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Geographic variations in reported and treated pain and mental health problems in the first two years after transport-related major trauma

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ABSTRACT

Context: Persistent pain and mental health conditions are prevalent and disabling after transport injury. To date, few studies have explored geographic variations in the prevalence of those conditions, or treatments received, for those conditions.

Aims and methods: This study aimed to examine the prevalence and population adjusted incidence of (a) patient reported problems of persistent or worsening pain or discomfort, and anxiety or depression, over 6, 12 and 24 months (EQ-5D); and (b) treatments received for pain and mental health conditions up to 24-months (funded by the compensation system) after transport-related major trauma across residential locations in Victoria, Australia. People aged > 15 years, living in Victoria, with unintentional road transport-related major trauma who survived to 24 months post-injury were included from the Victorian State Trauma Registry (N = 6,434 eligible cases).

Results: A total of 4,440 cases had two or more follow-ups to generate a reported problems profile, and 4,222 cases had a linked compensation claim to identify treatments. After adjusting for demographic, health and injury-related covariates, there was a lower probability of reported problems (pain: AOR = 0.81, 95%CI: 0.69, 0.95; mental health: AOR = 0.76, 95%CI: 0.65, 0.89) and treatment (pain: AOR = 0.64, 95%CI: 0.54, 0.76; mental health: AOR = 0.67, 95%CI: 0.55, 0.81) for people living in regional versus metropolitan areas. Across all cases reporting problems with pain or mental health in local government areas a median of 55% and 42% of people had received pain or mental health treatment, respectively; however, treatments were limited to those paid for by the compensation scheme, and it is possible that people received treatment privately or through Medicare.

Conclusions: The variations in reported problems and treatment suggest a high level of potential unmet treatment need. Targeted strategies should now be developed to facilitate access to pain or mental health treatment when it is needed, regardless of where one lives.

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1. Introduction

In Victoria, Australia, there are more than 1,000 hospital admissions following transport-related major trauma each year. After major trauma, approximately 20–25% of people go on to develop chronic, disabling pain (Holmes et al., 2010, 2014) or mental health conditions including anxiety, depression and post-traumatic stress disorder (Giummarra et al., 2017; O'Donnell et al., 2016). Of the few studies examining treatment rates for pain and mental health after traumatic injury it appears that there is a substantial level of under-treatment of both conditions.

One study found that 6% of people received treatment for persistent pain after compensable transport injury (Giummarra et al., 2018), and another found that 27–50% of trauma patients reporting neuropathic pain received multimodal pharmacological or non-pharmacological treatments, respectively (Rosenbloom et al., 2016). Similar concerns for under-treatment are apparent in the community, despite global concerns about escalating opioid prescribing and use (Islam et al., 2016; Rummans et al., 2018). That is, less than 10% of people with persistent pain report having access to effective pain management (Miller et al., 2017; PainAustralia, 2010), and 30% of people report that they receive no treatment at all for their persistent pain (Breivik et al., 2006). Treatment rates for mental health conditions are even lower than treatment rates for pain. For instance, 3% of people received pharmacological or non-pharmacological treatment for a mental health condition after compensable transport injury in Australia (Giummarra et al., 2018). In a US study, only 18% and 30% of consecutive admissions to a level 1 trauma service who developed depression or PTSD received treatment for the respective condition within the first year post-injury (Bell et al., 2018). The mental health treatment rates post-injury are similar to treatment of mental health conditions in the Australian community with less than one in three people receiving treatment (Australian Bureau of Statistics, 2007).

Altogether, while pain and mental health conditions are relatively common after major trauma, it is clear that only a small proportion of people go on to access treatment for those conditions. Several factors can influence treatment access. These include: (a) *micro-level* characteristics such as individual needs (e.g., symptom severity, actual or perceived need), resources (e.g., financial resources, carer availability and attitudes), and health literacy or attitudes (Andersen, 1995); (b) *meso-level* factors such as service and clinician availability and attitudes; and (c) *macro-level* factors such as health service funding models, and referral or claims-related policies (e.g., with public, private and injury-specific insurance or compensation schemes; Slater and Briggs, 2017). Importantly, many of these factors vary across neighbourhoods in relation to remoteness and socioeconomic disadvantage. In particular, treatment access in rural and remote areas is reduced due to low population density, limited service availability, threats to service sustainability, distance from specialised services or clinicians, affordability, lower education and heightened stigma (Australian Institute of Health and Welfare, 2007; Dent et al., 2016; Fraser et al., 2002; Judd and Humphreys, 2001; Moore et al., 2010; Piper et al., 2014). Geographically-bound drivers of treatment access have major implications for the implementation of policies and practices to support injury recovery. Therefore it is important that we better understand how the prevalence and treatment of health conditions vary across neighbourhoods.

The aim of this study was to fill a much needed gap in our understanding of geographic variations in the prevalence and population adjusted incidence of persistent or worsening pain and mental health after transport-related major trauma, and to identify potential unmet treatment needs.

2. Materials and methods

Ethics approval for the study was received from the Monash University Human Research Ethics Committee.

2.1. Datasets and participants

The Victorian State Trauma Registry (VSTR) is a population-based registry comprising all major trauma cases in the State of Victoria, Australia that was established to aid monitoring of trauma system performance, compliance and outcomes (Cameron et al., 2005). The VSTR is a population based registry capturing data on all major trauma patients admitted to one of 138 trauma-receiving hospitals in Victoria. 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 $\geq$ 24 h and requiring mechanical ventilation for at least part of their ICU stay; and (d) urgent surgery for intracranial, intrathoracic or intraabdominal injury, or fixation of pelvic or spinal fractures. Patients are given the opportunity to opt-off the registry; however fewer than 1% of cases elect to be removed. The VSTR contains data on prehospital care, pre-existing conditions recorded during the hospital admission, injury characteristics and complications, and discharge details. Data are included in the VSTR from the hospital that provided each patient's definitive care when the admission is complete, and the fully coded record is available. Injury data are provided by coders with Abbreviated Injury Scale training. Some additional baseline data (e.g., prior work, disability) and outcomes are collected using structured telephone interviews by trained interviewers based in the Department of Epidemiology and Preventive Medicine with the injured person, or a proxy representative if the patient is unavailable or unable to respond, at 6 months, 12 months and 24 months post-injury. Additional data can be included from the National Coroners Information System, and the Victorian Registry of Births, Deaths and Marriages registries for mortality outcomes, and through data linkage with the Transport Accident Commission and Victorian Admitted Episodes Dataset for health service use outcomes.

For this study data were extracted from the VSTR for all cases aged 16 years or older at the time of injury who had an injury date between 1st January 2008 and 31st October 2014, and had a transport-related injury cause that involved 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 non-

motorized vehicle (i.e., bicycle). Injury cause was identified from the cause coding provided by the hospital providing definitive care, which were coded in accordance with the Victorian Emergency Minimum Dataset (VEMD) Business Rules for coding Injury Surveillance (Victorian Department of Health, 2013–14). The VEMD injury cause codes are cross-checked with the ICD-10-AM external cause codes (Chapters V to Y), and the text narrative of the injury event. Participants were excluded if they died in the first 2 years post-injury, if their injury resulted from an intentional event (e.g., self-harm or assault), if they lived outside of Victoria, or if their residential postcode was missing. Cases were also excluded if they lived in a region with fewer than five patients to protect patient anonymity. Cases were considered lost to follow-up if they were missing more than one follow-up interview as this would not enable the generation of an outcome profile of persistent or worsening problems over two or more follow-up periods.

For compensable cases, payments for medical and like services by the state's third party no-fault insurer for transport injury, the Transport Accident Commission (TAC), were obtained via the Compensation Research Database (CRD; Prang et al., 2016). These data were identified by the CRD data administrator using a linkage key between the admission identification number and the TAC claim number.

Demographic characteristics of the cohort included age at the time of injury, sex, highest self-reported level of education, pre-injury work status and occupation type, socioeconomic disadvantage and geographic location. The Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) was used to indicate neighbourhood level socioeconomic disadvantage. The IRSAD is defined by the Australian Bureau of Statistics using data on the typical education, employment and family structure in each postcode of Australia collected from the national census (Australian Bureau of Statistics, 2008). The Victorian ranked IRSAD deciles for each residential postcode at the time of injury were used in this study, and were summarised into quintiles ranging from 1 (most disadvantaged) to 5 (least disadvantaged). Residential area was dichotomized from the Accessibility/Remoteness Index of Australia (ARIA) as “major cities” and “regional and remote” areas (Department of Health and Aged Care and National Key Centre for Social Applications of Geographical Information Systems (GISCA), 2001).

The presence of pre-existing substance use conditions, mental health conditions, and conditions that increase the risk of mortality (using the Charlson Comorbidity Index (CCI) weightings (Charlson et al., 1987; Deyo et al., 1992)) were identified using the International Classification of Diseases (10) Australian Modification (ICD-10-AM) diagnosis codes. Disability level in the week prior to injury was collected during the follow-up interviews, and was coded using the earliest available response, which was the 6-month interview for the majority of cases (99.1% for reported problems sub-group, 98.8% for the treatment sub-group). Pre-injury disability levels have been validated for recall up to 6 months post-injury (Williamson et al., 2012). Disability was coded as no disability, mild disability and moderate to severe disability.

Injuries were coded using the maximum Abbreviated Injury Scale (AIS) 2005 Update 2008 severity scores. The AIS scores were used to classify the body regions injured, and to generate the Injury Severity Score (ISS). The ISS is calculated as the highest AIS severity scores from three different body regions that are squared and summed (Baker et al., 1974). The ISS was further classified into four categories (< 9; 9 to 15; 16 to 24; > 24), in accordance with recommended thresholds that have high discrimination of mortality (Copes et al., 1988).

2.2. Outcome measures

The EQ-5D-3L (The EuroQol Group, 1990) was used to identify the presence of reported problems with pain or discomfort, and anxiety or depression, after major trauma. In cases where the EQ-5D-3L was not completed by the patient, or a proxy, ratings on the SF-12 (Version 1) health survey were used to estimate missing EQ-5D-3L responses using an existing algorithm (Gray et al., 2006) that has been validated in trauma (Gabbe et al., 2015). Cases were classified as having persistent or worsening problems if they reported moderate or extreme problems at all follow up interviews (i.e., 6, 12 and 24 months, “persistent problems”), or at the final two follow up interviews (i.e., 12 and/or 24m post-injury after initially reporting no pain or discomfort, “worsening problems”) as per our recent study characterizing profiles and predictors of pain and mental health outcomes (Giummarra et al., 2019). These criteria are fully defined in Supplementary Table 1.

The TAC payments data were used to identify treatments for persistent pain and mental health conditions, between 12 weeks and 24 months post-injury using existing criteria (Giummarra et al., 2018); see Supplementary Table 2 for the treatment criteria.

2.3. Data analysis

Data were analysed in Stata Version 14, and ArcGIS desktop version 10.6 (ESRI, Inc.) was used to generate maps of the prevalence of reported problems and treatments received across metropolitan and regional and remote Local Government Areas (LGAs).

Logistic regression was used to determine the adjusted odds of reporting problems and receiving treatment for pain or mental health in regional and remote areas compared with metropolitan areas. We report the Odds Ratio (OR) and corresponding 95% Confidence Intervals (CI). If the 95%CI does not include 1.00, then the association between the independent variable and the dependent variable is considered to be significantly different to the reference category. Factors that are associated with worse pain and mental health after injury were included as covariates, including age, sex, socioeconomic disadvantage (IRSAD quintiles), preinjury disability, road user group, injury severity, and injury type.

Residential area (LGA) at the time of injury was generated from residential postcode. Maps of metropolitan and regional areas were generated separately as there are often lower rates of treatment (Giummarra et al., 2018) and reported problems (Giummarra et al., 2019) with pain and mental health across remoteness areas. Mapping of reported problems and treatments received were generated to present (a) the percentage of cases with the respective reported problem or treatment relative to the number of injury

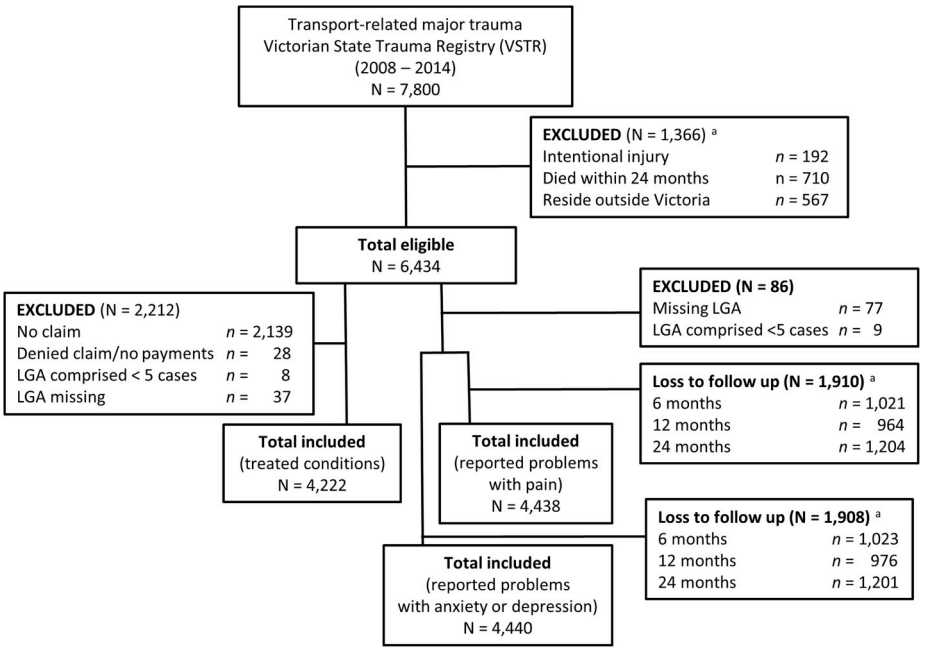

Fig. 1. Participant inclusion chart.
Notes: [a] Some cases met multiple exclusion criteria, and had data missing over multiple different follow-up periods. Cases excluded because the LGA comprised fewer than five cases resided in Queenscliff, West Wimmera and Towong.

cases in the respective area, and (b) the incidence of the respective reported problem or treatment per 100,000 population in the LGA using census data from the Australian Bureau of Statistics (2011).

3. Results

3.1. Cohort overview

Of a total eligible sample of 6,434 cases, 4,440 cases were included in mapping of reported problems with anxiety or depression, 4,438 were included in mapping of reported problems with pain or discomfort, and 4,250 cases with compensable injuries were included in mapping of treatments received, Fig. 1.

A total of 5,485 cases were included in the mapping of treatments received or reported problems, and 3,257 cases (59.4%) were included in both maps. There were differences in demographic and injury characteristics between the cohorts included in the treatment maps compared with those included only in the reported conditions maps with respect to age, sex, education level, residential area, prior conditions (mental health, substance use, disability and CCI weighting), occupation, road user, injury severity, nature of the injury, and discharge destination, Table 1.

A total of 1,909 and 1,911 cases were lost to follow-up for reported problems with anxiety or depression, and pain or discomfort, respectively. A higher proportion of cases who were lost to follow up were younger, living in major cities, had lower education level, pre-existing substance use disorders or moderate-severe disability, were unemployed, injured as pedestrians and passengers, had less severe injury, and were discharged directly home, Table 2. These factors were therefore included as covariates in the multivariable analyses.

3.2. Regional variations in the prevalence of pain outcomes

A total of 2,457 (55.3%) cases reported persistent or worsening problems with pain or discomfort, and 1,814 (42.7%) cases had treatment for pain. Of 1,967 cases reporting problems with pain who had a linked compensation claim, 1,081 (55.0%) had received treatment for pain.

When adjusting for demographic, health and injury characteristics, the odds or reporting problems with pain (AOR = 0.81, 95%CI: 0.69, 0.95), and receiving treatment for pain (AOR = 0.64, 95%CI: 0.54, 0.76) were lower in regional and remote areas compared to metropolitan areas (see Table 3, and Supplementary Table 5).

There were 1,631 (54.8%) cases in metropolitan areas, and 826 (56.4%) cases in regional and remote areas, who reported persistent or worsening problems with pain or discomfort. The median prevalence of reported problems was 52.5% (IQR: 48.9%–59.8%; Fig. 2a) across metropolitan LGAs, and 55.6% (IQR: 51.7%–63.0%; Fig. 3a) across regional and remote LGAs. Fewer cases had treatment for pain, including 1,347 (45.7%) cases in metropolitan areas, and 467 (36.2%) cases in regional and remote

Table 1
Characteristics of participants included in the mapping of treatment received and reported problems [n (%)], N = 5,509.

	Treatment Received	Reported Conditions only	p
Sex			
Male	2,970 (69.5)	1,005 (81.2)	< 0.001
Female	1,302 (30.5)	232 (18.8)	
Age (years)			
16 to 24	938 (22.0)	282 (22.8)	< 0.001
25 to 34	749 (17.5)	169 (13.7)	
35 to 44	715 (16.7)	230 (18.6)	
45 to 54	631 (14.8)	231 (18.7)	
55 to 64	483 (11.3)	180 (14.6)	
65 to 74	363 (8.5)	84 (6.8)	
75+	393 (9.2)	61 (4.9)	
ARIA [a]			
Regional and remote	1,211 (28.6)	414 (33.5)	< 0.001
Major cities	3,028 (71.4)	820 (66.5)	
IRSAD (quintiles) [a]			
1, most disadvantaged	525 (12.4)	127 (10.3)	0.028
2	495 (11.7)	145 (11.8)	
3	939 (22.1)	238 (19.3)	
4	1,195 (28.1)	382 (31.0)	
5, least disadvantaged	1,093 (25.7)	340 (27.6)	
Highest level of education [c]			
University	666 (16.6)	291 (24.4)	< 0.001
High school	661 (16.5)	160 (13.4)	
Advanced diploma	1,211 (30.3)	326 (27.3)	
High school not completed	1,463 (36.6)	418 (35.0)	
Pre-existing mental health disorder [d]			
No	3,477 (82.1)	1,035 (87.8)	< 0.001
Yes	760 (17.9)	144 (12.2)	
Pre-existing substance use disorder [d]			
No	3,754 (88.6)	1,118 (94.8)	< 0.001
Yes	483 (11.4)	61 (5.2)	
Pre-injury Disability [e]			
None	3,438 (80.6)	1,091 (88.2)	< 0.001
Mild	380 (8.9)	98 (7.9)	
Moderate to severe	449 (10.5)	48 (3.9)	
CCI weighting			
0	2,680 (62.7)	966 (78.1)	< 0.001
1	1,254 (29.4)	217 (17.5)	
> 1	338 (7.9)	54 (4.4)	
Occupation Skill level [f]			
Not working	1,268 (30.1)	238 (19.4)	< 0.001
Managers/professionals	611 (14.5)	302 (24.6)	
Associate professionals	268 (6.4)	75 (6.1)	
Trade/advanced clerical	888 (21.1)	241 (19.6)	
Intermediate	509 (12.1)	154 (12.6)	
Elementary/laborers	430 (10.2)	87 (7.1)	
Studying	244 (5.8)	130 (10.6)	
Fund			
Medicare or private	1 (< 1)	728 (58.9)	< 0.001
Compensable	4,271 (100.0)	509 (41.1)	
Road user			
Motor Vehicle driver	1,772 (41.5)	249 (20.1)	< 0.001
Motor Vehicle Passenger	690 (16.2)	90 (7.3)	
Motorcyclist	1,025 (24.0)	345 (27.9)	
Pedal cyclist	235 (5.5)	443 (35.8)	
Pedestrian and other	550 (12.9)	110 (8.9)	
Injury severity (ISS)			
< 9	218 (5.1)	95 (7.7)	< 0.001
10-15	1,164 (27.2)	432 (34.9)	
16-24	1,777 (41.6)	503 (40.7)	
> 24	1,113 (26.1)	207 (16.7)	
Injury group			
Isolated head injury	122 (2.9)	79 (6.4)	< 0.001
Head and other injuries	1,112 (26.0)	272 (22.0)	
Spinal cord injury	83 (1.9)	32 (2.6)	
Orthopedic injury	415 (9.7)	154 (12.4)	
Chest/abdominal injuries	166 (3.9)	84 (6.8)	

(*continued on next page*)

Table 1 (*continued*)

	Treatment Received	Reported Conditions only	p
Chest, abdominal and other injuries	1,791 (41.9)	491 (39.7)	
Other multiple injuries	583 (13.6)	125 (10.1)	
Discharge destination			
Home	1,634 (38.2)	819 (66.2)	< 0.001
Other (e.g., rehabilitation)	2,638 (61.8)	418 (33.8)	

Notes: Compensable injury can include transport compensation cases with the TAC and workplace injury cases with WorkSafe Victoria. Abbreviations: ARIA = Accessibility/Remoteness Index of Australia; CCI = Charlson Comorbidity Index; IRSAD = Index of Relative Socio-Economic Advantage and Disadvantage; ISS = Injury Severity Score.
[a] Missing n = 36; [b] Missing n = 30; [c] Missing n = 313; [d] Missing n = 93; [e] Missing n = 5; [f] Missing n = 64.

areas. There was a median prevalence of treatment for pain of 46.4% (IQR: 43.1%–50.0%; Fig. 2b) across metropolitan LGAs, and 35.3% (IQR: 27.8%–46.2%; Fig. 3b) across regional and remote LGAs.

3.3. Regional variations in the prevalence of mental health outcomes

A total of 1,861 (41.9%) cases reported persistent or worsening problems with anxiety or depression, and 1,220 (28.7%) cases had a treated mental health condition. Of 1,496 cases reporting problems with anxiety or depression who had a linked compensation claim, 627 (41.9%) had treatment for mental health.

When adjusting for demographic, health and injury characteristics, people living in regional and remote areas had lower odds of reporting persistent or worsening problems with anxiety or depression (AOR = 0.76, 95%CI: 0.65, 0.89), and of having treatment for mental health (AOR = 0.67, 95%CI: 0.55, 0.81) (see Table 3, and Supplementary Table 5).

There were 1,258 (42.3%) cases in metropolitan areas and 603 (41.0%) cases in regional areas who reported persistent or worsening problems with anxiety or depression. There was a median prevalence of reported problems of 42.5% (IQR: 37.3%–44.9%; Fig. 4a) across metropolitan LGAs and 39.3% (IQR: 33.3%, 47.4%; Fig. 4b) across regional LGAs. Less than a third of cases received mental health treatments, including 910 (30.9%) cases in metropolitan areas and 310 (24.1%) cases in regional areas. There was a median prevalence of treatment for mental health of 30.7% (IQR: 29.9%, 32.3%; Fig. 4b) across metropolitan LGAs, and 25.0% (IQR: 17.6%, 30.0%; Fig. 5b) across regional LGAs.

4. Discussion

To the best of our knowledge, this is the first study to examine regional variations in both the prevalence of persistent or worsening pain or mental health problems, and treatment for pain and mental health in Australia. The study therefore provides important new insights that can be used to improve health policy and service delivery. We found that 55% of people report persistent or worsening problems with pain, and 42% report persistent or worsening problems with anxiety or depression in the first two years after transport-related major trauma. Of those who reported problems and who had a compensation claim, only 55% and 42% of cases received treatment that was funded by the compensation system for the respective condition. People living in regional and remote areas had more than 19% lower adjusted odds of reporting persistent or worsening problems, and receiving treatment for pain or mental health, when compared with people living in metropolitan areas. As many people did not access treatment even though they experienced persistent or worsening problems with pain or mental health it appears that these conditions are under-treated after transport-related major trauma. In the least, these findings indicates that treatment of pain and mental health problems for these cases is probably not being covered through their compensation claim.

Our current understanding of regional variations in the prevalence and treatment of persistent pain in Australian community samples predominantly comes from opioid prescribing data, and there are no detailed published data on regional variations in pain post-injury. The studies examining opioid prescribing patterns show much *higher* population adjusted rates of opioid use in regional and remote areas compared with metropolitan areas in Australia, especially in regions that have a higher proportion of men, older people, and households with lower income and/or physical labour market (Degenhardt et al., 2016; Gisev et al., 2016). These patterns have also been observed in the state of Victoria where the consumption of strong opioids has been found to increase substantially across remoteness areas (i.e., 240mg/person in major cities, 471mg/person in inner regional areas, 621mg/person in outer regional areas and 798mg/person in remote areas; Degenhardt et al., 2016). While the prevalence of opioid prescribing in the community varies across remoteness areas, the prevalence of musculoskeletal conditions and persistent pain does not appear to differ according to remoteness (Currow et al., 2010; University of Sydney Family Medicine Research Centre, 2017) highlighting that population-level opioid use patterns are probably a surrogate marker of inadequate availability of evidence-based pain management options in rural areas (Finestone et al., 2016). The present finding of low treatment for pain using any available indicator likewise suggest that treatment accessibility may be a problem in regional and remote areas; however, it was notable that people living in these regions also had lower odds of *reporting* problems with pain when adjusting for covariates associated with pain after injury.

Studies examining regional variations in the population prevalence of mental health conditions and their treatment in Australia have revealed inconsistent results. Some studies have found that people living in regional and remote areas report better mental

Table 2
Characteristics of participants included compared with those lost to follow up who were excluded from the mapping analyses [n (%)], N = 6,348.

	Anxiety or Depression			Pain or Discomfort		
	Included	LTFU	p	Included	LTFU	p
Sex						
Male	3240 (73.0)	1360 (71.3)	0.17	3,231 (72.8)	1,369 (71.7)	0.36
Female	1200 (27.0)	548 (28.7)		1,207 (27.2)	541 (28.3)	
Age (years)						
16 to 24	944 (21.3)	527 (27.6)	< 0.001	940 (21.2)	531 (27.8)	< 0.001
25 to 34	678 (15.3)	413 (21.6)		684 (15.4)	407 (21.3)	
35 to 44	751 (16.9)	337 (17.7)		752 (16.9)	336 (17.6)	
45 to 54	728 (16.4)	255 (13.4)		730 (16.4)	253 (13.2)	
55 to 64	576 (13.0)	158 (8.3)		570 (12.8)	164 (8.6)	
65 to 74	377 (8.5)	110 (5.8)		383 (8.6)	104 (5.4)	
75+	386 (8.7)	108 (5.7)		379 (8.5)	115 (6.0)	
ARIA [a]						
Regional and remote	1367 (30.9)	456 (24.1)	< 0.001	1,362 (30.8)	461 (24.3)	< 0.001
Major cities	3057 (69.1)	1436 (75.9)		3,060 (69.2)	1433 (75.7)	
IRSAD quintile [b]						
1, most disadvantaged	508 (11.5)	267 (14.0)	0.017	508 (11.5)	267 (14.0)	0.027
2	521 (11.8)	225 (11.8)		519 (11.7)	227 (11.9)	
3	942 (21.3)	397 (20.8)		944 (21.3)	395 (20.7)	
4	1305 (29.5)	503 (26.4)		1,300 (29.4)	508 (26.6)	
5, least disadvantaged	1148 (25.9)	514 (27.0)		1,151 (26.0)	511 (26.8)	
Highest level of education [c]						
University	814 (19.2)	218 (12.4)	< 0.001	817 (19.3)	215 (12.2)	< 0.001
High school	640 (15.1)	228 (13.0)		636 (15.0)	232 (13.2)	
Advanced diploma	1273 (30.0)	374 (21.3)		1,267 (30.0)	380 (21.6)	
High school not completed	1510 (35.6)	933 (53.2)		1,510 (35.7)	933 (53.0)	
Pre-existing mental health disorder [d]						
No	3658 (83.9)	1545 (83.5)	0.69	3,664 (84.1)	1539 (83.1)	0.30
Yes	701 (16.1)	305 (16.5)		692 (15.9)	314 (16.9)	
Pre-existing substance use disorder [d]						
No	3,973 (91.1)	1,577 (85.2)	< 0.001	3,972 (91.2)	1,578 (85.2)	< 0.001
Yes	386 (8.9)	273 (14.8)		384 (8.8)	275 (14.8)	
Pre-injury disability [e]						
None	3,826 (86.3)	939 (49.2)	< 0.001	3,833 (86.5)	932 (48.8)	< 0.001
Mild	405 (9.1)	96 (5.0)		398 (9.0)	103 (5.4)	
Moderate to severe	204 (4.6)	873 (45.8)		202 (4.6)	875 (45.8)	
CCI weighting						
0	2,974 (67.0)	1,280 (67.1)	0.021	2,989 (67.4)	1,265 (66.2)	0.072
1	1,145 (25.8)	524 (27.5)		1,137 (25.6)	532 (27.9)	
> 1	321 (7.2)	104 (5.5)		312 (7.0)	113 (5.9)	
Occupation Skill level [f]						
Not working	1,175 (26.7)	438 (29.5)	< 0.001	1,178 (26.8)	435 (29.3)	< 0.001
Managers/professionals	786 (17.8)	196 (13.2)		791 (18.0)	191 (12.9)	
Associate professionals	285 (6.5)	74 (5.0)		286 (6.5)	73 (4.9)	
Trade/advanced clerical	900 (20.4)	319 (21.5)		898 (20.4)	321 (21.6)	
Intermediate	547 (12.4)	188 (12.7)		546 (12.4)	189 (12.7)	
Elementary/laborers	410 (9.3)	143 (9.6)		407 (9.2)	146 (9.8)	
Studying	301 (6.8)	125 (8.4)		296 (6.7)	130 (8.8)	
Fund						
Medicare or private	723 (16.3)	285 (14.9)	0.18	727 (16.4)	281 (14.7)	0.095
Compensable*	3,717 (83.7)	1,623 (85.1)		3,711 (83.6)	1,629 (85.3)	
Road user						
Motor Vehicle driver	1,574 (35.5)	674 (35.3)	< 0.001	1,578 (35.6)	670 (35.1)	< 0.001
Motor Vehicle Passenger	582 (13.1)	353 (18.5)		588 (13.2)	347 (18.2)	
Motorcyclist	1,158 (26.1)	423 (22.2)		1,156 (26.0)	425 (22.3)	
Pedal cyclist	630 (14.2)	193 (10.1)		630 (14.2)	193 (10.1)	
Pedestrian and other*	496 (11.2)	265 (13.9)		486 (11.0)	275 (14.4)	
Injury severity (ISS)						
< 9	250 (5.6)	131 (6.9)	< 0.001	250 (5.6)	131 (6.9)	< 0.001
10-15	1,275 (28.7)	666 (34.9)		1,278 (28.8)	663 (34.7)	
16-24	1,860 (41.9)	713 (37.4)		1,860 (41.9)	713 (37.3)	
> 24	1,055 (23.8)	398 (20.9)		1,050 (23.7)	403 (21.1)	
Injury group						
Isolated head injury	174 (3.9)	65 (3.4)	< 0.001	173 (3.9)	66 (3.5)	< 0.001
Head and other injuries	1,102 (24.8)	479 (25.1)		1,092 (24.6)	489 (25.6)	
Spinal cord injury	91 (2.0)	45 (2.4)		91 (2.1)	45 (2.4)	
Orthopedic injury	456 (10.3)	194 (10.2)		455 (10.3)	195 (10.2)	

(*continued on next page*)

Table 2 (*continued*)

	Anxiety or Depression			Pain or Discomfort		
	Included	LTFU	p	Included	LTFU	p
Chest/abdominal injuries	197 (4.4)	137 (7.2)		198 (4.5)	136 (7.1)	
Chest/abdominal/other injuries	1,879 (42.3)	706 (37.0)		1,888 (42.5)	697 (36.5)	
Other multiple injuries	541 (12.2)	282 (14.8)		541 (12.2)	282 (14.8)	
Discharge destination						
Home	2,007 (45.2)	989 (51.8)	< 0.001	2,006 (45.2)	990 (51.8)	< 0.001
Other (e.g., rehabilitation)	2,433 (54.8)	919 (48.2)		2,432 (54.8)	920 (48.2)	

Notes: Compensable injury can include transport compensation cases with the TAC and workplace injury cases with WorkSafe Victoria. Abbreviations: ARIA = Accessibility/Remoteness Index of Australia; CCI = Charlson Comorbidity Index; IRSAD = Index of Relative Socio-Economic Advantage and Disadvantage; ISS = Injury Severity Score. * Other transport injury circumstances included incidents involving mobility scooters, trams, trains and heavy vehicles.
[a] missing $n = 32$, [b] missing $n = 18$, [c] missing $n = 358$, [d] missing $n = 139$, [e] missing $n = 5$, [f] missing $n = 461$.

health (Jokela, 2014), whereas other studies have found no differences in the prevalence of mental health conditions across remoteness areas (Enticott et al., 2016; Phillips, 2009). Mental health treatment rates, however, do vary consistently across remoteness areas, but in the opposite direction to those observed for opioid treatment, with much lower levels of treatment in areas with higher levels of remoteness (Meadows et al., 2015). Moreover, people living outside of urban centres are less likely to endorse that evidence based mental health treatment are helpful for mental health conditions like depression (Griffiths et al., 2009). Instead, people living in rural or remote areas have been found to use informal supports from their social and community networks more often than clinical treatments when facing adversity or mental health problems (Hagler et al., 2019). Regional variations in treatment attitudes and preferences may partially explain the reduced mental health treatment rates found in the present study for people living in regional and remote areas.

It is well known that fewer healthcare providers in rural and remote areas have expertise in both pain management and mental health, and there are many challenges in maintaining a rural workforce with competencies in these areas, particularly for people recovering from major trauma. The challenges include fewer opportunities for professional development or training, greater professional isolation, and short-term or limited funding (Banbury et al., 2014; Deane et al., 2015; Moore et al., 2010). As a result, specialist care for pain and mental health in low-resource and rural settings is predominantly provided by primary care and non-specialist providers in non-specialist community settings (Moore et al., 2010). In order to meet the unmet treatment needs of people experiencing persistent or worsening problems with pain or mental health after major trauma, especially those living in regional and remote areas, greater emphasis should be placed on ensuring that non-specialists (e.g., nurses, community health officers, and paramedics) and primary care providers have sufficient skills, confidence and mentoring to provide integrated care for pain and mental health. These generalist providers could deliver evidence-based procedures and interventions especially patient screening, referral, monitoring, and follow-up (Rebello et al., 2014), and should involve specialists from metropolitan settings using telehealth.

4.1. Strengths and limitations

The major strength of this study is that it describes population level prospective data over a six year period. We provide the first comprehensive mapping of regional variations in pain and mental health outcomes, and treatment, following transport-related major trauma. Some limitations of the study design and data should, however, be considered when seeking to apply these findings to specific health and policy contexts.

First, the treatment data were only available for cases with a compensable injury for whom a linked compensation claim was identified. The treatment data did not include treatments for pain accessed through the public medical system (Medicare Benefit Schedule or Pharmaceutical Benefits Schedule), private health insurance, or private funds that may be used to manage pain or mental health after transport injury (Berecki-Gisolf et al., 2015, 2016). The present findings may, therefore, indicate an underestimation of the true treatment rates, and further research should employ linkages with additional data sources to more comprehensively examine regional variations in pharmacological and non-pharmacological treatments of pain and mental health after injury.

Second, reporting problems with pain or mental health on the EQ-5D-3L may have captured problems that are experienced after injury, but that are not strictly attributable to the injury per se. However, we have found that the pain profiles used in this study correspond to consistent differences in pain severity attributable to injuries sustained in the crash (Giummarra et al., 2019) and we adjusted for pre-injury mental health conditions in our analyses. Nonetheless, it is possible that those experiencing problems could have had those issues since before the injury, or they may have emerged due to unrelated reasons after the injury. On the contrary, treatments recorded against the compensation claim are generally only funded if they are related to the management of conditions arising because of the injury event. Therefore we emphasise that while the present data probably reflect pain and mental health problems and treatments arising because of the injury, there could be greater complexities contributing to differences in patterns from these the two key data sources.

On a related note, people with a compensation claim who were included in the treated conditions mapping had more severe injuries and a higher proportion also had pre-existing drug or mental health conditions and pre-existing disability. Those who were in

Table 3
Association between residential area and reported and treated problems with pain and mental health, multivariable logistic regression.

	Reported problems with pain or discomfort		Treated pain		Reported problems with anxiety or depression		Treated mental health	
	AOR	95%CI	AOR	95%CI	AOR	95%CI	AOR	95%CI
Residential area								
Metropolitan	1.00		1.00		1.00		1.00	
Regional and remote	0.81	(0.69, 0.95)	0.64	(0.54, 0.76)	0.76	(0.65, 0.89)	0.67	(0.56, 0.81)
Sex								
Male	1.00		1.00		1.00		1.00	
Female	1.50	(1.28, 1.77)	1.39	(1.18, 1.63)	1.45	(1.23, 1.69)	1.69	(1.43, 2.01)
Age (years)								
< 25	1.00		1.00		1.00		1.00	
25 to 34	1.49	(1.20, 1.85)	1.50	(1.20, 1.86)	1.71	(1.38, 2.12)	1.23	(0.97, 1.54)
35 to 44	2.37	(1.90, 2.95)	2.33	(1.87, 2.91)	2.01	(1.62, 2.50)	1.77	(1.40, 2.23)
45 to 54	2.47	(1.97, 3.09)	2.56	(2.03, 3.24)	1.73	(1.38, 2.16)	1.58	(1.23, 2.03)
55 to 64	1.66	(1.31, 2.10)	2.09	(1.63, 2.69)	1.29	(1.02, 1.64)	1.20	(0.91, 1.58)
65 to 74	1.81	(1.38, 2.38)	1.89	(1.43, 2.51)	1.27	(0.97, 1.67)	0.78	(0.57, 1.08)
75+	1.12	(0.84, 1.49)	1.02	(0.75, 1.38)	0.73	(0.54, 0.97)	0.35	(0.23, 0.52)
IRSAD (quintile)								
1, most disadvantaged	1.00		1.00		1.00		1.00	
2	0.97	(0.74, 1.28)	0.77	(0.58, 1.01)	0.82	(0.62, 1.07)	0.98	(0.72, 1.35)
3	0.95	(0.75, 1.21)	0.93	(0.73, 1.17)	0.79	(0.62, 1.00)	1.09	(0.83, 1.41)
4	0.78	(0.61, 0.98)	0.90	(0.71, 1.13)	0.66	(0.53, 0.83)	1.06	(0.82, 1.37)
5, least disadvantaged	0.66	(0.51, 0.85)	1.01	(0.79, 1.29)	0.64	(0.50, 0.82)	1.18	(0.90, 1.54)
Education								
University	1.00		1.00		1.00		1.00	
Completed high school	1.43	(1.13, 1.81)	1.04	(0.81, 1.32)	1.37	(1.08, 1.74)	1.22	(0.94, 1.58)
Advanced diploma	1.42	(1.16, 1.73)	1.24	(1.01, 1.53)	1.52	(1.24, 1.86)	1.19	(0.95, 1.50)
Did not complete high school	1.69	(1.38, 2.08)	1.03	(0.84, 1.27)	1.84	(1.50, 2.26)	1.04	(0.82, 1.31)
Pre-injury disability								
None	1.00		1.00		1.00		1.00	
Mild	1.43	(1.12, 1.82)	0.76	(0.60, 0.98)	1.58	(1.26, 1.98)	0.98	(0.74, 1.28)
Moderate to severe	1.28	(0.92, 1.79)	0.54	(0.43, 0.69)	2.33	(1.69, 3.22)	0.69	(0.53, 0.90)
Compensable injury								
No	1.00				1.00			
Yes	2.77	(2.22, 3.45)			2.02	(1.61, 2.55)		
Road user								
Motor Vehicle Driver	1.00		1.00		1.00		1.00	
Motor Vehicle Passenger	1.16	(0.93, 1.44)	1.26	(1.03, 1.55)	1.09	(0.89, 1.35)	0.95	(0.76, 1.19)
Motorcycle driver or passenger	1.02	(0.85, 1.22)	1.23	(1.03, 1.47)	0.83	(0.70, 0.99)	0.92	(0.75, 1.12)
Pedal cyclist	0.69	(0.53, 0.90)	0.85	(0.62, 1.16)	0.67	(0.51, 0.87)	0.84	(0.60, 1.19)
Pedestrian and other	0.94	(0.75, 1.19)	1.18	(0.94, 1.48)	1.12	(0.89, 1.40)	1.24	(0.97, 1.58)
Injury Severity Score								
< 13	1.00		1.00		1.00		1.00	
13-15	1.02	(0.76, 1.35)	0.91	(0.67, 1.22)	0.83	(0.63, 1.10)	0.77	(0.56, 1.08)
16-19	1.20	(0.90, 1.61)	1.25	(0.92, 1.69)	0.94	(0.71, 1.26)	0.98	(0.70, 1.38)
20-28	1.60	(1.17, 2.19)	1.85	(1.34, 2.56)	1.11	(0.82, 1.51)	1.15	(0.81, 1.65)
> 28	1.48	(1.06, 2.06)	3.21	(2.29, 4.48)	1.35	(0.97, 1.86)	2.45	(1.71, 3.53)
Nature of the injury								
Soft tissue injury	1.00		1.00		1.00		1.00	
Head and other injuries	1.85	(1.26, 2.71)	1.96	(1.20, 3.21)	0.90	(0.62, 1.29)	1.08	(0.68, 1.71)
Spinal cord injury	7.48	(3.91, 14.30)	4.53	(2.27, 9.02)	1.16	(0.66, 2.04)	2.00	(1.04, 3.83)
Orthopaedic injuries only	3.55	(2.31, 5.46)	5.56	(3.26, 9.47)	0.92	(0.61, 1.38)	0.92	(0.55, 1.53)
Chest and abdominal injuries only	0.76	(0.47, 1.24)	0.79	(0.42, 1.49)	0.65	(0.41, 1.03)	0.25	(0.13, 0.49)
Chest, abdominal and other injuries	2.10	(1.44, 3.05)	2.21	(1.36, 3.59)	0.73	(0.51, 1.05)	0.60	(0.38, 0.95)
Other/multi-trauma	3.16	(2.10, 4.75)	3.94	(2.37, 6.54)	0.95	(0.65, 1.40)	0.89	(0.55, 1.43)

the reported conditions only cohort included people who were either ineligible for a compensation claim (e.g., pedal cyclists with no impact with a motorized vehicle, tram or train), or they did not lodge a claim. The group without a compensation claim contained a higher proportion of males, people with higher education level, and pedal and motor cyclists. When considered together, however, these differences highlight that our data probably show an over-estimation of the prevalence of treatment for the major trauma population given that people with more serious injuries are more likely to develop problems with pain and mental health (Blaszczynski et al., 1998; Holmes et al., 2010; O'Donnell et al., 2004; Giummarra et al., 2019), and to seek treatment.

There was a low prevalence of treatment for pain and mental health at a pooled level, and 21 specific LGAs had fewer than five people who reported pain or mental health, or received treatment for those conditions. The maps demonstrating the prevalence and population adjusted incidence across LGAs should therefore be considered with caution, as a small difference in cell sizes can cause a

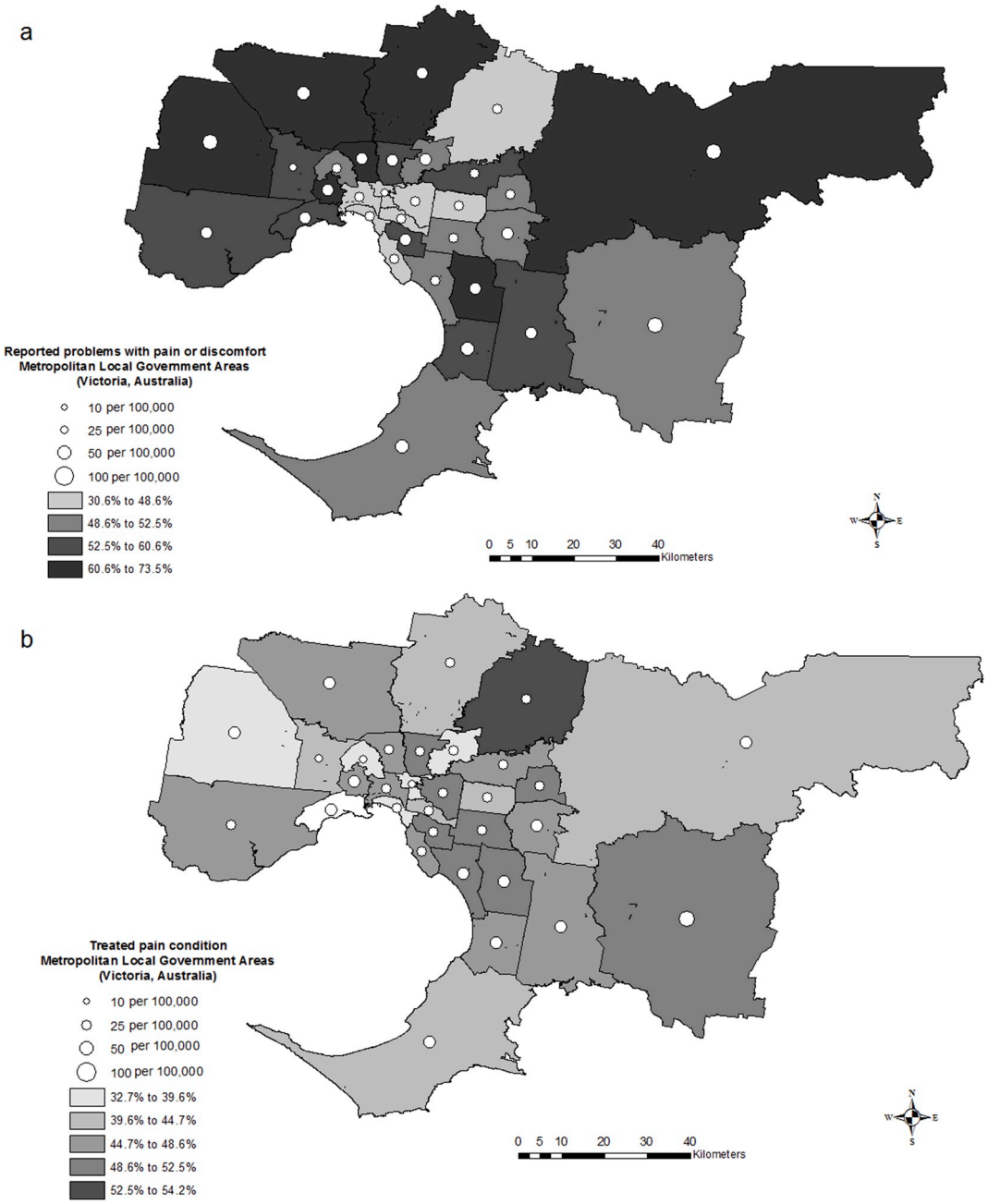

Fig. 2. Incidence (circles) and prevalence (shading) of (a) reported persistent or worsening problems with pain, and (b) treatment received for pain over 24 months post-injury in metropolitan local government areas.
Notes: The segments and shading in figure (b) were matched as closely as possible to the shading in figure (a), in which the cut-points were based on quintiles; data available in Supplementary Table 4.

large difference in the data. Moreover, due to small sample sizes in many LGAs the mapping data were purely descriptive, and we could not adjust for demographic or injury-related characteristics in, for instance, estimating the probability of reporting problems in each geographic region. It may be that differences in key factors known to be associated with reporting problems with pain or mental health, or accessing treatment, such as injury severity explain some of these regional variations. Further research including a longer inclusion period, and additional sources of treatments received may provide more stable patterns of pain and mental health outcomes. While the low prevalence of treatment may indicate that our treatment criteria were too stringent, we suggest that this is unlikely given that our levels of treatment were similar to, or higher than, those reported in other trauma and community samples. The prevalence also well exceeded that reported in a recent study of a population cohort including a higher proportion of cases with less serious injuries than the present study (i.e., 43.0% vs 6.3% for treated persistent pain, and 28.9% vs 3.3% for treated mental

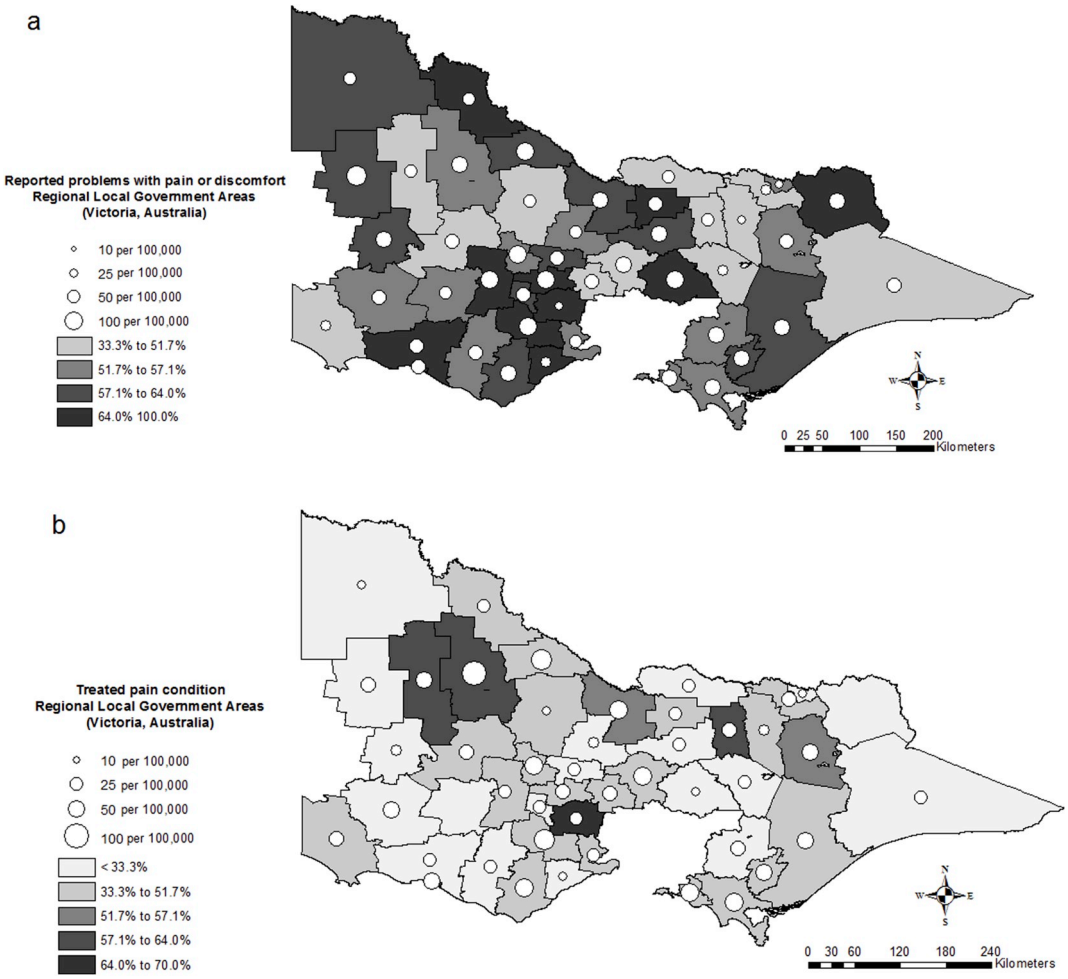

Fig. 3. Incidence (circles) and prevalence (shading) of (a) reported persistent or worsening problems with pain, and (b) treatment received for pain over 24 months post-injury in regional local government areas.
Notes: The segments and shading in figure (b) were matched as closely as possible to the shading in figure (a), in which the cut-points were based on quintiles; data available in Supplementary Table 4.

health conditions; Giummarra et al., 2018).

Finally, 30% of people were excluded from the reported problems analyses because they were missing from one or more follow up. A higher proportion of people who were lost to follow up were younger, living in metropolitan areas, had a pre-existing substance use disorder or moderate to severe disability, were not working prior to injury, had lower education level, were passengers, and sustained less severe injuries. While these characteristics were adjusted for in the multivariable analyses, the present findings may not generalize to people with those demographic and clinical characteristics.

4.2. Conclusions

This study examined the prevalence of problems with pain and mental health, and their treatment, in major trauma survivors. We found that although 42–55% of people experienced persistent or worsening problems with mental health and pain in the first two years following injury, respectively, only about a third to half of those received treatment for the respective condition during same period that was paid for by the compensation system. Moreover, there was lower prevalence of problems with both pain and mental health, and treatment for those conditions, in people living in regional and remote areas compared with people living in metropolitan areas. Future research is now required to understand the factors that facilitate or hinder treatment access and its effectiveness on pain and mental health, from individual demographic or clinical characteristics through to service availability, service funding or re-imbursement procedures. Modifiable factors should then be targeted to improve equitable service access in order to improve trauma recovery for every person injured in transport crashes, regardless of where they live.

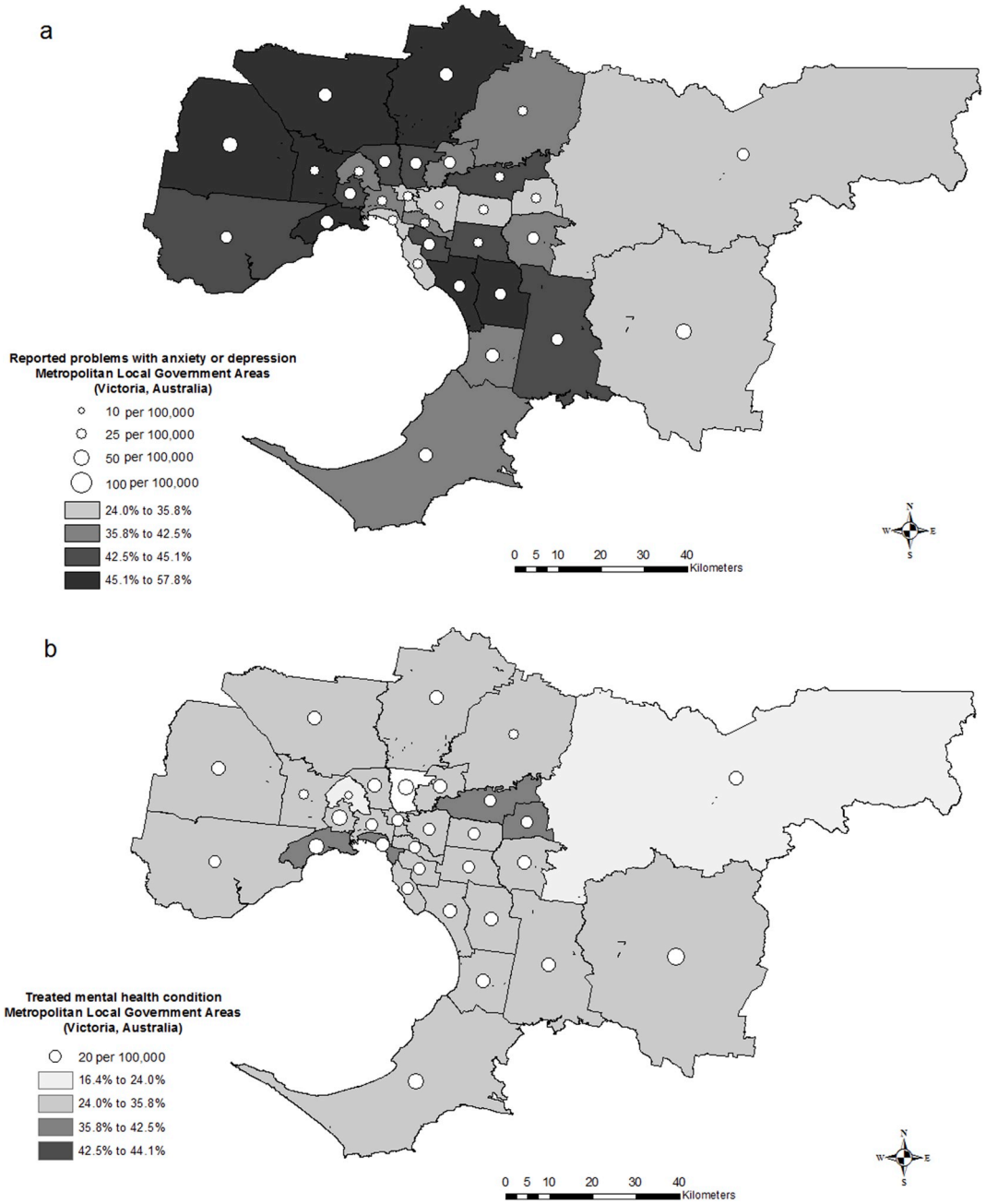

Fig. 4. Incidence (circles) and prevalence (shading) of (a) reported persistent or worsening problems with anxiety or depression, and (b) treated mental health conditions over 24 months post-injury in metropolitan local government areas.
Notes: The segments and shading in figure (b) were matched as closely as possible to the shading in figure (a), in which the cut-points were based on quantiles; data available in Supplementary Table 4.

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This project was funded by the Transport Accident Commission (TAC) through the Institute for Safety, Compensation and Recovery Research (ISCRR). ISCRR is a joint initiative of WorkSafe Victoria, the TAC and Monash University. The Victorian State Trauma Registry (VSTR) is a Department of Health and Human Services, State Government of Victoria and Transport Accident Commission funded project. MJG was supported by an Australian Research Council (ARC) Discovery Early Career Research Award (DE170100726), and a co-funded fellowship at ISCRR. BJG was supported by an ARC Future Fellowship (FT170100048).

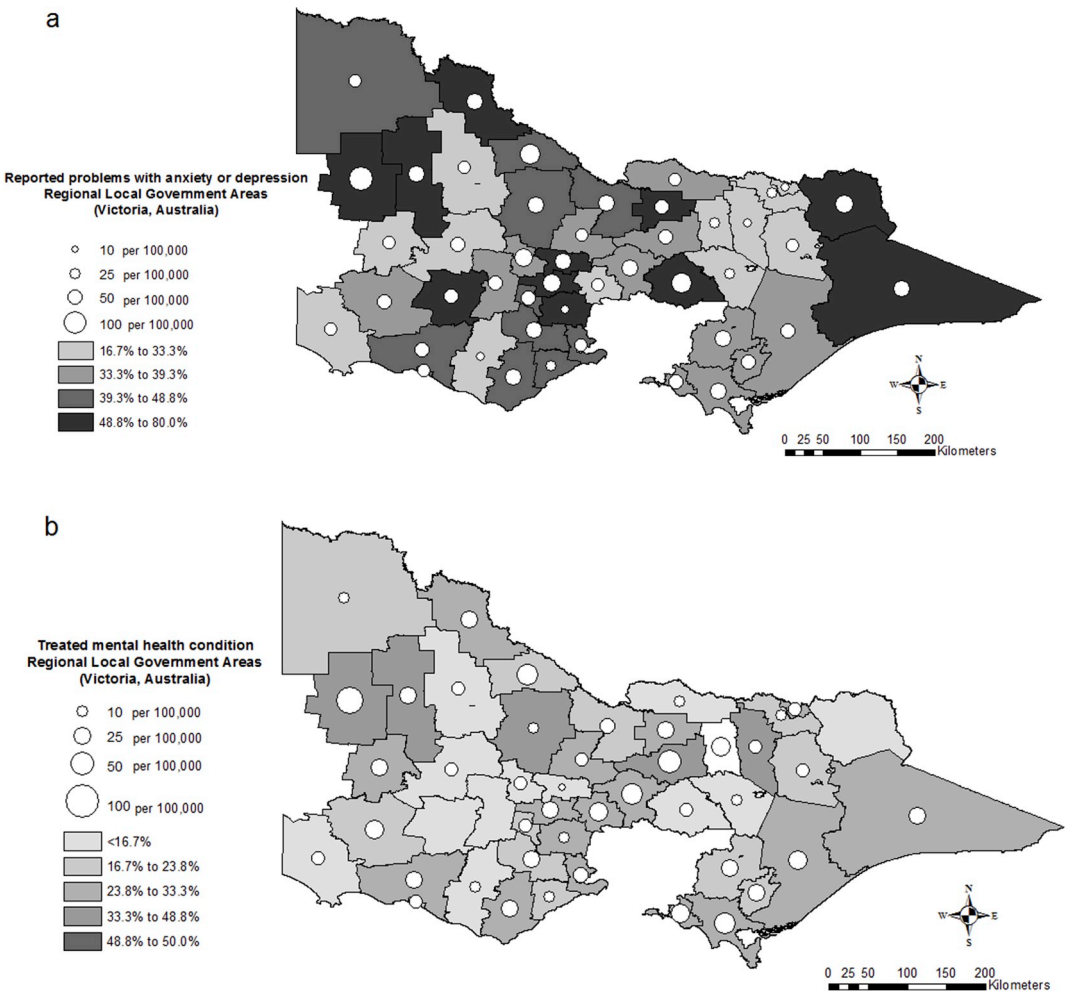

Fig. 5. Incidence (circles) and prevalence (shading) of (a) reported persistent or worsening problems with anxiety or depression, and (b) treated mental health conditions over 24 months post-injury in regional local government areas.
Notes: The segments and shading in figure (b) were matched as closely as possible to the shading in figure (a), in which the cut-points were based on quintiles; data available in Supplementary Table 4.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2019.100581.

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