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Review

Disadvantaged by More Than Distance: A Systematic Literature Review of Injury in Rural Australia

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Abstract: Rural populations experience injury-related mortality and morbidity rates 1.5 times greater than metropolitan residents. Motivated by a call for stronger epidemiological evidence around rural injuries to inform prevention, a systematic review of peer-reviewed literature published between January 2010 and March 2021 was undertaken to explore the epidemiology of rural injury and associated risk factors in Australia. A subsequent aim was to explore definitions of rurality used in injury prevention studies. There were 151 papers included in the review, utilizing 23 unique definitions to describe rurality. People living in rural areas were more likely to be injured, for injuries to be more severe, and for injuries to have greater resulting morbidity than people in metropolitan areas. The increase in severity reflects the mechanism of rural injury, with rural injury events more likely to involve a higher energy exchange. Risk-taking behavior and alcohol consumption were significant risk factors for rural injury, along with rural cluster demographics such as age, sex, high socio-economic disadvantage, and health-related comorbidities. As injury in rural populations is multifactorial and nonhomogeneous, a wide variety of evidence-based strategies are needed. This requires funding, political leadership for policy formation and development, and implementation of evidence-based prevention interventions.

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Keywords: regional; remote; trauma; accident; remoteness; rurality; safety; prevention; disadvantage

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1. Introduction

The World Health Organization identified injury as a global public health challenge, with over 521 million people sustaining injuries per annum and 4.5 million resulting in death [1]. Rural populations are known to have significantly poorer health outcomes when compared to their metropolitan counterpart [2], and Australia experience a hospitalization rate 1.8 times greater and a disease burden 1.7 times greater [2] than those residing in major cities. Those living in rural areas experience rates of injury-related mortality and morbidity 1.5 times greater than that of metropolitan residents [2,3].

Injury risk is influenced by the composition of rural areas, with rural populations being relatively older, having a higher proportion of males, an increased proportion of Indigenous Australians, a different occupation profile, increased prevalence of chronic disease morbidity, and higher levels of a socio-economic disadvantage when compared to metropolitan populations [4]. Lack of access to medical services [5], unreliable telecommunications [6], and higher rates of risky alcohol consumption have also been highlighted as factors impacting the risk of injury in rural Australia [7].

There is a call for stronger epidemiological evidence around rural injury [3,8,9] to inform prevention [10]. Currently, it is unclear which combination of human,

environmental, social, and agent factors contribute to increased rural injury risk [3,9]. When considering the determinants of health, it is important to distinguish which factors of rurality increase risk. Such factors may include characteristics intrinsic to rural populations such as environment, lifestyle, and occupations, as well as other determinants that are shared by urban counterparts with similar demographics such as being an Aboriginal and Torres Strait Islander, having low socio-economic status, or lower levels of education [8,11,12].

To better understand these factors, a systematic literature review was undertaken to explore the current knowledge of the epidemiology of rural injury and associated risk factors in Australia. A subsequent aim was to explore definitions of rurality used in injury prevention studies. This review examined both fatal and non-fatal and unintentional and intentional injury incidence between rural and metropolitan populations (all ages) in Australia. The review set out to answer the following research questions:

1. How is remoteness defined for studies of injury in Australia?
2. What is the difference in the incidence of unintentional and/or intentional injury by rurality?
3. Are there differences in the mechanism of injury by rurality?
4. What factors increase injury risk in rural areas?

2. Materials and Methods

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [13,14] and was prospectively registered with Prospero (#CRD42021255855). The study included peer-reviewed literature published in the English language between 1 January 2010 and 31 March 2021, with searches conducted in Medline, PubMed, Scopus, PsychInfo, SportDiscuss, and Cinahl. Search terms were intentionally broad, with no qualification of methodology or publication type, to enable all relevant articles to be captured. The search strategy included terms such as "rural", "regional", "remote", "injury", and "accident". Where possible, keywords were mapped to MESH terms (medical subject headings). Keywords, mesh terms, and Boolean search strings are described in Table S1.

Studies were included if they explored the epidemiology or risk factors associated with unintentional or intentional, fatal, or non-fatal injury in humans by rurality in Australia (Table 1). For this review, injury was defined as any cause (unintentional or intentional) of resulting pathological injury from an "energy" event, as stated by Haddon [15,16], and was expanded to also include psychological trauma resulting in injury. This review also incorporated injury as defined by the International Classification of Diseases (ICD) external cause codes; however, a definition of injury using ICD coding was not essential to determine inclusion for an injury event.

The Australian Statistical Geography Standard (ASGS) is currently the standardized structure used in Australia to define different locations across Australia and is also used as the basis for defining rurality based on social geography, developed to reflect the location of the people and communities [17]. The ABS (Australian Bureau of Statistics) currently uses the ASGS structure to classify Australia into five categories—major city, inner regional, outer regional, remote, and very remote—based on Australian population data [17]. ASGS takes into consideration the remoteness structure of the location, as defined by the Accessibility and Remoteness Index of Australia (ARIA+) [17]. For the purpose of this literature review, the term rural encompasses all areas outside Australia's major cities (inner regional, outer regional, remote, and very remote) [17].

The included studies used both standard and non-standard means of describing remoteness. In order to allow for comparison, studies reporting epidemiological data on fatal or non-fatal injuries that did not use the five categories of the ASGS [17] were transposed to one of the five ASGS categories for comparison. The definition utilized by the study was compared to that of ARIA+ in the transposition process, and the closest match

was identified. For those papers that reported on single locations or a statistical location, the location was transposed as per the ARIA+ coding for the location at the time of the study. Studies were identified by extracting the injury mechanism, which reported a proportion or rate for a rural area when compared to major cities. For the studies that recorded rates, an increase or decrease in rural injury compared to a major city population was recorded. Epidemiology was explored by age group defined as pediatric (<20 years), adult (≥18 years), and older adults (≥55 years). A meta-analysis of rural injury in the included studies was unable to be completed due to the reporting, both in terms of the inconsistent use of rural definition and the inconsistent definition of injury.

Studies from multiple countries where Australian-specific results could be extracted were included. Only peer-reviewed primary quantitative and qualitative studies were included if they addressed inclusion criteria. Studies that included data on areas classified as metropolitan or major cities were included if data specific to rural populations could be extracted. Studies of injury that occurred in rural Australia were included, regardless of the residential location of the person who was injured (Table 1).

Independent double-blind screening of studies by title and abstract, followed by a full-text review, was conducted by two authors (DHT and AEP). At either stage, a third reviewer (RCF) resolved conflicting votes. Two authors (DHT and AEP) conducted data extraction with a random 20% duplication. Epidemiological data were extracted for both fatal and non-fatal injuries (unintentional and intentional). Risk factors were defined as such if a statistically significant increase in injury risk was described ($p < 0.05$). Identified risk factors were assessed against Haddon's matrix and assigned to host, vector, or environment [16,18]. The environment was further split into physical and social environments.

Table 1. Inclusion and Exclusion Criteria.

Inclusion Criteria	Exclusion Criteria
• Data from primary analytical human studies that explore epidemiology, injury physiology, hospital reporting (i.e., severity), morbidity, mortality, and risk factors of injury in Australia • Unintentional or intentional injury • Fatal or non-fatal injury • Sample comprised of all injury types (there was no limitation placed on the classification of type of injury in individual studies) • Sample comprised of all age groups (no limitation placed on the age of the individuals in the individual studies) • English language published 1 January 2010 and 31 March 2021	• Studies were excluded if injury occurred outside Australia • Studies that were of a global comparison of Australian data could be extracted studies were included • Non-peer-reviewed or grey literature • Systematic or narrative literature reviews, commentaries, individual case reports • Non-human

A data extraction form used to assess the bias of the included studies for the purpose of this review was taken from the Critical Appraisal Tool for Case Series from the Joanna Briggs Institute (JBI) [19]. As this systematic review aimed to synthesize the best available evidence relating to rural injury in Australia, only studies with high methodological quality (global score of ≥70%) were included in the review [20]. Study quality included assessment of study design, sample (composition and size), measurements, and potential biases affecting validity. The level of evidence was also assessed, providing each article with a rank within the research hierarchy [21,22]. The rank provided reflects the potential of each study to adequately answer the set of research questions, based on the probability that its design has minimized the impact of bias on the results. The (Australian) National Health

and Medical Research Council (NHMRC) level of evidence hierarchy quantifies evidence into five levels (strongest evidence being I—a systematic review of randomized control trials, and V—non-analytical studies including case reports, expert opinion) was utilized [21,22].

3. Results

One hundred and fifty-one studies were identified for inclusion in this review (Figure 1; Table S2), with data ranging from 1983 to 2019. Evidence levels [21] ranged from III-2 to IV (Table S2). All studies met the inclusion criteria with respect to bias. Twenty-nine studies (19.2%) explored only the pediatric population, 28 studies (18.5%) explored the adult population only, and eight (5.3%) studies reported elders only. Eighty-eight studies explored all age groups (58.3%). Sixty-seven studies (44.4%) used ICD external cause coding to describe the injury.

Forty-three studies (28.5%) reported data by remoteness on a national level, 82 studies (54.3%) at a state/territory level, and 26 studies (17.2%) reported on a sub-state/territory or local level. Fifty-seven studies (37.8%) reported both epidemiology and risk factors.

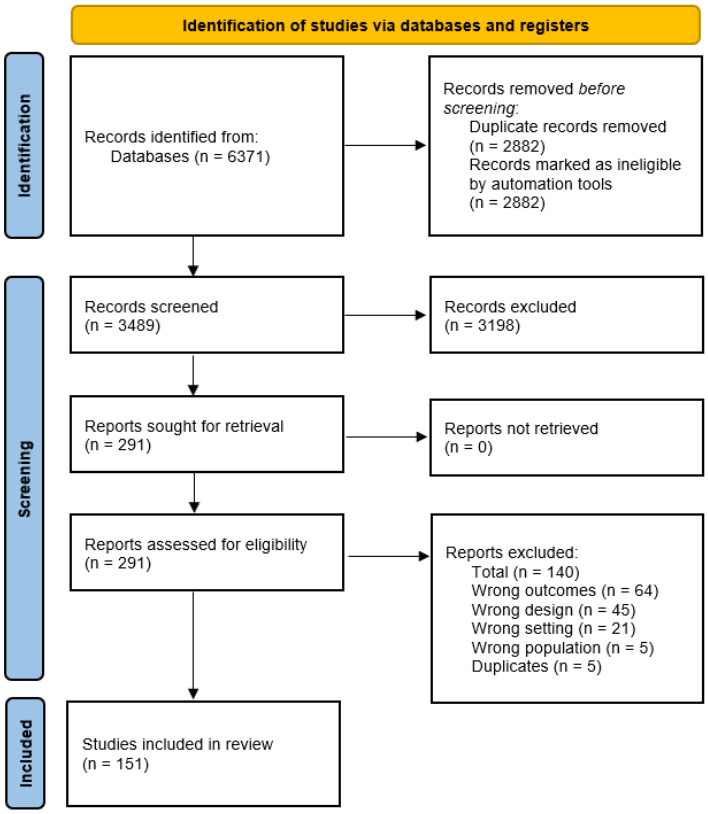


Figure 1. PRISMA Flow Diagram.

3.1. Rurality as Reported in Australia

Included studies used both standard classifications such as Accessibility/Remoteness Index of Australia (ARIA), ARIA+, ASGS, Australian Geographical Classification (ASGC), Rural Remote and Metropolitan Area (RRMA) (31.8%) [23–70], modified classifications (50.3%) [71–145], or their own classification system (23 different definitions) (17.9%) (Table 2) [146–171]. Those studies reporting epidemiological data on fatal or non-fatal injuries that did not use the ASGS were transposed to the ASGS categories for comparison (Table 2).

Table 2. Transposition of Remoteness Classifications.

Classifications in included Studies	Transposed Classifications				
	Major Cities	**Inner Regional**	**Outer Regional**	**Remote**	**Very Remote**
ARIA [23–40]	Highly accessible	Accessible	Moderately Accessible	Remote	Very Remote
ARIA+ [41–47]	Major Cities	Inner Regional	Outer Regional	Remote	Very Remote
ASGS [48–54]	Major Cities	Inner Regional	Outer Regional	Remote	Very Remote
ASGC [55–65]	Major Cities	Inner Regional	Outer Regional	Remote	Very Remote
RRMA [66–70]	Metropolitan centers (metropolitan zones 1 and 2)	Large and small rural centers (Rural zones 3–5)		Other rural and remote areas (remote zones 6 and 7)	
Other [a] [71–73]	Major City	Inner Regional	Outer Regional	Remote	
Other [b] [74]	Metro	Rural		Remote	
Other [c] [146]	Capital Cities	Regional Centres		Rural/Remote Areas	
Other [d] [75]	City	Town		Rural Areas	
Other [e] [76–89]	Urban (Metro)	Regional		Rural (or Remote)	
Other [f] [147–150]	Major City	Inner Regional		Other	
Other [g] [151]	Urban		Rural		Remote
Other [h] [90–105]	Metro (Urban or City)	Rural (Regional or other or rural/regional)			
Other [i] [152]	Paediatric TC Metro adult TC Metro local HF	Rural TC Rural local HF			
Other [j] [153]	Tertiary hospital	Large RH	Small RH		
Other [k] [154–165]	Urban		Rural (or regional or remote)		
Other [l] [166]	Greater Brisbane	Other Brisbane			
Other [m] [167,168]				Rural (5000 < 20,000)	
Other [n] [169,170]				Rural Scene	
Other [o] [171]	Remoteness (100 km from TH)				
Other [p] [106–109]	Statistical Local Areas (2006) (Transposed with ASGS)				
Other [q] [90,110–122]	Single Location (Transposed with ASGS)				
Other [r] [123–145]	LGA (Transposed with ASGS)				

HF—Health Facility, LGA—Local Government Area, RH—Regional Hospital, TC—Trauma Centre, TH—Tertiary Hospital.[a–r.] Alternative classification definitions as used by individual studies

From the 151 included studies, only 15 (9.9%) [9,23,25,27,28,33,43,44,50–52,55,57,58,122] recorded injury data using, or that could be transposed to, the five ASGS remoteness categories (Table 3) [17,172,173].

Table 3. Rural Australia Studies by ASGS Classification (included studies).

Author	Published	Date Range	Location	Age	Total Participants	Rurality Definition	Intention I/U/B	Injury Type/ Mechanism	ICD Coding	Fatal/ Non-Fatal
Berry et al. [58]	2010	2000–2006	Australia	0–14 yrs	95,485	ASGC	B	TBI (all-cause)	Yes	Non-Fatal
Cairns et al. [23]	2019	2015–2017	NSW	<18 yrs	506	ARIA	NR	Button Battery	No	Non-Fatal
Cenderadewi et al. [57]	2019	2006–2014	Australia	all ages	2731	Other	B	Drowning	Yes	Fatal
Esterman et al. [27]	2018	2007–2015	North QLD	15–64 yrs	3083	ARIA+	B	TBI	Yes	NR
Falster et al. [50]	2013	2001–2007	NSW	all ages	86,969	ASGS	NR	Road Traffic Injury	Yes	NR
Fatovich et al. [28]	2011a	1997–2006	WA	0–87 yrs	1328	ARIA	NR	All-cause Injury	No	NR
Franklin et al. [51]	2021	2010–2014	QLD	all ages	73,042	ASGS	B	All-cause Injury	No	NR
Gilligan et al. [44]	2007	2000–2013	SA	15+ yrs	162	ARIA+	NR	TBI	No	Both
Griffin et al. [25]	2018	1999–2009	QLD	0–14 yrs	1506	ARIA	U	Vehicle Run Over	No	Both

Harrison et al. [55]	2012	1970–2007	Australia	15–24 yrs	103,782	ASGS	B	TBI/HI	Yes	Both
Katzenellenbogen et al. [43]	2018	2002–2011	WA	15–79 yrs	16,601	ARIA+	U	TBI	Yes	Non-Fatal
Mitchell et al. [122]	2018	2010–2014	NSW	all ages	496,325	Other	B	All-cause Injury	Yes	Both
Osborne et al. [33]	2017	2001–2013	Australia	all ages	209	ARIA	B	Pesticide Ingestion	No	Both
Peden et al. [9]	2020	2007–2017	Australia	0–19 yrs	5153	ASGS	B	All-cause Injury	Yes	Fatal
Peden et al. [52]	2020	2013–2018	Australia	0–17 yrs	342	ASGC	U	Drowning	Yes	Fatal

B—Both, HI—Head Injury, I—Intentional, NR—Not Reported, TBI—Traumatic Brain Injury, U—unintentional, yrs—Year.

3.2. Epidemiology

Of the included studies, 102 (67.5%) reported epidemiological data (specifically reporting the distribution of injury in rural Australia with variables including age, sex, location, injury type/mechanism, intent, and fatal/non-fatal outcomes) (Table S3). Twenty-two studies included only fatal injuries (21.7%), 33 (33.4%) included only non-fatal injuries, and 29 (28.4%) reported both fatal and non-fatal injuries. Fourteen studies (13.7%) did not specify if injuries were fatal or non-fatal. Sixty-four studies (62.7%) reported an increase in injury (in terms of rates of injury) as remoteness increased.

Fifty-one studies (50.0%) explored the epidemiology of rural injury that encompassed all age groups (Table 4). Thirty-two studies (62.7%) reported an increase in injury in rural locations. A number of injuries increased in rural locations (regardless of age), including all-cause injury [31,45,48,54,59,62,115,118,119,129,135,136,139,141,143].

Table 4. All Age Rural Injury Epidemiology.

Age Range	Location	I/UI/B	Injury Type/Mechanism	Fatal/Non-Fatal	Increase with Rurality
All ages [75]	Victoria	Not Specified	Motorcycle crash injury	Both	Both
All ages [48]	Rural Victoria	Not Specified	All injury types and poisoning	Non-Fatal	NR
All ages [156]	Victoria	Not Specified	Cyclist crash	Both	Yes
All ages [57]	Australia	B	Drowning	Fatal	Yes
0–87 years [28]	Western Australia	Not Specified	All-cause injury	Not Specified	Yes
0–87 years [92]	Western Australia	B	All-cause injury	Not Specified	Yes
All ages [24]	Queensland	Not Specified	Road mortality hospitalizations	Fatal	Yes
All ages [148]	Australia	I	Opioid injection	Both	Yes
All ages [78]	Australia	UI	Snake bites	Both	Yes
All ages [31]	Rural Queensland	I	Suicide (all-cause)	Fatal	NR
All ages [171]	Northern Territory	Not Specified	Ocular injury—all-cause	Non-fatal	Yes
All ages [41]	Queensland	I	Suicide—all-cause	Fatal	Yes
All ages [26]	Western Australia	Not Specified	Jaw fractures—all-cause	Non-Fatal	Yes
All ages [79]	Queensland	UI	Horse-related injuries—all-cause	Non-fatal	Yes
All ages [71]	Australia	UI	Drowning (bystander)	Fatal	Yes
All ages [161]	Alice Springs/Darwin (NT)	I	Suicide—all-cause	Non-fatal	Yes
All ages [37]	New South Wales	B	Farm Injury (all-cause)	Both	Yes
All ages [129]	Rural Queensland	Not Specified	Injury (all hospitalization)	Non-fatal	NR
All ages [122]	New South Wales	B	All injury	Both	Yes
All ages [136]	Wagga Wagga (NSW)	UI	Eye Trauma (all-cause)	Non-fatal	NR
All ages [54]	QLD/NSW/VIC	UI	Cyclist injury	Fatal	NR *
All ages [89]	Australia	B	Road Injury (all-cause)	Fatal	Yes
All ages [139]	Rural Queensland	UI	Agriculture-related injuries	Both	NR
All ages [145]	Queensland	I	Suicide (all-cause)	Fatal	Yes

All ages [142]	Western Australia	B	Burns (all-cause)	Both	Yes
All ages [143]	Far North Queensland	I	Self-Harm (all-cause)	Non-Fatal	NR
All ages [81]	Queensland	UI	Drowning	Both	NR
All ages [60]	Far North Queensland	B	Injury—all-cause	Both	NR
All ages [68]	Australia	I	Suicide (all-cause)	Fatal	Yes
All ages [66]	Australia	I	Suicide (all-cause)	Fatal	Yes
All ages [116]	Western Australia	B	Burns	Non-Fatal	Yes
All ages [115]	Rural Western Australia	Not specified	Injury and poisoning	Not Specified	NR
All ages [165]	New South Wales	UI	Falls (all-cause)	Non-fatal	No
All ages [35]	Northern Territory	Both	Injury Trauma (all-cause)	Both	Yes
All ages [34]	Queensland	I	Suicidal Ideation (all-cause)	Non-fatal	Yes
10 + years [132]	Western Australia	I	Self-Harm (all-cause)	Non-Fatal	Yes
All ages [46]	New South Wales	B	All injury	Both	Yes
All ages [135]	Regional Tasmania	UI	All injury	Non-fatal	NR
All ages [33]	Australia	B	Pesticide Ingestion (all-cause)	Both	Yes
All ages [74]	New South Wales	B	Traumatic Brain Injury ()	Both	Yes
All ages [141]	Horsham (Victoria)	UI	Motocross injuries	Non-Fatal	NR
All ages [146]	Australia	I	Suicide (all-cause)	Fatal	Yes
All ages [105]	Victoria	B	Oxycodone Ingestion (all-cause)	Fatal	Yes
All ages [126]	New South Wales	I	Suicides and suicide attempts	Both	Yes
All ages [45]	Queensland	B	Road crashes	Both	Yes
All ages [59]	Australia	UI	Envenoming	Both	Yes
All ages [119]	Rural Queensland	B	Injury presentations	Not specified	NR
All ages [62]	Far North Queensland	B	Assault hospital presentations	Non-fatal	NR
All ages [100]	Victoria	UI	Sports injury hospital admissions	Non-fatal	Yes
All ages [118]	Regional Victoria	UI	Hospital sport injury (ED)	Non-fatal	NR
All ages [157]	New South Wales	Not Specified	Alcohol-related fatal traffic	Fatal	Yes

I—Intentional, U—unintentional, B—Both, NR—Not Reported or Not Applicable, ED—Emergency Department, * Number only—no rates.

Of the 25 studies (24.5%) that explored rural pediatric injury (Table 5), 20 (80.0%) reported an increase in injury in rural locations, such as splenic injury, [152] traumatic brain injury, [116] button battery injury, [23] road traffic injury, [76] all-cause injury, [28,92] low-speed vehicle run-overs, [150] burns, [47] drowning [80] and falls [87]. There were two studies that did not provide a comparator for rural injury [60,64].

Table 5. Paediatric Rural Injury Epidemiology.

Age Range	Location	I/UI/B	Injury Type/Mechanism	Fatal/Non-Fatal	Increase with Rurality
0–16 years [152]	New South Wales	UI	Splenic injury	Both	Yes
<16 years [49]	Victoria	UI	All-cause injury	Non-Fatal	No
0–14 years [58]	Australia	B	Traumatic brain injury	Non-fatal	Yes
<18 years [23]	New South Wales	Not Specified	Button battery exposure	Non-fatal	Yes
0–14 years [102]	Victoria	Not Specified	Road traffic injury	Fatal	Yes
0–15 years [168]	Victoria	Not Specified	all-cause pediatric trauma	Both	Yes
0–14 years [25]	Queensland	UI	LSVR injury	Both	Yes

<18 years [97]	Westmead (NSW)	B	Pediatric burns—all-cause	Not specified	Yes
<17 years [149]	Queensland	I	Assault related injury	Both	Yes
0–17 years [47]	New South Wales	B	Pediatric burns—all-cause	Non-fatal	Yes
0–17 years [53]	Australia	UI	Drowning (portable pools)	Fatal	Yes
0–17 years [9]	Australia	UI	Drowning (all-cause)	Fatal	Yes
0–4 Years [32]	New South Wales	UI	Poisoning (all-cause)	Both	Yes
0–19 years [60]	Far North QLD	UI	Dog bite injuries	Non-fatal	NR
0–14 years [103]	Victoria	UI	Drowning (all-cause)	Fatal	Yes
<18 years [77]	New South Wales	UI	Car-crash hospitalizations	Non-fatal	Yes
10–17 years [76]	New South Wales	Not Specified	Road traffic injury	Fatal	Yes
15+ years [98]	New South Wales	Not Specified	All-cause injury	Both	Yes
2–13 years [150]	New South Wales	B	All-cause injury	Non-fatal	No
18+ years [72]	Queensland	N	Injured trauma patients—all-cause	Both	Yes
11–18 years [87]	Western Australia	UI	Falls (all-cause)	Non-Fatal	Yes
0–16 years [40]	Australia	B	All-cause injury	Both	Yes
0–14 years [64]	Regional Victoria	UI	All-cause injury	Non-Fatal	NR
0–19 years [80]	Queensland	UI	Drowning (all-cause)	Both	Yes

I—Intentional, U—unintentional, B—Both, NR—Not Reported or Not Applicable, LSVR—Low-speed vehicle run-over.

Of the 21 studies (20.6%) exploring adult rural injury (18+ years) (Table 6), 10 (47.6%) reported an increase in injury in rural locations. Injuries that increased in rural locations for the adult population included suicide, [106] unintentional poisoning, [90] alcohol-related injuries, [70] traumatic brain injury, [27] ocular injury [42], and quad bike injuries [42]. Compared to metropolitan locations, the number of alcohol-related injuries was higher in larger regional and rural areas and similar in small rural towns [70]. Rates of alcohol-related injury were also significantly increasing over time for regional and rural locations [70].

Table 6. Adult Rural Injury Epidemiology.

Age Range	Location	I/U/B	Injury Type/Mechanism	Fatal/Non-Fatal	Increase with Rurality
all years [106]	Queensland	I	Suicide	Fatal	Yes
16+ years [154]	Victoria	B	Trauma all-cause	Both	No
17–25 years [90]	Wimmera (Victoria)	U	Poisoning	Non-fatal	Yes
<45 years [70]	Victoria	No specified	Alcohol-related injury	Non-fatal	Yes
15+ years [44]	South Australia	No specified	TIH—all-cause	Both	No
18+ years [147]	Australia	I	Suicide (all-cause)	Non-fatal	No
15–79 years [43]	Western Australia	U	TBI—all-cause	Non-fatal	Yes
40–98 years [42]	Australia	No specified	Ocular injury all-cause	Non-fatal	Yes
16–30 years [36]	Darwin (NT)	No specified	Quad bike injuries	Both	Yes
27–48 years [86]	Northern Territory	I	Interpersonal violence	Both	Both
45+ years [128]	The Kimberly (WA)	U	Falls (all-cause)	Non-fatal	NR
18–98 years [130]	Orange (NSW)	No specified	Femur fractures (all-cause)	Non-fatal	NA
18+ years [9]	Australia	B	All injury	Fatal	Yes
15–64 years [27]	North Queensland	B	TBI—all mechanism	Not specified	Yes
15–24 years [55]	Australia	B	TBI—all-cause	Both	Yes
>40 years [125]	Victoria	No specified	Hip fracture all-cause	Not specified	No
>40 years [123]	Victoria	No specified	Fall from height all-cause	Both	No
>40 years [124]	Victoria	No specified	Falls all-cause	Not specified	No
18+ years [38]	Australia	B	All injury	Non-fatal	NR *

18+ years [39]	Australia	B	All injury	Non-fatal	NR *
15+ years [144]	Hunter (NSW)	I	Suicide (all-cause)	Fatal	Yes

I—Intentional, U—unintentional, B—Both, NR—Not Reported or Not Applicable, TBI—Traumatic Brain Injury, TIH—Traumatic Intracranial Haemorrhage, * Numbers only (no rates).

Of the six studies (5.9%) exploring older adults' rural injury (55+ years) (Table 7), three studies had a comparison, of which two reported an increase in injury in rural locations for suicide [151] and non-fatal falls (<65 years) [91] and one exploring falls (both fatal and non-fatal) showed no difference by rurality [104].

Table 7. Elder Rural Injury Epidemiology.

Age Range	Location	I/IU/B	Injury Type/Mechanism	Fatal/Non-Fatal	Increase with Rurality
65+ years [153]	Regional QLD	Not Specified	All injury types	Both	NR
65+ years [151]	Queensland	I	Suicide—all-cause	Fatal	Yes
65+ years [91]	Victoria	UI	Falls	non-fatal	Yes
65+ years [127]	Regional Tasmania	UI	Hip fractures (all-cause)	Non-fatal	NA
60+ years [87]	Western Australia	I	Interpersonal violence	Non-Fatal	NR *
55+ years [104]	New South Wales	B	Falls (all-cause)	Both	No

I—Intentional, U—unintentional, B—Both, NR—Not Reported or Not Applicable * Numbers only (no rates).

3.2.1 ASGS Trends in Rural Injury

Fifteen studies [9,23,25,27,28,33,43,44,50–52,55,57,58,122] recorded injury data transposed to ASGS remoteness categories [17] (Tables 3 and S4). In general, the number of injury events decreased with remoteness, while rates per 100,000 population increased (Table S4).

The rates for head injury and traumatic brain injury increased with rurality across the five remoteness categories, [27,44,58] with injury rates in very remote locations up to 3.2 times more likely than in major cities [55] (Table S4). Youth and young adults (15–24 years) in very remote and remote areas had a greater risk of traumatic brain injury (2.5–3.0 times) and a greater rate of high threat to life (2.1–2.3 times), with males disproportionately affected [55] (Table S4). Aboriginal and Torres Strait Islander patients suffering a traumatic brain injury were also found to be more likely to live remotely [43]. Mechanism of injury differed by remoteness, with young Aboriginal patients in very remote locations more likely to be injured due to assault [3].

Drowning can be intentional or unintentional, for intentional drowning deaths by remoteness in inner regional (4.2 times), outer regional (4.1 times), and major cities (4.0 times) were higher when compared with that of very remote residents (Table S4). Unintentional drowning deaths were negatively correlated to intentional drowning deaths, with the highest mortality rate of 2.26 per 100,000 identified in residents of very remote areas [57] (Table S4).

There were five papers that explored poisoning [32,90,106,115,151], with outer regional and remote Queensland having significantly higher cases of pesticide poisoning than capital cities and very remote regions [33]. Pesticide poising appears to display cluster incidence coinciding with sugar cane growing regions and not remoteness [33]. When considering road transport injuries, Aboriginal and Torres Strait Islander people had higher rates of injury; however, when geographic clustering was taken into consideration, no difference in rurality was apparent [50] (Table S4). For children living in inner regional areas, low-speed vehicle run-over incidence increased significantly over time [25]. In contrast, the incidence of low-speed vehicle run-over events decreased significantly over time among children living in remote/very remote areas [25]. Incidence rates were lowest in major cities, with the highest incidence recorded in outer regional areas (42.5 per 100,000

population) [25]. Heavy vehicles such as four-wheel drives, utilities, trucks, and tractors were more frequently involved in low-speed run-over events that occurred outside major cities [25].

Female fatality rates for child and adolescent injury (8.73) were nine times high than in major cities [65]. Fatality rates increase with remoteness, with very remote areas recording an injury-related fatality rate six times greater than that of major cities [23,65] (Table S4).

3.3. Risk Factors

There were 108 (71.5%) studies that reported risk factors for rural injury (Table S5). Forty studies (37.0%) listed rurality itself as a risk factor for injury [9,23–25,37,41,42,49,53,57,58,61,69-71,78,79,82–85,90,94,95,97,101,121,137,151,154,157,159,160, 163, 167–169,171, 174,175]. Rurality significantly affected the age of the injured, mechanism of injury, bodily site of injury, and mode of arrival to initial hospital [167]. Rurality was found to significantly increase the risk of unintentional drowning [9,97,112], traumatic brain injuries [116], firearm injuries [67], child injury [9], snake bites [28], trauma-related injuries [62], motor transport [51] and agricultural farm-related injuries [29] (Table S5).

Risk factors that increase injury within rural locations were also identified. These risk factors were considered in terms of influence or effect on the pre-event, event, and post-event of the injury sequence and were mapped to the four factors of the Haddon Matrix (Tables 8 and S5).

Table 8. Haddon Matrix Factors by Rural Injury Risk Factors.

Host	Agent/Vehicle	Physical Environment	Social Environment
Age [24,28,31,37,54,56,60,90,92,97,106,113,120,128,140,142,143,159,162] Sex—Male [32,41,44,63,73,96,97,120,136,145,149,162] Sex—Females [41,79,114] Aboriginal and Torres Strait Islander [26,30,43,47,50,83,86,97,131,161,163,171,174] Less comorbidities [162] Comorbidities [43,73,114] Mental Health History [56,73,113,114,147,163]	BAC > 0.05 [99,109] Alcohol [52,107,109,129,133,175] Involving Equipment [139] Sport/Leisure [79] Work-Related Injuries [79,170] Motocross Sport [169] Non-Riders(horse-riding) [79]	Road Conditions—Straight/Open Road [109] Dark/Wet Conditions [155] Unlit/Dawn/Dusk [109] Day of Week/Season [166] Seasonal/Wet Season [117] Drought [96]	Previous attempts and Drug overdose [120] Speeding Related [89,109,164] Road rule violation [109] Low ISRAD [9,147,159,176] Risky Behaviour [54,97,110,111,138] History of abuse/neglect [108] Parent Separation [108] Retired/Unemployed [56] Employment Type (Farmer) [106] Cluster Demographics [145] Metropolitan Residential Postcode [137]

BAC—Blood Alcohol Concentration, ISRAD—Index of Relative Socio-Economic Advantage and Disadvantage.

A range of host/individual demographics was found to be directly responsible for the increased risk of rural injury. Age was found to be a risk factor for multiple injury mechanisms [24,28,31,37,54,56,60,90,92,97,106,113,120,128,140,142,143,159,162] (Table 8). Age risk factors varied depending on the injury modality (i.e., burns and drowning in a

pediatric population, and falls more prevalent in older persons). Males were at a significantly higher risk of injury in rural areas for all-cause injury [32,41,44,63,73,96,97,120,136,145,149,162], while being female was found to be a risk factor for horse-related injuries, suicide, depression, and suicidal ideation [41,79,114]. An Aboriginal and Torres Strait Islander person was also a risk factor for rural injury [26,30,43,47,50,83,86,97,131,161,163,171].

The number of comorbidities among rural individuals increased the risk of injury [43,73,114], including mental health [56,73,113,114,147,163] (Tables 8 and S5). Hip fractures and fall injuries in rural populations represented an inverse correlation when compared to other injury modalities. People who sustained hip fractures in rural areas were more likely to live independently and had fewer comorbidities [94].

Alcohol was found to be a significant agent increasing the risk of injury in rural environments [52,107,109,129,133,175] This included both general alcohol usage [52,107,109,129,133,175], and blood alcohol concentrations >0.05% [99,109]. Rural injuries involving equipment (e.g., farming equipment) were significantly greater in rural locations than in metropolitan areas [139]. This reflects both the rural workforce and the exposure to equipment in the home environment (Table 8).

Physical environmental conditions, [109,177] from landscape to infrastructure to wildlife, in Australia, are unique and carry specific risk factors that expose rural individuals to an increased risk of injury (Table 8). Road conditions were identified as a significant risk factor for rural injury, with significantly more rural road transport injuries occurring on a straight/open road than in metropolitan areas [109]. Wet and dark conditions were also highlighted as a risk factor [155], along with unlit/dawn/dusk environments [109]. The wet season and the environment it creates was identified as a risk factor for rural suicide [117]. Drought was also identified as a risk factor for rural suicide [96]. Snakebites, although a vehicle of injury, reflect the rural environment. Related work-related injuries in rural locations were also significantly increased, reflecting both the agent/vehicle of injury (heavy machinery, increased motor transport) and the environmental exposure (lack of safety precautions and enforcement in rural workforce industries, rural roads, etc.) [79,170]. Experience or familiarity with the activity or environment was found to be a risk factor for rural injury [79].

The social environment and social factors were found to impact the risk of injury in rural locations (Table 8). Speeding [110,164] was highlighted as a risk factor for rural motor transport injury. Among rural males, speeding was considered to be less risky than drunk driving [110] Speeding behavior was viewed as both acceptable and inevitable, with a reduction in trip time highlighted as a causative factor [110]. This demonstrated the interconnectivity between the social environment, agent/vehicle of injury, and host factors.

The socio-economic index (Index of Relative Socio-economic Advantage and Disadvantage (IRSAD)) was found to be a significant risk factor for injury in rural areas [9,65,147,159,176]. In most circumstances, relative disadvantage positively correlated to an increased risk of injury [9,147,159,177]. However, in some circumstances, this was not the case [25]. Over 50% of all pediatric low-speed run-over events in remote/very remote areas reflected a level of relative advantage [25]. Social protective factors for suicide in rural areas include being married and currently employed [69,113,178].

3.3.1 Increase in Morbidity/Mortality—Risk Factors

From the 108 studies identifying injury risk factors, 26 (24.1%) showed risk factors relating to the increased burden of rural injury [6,25,26,28,29,43,48,51,75,79,88,92,112,122,130,134,139,140,153,154,156,158,160,164,171,177] (Table S6). The increased morbidity, mortality, and burden of rural injury related directly to the severity of the incident, access to medical services, definitive care management received, and some demographical features (i.e., socio-economic disadvantage, private health insurance, being an Aboriginal and Torres Strait Islander person, etc.).

Severity was increased in many rural injury circumstances. This, in part, reflects the high energy exchange in rural injury events [79,97,112,164]. An increase in injury severity was seen across all age groups, both sexes, all locations, and injury mechanisms [25,79,92,97,112,140,156,160,164]. All-cause injury in rural locations was more frequently seen in a single site on the body; however, it was more severe [48] (Table S6).

The morbidity of a rural injury was found to be increased when compared to metropolitan injury events, mainly due to access to services (Table S6). The hospital re-presentation (under 72 h) rate was found to be 5.5% higher for rural injury incidents than those occurring in major cities [51,88,134]. The lack of outpatient and specialty services in regional areas significantly impacts the ability of the local emergency department (ED) and, in turn, increases the burden of injury events on the healthcare system with increased hospital re-presentations [134].

Time to definitive treatment was also found to be a risk factor for increased morbidity/mortality (Table S6). The median time between snake bite and first administration of antivenom was significantly greater in rural areas, with this interval not improving over a 10-year period [78]. Rural injuries had an increase in mortality when compared to major cities (major trauma), despite being adjusted for age, severity, and effect of time of treatment [28,92,158].

3.4. Quality Assessment

Lack of consistency in the measure of injury and rurality introduced methodological limitations and data quality issues. Measures of the severity of injury were also not reported consistently between studies. Many studies included objective morbidity and mortality measures only. Analysis between studies was limited, primarily attributed to the results based on numbers across remote and very remote Australia being too small in reporting and a combination of locality measures.

The sample size throughout most included studies was adequate for the statistical modeling used, and no studies reported significant underpowering (excluding three case series studies). Most studies utilized odds-adjusted ratios or adjusted-risk ratios, where rural areas were adjusted for age and sex. This limits the bias rurality creates when examining relative risks, such as a higher proportion of males and older populations. Pediatric studies utilized a pediatric-specific risk-adjustment model when considering pediatric injury. This allowed for exposure to be controlled for and promoted effective quality improvement in trauma care and delivery of prevention interventions, which are not undermined by misleading epidemiological analysis [168].

Both retrospective and prospective studies were used for data extraction. The three prospective studies included in this review reflected an adequate follow-up period, which attempted to provide trends over time, and the effects of injury acquisition in rural environments [69,131,163]. There was a measurement of bias associated with self-reported injury data that was impacted by the individual cofounders in the studies [32,110,133]. Additional limitations that affected systematic bias in the review included the lack of consistency in measures of the exposure, lack of clarity in the definition of injury and rurality, and small sample size for injury epidemiology in many studies for remote and very remote categories.

4. Discussion

This study identified that people living in rural areas are more likely to be injured, for injuries to be more severe, and for injuries to have greater resulting morbidity than people in metropolitan areas. Rural injury is challenging as rural areas are geographically vast and nonhomogeneous in nature.[179] Taking into consideration the non-homogeny, policy formation for prevention needs to encompass the multifactorial nature of the injury, at times with localized influences [3,180]. There are, however, some factors that appear to be consistent in rural environments (for example, male, alcohol consumption, high levels of socio-economic disadvantage, and high-risk occupations). Being able to identify

key risk factors specific to a given rural population will be required for successful preventative action to occur.

The burden of rural injury is increased in both terms of morbidity and mortality, with the incidence of injury and morbidity increasing with rurality, as does the cost per person [40,45,77,122,157]. This review found that although the rate per 100,000 population of alcohol-related crashes was 1.5 times higher in rural communities relative to urban communities, the attributed cost of the injury was more than four times greater [157]. The cost of injury is increased due to the cost increases associated with severity (with rural injury on average being more severe) and the cost of accessing services (with rural residents traveling great distances for definitive treatment) [45].

4.1. Defining the Burden of Rural Injury

In order to address the increased burden of rural injury, it must first be appreciated what rurality is. The term "rural" has a multitude of meanings and often encompasses distance from major centers, access to services, population density, and land use (e.g., farming), with it encompassing populations with a range of social and economic features [12,181,182]. Often rural populations are grouped by the use of the term "rural" and compared to "urban" populations [2]. This does not take into account the difference between or within rural locations. When defining rurality, this review found the terms describing rurality were not used consistently [57,74–105,146–151,154–165,167–170]. The terms "rural", "remote", and "regional" were also used interchangeably, as were "metropolitan", "metro", "urban", and "city" [57,74–105,146–151,154–165,167–170]. Transposition was challenging in studies that used Statistical Local Areas (SLA) [106–109] or Local Government Areas (LGA) [106–109] that spanned large geographical areas, as there were multiple rurality categories represented. Further work exploring services required for trauma by rural classification is needed.[183]

4.2. Risk Factors Affecting Rural Injury

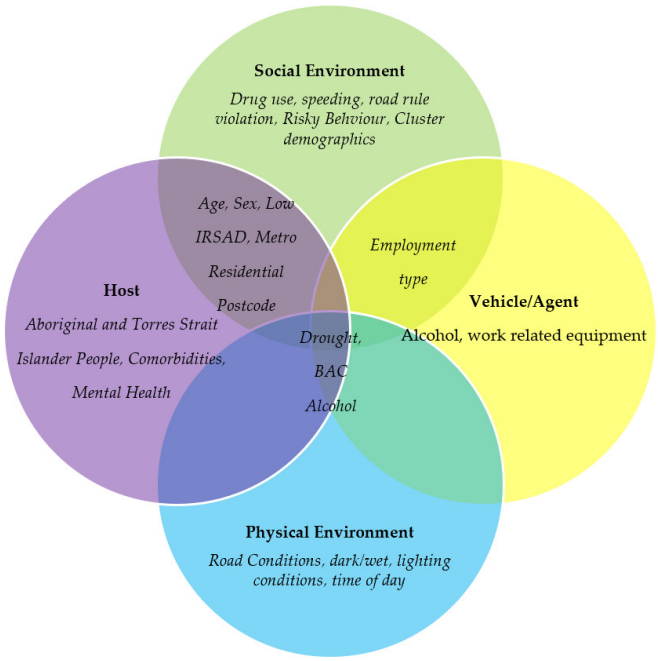
Risk factors affecting injury in rural areas were classified into the four Haddon Matrix factors, with these factors affecting the severity of injury (both morbidity and mortality). While this paper reported injury risk factors in terms of the Haddon Matrix Factors, it appreciated that risk factors could play a role in the pre-event, event, and post-event stages. The interconnection of the risk factor between the Haddon Matrix factors (host, environment, vehicle/agent) and the event (pre-event, event, and post-event) is complex and multidimensional. Age, for example, can affect the injury sequence from pre-event (risk-taking behavior and risk perception) and event (physiological responses to injury) through to post-event (recovery time, engagement in recovery process) [15,16,184,185].

Rural injury, once adjusted for social factors such as age and education, remains higher than metropolitan injury except for falls and hip fractures [142]. This highlights there are more than social factors and demographics of rural populations impacting injury risk (such as socio-economic status, education levels, etc.).[184] From this study, there is an increase and diversity of risk factors in rural environments that play a role in the increase in rural injury.

4.2.1. Risk Factors—Age (Host)

Age was a risk factor, and age was also found to impact social factors such as risk perception, attitudes/risk-taking behaviors (social environment), and exposure (physical environment and agent/vehicle) [110]. Age was found to be a risk factor for rural injury, with age influencing the distribution of rural injury [24,28,31,37,54,56,60,90,92,97,106,113,120,128,140,142,143,159,162]. For example, there were proportionately more pediatric burns, with significant variation existing between burns sustained by rural children as compared to their metropolitan counterparts [97]. Depending on the injury mechanism, many injury rates can be attributed to the age

distribution of the studied population (i.e., fall injury risk increases with age, and burn injury risk greater in a younger cohort) [8]. Rural populations typically consist of a younger population and an older population; however, "high risk" adults with an increasing number of comorbidities tend to relocate to urban centers with more services [4]. While limited, some studies show no consistent differences between rural and urban areas for specific injury types, such as falls in the older adult population [186] and hip fractures [125], and injury from falling objects in the general adult population [123]. The risk factors, although unique in their own right, are complex, with an interconnecting relationship influencing the injury event (Figure 2).



Note: IRSAD: Index of Relative Socio-economic Advantage and Disadvantage, BAC: Blood Alcohol Content

Figure 2. Interconnecting Relationship of Haddon Matrix Risk Factors (Road Injury).

4.2.2. Risk Factors—Aboriginal and Torres Strait Islander Peoples (Host)

While Aboriginal and Torres Strait Islander Peoples make up a higher proportion of the population in rural areas [85], they were also proportionately more likely to be at an increased risk of motor transport injury. However, they are less often the driver, although more likely to have been over the legal alcohol limit if driving, as well as being more likely to be an alcohol inebriated passenger [30]. Aboriginal and Torres Strait Islander Peoples were also more likely to be unemployed, unlicenced, distracted or fatigued, alcohol dependent, and to have a lower perceived social (but not personal) locus of control than non-Indigenous individuals [30]. Like many injury incidents, this interconnected relationship between host, vehicle/agent, and social factors must be taken into account when developing rural injury prevention strategies, highlighting the need to address the determinants of health [9]. The difference between the Aboriginal and Torres Strait Islander populations and non-indigenous populations in motor vehicle transport injuries can be in part attributed to the lack of access to licensing and associated limitations on employment opportunities [30]. These factors lend themselves well to preventative policy formation, with an emphasis on education, enforcement, and engineering issues [30,181,183]. Providing education specific to rural populations promoting social behavior change is necessary, with education accessibility addressed. Evidence would also suggest culturally appropriate Aboriginal and Torres Strait Islander Peoples strategy is needed to address road

fatalities in rural areas. The challenge of enforcement of workplace health and safety procedures on farms and generalized road rules (speeds) needs to be addressed.

4.2.3. Risk Factors—Environment

The environment (physical and social) plays a role in the risk of injury in rural locations. Rural locations have challenges in terms of reduced access to purpose-built infrastructure and the age and quality of current infrastructure. Infrastructure challenges in rural communities are wide-ranging, including sporting grounds (both aging and maintenance), which can also place populations at greater injury risk [169,187], decreased medical and allied health infrastructure, aging airstrips, unsealed roads, and telecommunication black spots. There is also greater variation in occupations in rural populations, with many occupations presenting increased injury risk [4], including agriculture [188,189], mining, forestry, fishing, and rural pilots [190]. The call to address these specific occupation rural injury risks needs to be examined further.

Addressing environmental factors associated with rural roads plays a factor in increased injury risk [3,40,122]. The physical environment, such as the increase in unsealed roads and animals on roads in rural areas [46,191], and sociocultural norms such as reduced enforcement of speed limits or random alcohol tests [192] need to be considered in preventative policy formation. Unsealed roads also do not accommodate modern automobile safety features, such as lane keep assist, further increasing the rural and metropolitan disparity. Distances traveled by rural populations, fatigue, vehicle speed, lighting, and road conditions were all found to contribute to higher injury mortality, hospitalization, and morbidity [46,191]. Environmental factors, such as drought and the flow-on income-driven effects of the heavily environment-dependent workforce, increased access to firearms, and decreased access to mental health services, also play a factor in the increase in self-harm injuries in rural Australia [193].

4.3. Protective Factors Affecting Rural Injury

There are studies that report protective factors associated with injury in rural populations. [157,194–198] New South Wales rural residents were less likely to make the wrong choice with respect to rip identification when compared to other Australian beachgoers [196]. Western Australia and New South Wales rural residents were reported to be more likely to have completed cardiopulmonary resuscitation (CPR) training than metropolitan residents [197,198]. While studies show protective factors, there are also contradicting studies showing injuries that occurred in rural regions had significantly lower odds of attempted resuscitation relative to those in urban regions [154]. Attempted resuscitation has two parts, the first being individual willingness and ability to assist as a first responder and the second being the injury severity warranting resuscitation on-site. A number of casualties in high energy transfer injuries are pronounced deceased at the site of injury, which limits the participation of resuscitation [154]. This can impact reporting in rural injury events, where high energy transfer injuries are more prevalent and injury severity is increased.

4.4. Rural Injury Severity

Injury severity in rural Australia is also elevated by distinctive factors present in rural populations, including the lack of access to major services (i.e., medical services) [152], decreased or unreliable telecommunications access [7], and increased rates of risky alcohol consumption [194]. Telecommunication services play a vital role in reducing the burden of rural injury in terms of access to emergency services, access to prevention materials (education materials or safety information), and access to rehabilitation services. The connectivity issues across rural Australia, although improved greatly in recent years [51], are still not equitable to metropolitan counterparts, both in terms of available service and service reliability [48,149].

4.5. Strengths and Limitations

This study was strengthened by the deliberately broad search strategy, encompassing a more holistic definition of injury in the literature and examining the differing definitions of "rural" within the academic literature. However, it has a number of limitations. Studies within the review were not differentiated with respect to the rurality of residence or the rurality of the injury incident location. It is appreciated that risk factors or the risk of injury differ by residential status. Rural residents have a different risk profile for injury in a rural location than metropolitan residents in the same rural environment simply due to familiarity and increased exposure, with limited studies exploring exposure in any detail.

Limitations continue in the synthesis of information from the included studies with the non-standardized rural definition used across most of the studies. The use of non-standardized definitions limits the comparability between the individual studies. Due to small numbers in remote/very remote locations, re-classification of rurality codes and non-homogenous locations were reported as a single location. Few studies displayed trend over time data, and any trend over time data was incomparable (due to definition and injury mechanism explored) between studies limiting any analysis that could be performed. Studies in the review highlighted study bias, which continued through many of the individual studies. Potential biases in the data sets utilized in individual studies exist due to the preferential reporting from metropolitan areas, with reports not capturing deaths that occur prior to transport or the following discharge. Ultimately, this leads to an increased odds of mortality for metropolitan regions and for patients transported directly from the scene of the injury [104].

5. Conclusions

Epidemiological data suggest rural populations are proportionately overrepresented in injury statistics. Policy, prevention programs, and interventions for rural populations, which are often small, dispersed populations throughout Australia, are challenging. This necessitates the need for strong leadership and innovative, evidence-based approaches to be taken. For this to be materialized, funding supporting injury issues identified by strong epidemiological evidence are needed for policy formation and prevention. As injury in rural populations is multifactorial in nature, no one strategy will prevent all rural injuries or lessen the burden of rural injury in Australia.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/safety8030066/s1, Table S1: Database and search strategy; Table S2: Australian rural injury included studies; Table S3: Epidemiology of rural injury included studies; Table S4: Injury Epidemiology by rural in Australia; Table S5: Risk factors for rural injury; Table S6: Increase Morbidity/Mortality of injury risk factors.

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