.

When examining course of depression, the direction of the impact is less important. Only for the most benign course of depression (depression with resolution) was being struck from the rear protective (compared with frontal collisions), and the association was relatively modest (OR approximately 0.65). Direction of impact had no association with the other courses of depression.

There was an interesting pattern in the relationship between neck/low back pain intensity and course of depression. For example, for each one-point increase on the 11-point scale measuring neck pain, there was an 8% greater chance of late onset depression (than no depression at all), a 16% greater chance of depression that resolves with no recurrence, a 24% greater chance of recurrent depression, and a 30% greater chance of persistent depression. Likewise, low back pain also increased the risk of onset and poor resolution of depressive symptoms. It should be noted that over 60% of those with WAD also report low-back pain after the collision, so this is an important finding [12].

This suggests that the initial assessment of pain intensity is vital for understanding the possible development of depressive symptoms and subsequent poor recovery. Other post-crash symptoms were also associated with particular courses of depression. For example, those reporting post-crash dizziness or hearing problems were also much more likely to experience a persistent course of depression than no depression at all.

The association between prior severe mental health problems and depression was especially strong in the persistent course, although the exact strength of the relationship cannot be determined with confidence in this study because of imprecision in the estimates. The association was also strong (but less so) for recurrent depression and

for depression that resolves. Other aspects of prior health were less consistently associated with course of depression, although having only poor to good prior health rather than excellent prior health appears to increase the risk of experiencing persistent depressive symptoms.

This paper has some important strengths. It is population-based with complete ascertainment of all eligible cases. Since Saskatchewan mandates that all health care providers report traffic injuries, we were able to capture all eligible cases. Additionally, base-line data were available from insurance claims, so we had almost complete information for our estimates of early onset of depressive symptoms, although there were some missing data due to failure to complete the depression questionnaire at base-line. In addition, we measured depression using the CES-D, which is a commonly used and valid, reliable instrument for assessing self-reported depressive symptomatology. Use of valid and reliable questionnaires decreases the likelihood of introducing measurement bias.

Low participation rates are common with large prospective cohort studies. In the current study, there was actually a very high participation rate, with over 90% of participants completing at least one follow-up measure. However, fewer met our stringent inclusion criteria of full follow-up, and the current findings regarding factors associated with course of depression includes 59% of the baseline participants. We found some evidence of selective attrition, and several of these factors were highly associated with poor resolution of depressive symptomatology, especially the persistent course. This suggests that those with persistent depression were more likely to have missed at least one follow-up and therefore not included in the current study. Thus, our findings likely underestimate the risk of poor resolution of depressive symptoms.

Another possible limitation to our study is misclassification. We did not have access to clinical diagnoses of WAD, and relied on an operational definition of neck pain after the collision. We attempted to exclude more serious injuries by excluding those who were hospitalized for more than 2 days, but it is possible that we included those who would not have had the clinical diagnosis of WAD, and excluded some that might have had such a diagnosis. We have also risked misclassifying prior general health, since it has been reported that persons with WAD have poor recall/poor reporting of prior symptoms [4]. However, that study was performed in a state with a tort insurance system, which may increase the likelihood of such misclassification. At the time of the current study, Saskatchewan had a 'no-fault' insurance system, and there may have been less incentive to report exaggerated prior good health.

One further limitation to our study is the fact that, although we identified a number of factors that were strongly

associated with post-WAD depression and the course of that depression, it is clear that our models explained only part of the variance in these outcomes. Clearly, there were unmeasured factors that played a role in post-WAD depression. Although we can only speculate on what these factors included, such things as unmeasured aspects of crash characteristics and severity; claimants' expectations of and experiences with health care professionals and with the insurance system; and family and friends' responses to the injured individual, may be important variables to consider in future research in this area.

Conclusion

In a prior study we reported that post crash depression is common following crash related WAD. As a follow-up to that, we now report the characteristics that can assist clinicians to identify not only which patients are more likely to experience post-crash depression, but also identify which are at risk for a more severe course of depression. This is important because depressed mood in those with WAD is not only an additional health burden in itself, but is also associated with slower recovery. The most important characteristics in identifying those with WAD who are likely to experience depression were higher post crash pain, other post-crash symptoms, sustaining a fractured bone, the presence of post-crash anxiety, and the presence of prior mental health problems.

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Conflict of interest statement None.

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