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Pain, Anxiety, and Depression in the First Two Years Following Transport-Related Major Trauma: A Population-Based, Prospective Registry Cohort Study

Melita J. Giummarra, PhD,*,† Pamela Simpson, Grad Dip Biostat,* and Belinda J. Gabbe, PhD, MBiostat*,‡

*Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia; †Caulfield Pain Management and Research Centre, Caulfield Hospital, Caulfield, Victoria, Australia; ‡Health Data Research UK, Swansea University Medical School, Swansea University, Wales, UK

Correspondence to: Melita J. Giummarra, PhD, School of Public Health and Preventive Medicine, Monash University, 553 St Kilda Road, Melbourne, VIC 3004, Australia. Tel: 61-3-9903-0365; fax: 61 3 9903 0556; E-mail: melita.giummarra@monash.edu.

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Abstract

Objectives. This study aimed to characterize the population prevalence of pain and mental health problems postinjury and to identify risk factors that could improve service delivery to optimize recovery of at-risk patients. **Methods.** This population-based registry cohort study included 5,350 adult survivors of transport-related major trauma injuries from the Victorian State Trauma Registry. Outcome profiles were generated separately for pain and mental health outcomes using the "pain or discomfort" and "anxiety or depression" items of the EuroQol Five Dimensions Three-Level questionnaire at six, 12, and 24 months postinjury. Profiles were "resilient" (no problems at every follow-up), "recovered" (problems at six- and/or 12-month follow-up that later resolved), "worsening" (problems at 12 and/or 24 months after no problems at six and/or 12 months), and "persistent" (problems at every follow-up). **Results.** Most participants had persistent (pain/discomfort, N = 2,171, 39.7%; anxiety/depression, N = 1,428, 26.2%) and resilient profiles (pain/discomfort, N = 1,220, 22.3%; anxiety/depression, N = 2,055, 37.7%), followed by recovered (pain/discomfort, N = 1,116, 20.4%; anxiety/depression, N = 1,025, 18.8%) and worsening profiles (pain/discomfort, N = 956, 17.5%; anxiety/depression, N = 948, 17.4%). Adjusted multinomial logistic regressions showed increased risk of problems (persistent, worsening, or resolved) vs no problems (resilient) in relation to female sex, middle age, neighborhood disadvantage, pre-injury unemployment, pre-injury disability, and spinal cord injury. People living in rural areas, motorcyclists, pedal cyclists, and people with head, chest, and abdominal injuries had lower risk of problems. **Discussion.** Targeted interventions delivered to people with the risk factors identified may help to attenuate the severity and impact of pain and mental health problems after transport injury.

Key Words: Trauma; Injury; Recovery; Motor Vehicle; Prognostic

Introduction

Injury is a leading cause of disability globally [1]. In Australia, there are more than 447,000 injury-related hospitalizations each year [2,3], including 16 major trauma traffic-related admissions per 100,000 people living in the state of Victoria [4]. After major trauma and orthopedic injury, about 15% of people develop chronic disabling pain [5], and 10% to 30% develop secondary mental health conditions or symptoms including anxiety, depression, and post-traumatic stress disorder [6–8].

As both pain and mental health conditions after injury are associated with poorer quality of life, longer duration of work disability [9], higher health care use [10], and longer and more costly compensation claims [11,12], we must understand patterns of pain and mental health outcomes postinjury.

To date, many studies have examined trajectories of single symptoms of pain [13,14] or mental health [15–17] over time, with nearly all studies on mental health outcomes focusing on post-traumatic stress disorder (PTSD). These studies show that for mental health outcomes, the majority of people follow a resilience or low–PTSD symptom trajectory (~59–73%), up to one-quarter report persistent symptoms (4–22%), and smaller groups show delayed worsening of symptoms (~6–10%) or early symptoms that recover (~8–13%) [15,17]. Pain trajectories after traumatic injury, with most studies focusing on whiplash injury, have revealed three predominant patterns: mild pain-related disability (45%), moderate pain disability (~39%), and chronic and severe pain disability (~16%) [14]. Only one study examined the relationship between mental health symptom trajectories and pain trajectories; however, both were modeled in isolation and found that people who develop any one of these outcomes tend to report problems across multiple pain and mental health outcome domains [18]. No studies to date have examined trajectories or patterns of pain or mental health outcomes like anxiety or depression after serious injury.

Prognostic and cross-sectional studies have revealed a range of risk factors for pain and mental health conditions after injury, including female sex [12], middle age [12], comorbid conditions [19,20], higher injury severity [5,21,22] or trauma severity [5,22], negative acute psychological response to the injury [21], external attribution of fault or blame [23,24], higher levels of pain catastrophizing [18], poorer pre-injury health [18], and lodging a compensation claim [14,25,26]. However, little is known about the association between these factors and longitudinal outcome patterns, including the recovery, worsening, or persistence of problems over time.

In this population-based, prospective registry cohort study, we used a manual classification procedure to determine whether people had no problems, resolved problems, worsening problems, or persistent problems with pain or discomfort and anxiety or depression. We aimed to a) characterize the population prevalence of problems with pain and mental health (anxiety or depression) in the first two years after transport-related major trauma; b) identify demographic, clinical, and injury-related risk factors for having problems with pain or mental health within 24 months following injury; and c) assess the association between pain and mental health outcomes. In particular, we sought to understand who had problems that recovered, emerged late, or persisted over time in order to inform strategies that service providers and funders specialized in transport-related trauma care and recovery can implement to reduce the burden of pain and mental health conditions after injury.

Methods

Participants

Participants in the Victorian State Trauma Registry (VSTR) were included if they sustained a transport-related injury between January 2008 and October 2014 and were aged 18 years or older at the time of injury. Transport-related injuries were defined as any injury caused by events or circumstances involving at least one motorized vehicle (i.e., motor vehicle, truck, bus, or motorcycle), a vehicle that operates on roads or rails (i.e., trains and trams), or a nonmotorized vehicle (e.g., pedal cycle). Participants were excluded if they died within 24 months of injury or if their injury resulted from an intentional event (i.e., self-harm or assault).

Materials and Procedures

The VSTR has approval from ethics committees at each participating hospital and Monash University. All eligible patients are enrolled and given the opportunity to opt out before the six-month interview (<1% of cases opt out). This specific project received an exemption from the Monash University Human Research Ethics Committee for the analysis of de-identified data (Project Number 1544).

Data Source and Linkage

The VSTR is a population-based registry capturing data on all major trauma patients admitted to one of 138 trauma-receiving hospitals in Victoria [27]. The registry includes cases meeting major trauma criteria of a) death after injury; b) Injury Severity Score (ISS) >12; c) admission to an intensive care unit (ICU) for ≥24 hours, requiring mechanical ventilation for at least part of their ICU stay; and d) urgent surgery for intracranial, intrathoracic, or intra-abdominal injury or fixation of pelvic or spinal fractures.

The Supplementary Data provide an overview of the registry data collection and linkage procedures. The registry was established to aid monitoring of trauma system performance and compliance. Prehospital data (e.g., clinical observations, transport mode), injury event, diagnoses, procedures, injury severity, and preexisting conditions (e.g., psychological, cardiovascular, endocrine disorders) provide a comprehensive description of the population. The VSTR records information on mortality outcomes from the National Coroners Information System and the Victorian Registry of Births, Deaths and Marriages. The VSTR uses structured telephone interviews at six months, 12 months, and 24 months after injury to collect outcomes and to record additional pre-injury characteristics that are not available from hospital records.

Outcome: Pain and Mental Health

The EuroQol Five Dimensions Three-Level questionnaire (EQ-5D-3L) [28] is a standardized tool that is used to measure health-related quality of life. The EQ-5D-3L measures the level of problems on five primary outcome domains of mobility, self-care, usual activities, pain or discomfort, and anxiety or depression [28]. Each dimension is rated from no problems (level 1) to moderate problems (level 2) to severe problems (level 3). The EQ-5D-3L dimensions of pain or discomfort and anxiety or depression were dichotomized into "no problems" (i.e., level 1) and "problems" (level 2 and 3), consistent with the EQ-5D user guide [29] and previous studies [23]. Ratings from the 12-item Short-Form Health Survey Version 1 (SF-12), which is administered in the routine VSTR follow-up interviews, were used to estimate any missing EQ-5D-3L responses for anxiety or depression and pain or discomfort if the EQ-5D was not completed by the patient, or a proxy, using an existing validated algorithm [30]. This algorithm has previously been validated in VSTR cases [31] and allows a direct mapping from SF-12 item responses to the three-level EQ-5D item responses.

A numerical rating scale was used to measure the level of pain experienced at the time of the interview, ranging from 0 (no pain) to 10 (worst possible pain). The SF-12 mental component score (MCS) was used to summarize overall mental health outcomes. The MCS ranges from 0 to 100, where higher scores indicate better mental health, and scores lower than 45.6 have been found to be indicative of potential depressive disorders [32].

Demographics and Pre-injury Health

Covariates that have previously been identified as predictors of developing pain, mental health conditions, and disability were included in the study [5,12,14,18–22,25,26]. Patient demographics included age at the time of injury, sex, highest level of education (did not complete high school, high school completion, advanced diploma, or university education), pre-injury work status, and occupation group at the time of injury. Occupation skill groups were classified based on the Australian Standard Classification of Occupations (ASCO) [33] into six levels: managers and professionals; associate professionals; tradespersons and advanced clerical workers; intermediate sales, clerical, service, production, and transport workers; elementary sales, clerical, and service workers and laborers. Students and people who were unemployed were included as separate groups. The Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) [34] and Accessibility/Remoteness Index of Australia (ARIA) [35] scores were generated from participants' postcode of residence. The IRSAD is calculated from typical education, employment, and family structure in each postcode based on national census data. The Victorian ranked IRSAD decile was summarized into quintiles ranging from 1 (least advantaged) to 5 (most advantaged). As Victoria has very few remote regions, the ARIA categories were collapsed into major cities compared with regional and remote areas (combining inner regional, outer regional, and remote).

Pre-injury comorbidities were characterized from the International Classification of Diseases [10] Australian Modification (ICD-10-AM) diagnosis codes, which were provided to the VSTR from the hospitals. Consistent with previous studies using the VSTR (e.g., Gabbe et al. [36]), the ICD-10-AM diagnosis codes were used to generate Charlson Comorbidity Index (CCI) scores [37,38]. The CCI contains 19 comorbidity categories that are predictive of 10-year mortality, and each condition is assigned a weighted score of 1 (e.g., myocardial infarction), 2 (e.g., diabetes with end-organ damage), 3 (e.g., moderate–severe liver disease), or 6 (e.g., metastatic solid tumor), with higher weightings for conditions that have a higher risk of dying. As people with a comorbidity weighted at >1 have been found to have elevated risk of mortality after major trauma [39] the CCI weightings were classified as 0, 1 and >1. Preexisting substance use (i.e., drug or alcohol conditions) and mental health conditions (i.e., mood, stress and somatoform disorders, and neurotic conditions) present at the time of trauma admission were identified from the ICD-10-AM diagnosis codes (Chapter F) using published criteria developed in a sample from the VSTR [40]. The Australian Coding Standards [41] specify that the diagnosis codes that must be recorded if present during an admission (e.g., pregnancy), and all other conditions are typically coded by the hospital if they affect the episode of care.

Disability in the week before injury was recorded in the six-month interview for all but eight cases whose pre-injury disability level was collected at the 12-month interview. Pre-injury disability was rated in response to the prompt "The level of disability patient reported, during the week before the injury event" (1 = no disability, 2 = mild disability, 3 = moderate disability, 4 = marked disability to 5 = severe disability). Patient recall of pre-injury disability has been validated at six months postinjury [42]. Pre-injury disability level was classified as no disability, mild disability, and moderate to severe disability.

Injury Characteristics

The highest Abbreviated Injury Scale (AIS) 2005, Update 2008, severity scores from three different body regions were squared and summed to calculate the Injury Severity Score (ISS) [43]. Injury severity was classified into five levels to distinguish injuries that accommodate the cut-points for major trauma used by the VSTR, and serious injury was indicated by ISS ≥16 [44]. The nature of injury groups was classified using the maximum AIS body region severity scores. Length of hospital stay was classified into four durations: zero to two days, three to six days, eight to 13 days, and ≥14 days.

Data Analysis

The data were analyzed in Stata, version 14. Plots were generated in Stata or the R statistical environment using the alluvia package [45]. Summary data are presented as frequencies and percentages.

Profiles of reported problems were dichotomized for pain (pain or discomfort) and mental health (anxiety or depression) as reported problems (rating levels of 2 to 3) and no problems (rating level of 1), consistent with previous studies [23,46]. Profile groups were generated for all cases with a minimum of two follow-ups and were classified as resilient (no problems reported at any follow-up, consistent with the definition of resilience as the ability to resist or bounce back from potentially traumatic events [47], such as traumatic injury, with no problems from the respective condition), recovered (problems that were present at six and/or 12 months but not at the final interview/s), worsening problems (no problems at six and/or 12 months but problems reported during the final interview/s), or persistent problems (problems reported at every follow-up) (Table 1). This method is similar to the approach taken to classify time-varying patterns of other types of binary outcomes (e.g. return to work) after major trauma [48]. This manual classification approach was taken because it is not appropriate to run trajectory analyses on data from three or fewer follow-up periods [49].

People who did not complete the EQ-5D-3L or SF-12 at a minimum of two follow-up interviews were considered lost to follow-up. Demographic and injury characteristics associated with loss to follow-up were examined with chi-square tests, and factors associated with loss to follow-up were included in the multivariable analyses.

To confirm that the outcome groups differed in severity of pain (numeric rating scale) and mental health (SF-12 Mental Component Score), we used mixed-effects linear regression, allowing for repeated measures across participants, to model change over time (six, 12, and 24 months). Post hoc simple effects contrasts were then used to examine differences in pain severity and overall mental health across the respective profile groups.

Multinomial logistic regression was used to identify characteristics associated with the pain and mental health outcome profiles, respectively. We used multinomial logistic regression to estimate The relative risk that patients would belong to the recovered, worsening, or persistent problem group relative to the resilient group was estimated. As each "predictor" variable was categorical, each level of a factor was compared with a reference category to generate a relative risk ratio (RRR) and corresponding 95% confidence interval (CI). Multinomial logistic regression assumes the Independence of Irrelevant Alternatives such that elimination of any category of the dependent variable should not change the coefficients of the other categories relative to the reference group. Hausman diagnostic tests of the multivariable analyses revealed no violations of this assumption ($P = 0.57$ to 0.94). Multicollinearity was assessed for all variables selected for inclusion in the multivariable analyses, and no issues were identified. Missing data from the covariates were modeled using multiple imputation by chained equations, which imputes one variable at a time, conditional on the other variables included in the model, through multiple iterations [50]. Twenty imputed data sets were produced and then combined using Rubin's rules [51]. As profiles were estimated from only two assessments in 18.5% of participants, post hoc sensitivity tests statistically examined whether there were differences in the estimates for the whole sample compared with those who had complete follow-up (i.e., excluding those with partial follow-up).

Kappa statistics were used to examine agreement between pain or discomfort and anxiety or depression profiles. A kappa statistic of <0 suggests poor agreement, 0 to 0.20 slight agreement, 0.21 to 0.40 fair agreement, 0.41 to 0.60 moderate agreement, 0.61 to 0.80 substantial agreement, and 0.81 to 1.00 almost perfect agreement [52]. Bowker's asymptotic test for table symmetry was performed to identify unidirectional bias when comparing the classifications for pain/discomfort and anxiety/depression.

Results

Cohort Overview

From 2008 to 2014, a total of 7,800 major trauma cases were admitted to Victorian hospitals after transport-related major trauma, of whom 6,177 met the inclusion criteria. The number of potential participants who were excluded is reported in Figure 1, and a total of 858 (13.9%) people were lost to follow-up. People lost to follow-up differed from those who were followed up on sex, age, education level, geographic remoteness, CCI score, pre-injury disability, pre-injury substance use condition, injury year, road user group, hospital length of stay, injury severity, nature of injury group, and discharge destination (Table 2).

Prevalence of Problems with Pain or Discomfort and Anxiety or Depression

Fifty-seven percent of people reported persistent (N = 2,115, 39.6%) or worsening (N = 939, 17.6%) problems with pain, 1,195 (22.4%) reported no problems with pain, and 1,091 (20.4%) reported recovered pain or discomfort by 24 months postinjury (Table 1). The opposite pattern was apparent for anxiety or depression, with 57% of people reporting no problems (N = 2,021, 37.9%) or recovered problems (N = 1,002, 18.8%), 1,380 (25.9%) reporting persistent problems,

Table 1. Profile definitions based on EQ-5D-3L ratings of pain or discomfort (N = 5,340) and anxiety or depression (N = 5,333) at six, 12, and 24 months postinjury

Profile Group	Criteria 6 mo	12 mo	24 mo	Pain or Discomfort N (%)	Anxiety or Depression N (%)
Resilient				N = 1,195 (22.4)	N = 2,021 (37.9)
	0	0	0	948 (79.3)	1,656 (81.9)
	–	0	0	89 (7.4)	119 (5.9)
	0	–	0	33 (2.8)	63 (3.1)
	0	0	–	125 (10.5)	183 (9.1)
Recovered				N = 1,091 (20.4)	N = 1,002 (18.8)
	1	1	0	372 (34.1)	277 (27.6)
	1	0	0	377 (34.6)	320 (31.9)
	0	1	0	213 (19.5)	257 (25.6)
	–	1	0	49 (4.5)	48 (4.8)
	1	–	0	27 (2.5)	26 (2.6)
	1	0	–	53 (4.9)	74 (7.4)
Worsening				N = 939 (17.6)	N = 930 (17.4)
problems	0	0	1	231 (24.6)	296 (31.8)
	0	1	1	281 (29.9)	266 (28.6)
	1	0	1	301 (32.1)	241 (25.9)
	–	0	1	36 (3.8)	34 (3.7)
	0	–	1	20 (2.1)	38 (4.1)
	0	1	–	70 (7.5)	55 (5.9)
Persistent				N = 2,115 (39.6)	N = 1,380 (25.9)
problems	1	1	1	1,625 (76.8)	1,036 (75.1)
	–	1	1	155 (7.3)	123 (8.9)
	1	–	1	102 (4.8)	59 (4.3)
	1	1	–	233 (11.0)	162 (11.7)

The mental health and persistent pain profiles were based on EQ-5D-3L ratings of anxiety or depression and pain or discomfort, respectively. Participants were defined as having "no problems" (0), or "problems" (1). The "no problems" outcome was indicated by a rating of no problems (rating of level 1) on the respective EQ-5D-3L item, whereas the "problems" (1) outcome was indicated if they reported moderate (rating of level 2) or extreme (rating of level 3) problems on the respective EQ-5D-3L item. Missing data from a single interview are indicated by a dash (–).

EQ-5D-3L = EuroQol Five Dimensions Three-Level questionnaire.

and 930 (17.4%) reporting worsening problems over the first 24 months postinjury.

Symptom Differences and Changes Over Time Between Outcome Profiles

Mixed-effects models showed an interaction between group and time for pain severity (pain intensity; $\chi^2(6) = 679.62$, $P < 0.001$) and overall mental health (SF 12 MCS; $\chi^2(6) = 278.87$, $P < 0.001$), such that symptoms were consistent with the respective group (Figure 2).

Pain severity and overall mental health differed between groups at six, 12, and 24 months, except for the recovered and worsening problems groups at 12 months (Figure 4). Symptoms did not differ over time for the resilient groups (pain: $\chi^2(2) = 0.75$, $P = 0.69$; MCS: $\chi^2(2) = 3.17$, $P = 0.20$) or persistent problems groups (pain: $\chi^2(2) = 1.07$, $P = 0.56$; MCS: $\chi^2(2) = 4.09$, $P = 0.13$). Pain severity and overall mental health improved over time for the recovered (pain: $\chi^2(2) = 403.36$, $P < 0.001$; MCS: $\chi^2(2) = 123.59$, $P < 0.001$) group from six months to 12 months and 24 months and from 12 months to 24 months, and worsened over time for the worsening problems group (pain: $\chi^2(2) = 286.95$, $P < 0.001$; MCS: $\chi^2(2) = 155.18$, $P < 0.001$) from six months and 12 months to 24 months (with no change between six months and 12 months for pain severity).

Predictors of Outcome Profiles

After adjusting for demographic and injury characteristics, people were at higher risk of having worsening or persistent problems with pain (Table 3) and with anxiety or depression (Table 4), relative to the resilient group, if they were female, middle aged, had lower levels of education (i.e., lower than university education), were unemployed before the injury, lived in metropolitan areas or areas of lower socioeconomic advantage, had mild pre-injury disability, or if their injury was compensable. People had lower risk of having persistent problems on both outcomes compared with the resilient group if they were pedal cyclists or if they sustained chest and/or abdominal injuries (relative to orthopedic injuries). People who sustained a spinal cord injury had higher risk of having problems with pain and discomfort and anxiety or depression relative to those with orthopedic injuries.

People had a higher risk of problems with pain, but not anxiety or depression, if they were a pedestrian (recovered problems only) or if they sustained head injuries (recovered, worsening and persistent problems) in the adjusted analyses. On the contrary, people had a higher risk of problems with anxiety or depression, but not pain, if they had pre-injury substance use or psychological conditions (persistent problems only) or at least one condition with a CCI weighting of 1 (worsening problems only), and they had lower risk of persistent problems with anxiety or depression, but not pain, if they were injured as a motorcyclist (persistent problems only). In the adjusted analyses, problems with pain were not associated with having a substance use or mental health condition, disability, or CCI conditions pre-injury. Having recovered from problems with pain was not associated with education level. Recovered problems and worsening problems were not associated with being unemployed or living in a regional and remote area before injury. Being admitted to a major trauma service did not increase the risk of worsening or persistent problems with pain. Road user group was not associated with having problems with pain, with the exception of pedestrians, who had a 46% higher risk of having problems that recover, and pedal cyclists, who had a 67% lower risk of having persistent problems.

Having problems with anxiety or depression was not associated with admission to a major trauma service; having recovered from problems was not associated with education level, pre-injury unemployment, or having CCI conditions; and having problems that recover or worsen was not associated with having a pre-injury substance use or mental health condition. Road user group was not associated with having

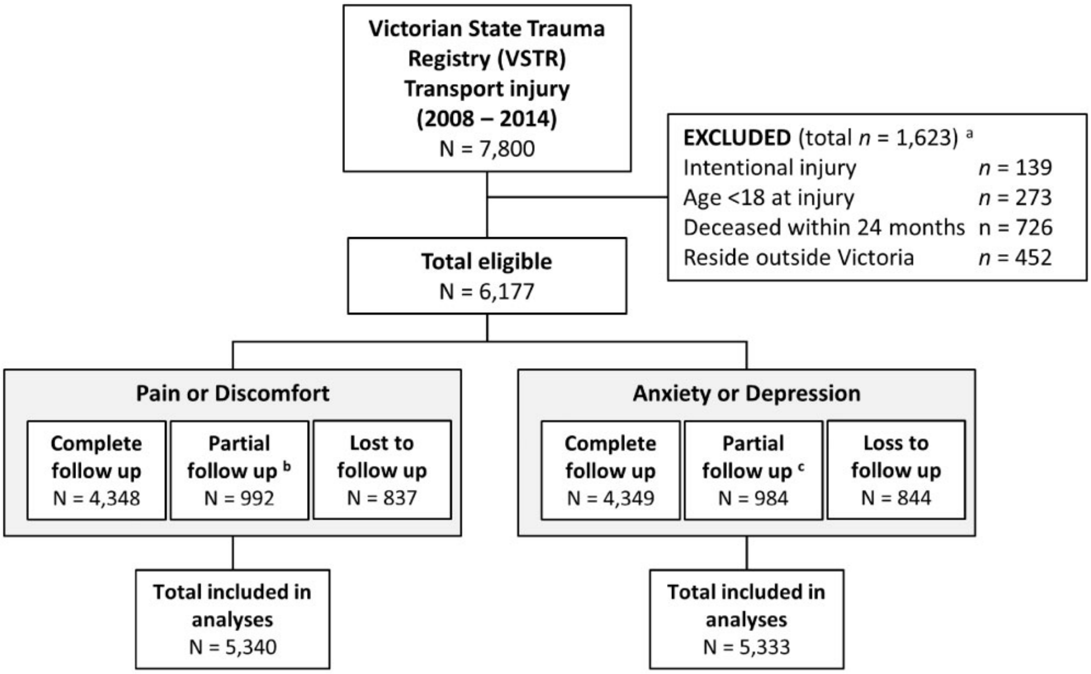

Figure 1. Participant inclusion chart. *Some cases met multiple exclusion criteria. †N = 329 missing six months, N = 182 missing at 12 months, N = 481 missing at 24 months for pain or discomfort outcome. ‡N = 324 missing six months, N = 186 missing at 12 months, N = 474 missing at 24 months for anxiety or depression outcome.

problems with anxiety or depression, with the exception of motorcyclists, who had 36% lower risk of reporting persistent problems, and pedal cyclists who had 41% and 39% lower risk of problems that recover or worsen, respectively, and 60% lower risk of persistent problems.

Sensitivity analyses compared the aRRRs for the whole sample, reported above, with the aRRRs for participants who had complete follow-up. There was some variation in the magnitude of effects for people with recovered problems (pain: $\chi^2(35) = 60.82$, $P = 0.004$; anxiety or depression: $\chi^2(35) = 59.07$, $P = 0.007$), worsening problems (pain: $\chi^2(35) = 52.36$, $P = 0.03$; anxiety or depression $\chi^2(35) = 58.09$, $P = 0.008$) and persistent problems with anxiety or depression ($\chi^2(35) = 52.64$, $P = 0.03$) but not persistent problems with pain ($\chi^2(35) = 48.28$, $P = 0.07$) relative to the resilient group, these differences were predominantly attributable to age and self-reported pre-injury disability (Supplementary Data).

Association Between Pain and Mental Health Outcomes

Although the overall percentage of people who had problems with either outcome was fairly consistent over time, there was substantial variation in individual patterns of problems over time (Figure 3). A third of the cohort (N = 1,875, 34.4%) had persistent or worsening problems with both pain or discomfort and anxiety or depression, a third (N = 1,809, 34.0%) reported no persistent problems (i.e., the resilient and recovered profile groups) with either pain or discomfort and anxiety or depression, 1,209 (22.7%) reported persistent or worsening problems with pain or discomfort only, and 472 (8.9%) reported persistent or worsening problems with anxiety or depression only. Overall there was fair agreement between pain or discomfort and anxiety or depression profiles (kappa = 0.24, 95% CI = 0.23–0.27), suggesting that people with problems with pain tended to have problems with anxiety or depression, and vice versa. Tests of symmetry showed a unidirectional bias in classification such that the cohort showed a higher level of pain problems compared with mental health problems ($\chi^2(6) = 650.99$, $P < 0.001$) (Table 5).

Discussion

In this population-based study comprising 5,350 major trauma transport injury survivors, we found that more than half of the cohort had worsening or persistent problems with pain or mental health over the first two years postinjury. One third had persistent or worsening problems with both pain or discomfort and anxiety or depression, and only a small proportion of patients had problems exclusively with pain or mental health. Importantly, classifying people into groups with recovered, worsening, or persistent problems over time was well validated against the severity of pain (numeric rating scale) and overall mental health (SF-12–MCS) over time, highlighting that using a simple classification system to derive profile groups gave rise to groups with distinct clinical symptoms consistent with their longitudinal profile. In particular, people with persistent problems with pain had pain of moderate to severe intensity over time,

Table 2. Characteristics of participants included compared with those lost to follow-up

		Included N (%)	Complete Loss to Follow-up* N (%)	*P* Value
Total		5,319	858	
Sex	Male	3,885 (73.0)	583 (67.9)	0.002
	Female	1,434 (27.0)	275 (32.1)	
Age group, y	18–24	1,068 (20.1)	195 (22.7)	<0.001
	25–34	885 (16.6)	209 (24.4)	
	35–44	932 (17.5)	165 (19.2)	
	45–54	873 (16.4)	122 (14.2)	
	55–64	679 (12.8)	66 (7.7)	
	65–74	435 (8.2)	54 (6.3)	
	75+	447 (8.4)	47 (5.5)	
Highest education level†	University	964 (18.1)	68 (8.0)	<0.001
	Completed high school	773 (14.5)	71 (8.4)	
	Advanced diploma	1,532 (28.8)	111 (13.1)	
	Did not complete high school	2,050 (38.5)	599 (70.6)	
Region of residence‡	Regional and remote	1,776 (33.9)	224 (26.7)	<0.001
	Major cities	3,460 (66.1)	616 (73.3)	
IRSAD, quintiles§	5 (most advantaged)	1,380 (26.4)	235 (27.6)	0.055
	4	1,511 (28.9)	216 (25.4)	
	3	1,124 (21.5)	172 (20.2)	
	2	613 (11.7)	105 (12.3)	
	1 (least advantaged)	608 (11.6)	123 (14.5)	
Preferred language	English	4,616 (86.8)	715 (83.3)	0.006
	Language other than English	703 (13.2)	143 (16.7)	
Occupation skill group¶	Managers/ professionals	945 (17.9)	54 (11.3)	0.003
	Associate professionals	341 (6.4)	28 (5.9)	
	Trades/advanced clerical	1,108 (20.9)	92 (19.2)	
	Intermediate	672 (12.7)	66 (13.8)	
	Elementary/ laborers	497 (9.4)	50 (10.5)	
	Studying	264 (5.0)	34 (7.1)	
	Unemployed or home duties	1,463 (27.7)	154 (32.2)	
Compensable status	Medicare or private	852 (16.0)	113 (13.2)	0.033
	Compensable (TAC/ Worksafe)	4,467 (84.0)	745 (86.8)	
CCI weight‖	0	3,560 (66.9)	290 (50.4)	<0.001
	1	1,383 (26.0)	245 (42.6)	
	>1	376 (7.1)	40 (7.0)	
Substance use condition‖‖	No	4,707 (90.3)	352 (82.2)	<0.001
	Yes	508 (9.7)	76 (17.8)	

(continued)

Table 2. continued

		Included N (%)	Complete Loss to Follow-up* N (%)	*P* Value
Psychological conditionˆ	No	4,385 (84.1)	350 (81.8)	0.21
	Yes	830 (15.9)	78 (18.2)	
Pre-injury disability	None	4,349 (81.8)	211 (24.6)	<0.001
	Mild	459 (8.6)	25 (2.9)	
	Moderate to severe	511 (9.6)	622 (72.5)	
Injury year	2008	540 (10.2)	217 (25.3)	<0.001
	2009	699 (13.1)	96 (11.2)	
	2010	719 (13.5)	110 (12.8)	
	2011	866 (16.3)	93 (10.8)	
	2012	794 (14.9)	115 (13.4)	
	2013	898 (16.9)	117 (13.6)	
	2014	803 (15.1)	110 (12.8)	
Road user group	Motor vehicle driver	1,951 (36.7)	298 (34.7)	<0.001
	Motor vehicle passenger	705 (13.3)	173 (20.2)	
	Motorcyclist	1,336 (25.1)	176 (20.5)	
	Pedal cyclist	735 (13.8)	78 (9.1)	
	Pedestrian and other	592 (11.1)	133 (15.5)	
Hospital LOS, d	0–2	244 (4.6)	55 (6.4)	<0.001
	3–6	1,712 (32.2)	341 (39.7)	
	7–13	1,962 (36.9)	293 (34.1)	
	14+	1,401 (26.3)	169 (19.7)	
ISS	<13	466 (8.8)	96 (11.2)	<0.001
	13–15	1,423 (26.8)	304 (35.4)	
	16–19	1,357 (25.5)	170 (19.8)	
	20–28	1,167 (21.9)	160 (18.6)	
	>28	906 (17.0)	128 (14.9)	
Nature of injury	Isolated head injury	195 (3.7)	30 (3.5)	<0.001
	Head and orthopedic injuries	1,296 (24.4)	208 (24.2)	
	Spinal cord injury	106 (2.0)	22 (2.6)	
	Orthopedic injuries only	555 (10.4)	85 (9.9)	
	Chest or abdominal injuries only	252 (4.7)	69 (8.0)	
	Chest or abdominal injuries and other orthopedic injuries	2,240 (42.1)	319 (37.2)	
	Other	675 (12.7)	125 (14.6)	
Discharge destination	Home	2,455 (46.2)	455 (53.0)	<0.001
	Other	2,864 (53.8)	403 (47.0)	

CCI = Charlson Comorbidity Index; EQ-5D = EuroQol Five Dimensions Three-Level questionnaire; IRSAD = Index of Relative Socio-Economic Advantage and Disadvantage; ISS = Injury Severity Score; LOS = length of stay; TAC = Transport Accident Commission.

*Complete loss to follow-up for pain or mental health outcomes.

†Missing N = 9, all lost to follow-up.

‡Missing N = 101 including N = 18 lost to follow-up.

§Missing N = 90 including N = 7 lost to follow-up.

¶Missing N = 409, including N = 380 lost to follow-up.

‖Missing N = 283, all lost to follow-up.

‖‖Missing N = 534, including N = 430 lost to follow-up.

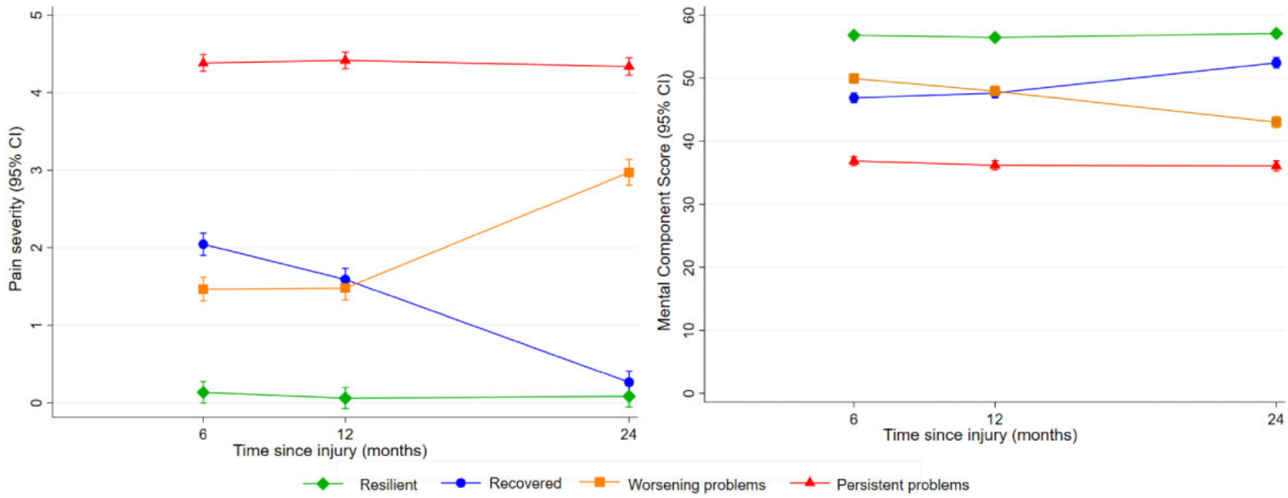

Figure 2. Pain severity and mental component scores (linear prediction, fixed portion, 95% confidence interval) at six, 12, and 24 months across pain and mental health outcome profiles, respectively. Higher mental component scores indicate better mental health, and pain was measured on a numerical rating scale from 0 to 10, where 10 = worst possible pain.

whereas when people in the recovered or worsening problems with pain groups reported pain, it was of a severity that would be considered mild (i.e., <3/10) in the majority of cases. Likewise, only people with worsening or persistent problems with anxiety or depression had mental component scores indicative of probable depression 24 months postinjury, whereas the recovered and resilient anxiety or depression profile groups had mental component scores in the normal range that nonetheless varied in a manner that was consistent with their profile over time.

There was fair agreement between the pain and mental health profiles with a bias toward higher prevalence of worsening or persistent pain problems in those with better mental health profiles (i.e., resilient or recovered). The majority of major cases in this study followed a resilient or recovery pattern of mental health (56.7%) but a worsening or persistent pattern for pain (57.2%), consistent with previous studies of post-traumatic mental health after traumatic injury hospital admission [15,17] or pain after whiplash injury [14]. We found that people had higher risk of worsening or persistent problems with pain and mental health if they were female, were middle aged, had a lower level of education, were unemployed before the injury, lived in metropolitan areas or areas of lower socioeconomic advantage, had pre-injury disability, had a compensable injury, or sustained a spinal cord injury. Pre-injury substance use conditions, psychological conditions, and conditions that increase the risk of mortality increased the risk of having problems with anxiety or depression but did not increase the risk of pain or discomfort.

Women have been found to be twice as likely to develop persistent pain [53] and mental health conditions [54,55] after whiplash [56], spinal cord [57], and orthopedic [58] injury and to have higher rates of treatment for pain or mental health after transport injury [12]. These sex effects have been attributed to both biological (e.g., endogenously inhibition) [59] and social factors (e.g., willingness to disclose or seek help for problems). We further speculate that major trauma may have greater impacts if the injury leads to reduced independence or impaired capacity to fulfill both paid and unpaid occupational roles, including caring for dependent children or aging parents.

In Australia, the prevalence of mental health conditions is about 50% higher in areas with higher socioeconomic disadvantage compared with areas with the lowest socioeconomic disadvantage [60]. This could be due to effects of lower education, poorer health literacy, household instability, limited financial and social resources, and unemployment, which altogether negatively impact physical and mental health [61,62], especially after traumatic injury [63], as per the Social Causation Hypothesis [64]. It is therefore not surprising that people experiencing socioeconomic disadvantage (including pre-injury unemployment) had a higher risk of having problems with anxiety, depression, and pain. It is likely that people who were already unemployed before injury had fewer financial and social resources to cope with the impacts of the injury and may be more reliant on compensation or welfare to support recovery. Compensable injury was associated with worse outcomes in this study. This finding is consistent with previous research, where compensable injury is often found to be independently associated with worse and persistent pain [25], disability [65], and distress after injury, especially in those who already have higher levels of distress at the time of the injury [66] or who find the compensation process itself to be stressful [67].

The risk of persistent problems with pain, and recovered, worsening or persistent problems with mental

Table 3. Factors associated with persistent pain outcome profiles (N = 5,340), multinomial logistic regression

		Recovered vs Resilient aRRR (95% CI)	Worsening vs Resilient aRRR (95% CI)	Persistent vs Resilient aRRR (95% CI)
Sex	Male	1.00	1.00	1.00
	Female	**1.25 (1.01–1.56)**	**1.56 (1.25–1.96)**	**1.68 (1.38–2.05)**
Age, y	18–24	1.00	1.00	1.00
	25–34	**1.60 (1.22–2.12)**	1.23 (0.91–1.66)	**2.15 (1.67–2.77)**
	35–44	**1.70 (1.28–2.27)**	**1.81 (1.34–2.44)**	**3.36 (2.60–4.36)**
	45–54	**1.82 (1.35–2.44)**	**2.06 (1.51–2.81)**	**3.44 (2.62–4.52)**
	55–64	**1.54 (1.13–2.10)**	1.25 (0.89–1.76)	**2.35 (1.76–3.13)**
	65–74	1.34 (0.90–1.99)	**1.79 (1.19–2.70)**	**1.67 (1.15–2.42)**
	75+	1.20 (0.79–1.83)	1.24 (0.79–1.94)	0.85 (0.57–1.26)
Highest education level	University	1.00	1.00	1.00
	Completed high school	1.05 (0.78–1.42)	**1.39 (1.01–1.90)**	1.30 (0.99–1.72)
	Advanced diploma	1.22 (0.96–1.57)	**1.38 (1.05–1.81)**	**1.67 (1.32–2.12)**
	Did not complete high school	1.14 (0.88–1.47)	**1.49 (1.12–1.97)**	**1.91 (1.50–2.43)**
Work before injury	Employed	1.00	1.00	1.00
	Unemployed	1.15 (0.88–1.50)	1.21 (0.91–1.60)	**1.32 (1.04–1.68)**
Region of residence	Regional and remote	1.00	1.00	1.00
	Major cities	1.06 (0.86–1.31)	1.07 (0.86–1.33)	**1.34 (1.10–1.62)**
IRSAD, quintiles	5 (most advantaged)	1.00	1.00	1.00
	4	1.05 (0.83–1.31)	1.12 (0.87–1.43)	1.08 (0.87–1.34)
	3	1.00 (0.75–1.32)	**1.49 (1.12–1.98)**	**1.37 (1.06–1.76)**
	2	1.31 (0.92–1.87)	**1.61 (1.11–2.33)**	**1.95 (1.41–2.69)**
	1 (least advantaged)	1.28 (0.92–1.78)	**1.67 (1.19–2.34)**	**1.82 (1.35–2.45)**
CCI weight	0	1.00	1.00	1.00
	1	0.91 (0.70–1.19)	0.89 (0.67–1.18)	1.09 (0.85–1.38)
	>1	0.96 (0.67–1.36)	0.78 (0.53–1.16)	0.90 (0.64–1.25)
Substance use condition	No	1.00	1.00	1.00
	Yes	0.99 (0.70–1.39)	1.21 (0.85–1.73)	1.02 (0.76–1.39)
Psychological condition	No	1.00	1.00	1.00
	Yes	0.90 (0.66–1.21)	1.14 (0.84–1.55)	0.95 (0.73–1.24)
Pre-injury disability	None	1.00	1.00	1.00
	Mild	1.30 (0.92–1.82)	1.40 (0.97–2.01)	**1.59 (1.15–2.20)**
	Moderate to severe	0.87 (0.63–1.19)	0.85 (0.61–1.17)	1.05 (0.80–1.39)
Major trauma service	No	1.00	1.00	1.00
	Yes	**1.54 (1.11–2.15)**	1.22 (0.86–1.72)	1.24 (0.91–1.68)
Compensable status	Medicare or private	1.00	1.00	1.00
	Compensable (TAC/Worksafe)	**1.83 (1.43–2.34)**	**2.60 (1.97–3.44)**	**4.24 (3.27–5.50)**
Road user group	Motor vehicle driver	1.00	1.00	1.00
	Motor vehicle passenger	1.03 (0.76–1.39)	1.11 (0.82–1.50)	1.27 (0.98–1.65)
	Motorcyclist	1.04 (0.82–1.32)	1.13 (0.88–1.45)	0.99 (0.80–1.22)
	Pedal cyclist	0.76 (0.56–1.03)	0.91 (0.65–1.27)	**0.43 (0.32–0.59)**
	Pedestrian and other	**1.46 (1.07–1.99)**	1.12 (0.80–1.58)	1.28 (0.96–1.70)
Injury group	Orthopedic injury	1.00	1.00	1.00
	Isolated head injury	**0.39 (0.24–0.63)**	**0.37 (0.22–0.63)**	**0.14 (0.08–0.22)**
	Head and other orthopedic	**0.60 (0.43–0.84)**	**0.63 (0.44–0.90)**	**0.45 (0.33–0.62)**
	Spinal cord injury	1.50 (0.63–3.59)	**3.48 (1.50–8.08)**	**2.75 (1.24–6.12)**
	Chest or abdominal injuries only	**0.35 (0.23–0.55)**	**0.24 (0.14–0.40)**	**0.14 (0.09–0.22)**
	Chest or abdominal injuries and other orthopedic injuries	**0.65 (0.47–0.89)**	**0.69 (0.50–0.97)**	**0.52 (0.39–0.70)**
	Other	0.71 (0.48–1.04)	0.97 (0.65–1.44)	0.75 (0.53–1.06)

Significant associations are bolded for emphasis. Missing values for region of residence and IRSAD quintile (N = 83), pre-injury work (N = 6), and substance use and psychological conditions (N = 104) were estimated using multiple imputation with chained equations. The adjusted RRR was considered significant if the confidence interval did not include 1.00. Descriptive statistics (No. (%)) and unadjusted risk ratios are reported in the Supplementary Data.

aRRR = adjusted Relative Risk Ratio; CCI = Charlson Comorbidity Index; CI = confidence interval; IRSAD = Index of Relative Socio-Economic Advantage and Disadvantage; TAC = Transport Accident Commission.

health was higher in people living in regional areas when adjusting for all other demographic, clinical and injury characteristics. To date, few studies have examined regional variations in the prevalence of persistent pain in Australia, although population-adjusted rates of opioid prescribing are markedly higher in regional and remote areas [68,69], which is thought to be a proxy indicator of the absence of accessible high-quality pain management treatment options [70]. The prevalence of mental health conditions across regions is more inconsistent, however, with some studies reporting lower rates of mental health conditions [71] and mental health treatment in rural

Table 4. Factors associated with mental health outcome profiles (N = 5,333), multinomial logistic regression

		Recovered vs Resilient aRRR (95% CI)	Worsening vs Resilient aRRR (95% CI)	Persistent vs Resilient aRRR (95% CI)
Sex	Male	1.00	1.00	1.00
	Female	**1.40 (1.15–1.70)**	**1.43 (1.17–1.75)**	**1.80 (1.50–2.17)**
Age, y	18–24	1.00	1.00	1.00
	25–34	**1.37 (1.06–1.78)**	1.21 (0.92–1.60)	**2.28 (1.79–2.92)**
	35–44	1.30 (0.99–1.71)	**1.63 (1.25–2.12)**	**2.44 (1.90–3.13)**
	45–54	**1.73 (1.32–2.26)**	**1.70 (1.29–2.24)**	**2.25 (1.73–2.93)**
	55–64	1.23 (0.92–1.64)	1.07 (0.79–1.46)	**1.49 (1.12–1.98)**
	65–74	0.79 (0.55–1.14)	0.73 (0.50–1.07)	0.81 (0.57–1.15)
	75+	**0.66 (0.44–0.98)**	**0.52 (0.35–0.78)**	**0.32 (0.22–0.47)**
Highest education level	University	1.00	1.00	1.00
	Completed high school	0.96 (0.72–1.28)	1.01 (0.74–1.37)	**1.45 (1.09–1.92)**
	Advanced diploma	1.05 (0.83–1.34)	**1.34 (1.04–1.73)**	**1.69 (1.32–2.16)**
	Did not complete high school	1.17 (0.92–1.50)	**1.45 (1.12–1.87)**	**2.05 (1.60–2.62)**
Work before injury	Employed	1.00	1.00	1.00
	Unemployed	1.28 (1.00–1.65)	**1.58 (1.23–2.02)**	**2.04 (1.63–2.54)**
Region of residence	Regional and remote	1.00	1.00	1.00
	Major cities	**1.22 (1.01–1.49)**	**1.28 (1.05–1.56)**	**1.63 (1.35–1.96)**
IRSAD, quintiles	5 (most advantaged)	1.00	1.00	1.00
	4	1.01 (0.81–1.25)	0.90 (0.71–1.13)	0.95 (0.77–1.18)
	3	1.07 (0.83–1.38)	1.16 (0.90–1.50)	1.22 (0.97–1.55)
	2	1.11 (0.81–1.54)	**1.40 (1.01–1.92)**	**1.46 (1.08–1.98)**
	1 (least advantaged)	**1.56 (1.16–2.09)**	**1.52 (1.12–2.05)**	**1.72 (1.30–2.28)**
CCI weight	0	1.00	1.00	1.00
	1	1.19 (0.94–1.52)	**1.30 (1.03–1.66)**	1.21 (0.96–1.52)
	>1	1.00 (0.72–1.41)	**1.72 (1.26–2.34)**	1.19 (0.86–1.63)
Substance use condition	No	1.00	1.00	1.00
	Yes	1.29 (0.93–1.77)	1.06 (0.77–1.47)	**1.40 (1.05–1.87)**
Psychological condition	No	1.00	1.00	1.00
	Yes	1.04 (0.78–1.38)	1.28 (0.98–1.66)	**1.45 (1.13–1.86)**
Pre-injury disability	None	1.00	1.00	1.00
	Mild	**1.41 (1.04–1.91)**	1.27 (0.93–1.73)	**1.66 (1.26–2.18)**
	Moderate to severe	1.16 (0.87–1.57)	1.02 (0.75–1.39)	**1.82 (1.40–2.35)**
Major trauma service	No	1.00	1.00	1.00
	Yes	1.11 (0.82–1.52)	1.39 (0.98–1.97)	1.19 (0.87–1.61)
Compensable status	Medicare or private	1.00	1.00	1.00
	Compensable (TAC/Worksafe)	**2.02 (1.56–2.62)**	**1.98 (1.51–2.61)**	**2.53 (1.92–3.33)**
Road user group	Motor vehicle driver	1.00	1.00	1.00
	Motor vehicle passenger	1.28 (0.99–1.66)	1.07 (0.82–1.40)	1.19 (0.94–1.52)
	Motorcyclist	0.81 (0.65–1.01)	0.82 (0.66–1.01)	**0.64 (0.53–0.79)**
	Pedal cyclist	**0.59 (0.43–0.80)**	**0.61 (0.44–0.85)**	**0.40 (0.29–0.55)**
	Pedestrian and other	1.10 (0.83–1.46)	1.08 (0.81–1.44)	1.05 (0.81–1.35)
Injury group	Orthopedic injury	1.00	1.00	1.00
	Isolated head injury	0.69 (0.42–1.13)	0.88 (0.53–1.47)	0.98 (0.62–1.54)
	Head and other orthopedic	**0.74 (0.55–0.99)**	0.94 (0.69–1.28)	0.79 (0.59–1.04)
	Spinal cord injury	**2.20 (1.22–3.97)**	**2.39 (1.26–4.54)**	1.70 (0.92–3.16)
	Chest or abdominal injuries only	**0.55 (0.36–0.86)**	0.81 (0.52–1.26)	**0.53 (0.35–0.81)**
	Chest or abdominal injuries and other orthopedic injuries	**0.68 (0.52–0.88)**	**0.71 (0.54–0.95)**	**0.63 (0.49–0.82)**
	Other	0.86 (0.62–1.18)	1.02 (0.73–1.43)	0.78 (0.57–1.06)

Significant associations are bolded for emphasis. Missing values for region of residence and IRSAD quintile (N = 83), pre-injury work (N = 5), and substance use and psychological conditions (N = 105) were estimated using multiple imputation with chained equations. The adjusted RRR was considered significant if the confidence interval did not include 1.00. Descriptive statistics (No. (%)) and unadjusted risk ratios are reported in the Supplementary Data.

aRRR = adjusted Relative Risk Ratio; CCI = Charlson Comorbidity Index; CI = confidence interval; IRSAD = Index of Relative Socio-Economic Advantage and Disadvantage; TAC = Transport Accident Commission.

areas [72], whereas others show no regional variations in the prevalence of mental disorders [60,73,74]. Although we found that people living in rural areas had higher risk of reporting problems with pain or discomfort and anxiety or depression, it is difficult to know whether this is consistent with population trends or if it reflects the impact of other social, or psychological or treatment access factors that may also vary between metropolitan and regional and remote areas.

Although psychiatric diagnoses typically increase the risk of developing both persistent pain [75] and psychological conditions [76–78] after injury, we found that a prior

Table 5. Number of people classified into pain or discomfort and anxiety or depression profiles, respectively

	Anxiety or Depression Profile				
	Resilient	Recovered	Worsening	Persistent	Total
Pain or discomfort profile					
Resilient	**853**	169	126	67	1,215
Recovered	526	**293**	142	155	1,116
Worsening	340	169	**239**	202	950
Persistent	332	393	439	**995**	2,159
Total	2,051	1,024	946	1,419	5,440

substance use or psychological condition increased the risk of worsening problems with anxiety or depression but did not increase the risk of having problems with pain. People with a preexisting disability were, however, at greater risk of having problems with both pain and anxiety or depression. This may be because conditions associated with disability are often also painful [8,79].

Compared with motor vehicle drivers, we found that pedal cyclists had a lower risk of reporting persistent problems with pain and pedal cyclists and motorcyclists had a lower risk of problems with anxiety or depression, whereas pedestrians had a greater risk of problems with pain that then recovered. A recent study with 74,217 transport injury claimants, also in the State of Victoria, Australia, reported similar patterns, but of a much lower prevalence, across road user groups, with markedly lower rates of treated pain and mental health conditions in pedal cyclists (4.4% and 1.9%, respectively), and higher rates of pain but lower rates of mental health conditions in motor cyclists (8.2% and 2.0%, respectively), and higher rates of both treated conditions in pedestrians (9.3% and 7.3%, respectively) [12]. Although the former study comprised a population-representative cohort of all transport injury claimants, including those with less serious injuries, the present sample comprises major trauma cases only. Moreover, although the magnitude and direction of our risk estimates were similar to the former study, we found that a much higher proportion of motor cyclists, pedal cyclists, and pedestrians with major trauma had recovered, worsening, or persistent problems (pain or discomfort: 73.7%; anxiety or depression: 55.0%) than in the former study. When taken together with the present findings, therefore, it may be that pedestrians are more likely than other road users to seek or receive treatment enabling their problems to resolve. Pedal cyclists typically have the best recovery of all road users, with 92% returning to work and 42% returning to pre-injury function within 12 months of orthopedic injury [36,80], most likely because they are predominantly younger, male, and have better pre-injury health and higher socioeconomic position [80]. It may be that these demographic and recovery characteristics of pedal cyclists, which were adjusted for but not independently examined in pedal cyclists in the present study, covary or directly impact the predominant resilient outcomes in pedal cyclists compared with motor vehicle occupants.

People who sustained a spinal cord injury were the only injury group with an increased risk of having worsening or persistent problems with pain compared with orthopedic injuries. Persistent pain after traumatic spinal cord injury is known to affect about 62% (±18%) of patients, and the level of injury (i.e., complete/incomplete, paraplegia, tetraplegia) does not seem to influence the risk of developing pain [57]. Several types of pain are common after spinal cord injury, including neuropathic pain (e.g., burning, electrical, or shooting pain felt at the level of injury and phantom pain experienced below the level of injury), musculoskeletal pain (e.g., due to increased demands placed on upper limbs or secondary to postural changes), and visceral pain (e.g., due to urinary tract infection or bowel impaction) [81]. People with a spinal cord injury also had increased risk of having mental health problems that recover or worsen (but not those that were persistent), which may reflect the changing and divergent patterns of adjustment in the first two years following such a serious injury.

People who sustained chest/abdominal injuries had lower risk of problems with both pain and anxiety or depression compared with people with orthopedic injuries. Other studies have also shown that this injury group typically have the best recovery outcomes in the first two [36] to three [46] years postinjury compared with other orthopaedic injuries. It may be that patients with chest and abdominal injuries experience fewer problems in general, including pain and mental health problems after injury. People who sustained a head injury had a lower risk of having problems with pain (but not mental health). The incidence of anxiety and depressive disorders in the first year after traumatic brain injury is remarkably similar to the community prevalence of those conditions (i.e., 21% for anxiety and 17% for depression), and the prevalence only increases after the first year to affect 36% to 43% of people after brain injury, respectively [82]. This suggests that people with brain injury may, in fact, cope as well as those with orthopedic injuries in the first 24 months postinjury, and differences may only emerge after the first two years [46].

Implications

The present findings add to the growing literature examining the co-occurrence of pain and mental health symptoms and shared risk factors for both conditions, providing novel insight into longitudinal patterns of pain and anxiety or depression. Several theories have been proposed to explain the co-occurrence of post-traumatic distress (i.e., PTSD symptoms) and pain, which may also apply to other mental health symptoms like anxiety or depression. These models include the mutual maintenance [83], shared vulnerability [84], triple vulnerability [85], diathesis–stress [86], and pain traumatization [87]

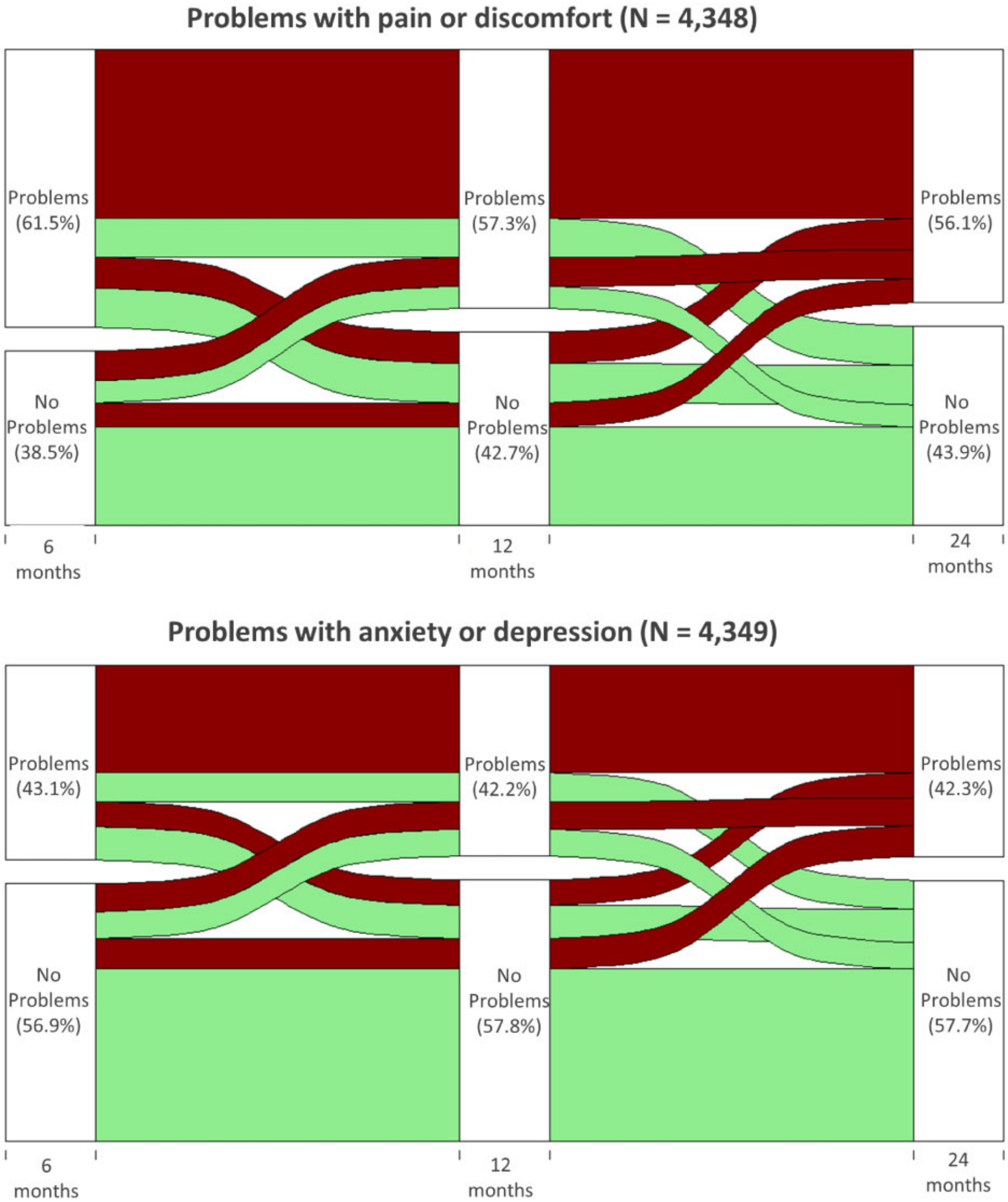

Figure 3. Flow plot showing the proportion of patients who reported no problems (EQ-5D = 1, light/green) or moderate to extreme problems (EuroQol Five Dimensions Three-Level questionnaire = 2 or 3, dark/red) with pain or discomfort and anxiety or depression at six, 12, and 24 months postinjury. The boxes indicate the total number (%) reporting problems or no problems at the respective follow-up interview, and the colored alluvial flow paths indicate the proportion of people transitioning from categories (i.e., problems/no problems) between each follow-up. The shade of color over the whole figure indicate whether people had problems (dark/red) or no problems (light/green) at the final follow-up at 24 months postinjury. This figure therefore allows us to see the proportion of people who reported problems at 24 months who had stable or fluctuating problems over time. Figure 2 only includes cases with complete follow-up.

models, and all emphasize potential shared causal mechanisms underlying the common co-occurrence and/or maintenance of pain and poor mental health outcomes after trauma. The present findings suggest that some preexisting vulnerabilities, particularly socioeconomic disadvantage (i.e., unemployment, neighborhood disadvantage) and preexisting disability, increased the risk of developing problems with both pain and anxiety or depression after major trauma. However, preexisting psychological and health-related vulnerabilities (i.e., preinjury substance use or psychological conditions and comorbid conditions that increase risk of mortality) only increased the risk of reporting mental health problems postinjury and do not increase vulnerability for pain. Therefore, we provide only limited evidence to support "shared vulnerability" models for pain and mental health problems other than PTSD that should be examined further in future studies.

Strengths and Limitations

Key strengths of the present study include the large population-based sample and high rates of prospective follow-up using a standardized and validated outcome assessment battery. This is the first study to examine patterns of pain and mental health over time after transport-related major trauma, and therefore provides novel data on the population prevalence of these problems and their risk factors.

Some limitations of this study should be noted. We manually classified people into the outcome groups based on whether they reported problems at each follow-up interview. This approach was taken because we only had three follow-up interviews, and growth modeling and longitudinal clustering statistical approaches are likely to overidentify linear profiles with only three repeated measures. Ideally growth-type analyses require four or more repeated measures to reliably identify growth patterns [49]. Our approach offers the benefit of simplicity, however, presenting a method that can easily be adopted by clinicians or case managers seeking to monitor injury outcomes in individual cases, small groups, or whole populations. Although the proportion of people belonging to each group was broadly consistent with previous data-driven modeling approaches, future research is recommended to explore whether the same types of profiles or trajectories emerge using data-driven modeling using class and trajectory analyses and whether there are nuanced trajectories that share pain and mental health symptoms over time. This will fill a significant gap in knowledge given that no study has previously used data-driven modeling (e.g., using mixed linear growth modeling approaches) to concurrently examine recovery patterns across pain and mental health symptoms. We are currently using such an approach to identify latent classes and to understand how both pain and mental health symptoms transition over time in a separate cohort of more than 30,000 trauma registry cases.

People who were lost to follow-up were predominantly younger, male, and more seriously injured, and a higher proportion had a preexisting disability or substance use condition, suggesting that there may be responder biases that limit our study generalizability. Moreover, inclusion of people who missed one of the three follow-up interviews may have underestimated the effects of age and preexisting disability on outcome profiles, two key characteristics known to be independently associated with both loss to follow-up and adverse outcome.

The lack of an association between preexisting psychological conditions and pain may be due to the lack of self-report or diagnostic data on prior mental health conditions. Rather, these data were only available from the hospital records and are only mandatorily recorded if the condition affected the treated episode. We know that mental health conditions are typically under-reported during major trauma admissions [40]. Finally, although we did screen for opioid addiction disorders at the time of hospital admission, as part of our "substance use disorders" variable, we did not have access to data on medications received during or after the definitive hospital stay, and therefore could not examine their role in pain or mental health outcomes.

Conclusions

This population-based study showed that more than half of people report worsening or persistent problems with pain or anxiety and depression after transport-related major trauma. These problems often co-occurred, but varied both within and between people over time. Many of the same demographic and injury characteristics increased the risk of problems with pain and mental health. Given that in many settings these risk factors are already recorded in administrative records during or soon after the hospital admission, cases at greater risk of persistent pain or mental health conditions could be identified before or at the time of discharge and referred for ongoing monitoring by the injured person's primary care provider or a case manager. For instance, it is possible to implement electronic medical record–based risk screening in the hospital setting (e.g., to identify people at risk of PTSD using a 10-item risk screening tool) [88]. However, these types of alerts are unlikely to be easy to implement across all trauma and health care settings. Instead, we emphasize that it is simply important that someone managing patient care after major trauma—a primary care or specialist clinician, case manager, or claims manager—understands whether their patient is at greater risk of problems with pain or mental health so that they can monitor their symptoms and facilitate timely treatment to optimize recovery.

Supplementary Data

Supplementary data are available at *Pain Medicine* online.

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