Accident Analysis and Prevention 132 (2019) 105279

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

The road to recovery for vulnerable road users hospitalised for orthopaedic injury following an on-road crash

Anna Devlin[a], Ben Beck[a], Pam M. Simpson[a], Christina L. Ekegren[a], Melita J. Giummarra[a,b], Elton R. Edwards[a,d], Peter A. Cameron[a,f], Susan Liew[d,e], Andrew Oppy[g], Martin Richardson[h], Richard Page[i,j], Belinda J. Gabbe[a,c,*]

[a] School of Public Health and Preventive Medicine, Monash University, Faculty of Medicine, Nursing and Health Sciences, 553 St Kilda Road, Melbourne, VIC, 3004, Australia
[b] Caulfield Pain Management and Research Centre, Caulfield Hospital, 260 Kooyong Road, Caulfield, VIC, 3162, Australia
[c] Health Data Research UK, Swansea University Medical School, Swansea University, Singleton Park Swansea, United Kingdom
[d] Department of Orthopaedic Surgery, The Alfred Hospital, Melbourne, Australia
[e] Department of Surgery, Monash University, Melbourne, Australia
[f] Emergency and Trauma Centre, The Alfred Hospital, Melbourne, Australia
[g] Department of Trauma and Orthopaedic Surgery, The Royal Melbourne Hospital, Melbourne, Australia
[h] Department Surgery, Epworth Clinical school, University of Melbourne, Melbourne, Australia
[i] Barwon Centre for Orthopaedic Research and Education, Barwon Health and St John of God Hospital Geelong, 80 Myers St, Geelong 3220, Australia
[j] School of Medicine, Deakin University, 75 Pigdons Road, Waurn Ponds 3216, Australia

ARTICLE INFO

Keywords:
Pedestrian
Pedal cyclist
Cyclist
Motorcyclist
Motorcycle rider
Bicyclist
Orthopaedic injury
Quality of life
Road crash

ABSTRACT

Background: Pedestrians, cyclists and motorcyclists are vulnerable to serious injury due to limited external protective devices. Understanding the level of recovery, and differences between these road user groups, is an important step towards improved understanding of the burden of road trauma, and prioritisation of prevention efforts. This study aimed to characterise and describe patient-reported outcomes of vulnerable road users at 6 and 12 months following orthopaedic trauma.

Methods: A registry-based cohort study was conducted using data from the Victorian Orthopaedic Trauma Outcomes Registry (VOTOR) and included pedestrians, cyclists and motorcyclists who were hospitalised for an orthopaedic injury following an on-road collision that occurred between January 2009 and December 2016. Outcomes were measured using the 3-level EuroQol 5 dimensions questionnaire (EQ-5D-3 L), Glasgow Outcome Scale – Extended (GOS-E) and return to work questions. Outcomes were collected at 6 and 12 months post-injury. Multivariable generalized estimating equations (GEE), adjusted for confounders, were used to compare outcomes between the road user groups over time.

Results: 6186 orthopaedic trauma patients met the inclusion criteria during the 8-year period. Most patients were motorcyclists (42.8%) followed by cyclists (32.6%) and pedestrians (24.6%). Problems were most prevalent on the usual activities item of the EQ-5D-3 L at 6-months post-injury, and the pain/discomfort item of the EQ-5D-3 L at 12 months. The adjusted odds of reporting problems on all EQ-5D-3 L items were lower for cyclists when compared to pedestrians. Moreover, an average cyclist had a greater odds of a good recovery on the GOS-E, (AOR 2.75, 95% CI 2.33, 3.25) and a greater odds of returning to work (AOR = 3.13, 95% CI 2.46, 3.99) compared to an average pedestrian.

Conclusion: Pedestrians and motorcyclists involved in on-road collisions experienced poorer patient-reported outcomes at 6 and 12 months post-injury when compared to cyclists. A focus on both primary injury prevention strategies, and investment in ongoing support and treatment to maximise recovery, is necessary to reduce the burden of road trauma for vulnerable road users.

* Corresponding author at: School of Public Health and Preventive Medicine, Monash University, 553 St Kilda Rd, Melbourne, Victoria, 3004, Australia.
E-mail addresses: Anna.Devlin@monash.edu (A. Devlin), Ben.Beck@monash.edu (B. Beck), Pamela.Simpson@monash.edu (P.M. Simpson), Christina.Ekegren@monash.edu (C.L. Ekegren), Melita.Giummarra@monash.edu (M.J. Giummarra), ere@bigpond.net.au (E.R. Edwards), Peter.cameron@monash.edu (P.A. Cameron), s.liew@alfred.org.au (S. Liew), Andrew.Oppy@mh.org.au (A. Oppy), orthovic@gmail.com (M. Richardson), richard.page@deakin.edu.au (R. Page), Belinda.Gabbe@monash.edu (B.J. Gabbe).

https://doi.org/10.1016/j.aap.2019.105279
Received 6 March 2019; Received in revised form 1 July 2019; Accepted 21 August 2019
Available online 03 September 2019

1. Introduction

Pedestrians, cyclists and motorcyclists are considered vulnerable road users, and according to the World Health Organization comprise more than half of all global road transport fatalities (World Health Organization, 2018). Vulnerable road users have limited external devices to protect them from mechanical force during a crash and are therefore more susceptible to sustaining serious trauma. The effects of road trauma on vulnerable road users extend well beyond the physical injuries. Traumatic road injuries can cause psychological distress, which may become prolonged in the form of mental illnesses such as post-traumatic stress disorder, and generalised anxiety disorder (Holbrook et al., 2005; Vincent et al., 2015). Involvement in a road transport crash also increases vulnerability to experiencing problems with social and physical functioning, and can negatively impact on health-related quality of life (Gabbe et al., 2017; Papadakaki et al., 2017). Furthermore, a proportion of people involved in a traumatic road-transport injury will go on to develop chronic pain that persists for greater than six months, which can significantly impact upon performing daily activities and working capacity (Rosenbloom et al., 2013). The societal burden of orthopaedic transport injury is borne through the high costs of hospitalisation and treatment (Beck et al., 2017a), loss of work productivity (Gabbe et al., 2007), involvement in adversarial aspects of compensation schemes (Ioannou et al., 2016) and misuse of prescription opioids to name a few (Hahn et al., 2018).

Previous studies have examined injury outcomes for vulnerable road users in the hospital setting, with a focus on length of stay and injury characteristics (Brockamp et al., 2017; Cevik et al., 2013; O'Hern et al., 2015). Others have investigated long-term outcomes such as return to work, function and quality of life (Dinh et al., 2016; Gabbe et al., 2017; Kenardy et al., 2017). Of the longitudinal studies conducted, the prevalence of people reporting problems up to two and three years post-injury from road trauma in Australia remains high, indicating that further research in this area is warranted to attenuate the burden of road trauma for our most vulnerable road users (Gabbe et al., 2017; Kenardy et al., 2017). Vulnerable road user groups included in studies to date are rarely considered separately, and pedestrians are often combined with cyclists (Gabbe et al., 2017; Heron-Delaney et al., 2017; Kenardy et al., 2017). Consequently, the rate of recovery and improvements in health-related quality of life for different types of vulnerable road users after orthopaedic injury remains unclear. Prior research has demonstrated that pedestrians sustain higher rates of severe head injury compared to motor vehicle drivers (Reith et al., 2015), and when compared to other vulnerable road users, comprise a larger proportion of older adults (Vanlaar et al., 2016). Unlike pedestrians and motorcyclists, cyclists generally have the best improvements in health status over time (Tournier et al., 2014; Vanlaar et al., 2016). The group most commonly admitted to hospital after a motorcycle-related injury comprise young males with low education (Papadakaki et al., 2018). Few longitudinal studies have investigated health outcomes of motorcyclists compared to other road users (Hours et al., 2010), however it has been reported that compared to other vulnerable road user groups a larger proportion of motorcyclists experience pain six months after the injury (Hours et al., 2010). There is a need for longitudinal studies to explore health outcomes of injured motorcyclists over longer periods of time.

Understanding and improving mental and physical health recovery specific to each vulnerable road user group after orthopaedic transport injury is an important step towards improving care post-discharge from hospital. Identifying factors that place an individual at risk of experiencing poor quality of life outcomes could assist with the delivery of targeted interventions and detection of financial resources to specific individuals at an appropriate time along the journey to recovery. The aim of the present study was to characterise and describe patient reported outcomes of vulnerable road users at 6 and 12 months post-injury for pedestrians, cyclists and motorcyclists who sustained an orthopaedic injury following an on-road collision.

2. Methods

2.1. Victorian Orthopaedic Trauma Outcomes Registry (VOTOR)

The VOTOR includes patients admitted with orthopaedic injury to four hospitals in Victoria, including two major trauma centres, one metropolitan trauma centre and one regional trauma centre. Patients are included in the registry if they are aged $\geq$ 16 years, and have a length of hospital stay > 24 h following orthopaedic trauma. Patients are excluded if they have a pathological fracture related to metastatic disease or an isolated soft tissue injury managed non-operatively. Patient outcomes are collected via telephone interview at 6, 12 and 24 months post-injury. At each interview, the patient can choose to opt-off from the registry, with a current opt-off rate of less than one percent. Regular linkage with the Births, Deaths and Marriages Registry is conducted to identify post-discharge deaths. Ethics approval for the registry has been granted by the Monash University Human Research Ethics Committee (HREC), each participating hospital, and the Department of Health and Human Services HREC.

2.2. Participants

Participants registered to the VOTOR were included in this study if they were admitted to hospital as a result of an injury as a pedestrian, pedal cyclist, or motorcycle rider in a crash that occurred on a public road, street or highway. This registry-based cohort study included eligible patients who survived to hospital discharge, with a date of injury from 1st January 2009 to 31st December 2016, and included outcomes collected at 6 and 12 months post-injury, as the 24 month interview was added later and therefore not available for all cases. The International Statistical Classification for Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) codes for external causes were used to identify pedestrians (V00-V09), cyclists (V10-V19), and motorcyclists (V20-V29) injured in a transport crash.

2.3. Data collection

Patient demographics, major trauma status (defined as an Injury Severity Score > 12) (Palmer et al., 2016), nature of injury, pre-existing conditions, pre-injury work status, highest level of education completed, funding source and patient reported outcomes were extracted from the registry.

The Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) was used to measure socioeconomic status based on residential postcode. The IRSAD deciles were summarised into quintiles with quintile one indicating the most disadvantaged neighbourhoods and quintile five indicating the most advantaged neighbourhoods. Patient age was stratified into five categories (16–24, 25–34, 35–54, 55–75, 75+ years), and ICD-10-AM injury diagnoses were grouped into eight primary nature of injury categories. Comorbid health conditions were measured using the Charlson Comorbidity Index (CCI) mapped from ICD-10-AM codes, with zero representing no CCI comorbidities, one representing at least one comorbidity with a weight of one, and two representing at least two comorbidities with a weight of two or greater. Pre-existing mental health, drug or alcohol conditions were mapped from ICD-10-AM codes. Pre-injury disability was obtained by asking patients to report their level of disability in the week prior to injury as none, mild, moderate, marked or severe in the six month follow up interview. This question has been validated for recall up to six months post-injury (Williamson et al., 2012).

The funding source was categorised as: Transport Accident Commission (TAC), WorkSafe or other compensable, Private insurer or Department of Veteran Affairs, and universal health care (Medicare). In Victoria, Australia there is a no-fault compensation system in place for work-related injuries (WorkSafe Victoria) and road transport-related injuries (TAC) that fund medical expenses including treatment, loss of

Table 1
Profile of patients injured as a motorcycle driver, pedestrian, or pedal cyclist on a road, street or highway who were admitted to hospital and survived to discharge.

	Motorcyclist (n = 2650)	Cyclist (n = 2014)	Pedestrian (n = 1522)	*p*-value
Age, mean (SD)	37.8 (13.9)	44.6 (14.4)	48.8 (21.9)	< 0.001
Sex				< 0.001
Male	2,466 (93.1%)	1579 (78.4%)	811 (53.3%)	
Female	184 (6.9%)	435 (21.6%)	711 (46.7%)	
Age group				< 0.001
16-24 years	554 (20.9%)	157 (7.8%)	264 (17.3%)	
25-34 years	676 (25.5%)	405 (20.1%)	254 (16.7%)	
35-54 years	1,036 (39.1%)	928 (46.1%)	383 (25.2%)	
55-74 years	376 (14.2%)	483 (24.0%)	367 (24.1%)	
75+ years	8 (0.3%)	41 (2.0%)	254 (16.7%)	
Funding source				< 0.001
TAC	2,368 (89.8%)	822 (41.6%)	1,392 (92.0%)	
WorkSafe/Other compensable	36 (1.4%)	14 (0.7%)	35 (2.3%)	
Private/Department of Veteran Affairs	41 (1.6%)	341 (17.3%)	29 (1.9%)	
Medicare/not compensable	192 (7.3%)	798 (40.4%)	57 (3.8%)	
Discharge destination[b]				< 0.001
Home	1,685 (63.6%)	1,664 (82.7%)	617 (40.5%)	
Rehabilitation	901 (34.0%)	317 (15.7%)	836 (54.9%)	
Hospital for convalescence	38 (1.4%)	22 (1.1%)	45 (3.0%)	
Other	25 (0.9%)	10 (0.5%)	24 (1.6%)	
Working prior[c]				< 0.001
No	339 (13.8%)	266 (14.0%)	618 (46.4%)	
Yes	2,125 (86.2%)	1633 (86.0%)	713 (53.6%)	
Occupation group (ASCO)[d]				< 0.001
Professionals	292 (15.0)	659 (44.1)	145 (25.7)	
Tradespersons	709 (36.3)	157 (10.5)	99 (17.5)	
Associate professionals	180 (9.2)	234 (15.7)	57 (10.1)	
Managers and administrators	172 (8.8)	221 (14.8)	42 (7.4)	
Intermediate production and transport workers	222 (11.4)	38 (2.6)	50 (8.8)	
Intermediate clerical, sales and service workers	117 (6.0)	82 (5.5)	56 (9.9)	
Elementary clerical, sales and service workers	95 (4.9)	36 (2.4)	40 (7.1)	
Self-employed (not further specified)	88 (4.5)	26 (1.7)	32 (5.7)	
Labourers and related workers	54 (2.8)	18 (1.2)	34 (6.0)	
Education Level[e]				< 0.001
University	449 (24.9%)	1,051 (56.5%)	276 (23.0%)	
Completed high school	329 (18.3%)	188 (10.1%)	178 (14.8%)	
Advanced diploma	933 (51.8%)	410 (22.0%)	287 (23.9%)	
Did not complete high school	691 (38.3%)	212 (11.4%)	459 (38.3%)	
Charlson Comorbidity Index				< 0.001
None	2,218 (83.7%)	1,821 (90.4%)	1,045 (68.7%)	
CCI = 1	345 (13.0%)	163 (8.1%)	368 (24.2%)	
CCI > 1	87 (3.3%)	30 (1.5%)	109 (7.2%)	
Nature of injury				< 0.001
Isolated upper extremity	477 (18.0%)	706 (35.1%)	160 (10.5%)	
Multiple upper extremity	185 (7.0%)	193 (9.6%)	42 (2.8%)	
Isolated lower extremity	549 (20.7%)	372 (18.5%)	496 (32.6%)	
Multiple lower extremity	305 (11.5%)	71 (3.5%)	174 (11.4%)	
Upper & lower extremity	373 (14.1%)	108 (5.4%)	182 (12.0%)	
Spinal injuries only	223 (8.4%)	328 (16.3%)	140 (9.2%)	
Spinal injuries other	490 (18.5%)	215 (10.7%)	305 (20.0%)	
Amputation and soft tissue injuries	48 (1.8%)	21 (1.0%)	23 (1.5%)	
Socioeconomic status (IRSAD)[f]				< 0.001
1 (Most disadvantaged)	426 (16.4%)	115 (5.8%)	281 (19.1%)	
2	461 (17.7%)	152 (7.6%)	180 (12.2%)	
3	517 (19.9%)	275 (13.8%)	232 (15.8%)	
4	578 (22.2%)	428 (21.5%)	284 (19.3%)	
5 (Least disadvantaged)	622 (23.9%)	1,017 (51.2%)	495 (33.6%)	
Associated injuries				
Traumatic brain injury	227 (8.6%)	185 (9.2%)	312 (20.5%)	< 0.001
Intra-abdominal organ injury	316 (11.9%)	55 (2.7%)	147 (9.7%)	
Intra-thoracic organ injury	644 (24.3%)	339 (16.8%)	255 (16.8%)	< 0.001
Multiple rib fractures	636 (24.0%)	396 (19.7%)	298 (19.6%)	
Burns	32 (1.2%)	3 (0.1%)	16 (1.1%)	< 0.001
Major Traumatic Injury				
Yes	1124 (42.4%)	608 (30.2%)	666 (43.8%)	
Pre-existing mental health condition				< 0.001
No	2,488 (93.9%)	1,933 (96.0%)	1,357 (89.2%)	
Yes	162 (6.1%)	81 (4.0%)	165 (10.8%)	
Pre-existing drug or alcohol condition				< 0.001
No	2,507 (94.6%)	1,963 (97.5%)	1,315 (86.4%)	
Yes	143 (5.4%)	51 (2.5%)	207 (13.6%)	
Pre-injury disability rating[g]				< 0.001
None	2,171 (89.4%)	1,723 (91.7%)	1,027 (79.4%)	

(*continued on next page*)

Table 1 (*continued*)

	Motorcyclist (n = 2650)	Cyclist (n = 2014)	Pedestrian (n = 1522)	*p*-value
Mild	163 (6.7%)	110 (5.9%)	160 (12.4%)	
Moderate	60 (2.5%)	33 (1.8%)	74 (5.7%)	
Marked/severe	34 (1.4%)	13 (0.7%)	32 (2.5%)	

[a] n = 61 missing; [b] n = 2 missing; [c] n = 492 missing; [d] if working prior to injury, ASCO, Australian Standard Classification of Occupations [e] n = 723 missing ; [f] n = 123 missing ; [g] n = 586 missing.

earnings, and ongoing support. During the study period, cyclist injuries were covered by the TAC if they were injured in a collision with a motor vehicle, including with an open or opening car door. Additionally, cases where the cyclist did not collide with a motor vehicle but the crash resulted from the driving of a motor vehicle, or a collision with a stationary vehicle (for crashes on or after 9 July 2014), were covered by the TAC. Pedestrian related injuries were covered by the TAC when their injuries arose as a direct result of impact with a motor vehicle, motorcycle, train or tram. Motorcyclists were covered by TAC except for transport crashes involving an unregistered motorcycle on private land. The road user counterparts were classified according to ICD-10-AM external cause codes according to the following criteria: car, pick-up truck or van, non-collision (including fallen or thrown from pedal cycle or motorcycle), fixed or stationary object, cyclist, heavy vehicle or bus, two or three-wheeled motor vehicle, animal or pedestrian, and railway train (includes train or light rail tram).

Three outcome measures collected at six and 12 months post-injury were examined. The 3-level EuroQol 5 dimensions questionnaire (EQ-5D-3 L) was used to measure health-related quality of life, and comprises the following dimensions; mobility, self-care, usual activities, pain/discomfort and anxiety/depression (Dolan, 1997). Each dimension is rated as no problems, some/moderate problems, and severe/extreme problems, and responses were collapsed into two categories (no problems, and some-severe problems) for analysis. The United Kingdom tariffs were used to generate the EQ-5D preference score, which results in a utility score ranging from -0.594 to 1, whereby one represents perfect health, zero represents death, and < 0 represents a health state worse than death. Level of function was measured using the Glasgow Outcome Scale-Extended (GOS-E). The GOS-E classifies recovery into eight categories, where one indicates death and eight indicates upper good recovery representing a return to pre-injury function (Wilson et al., 1998). The GOS-E was dichotomised for this study as good recovery (GOS-E = 7 or 8) and less than a good recovery (GOS-E $\leq$ 6). Good inter-rater reliability has been found for the GOS-E and it has been recommended for use in injury populations (Ekegren et al., 2016; Williamson et al., 2012). Return to work or study status (yes/no) was defined as return to work or study in any capacity for patients who were working or studying prior to injury. In circumstances where the patient was unable to complete the interview (i.e., if the patient experiences cognitive or physical problems that precludes them from participating), their immediate next of kin or carer was interviewed.

2.4. Data analysis

Descriptive statistics were used to present demographics for each road user group at baseline. Patients were considered lost to follow-up if the GOS-E was missing at both 6 months and 12 months. Deaths that occurred post-discharge were counted as successful follow-up as outcomes were known for these patients and a GOS-E score could be allocated.

To compare the difference between road users for health-related quality of life, return to work and function, multivariable linear and logistic generalized estimating equations (GEE) with an exchangeable working correlation matrix were employed to account for repeated measures for each patient (Hubbard et al., 2010). The GEE models provide estimates that are population-averaged effects of the difference between road users. Pedestrians were the reference group in all analyses. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) were reported for all dichotomous outcomes, and adjusted means with 95% CI were calculated for the EQ-5D-3 L preference score.

The percentage of cases omitted from each model due to missing data was less than 4% and therefore complete case analyses were conducted. Covariates that were identified in published studies as predictors of outcome were included in the models: age, sex, injury severity (i.e., a major traumatic injury), the presence of associated non-orthopaedic injuries, education level, pre-injury disability, comorbid status (CCI weighting), socio-economic status (IRSAD) and injury type. A *p*-value of < 0.05 was considered statistically significant. Data analysis was performed using Stata (Version 15, StataCorp, College Station,TX).

3. Results

There were 8528 injury pedestrians, motorcyclists and cyclists during the study period of which 6186 (72.5%) were injured on a road, street or highway, and therefore met the inclusion criteria for the study (Table 1). One hundred and thirty-three patients (2.2%) died during their hospital stay including 27 motorcyclists, 16 cyclists and 90 pedestrians. A further 48 patients died post-discharge prior to the 12-month follow up time point (Fig. 1).

The follow-up rates at 12 months post-injury were 84% for motorcyclists, 88% for cyclists and 80% for pedestrians. Over the study period, 799 patients (12.9%) did not record a GOS-E score at 6 months and 936 patients did not report a GOS-E at 12 months (15.1%). Of these, 524 patients (8.5%) did not complete a GOS-E at 6 and 12 months and were therefore considered lost to follow-up (Appendix 1). Patients lost-to follow-up were younger, had a higher prevalence of a pre-existing mental health, drug or alcohol condition, reported a greater level of pre-injury disability and were more commonly classified as major trauma (Appendix 1).

There were differences between the road user groups for age, education level, discharge destination and pre-morbid levels of disability (Table 1). The mean (SD) age of motorcyclists, cyclists and pedestrians was 37.8 (13.8) years, 44.6 (14.4) years and 48.8 (21.9) years respectively. A larger proportion of motorcycle riders were male (93.1%) compared to pedal cyclists (78.4%) and pedestrians (53.3%). Motorcyclists were more commonly male (93%), aged between 35–54 years and approximately 40% had not completed high school. Over half of the cyclists had completed a University degree and 51% were in the highest quintile of socioeconomic advantage. While a higher proportion of motorcyclists and cyclists were working prior to injury compared to pedestrians, the type of occupation differed by road user group. Consistent with higher levels of socioeconomic advantage, a higher proportion of cyclists were employed in professional, associate professional and managerial occupations. A lower proportion of cyclists had co-morbid health conditions compared to pedestrians and

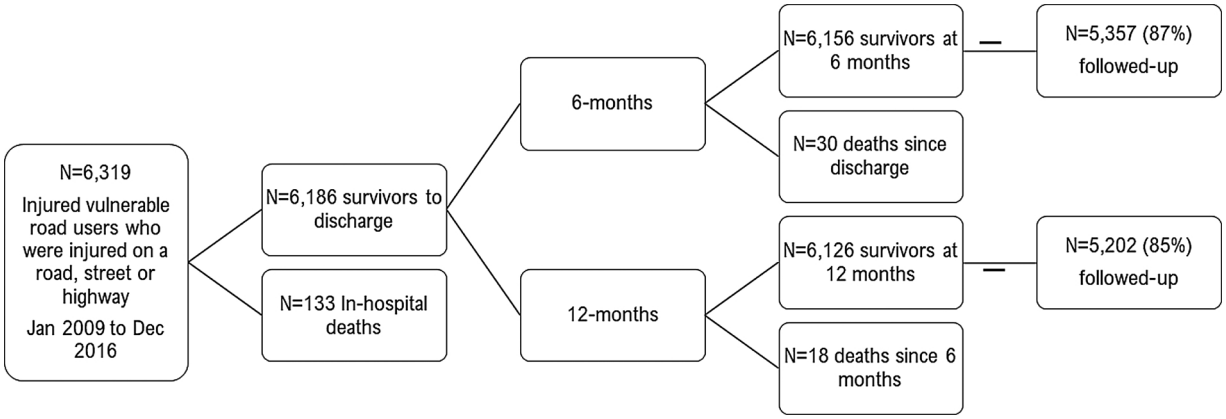

Fig. 1. Flow of participants through the study.

motorcyclists. Most motorcyclists and pedestrians were funded by the TAC (89.8% and 90.0%), while only 42% of the cyclists were supported by the TAC. A higher proportion of pedestrians were aged above 75 years compared to the other road user groups and just under half of all pedestrians included in the study were not working prior to injury. A larger proportion of pedestrians reported disability prior to injury (20.6%) compared to motorcyclists (10.6%) and cyclists (8.4%). Similarly, a larger proportion of pedestrians had a prior mental health, drug or alcohol condition and one or more co-morbidities (Table 1).

Motorcyclists and pedestrians sustained injuries of greater severity, and a higher proportion sustained spinal injuries and isolated lower extremity injuries, than cyclists (Table 1). A larger proportion of pedestrians sustained a traumatic brain injury than cyclists and motorcyclists. Amongst cyclists, isolated upper extremity injuries were the most common (35.1%) followed by isolated lower extremity injuries (18.5%). Most (82.7%) cyclists were discharged to home compared to 41% of pedestrians and 64% of motorcyclists. Approximately half of all pedestrians were discharged from hospital to in-patient rehabilitation.

Differences in collision counterparts were observed between road users (Table 2). The road user with the highest proportion of crashes involving a collision with a car, pick-up truck or van was pedestrians (87%). The highest proportion of cyclist counterparts were non-collisions (fallen or thrown from the bicycle) (41%), followed by collisions with a car, pick-up truck or van (36%).

The prevalence of patients reporting problems at 6 and 12 months post-injury is displayed according to each EQ-5D-3 L domain and road user group in Table 3 and Fig. 2. More than half of motorcyclists and pedestrians reported problems with usual activities at both 6 and 12 months (Table 3). Only 44% of cyclists reported problems with usual activities at 6 months, and a third reported problems at 12 months. At 12 months post-injury, problems with pain were most prevalent across all road user groups. A higher proportion of motorcyclists (63%) and pedestrians (66%) reported problems with pain at 12 months compared to cyclists (37%).

Compared to the average pedestrian, the adjusted odds of reporting problems with anxiety/depression at follow-up were 25% lower for motorcyclists (Table 3). The adjusted odds of reporting problems on each EQ-5D-3 L item were significantly lower for the average cyclist when compared to pedestrians (Table 3). The mean (SD) EQ-5D-3 L summary score at 6 months was 0.60 (0.31) for pedestrians, 0.67 (0.27) for motorcyclists and 0.82 (0.20) for cyclists. At 12 months, the mean (SD) summary score had risen to 0.62 (0.31) for pedestrians, 0.69 (0.29) for motorcyclists and 0.84 (0.21) for cyclists (Fig. 2). The adjusted mean EQ-5D-3 L score was 0.12 (95% CI 0.10, 0.14) higher for cyclists when compared to pedestrians.

The prevalence of return to work and independent functional recovery at 6 and 12 months post-injury are presented in Table 4, and Fig. 3. A higher proportion of motorcyclists (86.2%) and cyclists (86.0%) were working prior to the injury compared to pedestrians (53.6%). A higher proportion of cyclists returned to work at 6 and 12 months post-injury compared to motorcyclists and pedestrians. At 12 months post-injury, 93% of pedal cyclists had returned to work, in comparison to 71% of motorcycle riders and 63% of pedestrians. The adjusted odds return to work, and reporting a good recovery, was 3.1 and 2.8 fold higher, respectively, for an average cyclist when compared to an average pedestrian (Table 4).

4. Discussion

We explored the demographic and injury characteristics, and longer term outcomes, of vulnerable road users who sustained orthopaedic injuries. To our knowledge, this is the first longitudinal study that has

Table 2
Collision partners of patients injured as a motorcycle driver, pedal cyclist or pedestrian on a road, street or highway.

	Motorcyclists[a] (n = 2,650)	Cyclists[b] (n = 2,014)	Pedestrians[c] (n = 1,522)
Car, pick-up truck or van	1,175 (48.5%)	667 (36.2%)	1,244 (86.6%)
Non-collision (includes fall or thrown from pedal or motor cycle)	702 (29.0%)	735 (40.8%)	–
Fixed or stationary object	322 (13.3%)	105 (5.7%)	11 (0.8%)
Pedal cyclist	*	146 (7.9%)	12 (0.8%)
Other and unspecified	89 (3.7%)	85 (4.6%)	22 (1.5%)
Heavy vehicle or bus	50 (2.1%)	43 (2.3%)	79 (5.5%)
Two or three-wheeled motor vehicle	38 (1.6%)	*	33 (2.3%)
Non motor (i.e., animal drawn carriage or tram), animal or pedestrian	41 (1.7%)	42 (2.3%)	19 (1.3%)
Railway train or light rail tram	*	*	14 (1.0%)
Total	2,421 (100%)	1,845 (100%)	1,434 (100%)

[a] n = 229 missing; [b] n = 169 missing ; [c] n = 88 missing; *Cell count < 5.

Table 3
Number and percentage of patients reporting problems with quality of life domains at 6 and 12 months post injury by road user group (a GEE population-averaged model for EQ-5D-3 L categories by road user group).

	Followed up at 6 months N	Problems at 6 months N (%)	Followed up at 12 months N	Problems at 12 months N(%)	*AOR (95% CI)	p-value
Mobility						
Pedestrian	1,233	725 (58.8%)	1,191	618 (52.0%)	1	
Motorcyclist	2,316	1,037 (45.0%)	2,241	894 (40.0%)	0.93 (0.80, 1.09)	0.38
Cyclist	1,806	335 (19.0%)	1,774	255 (14.4%)	0.33 (0.28, 0.40)	< 0.001
Anxiety/depression						
Pedestrian	1,213	627 (52.0%)	1,175	604 (51.4%)	1	
Motorcyclist	2,296	878 (38.2%)	2,226	845 (38.0%)	0.75 (0.65, 0.86)	< 0.001
Cyclist	1,795	414 (23.0%)	1,768	346 (20.0%)	0.40 (0.34, 0.46)	< 0.001
Pain						
Pedestrian	1,221	845 (69.2%)	1,181	777 (66.0%)	1	
Motorcyclist	2,297	115 (66.0%)	2,231	1,396 (63.0%)	1.00 (0.87, 1.16)	0.99
Cyclist	1,797	819 (46.0%)	1,771	656 (37.0%)	0.43 (0.37, 0.49)	< 0.001
Self-care						
Pedestrian	1,232	424 (34.4%)	1,192	348 (29.2%)	1	
Motorcyclist	2,313	574 (24.8%)	2,240	477 (21.3%)	0.94 (0.79, 1.10)	0.45
Cyclist	1,804	178 (9.9%)	1,773	147 (8.3%)	0.36 (0.29, 0.43)	< 0.001
Usual activities						
Pedestrian	1,230	903 (73.4%)	1,192	805 (67.5%)	1	
Motorcyclist	2,313	1,558 (67.4%)	2,240	1300 (58.0%)	0.97 (0.84, 1.13)	0.78
Cyclist	1,805	800 (44.3%)	1,774	588 (33.1%)	0.42 (0.36, 0.49)	< 0.001

*Adjusted for age, sex, socioeconomic status (SES) as measured by the IRSAD, injury severity as measured by the presence of a major traumatic injury, associated injuries, CCI, preinjury disability, pre-existing mental health, drug and alcohol conditions, highest level of education, injury type, working prior and follow-up time point. AOR, adjusted odds ratio; IRSAD, index of relative social and economic advantage and disadvantage; CI, confidence interval, CCI, Charlson Comorbidity Index.

compared health-related quality of life, function and work outcomes between vulnerable road user groups. We found no differences in health-related quality of life between motorcyclists and pedestrians (with the exception of anxiety/depression). In contrast, the longer term outcomes of cyclists were consistently better than pedestrians and motorcyclists. Nevertheless, disability was prevalent in all road user groups at 12-months post-injury, highlighting the need for primary prevention efforts to reduce the occurrence and severity of injury events

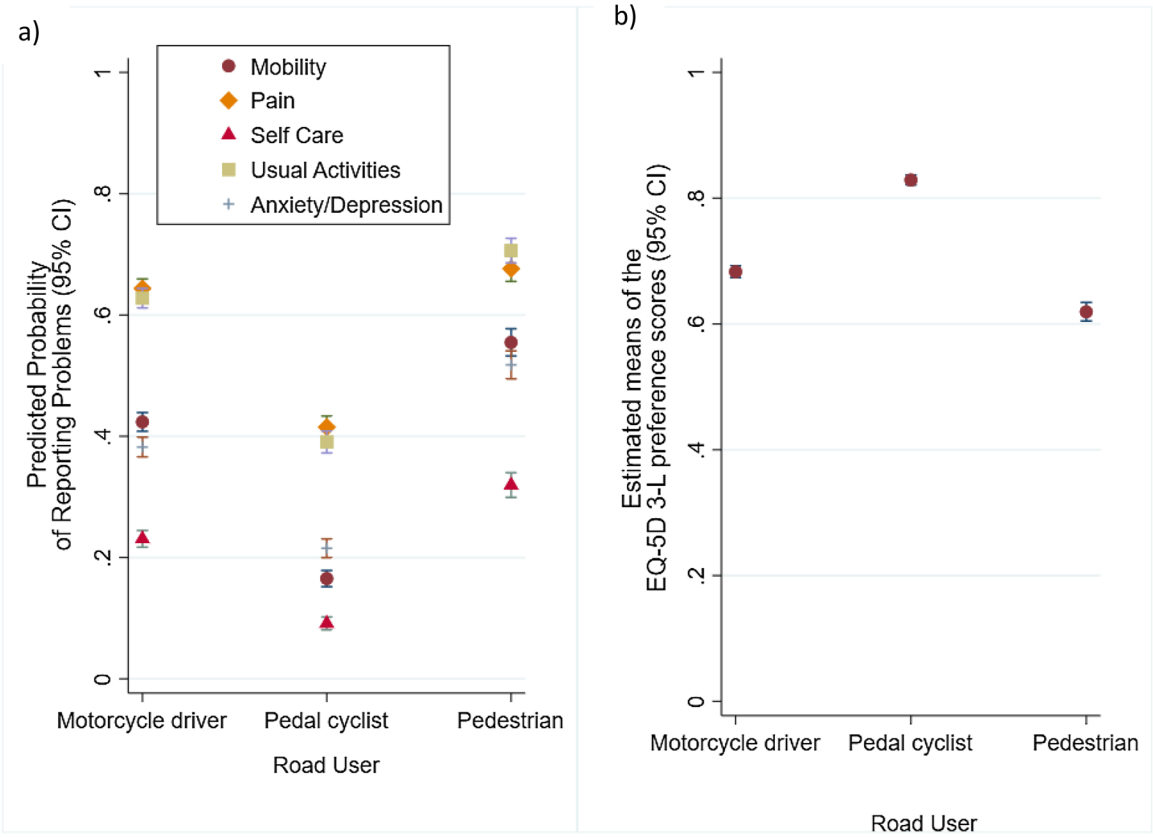

Fig. 2. a) Predicted probability of patients reporting problems (95% CI) on each 3-Level EuroQol 5 dimension – a GEE population-averaged model (6 and 12 month time points combined); b) Estimated means of the EQ-5D 3-L preference scores (95% CI) by road user group – a GEE population-averaged model (6 and 12 month time points combined).

Table 4
Proportion of patients reporting return to work and a good functional outcome (GOS-E) by road user group at 6 and 12 months post injury, a GEE population-averaged model.

	Followed up at 6 months	Outcome at 6 months	Followed up at 12 months	Outcome at 12 months	*AOR (95% CI)	*p*-value
Return to Work						
Pedestrian	630	378 (60.0%)	634	400 (63.1%)	Reference	
Motorcyclist	1,976	1,248 (63.2%)	1,932	1,379 (71.9%)	1.12 (0.91, 1.40)	0.39
Cyclist	1,538	1,377 (89.5%)	1,526	1,412 (92.5%)	3.13 (2.46, 3.99)	< 0.001
Good Recovery (GOS-E)						
Pedestrian	1,257	368 (29.3%)	1,229	391 (31.8%)	Reference	
Motorcyclist	2,318	708 (30.5%)	2,245	837 (37.3%)	1.13 (0.96, 1.33)	0.16
Cyclist	1,812	1095 (60.4%)	1,776	1207 (68.0%)	2.75 (2.33, 3.25)	< 0.001

*Adjusted for age, sex, socioeconomic status (SES) as measured by the IRSAD, injury severity as measured by the presence of a major traumatic injury, associated injuries, CCI, preinjury disability, pre-existing mental health, drug and alcohol conditions, highest level of education, injury type, working prior and follow-up time point. AOR, adjusted odds ratio; IRSAD, index of relative social and economic advantage and disadvantage; CI, confidence interval.

in vulnerable road user groups.

There were distinct differences in demographic characteristics between the road user groups. On average, motorcyclists and cyclists were younger than pedestrians. Consistent with prior studies, cyclists were predominantly aged in the 35–54 year age group, were more commonly working prior to the crash sustained less severe injuries, had fewer compensation claims and demonstrated improved outcomes (Beck et al., 2017a, b; Mayou and Bryant, 2003; Tournier et al., 2014). Furthermore, a previous study demonstrated high return to work rates for people after cycling injuries (Beck et al., 2017a), which is consistent with the present findings whereby 90% of cyclists had returned to work 6-months post-injury. In our study, this finding could be explained by the higher levels of socioeconomic advantage and greater employment in managerial and professional occupations of cyclists, which may support earlier return to work after serious injury.

Previous studies of trauma patients have shown that it is more common for motorcyclists and pedestrians to report ongoing problems with pain compared to cyclists, and it is not uncommon for trauma patients to report persistent pain up to three years post-injury (Mayou and Bryant, 2003; Gabbe et al., 2017). We found that approximately two thirds of pedestrians and motorcyclists reported pain at six months and little improvement was observed at 12 months. Women who sustain traumatic injury typically report worse outcomes than men (Gabbe et al., 2017). In our study, women were more prominent in the pedestrian group where poor outcomes were more prevalent, though the differences between road user groups persisted even after adjusting for sex. Previous road trauma studies have found pedestrians demonstrate poor in-hospital outcomes and greater mortality rates compared to other road user groups. However, the few longitudinal studies that distinguished between road user groups comprised small patient samples, included all injury types, and did not find any differences in long term outcomes attributable to road user group (Dinh et al., 2016; Kenardy et al., 2017). Our study is also the first to demonstrate that relative to pedestrians, cyclists and motorcycle riders have better outcomes, and cyclists have better outcomes than motorcyclists, in the first 12 months following crash-related orthopaedic trauma.

Numerous studies have identified people involved in bicycle crashes typically report excellent general health prior to injury (Beck et al.,

Fig. 3. Predicted probability of patients reporting return to work and a good functional recovery outcome (95% CI) – a GEE population-averaged model (6 and 12 month time points combined).

2017b; Gopinath et al., 2016).This phenomenon has been referred to as the "healthy cyclist effect" (Tournier et al., 2014). Cyclists in our study reported low rates of pre-injury disability, with 90% of pedal cyclists reporting no pre-injury disability, a very low prevalence of pre-existing CCI, mental health and drug conditions, and higher levels of education. In contrast, pedestrians were older than other road-user groups, a higher proportion had comorbid conditions, and traumatic brain injury was more common. The over-representation of older adults in pedestrian casualties and fatalities is well documented (Dommes et al., 2013; O'Hern et al., 2015), with contributory factors including age-related declines in sensory, physical and cognitive abilities combined with increased frailty and poorer mobility. These factors, along with pre-injury disability, not only increase their likelihood of being injured as a pedestrian but can also increase rates of complications post-surgery and delay recovery (Kirshenbom et al., 2017). While we adjusted for age, comorbidity and pre-injury disability, it is possible that some confounders remain due to the inability to accurately capture all aspects of frailty and illness.

It is well known that after sustaining a transport-related injury, people are at an increased risk of developing psychological disorders of which anxiety, depression and post-traumatic stress disorder are the most common (Mayou and Bryant, 2002). An important finding from the present study was that there was little change in the proportion of pedestrians, motorcyclists and cyclists reporting problems with anxiety and depression between 6 and 12 months post-crash. Studies have shown that for people with severe injuries, elevated psychological distress can remain stable for up to 12 to 24-months post-injury (Kenardy et al., 2017; Papadakaki et al., 2017; Tournier et al., 2014). The journey to recovery is highly individual and influenced by a number of factors that precipitate the injury and are associated with poor recovery outcomes. These factors include pre-morbid mental health, education level, drug and alcohol use and prior involvement in road trauma (Khati et al., 2013). Various factors are known to perpetuate poor physical and mental health outcomes and include a lack of social support, stress associated with interacting with a compensation system and attributions of fault (Gabbe et al., 2007; Murgatroyd et al., 2011). While we adjusted for some of these factors in our study, it was not possible to account for all (e.g., fault attributions were not available). Furthermore, the long-term trajectory of recovery from psychological conditions for pedestrians and motorcyclists is yet to be determined.

The early goal of rehabilitation is to assist physical recovery and improve health-related quality of life. However, as time passes, barriers towards recovery can either escalate or arise warranting specialised treatment. Given that at 12 months post-injury, half of all pedestrians continued to have problems with mental health, and two thirds of motorcyclists and pedestrians had problems with pain, ongoing screening and monitoring following discharge from hospital is recommended (Heron-Delaney et al., 2017). Appropriate screening and assessments help to ensure people receive the most appropriate treatment service when it is needed. The present findings highlight the potential need for early-intervention and prevention programs for the treatment of pain for more than half of vulnerable road users, particularly given that persistent pain is a known barrier to successful return to work and physical recovery (Rosenbloom et al., 2013). While a range of interventions exist to improve psychological distress after traumatic injury (Giummarra et al., 2018; Vincent et al., 2015), evidence for effective interventions that identify and prevent the development of persistent pain is lacking (Giummarra et al., 2018). A bigger challenge remaining is how to best coordinate the delivery of evidence-based interventions targeting the range of health-related outcomes from the hospital setting through to the community in order to reduce problems with usual activities at six-months post injury (reported by more than 60% of pedestrians and motorcyclists) and pain at 12-months post-injury (reported by approximately two thirds of pedestrians and motorcyclists).

The strengths of the study include the longitudinal prospective study design, the large sample size and low rates of attrition. Nevertheless, there were a number of limitations to the study. First, the data were limited to people who received care at the four hospitals participating in VOTOR in Victoria, Australia. Results may not be generalisable to all vulnerable road users who sustain traffic-related orthopaedic injuries across the state, or in other settings. Second, it is likely that comorbidities and prior mental health and substance use conditions were under-reported. The CCI was used as an indicator of comorbidity based on 19 conditions and excludes common conditions such as osteoarthritis which may impact on patient-reported outcomes. In addition, drug and alcohol conditions and pre-existing mental health conditions are inconsistently recorded in the administrative data relied on by the registry for comorbidity information (Nguyen et al., 2017). Third, proxy interviews were conducted when the person experienced cognitive or physical problems that precluded them from participating, and proxy interview was more common for older adults in this study, which may introduce bias. Finally, a substantial majority of road users received compensation for the transport-related injury under a statewide, no-fault compensation system and therefore findings may not be generalizable to other settings with different health funding and compensation schemes. Future research could endeavour to assess a larger sample of people across Victoria to include a larger representation of rural hospitals, and non-compensable patients. Comparisons with an uninjured control group is another future consideration.

5. Conclusion

This study demonstrated that health-related quality of life and return to work outcomes differed between vulnerable road user groups. In particular, pedestrians and motorcyclists experienced poorer health-related quality of life, function and return to work outcomes when compared to cyclists. Primary prevention efforts are the preferred method for reducing the burden of road trauma. Additional and targeted investment to protect these vulnerable road users is needed. Further, this study demonstrates that consideration of the appropriate timing and planning of health and disability interventions post-injury is required, particularly in the areas of persistent pain and mental health. A greater understanding of the barriers that delay recovery could also assist in the development of targeted public health interventions.

Acknowledgements

The Victorian Orthopaedic Trauma Outcomes Registry is funded by the Transport Accident Commission. Ben Beck and Melita Giummarra were supported by Australian Research Council Discovery Early Career Researcher Award Fellowships (DE180100825; DE170100726). Belinda Gabbe was supported by an Australian Research Council Future Fellowship (FT170100048). CE was supported by a National Health and Medical Research Council of Australia (NHMRC) Early Career Fellowship (1106633).

Appendix A

Table A1

Table A1
Demographics of patients lost to follow-up according to road user group.

	Motorcyclist (n = 208)	Cyclists (n = 130)	Pedestrians (n = 186)	*p*-value
Demographics				
Age, Mean (SD)	35.8 (13.0)	41.2 (15.4)	42.6 (19.6)	< 0.001
Age Group				< 0.001
16-24	48 (23.1%)	17 (13.1%)	35 (18.8%)	
25-34	62 (29.8%)	37 (28.5%)	48 (25.8%)	
35-54	74 (35.6%)	47 (36.2%)	50 (26.9%)	
55-74	24 (11.5%)	25 (19.2%)	36 (19.4%)	
75+	–	–	17 (9.1%)	
Funding[a]				< 0.001
TAC	173 (83.2%)	65 (50.0%)	172 (92.5%)	
Workcover/other compensable	6 (2.9%)	–	*	
Private/DVA	*	16 (12.3%)	–	
Medicare/not compensable	25 (12.0%)	49 (37.7%)	10 (5.4%)	
Discharge Destination				< 0.001
Home	145 (69.7%)	104 (80.0%)	97 (52.2%)	
Rehabilitation	55 (26.4%)	23 (17.7%)	79 (42.5%)	
Hospital for convalescence	*	–	6 (3.2%)	
Other	6 (2.9%)	*	*	
Working Prior[b]				0.088
No	8 (3.8%)	*	12 (6.5%)	
Yes	20 (9.6%)	16 (12.3%)	14 (7.5%)	
Highest Level of Education[c]				0.002
University	2 (1.0%)	11 (8.5%)	4 (2.2%)	
Completed high school	3 (1.4%)	*	4 (2.2%)	
Advanced diploma	14 (6.7%)	5 (3.8%)	9 (4.8%)	
Did not complete high school	7 (3.4%)	–	5 (2.7%)	
Sex				< 0.001
Male	194 (93.3%)	97 (74.6%)	100 (53.8%)	
Female	14 (6.7%)	33 (25.4%)	86 (46.2%)	
Charlson Comorbidity Index				< 0.001
None	173 (83.2%)	117 (90.0%)	132 (71.0%)	
1	27 (13.0%)	11 (8.5%)	48 (25.8%)	
2+	8 (3.8%)	*	6 (3.2%)	
Injury Group				< 0.001
Isolated upper extremity	37 (17.8%)	51 (39.2%)	28 (15.1%)	
Multiple upper extremity	18 (8.7%)	8 (6.2%)	*	
Isolated lower extremity	48 (23.1%)	27 (20.8%)	60 (32.3%)	
Multiple lower extremity	24 (11.5%)	*	18 (9.7%)	
Upper and lower extremity	22 (10.6%)	7 (5.4%)	20 (10.8%)	
Spinal injuries only	22 (10.6%)	17 (13.1%)	22 (11.8%)	
Spine and upper extremity	15 (7.2%)	8 (6.2%)	6 (3.2%)	
Spine and lower extremity	12 (5.8%)	6 (4.6%)	16 (8.6%)	
Spine and upper extremity and lower extremity	7 (3.4%)	*	10 (5.4%)	
Soft tissue or other injuries or amputee	*	*	*	
IRSAD[d]				< 0.001
1 (most disadvantaged)	41 (19.7%)	10 (7.7%)	29 (15.6%)	
2	34 (16.3%)	13 (10.0%)	22 (11.8%)	
3	38 (18.3%)	16 (12.3%)	29 (15.6%)	
4	42 (20.2%)	20 (15.4%)	36 (19.4%)	
5 (least disadvantaged)	44 (21.2%)	65 (50.0%)	55 (29.6%)	
Associated Injuries				< 0.001
Traumatic brain injury	13 (6.3%)	7 (5.4%)	28 (15.1%)	0 .002
Intra-abdominal organ injury	23 (11.1%)	*	20 (10.8%)	0.011
Intra-thoracic organ injury	56 (26.9%)	17 (13.1%)	20 (10.8%)	< 0.001
Multiple rib fractures/Burns	54 (26.0%)	16 (12.3%)	26 (14.0%)	0.011
Major traumatic injury[e]	81 (38.9%)	22 (16.9%)	64 (34.4%)	
Pre-injury disability	208 (100.0%)	129 (99.2%)	186 (100.0%)	
Pre-existing alcohol condition	13 (6.3%)	5 (3.8%)	27 (14.5%)	0.001
Pre-existing drug condition	11 (5.3%)	*	17 (9.1%)	0.036
Pre-existing mental health condition	12 (5.8%)	*	18 (9.7%)	0.012

[a]3 missing; [b] 451 missing; [c] 459 missing; [d] 30 missing; [e] 357 missing or unknown; * denotes less than 5 cases.

References

Beck, B., Cameron, P.A., Fitzgerald, M.C., Judson, R.T., Teague, W., Lyons, R.A., Gabbe, B.J., 2017a. Road safety: serious injuries remain a major unsolved problem. Med. J. Aust. 207 (6), 244–249. https://doi.org/10.5694/mja17.00015.

Beck, B., Ekegren, C.L., Cameron, P., Edwards, E.R., Bucknill, A., Judson, R., et al., 2017b. Predictors of recovery in cyclists hospitalised for orthopaedic trauma following an on-road crash. Accid. Anal. Prev. 106, 341–347.

Brockamp, T., Schmucker, U., Lefering, R., Mutschler, M., Driessen, A., Probst, C., et al., 2017. Comparison of transportation related injury mechanisms and outcome of young road users and adult road users, a retrospective analysis on 24,373 patients derived from the TraumaRegister DGU®. Scand. J. Trauma Resusc. Emerg. Med. 25 (1), 57.

Cevik, Y., Dogan, N., Das, M., Karakayali, O., Delice, O., Kavalci, C., 2013. Evaluation of geriatric patients with trauma scores after motor vehicle trauma. Am. J. Emerg. Med. 31 (10), 1453–1456. https://doi.org/10.1016/j.ajem.2013.07.021.

Dinh, M.M., Cornwall, K., Bein, K.J., Gabbe, B.J., Tomes, B.A., Ivers, R., 2016. Health status and return to work in trauma patients at 3 and 6 months post-discharge: an Australian major trauma centre study. Eur. J. Trauma Emerg. Surg. 42 (4), 483–490.
Dolan, P., 1997. Modeling valuations for EuroQol health states. Med. Care 1095–1108.
Dommes, A., Cavallo, V., Oxley, J., 2013. Functional declines as predictors of risky street-crossing decisions in older pedestrians. Accid. Anal. Prev. 59, 135–143.
Ekegren, C., Hart, M., Brown, A., Gabbe, B., 2016. Inter-rater agreement on assessment of outcome within a trauma registry. Injury 47 (1), 130–134.
Gabbe, B.J., Cameron, P.A., Williamson, O.D., Edwards, E.R., Graves, S.E., Richardson, M.D., 2007. The relationship between compensable status and long-term patient outcomes following orthopaedic trauma. Med. J. Aust. 187 (1), 14–17.
Gabbe, B.J., Simpson, P.M., Cameron, P.A., Ponsford, J., Lyons, R.A., Collie, A., et al., 2017. Long-term health status and trajectories of seriously injured patients: a population-based longitudinal study. PLoS Med. 14 (7), e1002322.
Giummarra, M.J., Dali, G., Lennox, A., Costa, B.M., Gabbe, B.J., 2018. Early interventions for pain after traumatic injury: a systematic review of randomised controlled trials evaluating non-pharmacological interventions. Injury Under Review.
Gopinath, B., Jagnoor, J., Craig, A., Kifley, A., Dinh, M., Ivers, R., et al., 2016. Describing and comparing the characteristics of injured bicyclists and other injured road users: a prospective cohort study. BMC Public Health 16 (1), 324.
Hahn, Y., Tiernan, G., Berecki-Gisolf, J., 2018. The impact of opioid analgesic prescription uptake on the costs of recovery from injury: evidence from compensable orthopaedic road trauma patients. Accid. Anal. Prev. 117, 32–39.
Heron-Delaney, M., Warren, J., Kenardy, J.A., 2017. Predictors of non-return to work 2 years post-injury in road traffic crash survivors: results from the UQ SuPPORT study. Injury 48 (6), 1120–1128. https://doi.org/10.1016/j.injury.2017.03.012.
Holbrook, T.L., Hoyt, D.B., Coimbra, R., Potenza, B., Sise, M., Anderson, J.P., 2005. Long-term posttraumatic stress disorder persists after major trauma in adolescents: new data on risk factors and functional outcome. J. Trauma Acute Care Surg. 58 (4), 764–771.
Hours, M., Bernard, M., Charnay, P., Chossegros, L., Javouhey, E., Fort, E., et al., 2010. Functional outcome after road-crash injury: Description of the ESPARR victims cohort and 6-month follow-up results. Accid. Anal. Prev. 42 (2), 412–421.
Hubbard, A.E., Ahern, J., Fleischer, N.L., Van der Laan, M., Satariano, S.A., Jewell, N., et al., 2010. To GEE or not to GEE: comparing population average and mixed models for estimating the associations between neighborhood risk factors and health. Epidemiology 467–474.
Ioannou, L., Braaf, S., Cameron, P., Gibson, S.J., Ponsford, J., Jennings, P.A., et al., 2016. Compensation system experience at 12 months after road or workplace injury in Victoria, Australia. Psychol. Inj. Law 9 (4), 376–389.
Kenardy, J., Heron-Delaney, M., Hendrikz, J., Warren, J., Edmed, S.L., Brown, E., 2017. Recovery trajectories for long-term health-related quality of life following a road traffic crash injury: results from the UQ SuPPORT study. J. Affect. Disord. 214, 8–14. https://doi.org/10.1016/j.jad.2017.02.031.
Khati, I., Hours, M., Charnay, P., Chossegros, L., Tardy, H., Nhac-Vu, H.-T., et al., 2013. Quality of life one year after a road accident: results from the adult ESPARR cohort. J. Trauma Acute Care Surg. 74 (1), 301–311.
Kirshenbom, D., Ben-Zaken, Z., Albilya, N., Niyibizi, E., Bala, M., 2017. Older age, comorbid illnesses, and injury severity affect immediate outcome in elderly trauma patients. J. Emerg. Trauma Shock 10 (3), 146.
Mayou, R., Bryant, B., 2002. Outcome 3 years after a road traffic accident. Psychol. Med. 32 (4), 671–675.
Mayou, R., Bryant, B., 2003. Consequences of road traffic accidents for different types of road user. Injury 34 (3), 197–202.
Murgatroyd, D.F., Cameron, I.D., Harris, I.A., 2011. Understanding the effect of compensation on recovery from severe motor vehicle crash injuries: a qualitative study. Inj. Prev. 17 (4), 222–227.
Nguyen, T.Q., Simpson, P.M., Gabbe, B.J., 2017. The prevalence of pre-existing mental health, drug and alcohol conditions in major trauma patients. Aust. Health Rev. 41 (3), 283–290.
O'Hern, S., Oxley, J., Logan, D., O'Hern, S., 2015. Older adults at increased risk as pedestrians in Victoria, Australia: an examination of crash characteristics and injury outcomes. Traffic Inj. Prev. 16 (2), S161–S167. https://doi.org/10.1080/15389588.2015.1061662.
Palmer, C.S., Gabbe, B.J., Cameron, P.A., 2016. Defining major trauma using the 2008 abbreviated injury scale. Injury 47 (1), 109–115.
Papadakaki, M., Ferraro, O.E., Orsi, C., Otte, D., Tzamalouka, G., von-der-Geest, M., et al., 2017. Psychological distress and physical disability in patients sustaining severe injuries in road traffic crashes: results from a one-year cohort study from three European countries. Injury 48 (2), 297–306.
Papadakaki, M., Tsalkanis, A., Sarris, M., Pierrakos, G., Ferraro, O.E., Stamouli, M.-A., et al., 2018. Physical, psychological and economic burden of two-wheel users after a road traffic injury: evidence from intensive care units of three EU countries. J. Safety Res. 67, 155–163.
Reith, G., Lefering, R., Wafaisade, A., Hensel, K.O., Paffrath, T., Bouillon, B., et al., 2015. Injury pattern, outcome and characteristics of severely injured pedestrian. Scand. J. Trauma Resusc. Emerg. Med. 23, 56.
Rosenbloom, B.N., Khan, S., McCartney, C., Katz, J., 2013. Systematic review of persistent pain and psychological outcomes following traumatic musculoskeletal injury. J. Pain Res. 6, 39.
Tournier, C., Charnay, P., Tardy, H., Chossegros, L., Carnis, L., Hours, M., 2014. A few seconds to have an accident, a long time to recover: consequences for road accident victims from the ESPARR cohort 2 years after the accident. Accid. Anal. Prev. 72, 422–432.
Vanlaar, W., Hing, M.M., Brown, S., McAteer, H., Crain, J., McFaull, S., 2016. Fatal and serious injuries related to vulnerable road users in Canada. J. Safety Res. 58, 67–77.
Vincent, H.K., Horodyski, M., Vincent, K.R., Brisbane, S.T., Sadasivan, K.K., 2015. Psychological distress after orthopedic trauma: prevalence in patients and implications for rehabilitation. PM&R 7 (9), 978–989.
Williamson, O.D., Gabbe, B.J., Sutherland, A.M., Hart, M.J., 2012. Does recall of pre-injury disability change over time? Inj. Prev. 19 (4), 238–243.
Wilson, J.L., Pettigrew, L.E., Teasdale, G.M., 1998. Structured interviews for the Glasgow outcome scale and the extended glasgow outcome scale: guidelines for their use. J. Neurotrauma 15 (8), 573–585.
World Health Organization, 2018. Global Status Report on Road Safety 2018. World Health Organization.