Rural, Semirural, and Urban Trauma in the Midland Region of New Zealand

Final report for the

Waikato Medical Research Foundation

(August, 2018)

Mr Grant Christey[a,g]
Alastair Smith[b]
Dr Anita Bell[c]
Alaina Campbell[d]
Dr Veronique Gibbons[e]
Prof. Ross Lawrenson[f]

[a]Clinical Director of Trauma Services, Midland Trauma System
[b]Biostatistician, Midland Trauma System
[c]Clinical Leader-Population Health, WDHB: study design, census rurality grouping
[d]Nurse Consultant, Midland Regional Trauma System. Project coordination.
[e]Researcher Waikato Clinical School. Manuscript preparation and formatting.
[f]Public Health Medicine and Rural Health: advice on study design, writing and dissemination
[g]Waikato Clinical School, University of Auckland

Correspondence to: Dr Grant Christey, Midland Trauma System,
Waikato Hospital, Hamilton 3204, New Zealand
email: Grant.Christey@waikatodhb.health.nz

Acknowledgements:
The authors would like to acknowledge the following people for their assistance in the preparation of this manuscript: Neerja Singh (Research Coordinator, Midland Trauma Research Centre).

Abstract

Large parts of the Midland region, as well as New Zealand as a whole, are very rural and sparsely populated. However, the incidence of trauma resulting in hospitalisation in relation to rurality of patient domicile has not been described for any representative population in New Zealand. Furthermore, studies in the UK, Europe, and North America suggest that trauma in rural areas has significant effects on health outcomes compared with urban trauma (Health, 2007; Lipsky et al., 2014; Litchfield, 2002; Singh & Siahpush, 2014). In this study, trauma registry data collected by the Midland Trauma System (MTS) for patients admitted to hospitals in the Midland region has been used to describe trauma patient demographics, causes of injury, and outcomes. These variables have been analysed in relation to patient domicile according to three principle rurality groups: urban, semirural, and rural, to identify similarities and variations between the groups.

The study has shown significant variations in the patterns and incidence of trauma between the three domicile rurality groups:

1. Males aged 15-34 years living in rural and semirural areas are at extreme risk of injury. Compared to females the same age, urban males are at 3 times higher risk of hospitalisation due to trauma, while males residing in rural and semirural areas are at almost 4 times higher risk.
2. Road traffic and motorcycle crashes are common causes of injury among young males (15-34 years) living rurally. Machinery and quad bike related injuries are also more common among this group. Injuries among those living in urban areas are dominated by falls, particularly among older adults aged 70 years and over.
3. Semirural populations exhibit a complex combination of both rural and urban trauma. They include both the same peak in trauma seen among young rural males 15-34 years, and same the high incidence of trauma seen among urban dwelling older females.
4. Māori residing in each of the rurality groups are at approximately 50% greater risk of hospitalisation due to trauma than non-Māori. Assault, struck (unintentional), and road traffic crash injuries are common causes of injury in each of the domicile rurality groups.
5. Across the Midland region, rural dwelling patients had almost three times higher rates of transfer from first arrival facility onwards to a second acute care facility. However, subsequent transfers to a third or more facility were significantly lower among rural resident patients than for urban resident patients. This may be a positive sign that most decisions surrounding first inter-hospital transfers for rural patients are appropriate.
6. Outcomes were similar between the three rurality groups. The demographic differences identified in this study may help to explain this. For example, the slightly longer average length of stay (LOS), and marginally higher case fatality rates, observed among urban residents may be linked to the high incidence of trauma among older persons (70+ Years), especially older females living in urban and semirural areas. Longer LOS and higher case fatality rates have previously been observed among older persons, even for those with non-major injuries. Further study will be required to examine this in greater detail.

This information will provide baseline data for evidence-based system change and prevention strategies that can be tailored to groups at risk of injury according to their domicile rurality.

Background

One in four New Zealanders live rurally or in small rural towns (Ministry of Health, 2018). For those who live in rural areas, the timeliness of treatment may be impeded by the long distances emergency services must travel to reach them and then convey them to trauma care facilities (Smith, Humphreys, & Wilson, 2008). Several studies in Australia, Europe, and North America have also demonstrated variations in the risk and causes of injury or death in urban and rural areas (Bakke et al., 2013; Harland, Greenan, & Ramirez, 2014; Jørgensen, 2013; Kristiansen, Rehn, Gravseth, Lossius, & Kristensen, 2012; Mitchell & Chong, 2010; Ryb, Dischinger, McGwin Jr, & Griffin, 2012; Singh & Siahpush, 2014).

One study that looked at location of crash and location of residence for victims found that rurality was an increased risk for both drivers who live in rural areas and to others who travel there (Jørgensen, 2013). A New South Wales, Australia, study examined differences in injury rates of child motor vehicle passengers using usual residence rather than crash location (Du, Finch, Hayen, & Hatfield, 2007). Children residing in rural areas also had significantly higher injury rates (Relative Risk = 2.1) than urban children across all injured body regions and specific injuries. This study citing literature that used crash location, stated that rural areas had three times the rate of injury than urban areas; with the authors suggesting the difference between this and their study may be attributed to locating people by their use of usual residence rather than the crash location. As yet there is sparse knowledge of the incidence and distribution of trauma requiring admission to hospital in New Zealand as it relates to the rurality of domicile of the patient.

The Midland Region (usually resident population count ~880,000, Census 2013) has a demographic and socio-economic profile that is broadly representative of New Zealand's total population (Census 2013) therefore providing a useful population model to study. The Midland Trauma System was established in 2010 to enable standardisation of trauma care consistent with international best practice (Christey, 2013). The Midland DHBs (Bay of Plenty, Lakes, Taranaki, Tairāwhiti and Waikato) contribute trauma data to a customised regional trauma registry that includes data from point of injury to discharge from acute care.

This study aims to determine the detailed nature and volume of injury associated with urban, semirural, and rural communities. The risk profiles of these populations will be identified and compared to guide further analysis. Care processes and outcomes will also be assessed according to rurality of patient residence. Remediable anomalies will be reported directly to regional care providers and injury prevention bodies, and the effects of evidence-based change measured in the MTS trauma registry.

Methods

A retrospective review of anonymised, prospectively-collected MTS registry data for the period 1 January 2012 to 31 December 2017 was conducted. Inclusion criteria for the study were: patients admitted to a Midland base hospital as a result of, and within 7 days of injury occurring within the Midland region excluding Tairāwhiti DHB which was a more recent addition to the registry. Consistent with trauma registries internationally, patients were excluded if they sustained insufficiency or periprosthetic fractures, exertional injuries, hanging/ drowning/asphyxiation without evidence of external force, poisoning, ingested foreign body, injury as a direct result of pre-existing medical conditions or late effects of injury, or the injury occurred more than 7 days prior to admission (Nwomeh, Lowell, Kable, Haley, & Ameh, 2006).

Event episodes were the unit of analysis. For example in situations where a patient was transferred to other hospital/hospitals in the region for the same injury event, this was counted as a single event and the event assigned to the first MTS hospital where the patient was treated. Length of stay was inclusive of the total days admitted to all hospitals for the index event. Variables examined included: patient demographic characteristics, injury event information, in-hospital management, type and severity of injuries, length of stay and discharge destination. The Injury Severity Score (ISS) numerically describes the overall severity of injury, and is calculated from the three most severely injured body regions as scored by the Abbreviated Injury Score (Medicine, 1990). Non-Major admitted trauma is classified as (ISS < 13) and major trauma as (ISS 13-75) (Baker, o'Neill, Haddon Jr, & Long, 1974). Ethnicity information was obtained from the patient's unique national health identifier (National Health Index number [NHI]) or directly from the patients themselves. Mechanisms of injury were categorised using the Intl. Classification of Disease (ICD-10AM 6th Edition) external cause codes (National Centre for Classification in Health., 2006).

Statistics New Zealand classifications were used to classify CAU populations as urban (Main Urban, Satellite Urban, Independent Urban), semirural (Rural with moderate or high urban influence), and rural (Rural with low urban influence, Highly rural/remote) (2013 NZ Census normally resident population (Statistics New Zealand, 2014, Wellington), see Appendix I. Patient domicile is recorded in the trauma registry at the census area unit (CAU) level and used to map to corresponding rurality groups. R-Studio statistical software [ref] was used for the analysis. Poisson regression was used to analyse urban, semirural, and rural risk differentials as relative risk together with ninety-five percent confidence intervals (95% CI), and P values were used to determine the result significance. T-Tests were used to compared continuous variables as appropriate. The study adhered to the MTS Data Use Policy and access to data approved by the MTS Strategic Group. Ethical approval was not required for this study as the analyses involved the use of anonymised secondary data. The MTS trauma registry meets HISO standard 12009:2015.[ref]

Results

Demographic groups at risk

During the six year period 1 January 2012 to 31 December 2017 there were 29,595 trauma events involving patients domiciled within the Midland Region (Excluding Tairāwhiti DHB). Table 1 shows the characteristics of trauma events according to key demographic features and the rurality of patient domicile.

Table 1. Characteristics of trauma in Midland Region (Excluding Tairāwhiti DHB) domiciled patients, 2012-2017, by rurality of patient domicile (Events, %), n = 29,595.

	Patient domicile rurality			
	Urban	**Semirural**	**Rural**	**Total**
Population	*455,667 (53.6%)*	*146,370 (17.2%)*	*247,737 (29.2%)*	*849,774 (100%)*
Total	15,364 (51.9%)	5,411 (18.3%)	8,820 (29.8%)	29,595 (100%)
Major/Non-Major				
Non-Major (ISS* <13)	14,501 (52.1%)	5,100 (18.3%)	8,226 (29.6%)	27,827 (100%)
Major (ISS > 12)	863 (48.8%)	311 (17.6%)	594 (33.6%)	1,768 (100%)
Gender				
Female	6,008 (55.1%)	1,971 (18.1%)	2,929 (26.9%)	10,908 (100%)
Male	9,328 (50.1%)	3,421 (18.4%)	5,869 (26.9%)	18,618 (100%)
Māori/Other				
Māori	4,140 (51.0%)	1,297 (16.0%)	2,682 (33.0%)	8,119 (100%)
Other	11,196 (52.3%)	4,095 (19.1%)	6,116 (28.6%)	21,407 (100%)
DHB (Patient domicile)				
Waikato	4,679 (37.1%)	3,173 (25.2%)	4,762 (37.8%)	12,614 (100%)
Bay of Plenty	6,026 (64.8%)	1,681 (18.1%)	1,593 (17.1%)	9,300 (100%)
Lakes	2,945 (74.7%)	63 (1.6%)	935 (23.7%)	3,943 (100%)
Taranaki	1,714 (45.9%)	494 (13.2%)	1,530 (40.9%)	3,738 (100%)

**ISS – Injury Severity Score*

Approximately 94% of all events were Non-Major admitted trauma (ISS < 12), 63% of all events were males, and 27% of all events were Māori.

Table 2 further shows annualised incidence per 100,000 population per year (Gender and Ethnicity population adjusted) according to patient domicile rurality.

Table 2. Average annualised incidence of trauma in Midland Region (Excluding Tairāwhiti DHB) domiciled patients, injury 2012-2017, by rurality of patient domicile (Incidence per 100,000 population/Yr, 95% Confidence Intervals).

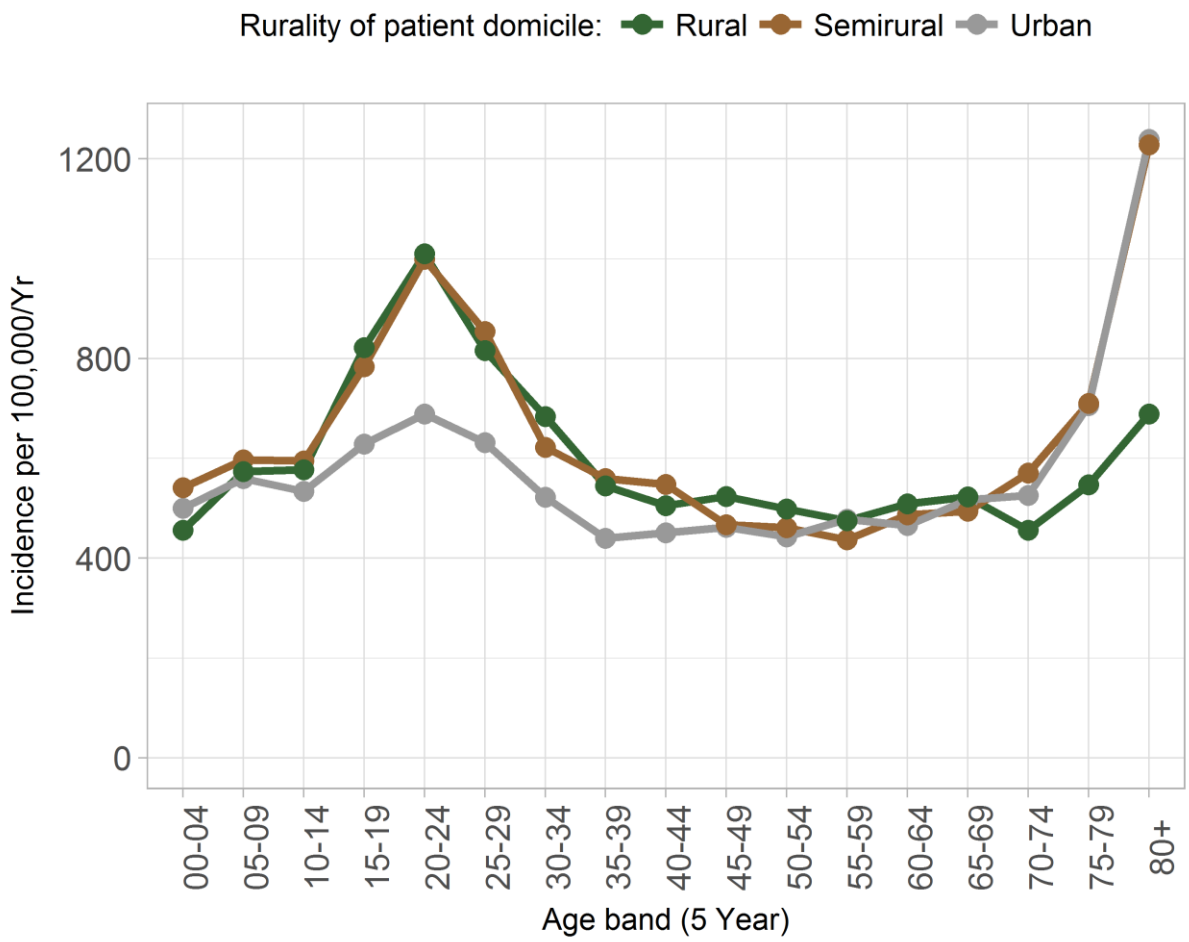
	Patient domicile rurality			
	Urban	**Semirural**	**Rural**	**Total**
Total	562 (517-610)	616 (569-667)	593 (547-643)	580 (535-629)
Major/Non-Major				
Non-Major (ISS* <13)	530 (487-577)	581 (536-630)	553 (509-601)	546 (502-594)
Major (ISS > 12)	32 (23-45)	35 (25-49)	40 (29-55)	35 (25-49)
Gender				
Female	420 (382-462)	438 (399-481)	390 (353-431)	414 (376-456)
Male	716 (665-770)	800 (746-857)	799 (745-856)	755 (703-811)
Māori/Other				
Māori	797 (744-854)	785 (732-842)	774 (721-830)	785 (732-842)
Other	506 (464-552)	545 (501-593)	537 (493-584)	521 (478-568)
DHB (Patient domicile)				
Waikato	492 (450-537)	547 (503-595)	567 (522-616)	532 (489-579)
Bay of Plenty	639 (591-691)	835 (780-894)	731 (680-786)	683 (634-736)
Lakes	573 (528-622)	600 (554-650)	640 (528-622)	598 (552-648)
Taranaki	526 (483-573)	509 (467-555)	541 (497-589)	530 (487-577)

**ISS – Injury Severity Score*

Across the Midland region (all ages, genders, and ethnicities) the overall incidence of trauma was 580 per 100,000 population/Yr (Table 2). Those living within CAUs classified as semirural had the highest incidence of overall trauma (616 per 100,000 population/Yr) while those living within urban CAUs had the lowest incidence of the three groups (562 per 100,000 population/Yr). No significant effect of domicile rurality on injury severity (major versus non-major) was found although the incidence of major trauma among rurally dwelling residents was slightly higher than among urban dwelling residents (40 versus 32 per 100,000 population respectively).

Males living in semirural and rural CAUs had the highest incidence of trauma (800 and 799 per 100,000 population/Yr respectively) compared to urban males (716 per 100,000 population/Yr). Incidence for females was comparable across the three domicile rurality groups but was slightly higher among urban and semirural dwelling female residents. Māori had a higher incidence of trauma compared to other non-Māori in each of three domicile rurality groups. The incidence of trauma among the three rurality groups by five-year age bands is shown in Figure 1.

Figure 1. Annualised incidence of trauma per 100,000 population/Yr in Midland Region (Excluding Tairāwhiti DHB) domiciled patients, 2012-2017, by 5 year age band and rurality of patient domicile.

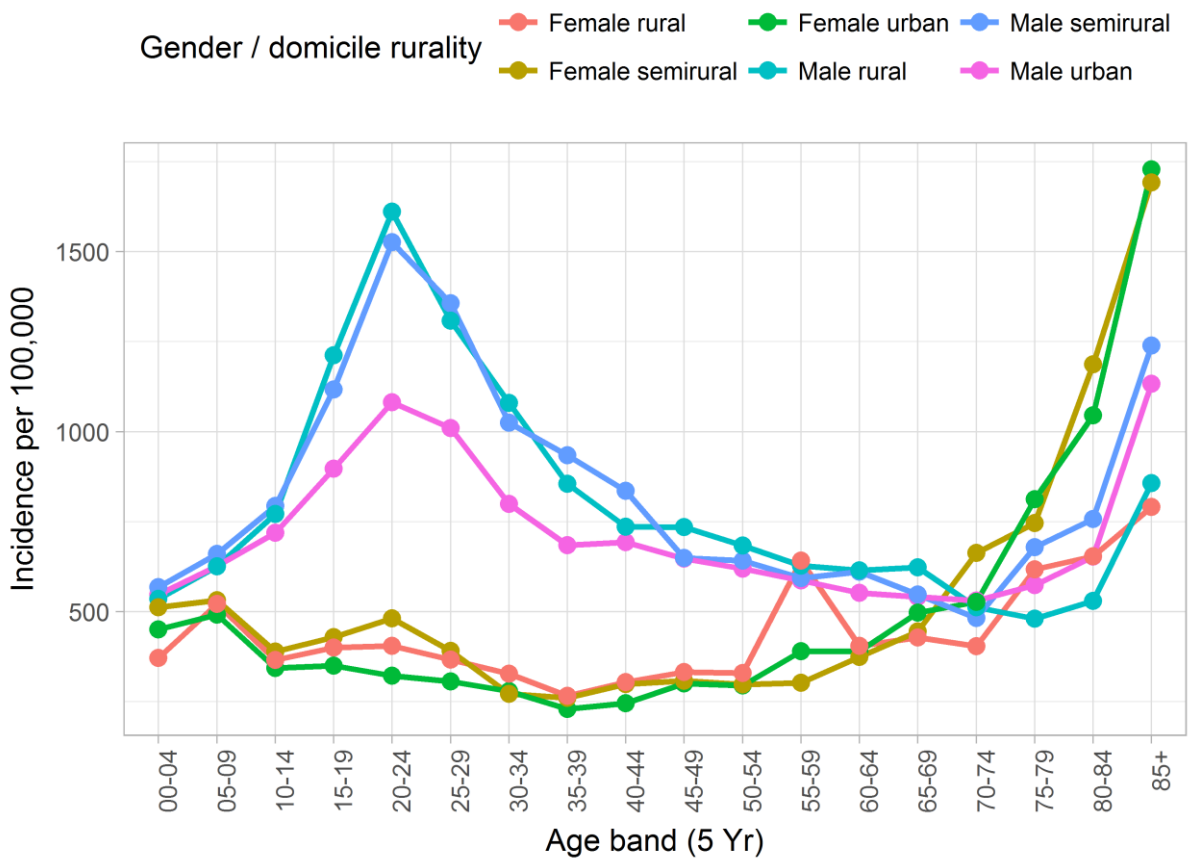


Rural and semirural residents had a steep increase in trauma incidence in the 15-29 year age range with a similar smaller peak in incidence for urban residents in the same age range. Incidence of trauma also increased among urban and semirural residents from age 75 years onwards, rural residents also showed an increase in trauma incidence from age 75 years onwards but not as steeply.

Figure 2 (next page) shows the incidence of trauma by age and gender, and rurality of patient domicile.

Rural and semirural resident males had a distinct peak in incidence of trauma in the 15-34 year age range while a similar but smaller peak in incidence was also present among urban resident males in the same age range. This peak among males was approximately 2-2.5 times higher than the incidence for females in the same age range in all of the domicile ruralities. The incidence for all genders in all three domicile ruralities increased from age 70 years onwards, this increase being steepest among females resident in urban and semirural CAUs. Rural females had an additonal small peak in incidence in the 55-59 year age range (Figure 2).

Figure 2. Annualised incidence of trauma per 100,000 population/Yr in Midland Region domiciled patients, 2012-2017, by age, gender, and rurality of patient domicile.



Poisson regression was used to assess the relative risk of trauma hospitalisation among 15-34 year olds by gender and domicile rurality and (Table 3),

Table 3. Gender/domicile-rurality gradients in age-gender adjusted incidence of trauma among 15-34 year olds Midland Region resident patients (Excluding Tairāwhiti DHB), 2012-2017, and relative risk (RR) derived from Poisson regression.

Gender / Domicile rurality (15-34 Yr old)	**Incidence per 100,000/Yr**	**RR (CI)**	**P**
Female Urban	316	Reference	
Female Semirural	396	1.25 (1.08-1.45)	0.01
Female Rural	377	1.19 (1.03-1.39)	0.05
Male Urban	951	3.01 (2.65-3.42)	0.001
Male Semirural	1244	3.94 (3.48-4.46)	0.001
Male Rural	1303	4.12 (3.65-4.67)	0.001

Relative risk (RR) of hospitalisation due to trauma for Māori and other Non-Māori by domicile rurality derived from Poisson regression is shown in Table 4.

Table 4. Māori and Non- Māori/domicile-rurality gradients in ethnicity adjusted incidence of trauma among Midland Region resident patients (Excluding Tairāwhiti DHB), 2012-2017, and relative risk (RR) derived from Poisson regression.

Domicile rurality / Ethnicity	**Incidence per 100,000/Yr**	**RR (CI)**	**P**
Urban Non-Māori	506	Reference	
Semirural Non-Māori	545	1.08 (0.95-1.22)	ns
Rural Non-Māori	537	1.06 (0.94-1.19)	ns
Urban Māori	797	1.57 (1.41-1.76)	0.001
Semirural Māori	785	1.55 (1.39-1.74)	0.001
Rural Māori	774	1.53 (1.37-1.71)	0.001

Māori are at significantly greater, approximately 1.5 times higher, risk of hospitalisation due to trauma compared to other non- Māori in each of the three rurality groups. The relative risk among Māori alone did not however differ significantly between the three rurality groups.

Type, Cause and Place of injury

Table 5 shows the injury type, intentionality, and top five causes and places of injury by patient domicile rurality across the Midland region (all ages, gender, ethnicity). Approximately 95% of all trauma events were blunt type injuries, 2.5% penetrating injuries, and 2.5% burns. The proportions of these injury type volumes in the three domicile rurality groups were similar to their corresponding population proportions in those rurality groups (Table 5).

Approximately 93% of all injuries were unintentional and the proportion of these injuries in each of the domicile rurality groups were similar to their corresponding population proportions. Injuries due to mechanism '*By other*' accounted for approximately 6% of all injuries with proportions in each of the three domicile rurality groups also similar to their corresponding population proportions. Self-inflicted injuries were higher among urban residents than the urban population proportion compared to self-inflicted injuries among rural and semirural residents which were lower than their corresponding population proportion.

Table 5. Total trauma events among Midland Region domiciled patients, all ages, gender, ethnicity (Excluding Tairāwhiti DHB), 2012-2017, type, intent, and circumstances of trauma by rurality of patient domicile, n = 29,595.

	Patient domicile rurality: Events (%)			
	Urban	**Semirural**	**Rural**	**Total**
Population	*455,667 (53.6%)*	*146,370 (17.2%)*	*247,737 (29.2%)*	*849,774 (100%)*
Total events	15,364 (51.9%)	5,411 (18.3%)	8,820 (29.8%)	29,595 (100%)
Type				
Blunt	14,583 (52.0%)	5,150 (18.4%)	8,321 (29.7%)	28,054 (100%)
Penetrating	380 (50.4%)	122 (16.2%)	252 (33.4%)	754 (100%)
Burn	401 (51.0%)	139 (17.7%)	247 (31.4%)	787 (100%)
Intent				
Unintentional	14,230 (51.5%)	5,126 (18.5%)	8,290 (30.0%)	27,646 (100%)
By other	923 (56.6%)	248 (15.2%)	460 (28.2%)	1,631 (100%)
Self-inflicted	152 (65.5%)	27 (11.6%)	53 (22.8%)	232 (100%)
Unknown	59 (68.6%)	10 (11.6%)	17 (19.8%)	86 (100%)
Cause†				
Fall	6,624 (57.6%)	1,967 (17.1%)	2,913 (25.3%)	11,504 (100%)
Struck (unintentional)	1,461 (54.6%)	473 (17.7%)	741 (27.7%)	2,675 (100%)
Road Traffic Crash	1,072 (45.9%)	454 (19.5%)	807 (34.6%)	2,333 (100%)
Motorcycle crash	707 (40.2%)	363 (20.6%)	690 (39.2%)	1,760 (100%)
Machinery	737 (42.4%)	377 (21.7%)	625 (35.9%)	1,739 (100%)
Place of injury†				
Home	6,651 (54.6%)	2,157 (17.7%)	3,364 (27.6%)	12,172 (100%)
Road	2,356 (50.1%)	853 (18.2%)	1,489 (31.7%)	4,698 (100%)
Sports area	1,473 (53.4%)	516 (18.7%)	771 (27.9%)	2,760 (100%)
Public admin. area	1,280 (58.5%)	393 (18.0%)	515 (23.5%)	2,188 (100%)
Farm	378 (18.1%)	553 (26.4%)	1,163 (55.5%)	2,094 (100%)

†Top 5 causes where known

The most common cause of injury in all of the domicile ruralities was falls (39% of all trauma events, Table 5). Falls among urban residents were slightly higher than the corresponding urban population proportion, and were slightly lower than population proportion among rural residents. The second most common cause of injury was unintentional struck injuries, defined as being hit unintentinoally by an inanimate object. Road traffic crashes and motorcycle crashes were the third and fourth most common causes of injury respectively (7.8% and 5.9% of all events respectively). The proportion of both of these injury causes was slightly higher than the corresponding population proportion among rural residents. Injuries caused by machinery were also slightly higher than the population proportion among both rural and semirural residents (Table 5).

Approximately 41% (12,172 events) of all injuries occurred in the home, a further 15% of events (4,698) occurred on roads, and proportionately these were similar to the corresponding population proportions in each of the domicile rurality groups. Not surprisingly, substantially more events occurred on farms where residents lived rurally although 18% of those injured on farms (378 events) resided in an urban area.

Risk group sub-analysis

Tables 6a and 6b present a sub-analysis of cause and place of injury for the high risk, male 15-34 year old group, by patient domicile rurality. Tables 7a and 7b show a similar sub-analysis of cause and place of injury for Māori by patient domicile rurality.

Approximately 26.7% of males resident in the Midland aged 15-34 years region live rurally. However, they accounted for 42.2% of all motorcycle crash casualties, 36.7% of all road traffic crashes, and 55.9% of all quad bike injuries, in this group of young injured males (Table 6a). Similarly, 34% of all injuries occurring on road among 15-34 year old males were rurally resident 15-34 year old males (Table 6b). The lower percentage of on-road crashes compared to motorcycle and road traffic crash proportions may partly be explained by some motorcycle crashes occurring off-road, as well as high volumes of pushbike injuries among urban dwelling males of the same age. Not surprisingly, 58% of all on farm injuries among 15-34 year-old males were also rurally resident, and a further 23% living semi-rurally.

Approximately 34.9% of all Māori residents in the Midland Region live in rural areas but accounted for 39.1% and 40.8% of all road traffic and motorcycle crashes involving Māori resident and injured within the region (Table 7a). Previous studies by MTS suggest many of these may again involve young 15-29 year old male Māori (unpubl). Pushbike and pedestrian related injuries appear to be of concern among urban dwelling Māori, while on farm, outdoors, and on road injuries are higher among rural dwelling Māori.

Table 6a. Top 10 causes of injury in Midland Region (excluding Tairāwhiti DHB) domiciled patients, 2012-2017, among male youth/early working life (Age 15-34 Years) by rurality of patient domicile, events (%), n = 8,925 events.

	Rurality of domicile, Events (%)			
	Urban	**Semirural**	**Rural**	**Total**
Population (Male 15-34 Yrs)	*58,788 (58.1%)*	*15,435 (15.2%)*	*26,994 (26.7%)*	*101,217 (100%)*
Falls	534 (55.1%)	177 (18.3%)	258 (26.6%)	969 (100%)
Struck*	492 (58.4%)	124 (14.7%)	226 (26.8%)	842 (100%)
Assault	346 (54.1%)	94 (14.7%)	200 (31.3%)	640 (100%)
Motorcycle crash**	213 (37.4%)	116 (20.4%)	240 (42.2%)	569 (100%)
Road Traffic Crash	215 (45.6%)	84 (17.8%)	173 (36.7%)	472 (100%)
Machinery	177 (45.2%)	82 (20.9%)	133 (33.9%)	392 (100%)
Pushbike	151 (60.6%)	28 (11.2%)	70 (28.1%)	249 (100%)
Crushed***	56 (49.1%)	27 (23.7%)	31 (27.2%)	114 (100%)
Burns	57 (52.3%)	17 (15.6%)	35 (32.1%)	109 (100%)
Quad bike	13 (22.0%)	13 (22.0%)	33 (55.9%)	59 (100%)

*Struck – unintentional, primarily sport related, **Includes road, sport, and off-road, ***Caught between, pinched etc.

Table 6b. Top 10 places of injury in Midland Region (excluding Tairāwhiti DHB), 2012-2017, among male youth/early working life (Age 15-34 Years) by rurality of patient domicile, events (%), n = 6,836 events.

	Rurality of domicile, Events (%)			
	Urban	**Semirural**	**Rural**	**Total**
Population (Male 15-34 Yrs)	*58,788 (58.1%)*	*15,435 (15.2%)*	*26,994 (26.7%)*	*101,217 (100%)*
Home	807 (55.2%)	216 (14.8%)	439 (30.0%)	1,462 (100%)
Road	532 (48.9%)	188 (17.3%)	367 (33.8%)	1,087 (100%)
Sports area	552 (53.2%)	176 (17.0%)	310 (29.9%)	1,038 (100%)
Industrial	201 (49.8%)	92 (22.8%)	111 (27.5%)	404 (100%)
Farm	69 (18.6%)	85 (23.0%)	216 (58.4%)	370 (100%)
Outdoors	123 (53.9%)	25 (11.0%)	80 (35.1%)	228 (100%)
Sidewalk	123 (63.1%)	31 (15.9%)	41 (21.0%)	195 (100%)
Public admin. area	69 (39.7%)	59 (33.9%)	46 (26.4%)	174 (100%)
Public building	77 (58.8%)	25 (19.1%)	29 (22.1%)	131 (100%)
Water	42 (60.0%)	9 (12.9%)	19 (27.1%)	70 (100%)

Table 7a. Top 10 causes of injury among Māori in Midland Region (excluding Tairāwhiti DHB), 2012-2017, by rurality of patient domicile, events (%), n = 15,232 events.

	Rurality of domicile, Events (%)			
	Urban	**Semirural**	**Rural**	**Total**
Population, Māori (all ages)	*86,622 52.3%*	*21,180 (12.8%)*	*57,759 (34.9%)*	*165,561 (100%)*
Falls	1,387 (54.5%)	392 (15.4%)	764 (30.0%)	2,543 (100%)
Assault	490 (53.7%)	133 (14.6%)	290 (31.8%)	913 (100%)
Struck*	487 (55.2%)	133 (15.1%)	262 (29.7%)	882 (100%)
Road Traffic Crash	314 (41.3%)	149 (19.6%)	297 (39.1%)	760 (100%)
Motorcycle crash**	133 (39.3%)	67 (19.8%)	138 (40.8%)	338 (100%)
Machinery	148 (45.0%)	56 (17.0%)	125 (38.0%)	329 (100%)
Crushed***	161 (50.5%)	56 (17.6%)	102 (32.0%)	319 (100%)
Burns	132 (50.4%)	41 (15.6%)	89 (34.0%)	262 (100%)
Pushbike	135 (60.8%)	25 (11.3%)	62 (27.9%)	222 (100%)
Pedestrian	93 (64.1%)	11 (7.6%)	41 (28.3%)	145 (100%)

*Struck – unintentional, primarily sport related, **Includes road, sport, and off-road, ***Caught between, pinched etc.

Table 7b. Top 10 places of injury in Midland Region (excluding Tairāwhiti DHB), 2012-2017, among Māori (all ages) by rurality of patient domicile, events (%), n = 15,232 events.

	Rurality of domicile, Events (%)			
	Urban	**Semirural**	**Rural**	**Total**
Population, Māori (all ages)	*86,622 52.3%*	*21,180 (12.8%)*	*57,759 (34.9%)*	*165,561 (100%)*
Home	1,948 (54.4%)	547 (15.3%)	1,085 (30.3%)	3,580 (100%)
Road	679 (46.4%)	249 (17.0%)	536 (36.6%)	1,464 (100%)
Sports area	383 (54.1%)	114 (16.1%)	211 (29.8%)	708 (100%)
Public admin. area	315 (51.1%)	130 (21.1%)	171 (27.8%)	616 (100%)
Industrial	156 (44.8%)	64 (18.4%)	128 (36.6%)	348 (100%)
Farm	64 (23.3%)	52 (18.9%)	159 (57.8%)	275 (100%)
Sidewalk	128 (58.4%)	27 (12.3%)	64 (29.2%)	219 (100%)
Outdoors	83 (43.7%)	20 (10.5%)	87 (45.5%)	190 (100%)
Public building	78 (53.8%)	20 (13.8%)	47 (32.4%)	145 (100%)
Water	38 (53.5%)	6 (8.5%)	27 (38.0%)	71 (100%)

Table 8 shows care processes and patient outcomes for trauma patients according to patient domicile rurality. Approximately half of all events were self-presenting. The event volume proportions for these self-presenting admissions did not differ markedly from their corresponding population proportions in the three domicile rurality groups. However, for patients who were not self-presenting, 55.6% of all patients transported by helicopter ambulance were rural resident patients, while making up 29.2% of the Midland region population (Table 8).

Table 8. Total trauma events in Midland Region (Excluding Tairāwhiti DHB), 2012-2017, care process factors by rurality of patient domicile, n = 29,595.

	Rurality of patient domicile: Events (%)			
	Urban	**Semirural**	**Rural**	**Total**
Population %	*53.6%*	*17.2%*	*29.2%*	*100%*
Self-presenting				
Yes	7,699 (52.6%)	2,627 (18.0%)	4,300 (29.4%)	14,626 (100%)
No	7,289 (50.7%)	2,724 (19.0%)	4,356 (30.3%)	14,369 (100%)
Unknown	376 (62.7%)	60 (10.0%)	164 (27.3%)	600 (100%)
Mode of transport†				
Road ambulance	6,911 (52.1%)	2,544 (19.2%)	3,808 (28.7%)	13,263 (100%)
Helicopter ambulance	271 (30.1%)	129 (14.3%)	500 (55.6%)	900 (100%)
Police/Prison vehicle	87 (51.2%)	46 (27.1%)	37 (21.8%)	170 (100%)
Other	20 (55.6%)	5 (13.9%)	11 (30.6%)	36 (100%)
Ave. length of stay (Days), (SD)				
All	4.5 (7.4)	4.2 (6.2)	4.4 (6.3)	3.7 (6.1)
Non-Major	3.6 (5.4)	3.5 (4.7)	2.8 (3.9)	3.3 (4.8)
Major	9.2 (15.0)	10.7 (12.8)	8.9 (13.3)	9.1 (14.3)
Final discharge destination††				
Home	12,949 (53.0%)	4,821 (19.7%)	6,642 (27.3%)	24,412 (100%)
Other acute care facility	984 (34.1%)	217 (7.5%)	1,681 (58.3%)	2,882 (100%)
Rehabilitation	690 (65.2%)	166 (15.7%)	203 (19.2%)	1,059 (100%)
Convalescence	170 (43.1%)	74 (18.8%)	150 (38.1%)	394 (100%)
Residential care	263 (74.3%)	51 (14.4%)	40 (11.3%)	354 (100%)
Left against medical advice	72 (61.0%)	16 (13.6%)	30 (25.4%)	118 (100%)
Special accomm.	29 (48.3%)	20 (33.3%)	11 (18.3%)	60 (100%)
Other/International	94 (72.9%)	12 (9.3%)	23 (17.8%)	129 (100%)
Survived				
Survived	15,256 (51.9%)	5,377 (18.3%)	8,784 (29.9%)	29,417 (100%)
Died	108 (60.7%)	34 (19.1%)	36 (20.2%)	178 (100%)
Case fatality rate	0.7%	0.6%	0.4%	0.6%

†Mode of transport where patient not self-presenting, ††Discharge destination where patient survived.

The average length of stay for patients across all severities did not differ significantly according to domicile rurality (unpaired t-test urban versus rural resident patients, t = -0.726, P = 0.47). Compared with rural residents, length of stay for non-major trauma patients was slightly higher among urban resident patients, although this was not statistically significant (unpaired t-test urban versus rural resident patients, P = 0.34).

Approximately 99% of all trauma admitted patients survived and case fatality rates again did not differ significantly according to patient domicile rurality, ranging from 0.4% among rural resident admitted patients to 0.7% among urban resident admitted patients. At time of discharge, approximately 83% went home and a total of 3,941 were discharged to either an additional acute care or rehabilitation facility.

Patient admissions and transfers

Care for the 29,595 events in Midland Region (2012-2017) resulted in a total of 35,270 hospital admissions. The ratio of admissions per event by patient domicile rurality is shown in Table 9.

Table 9. Admission to event ratio by patient domicile rurality.

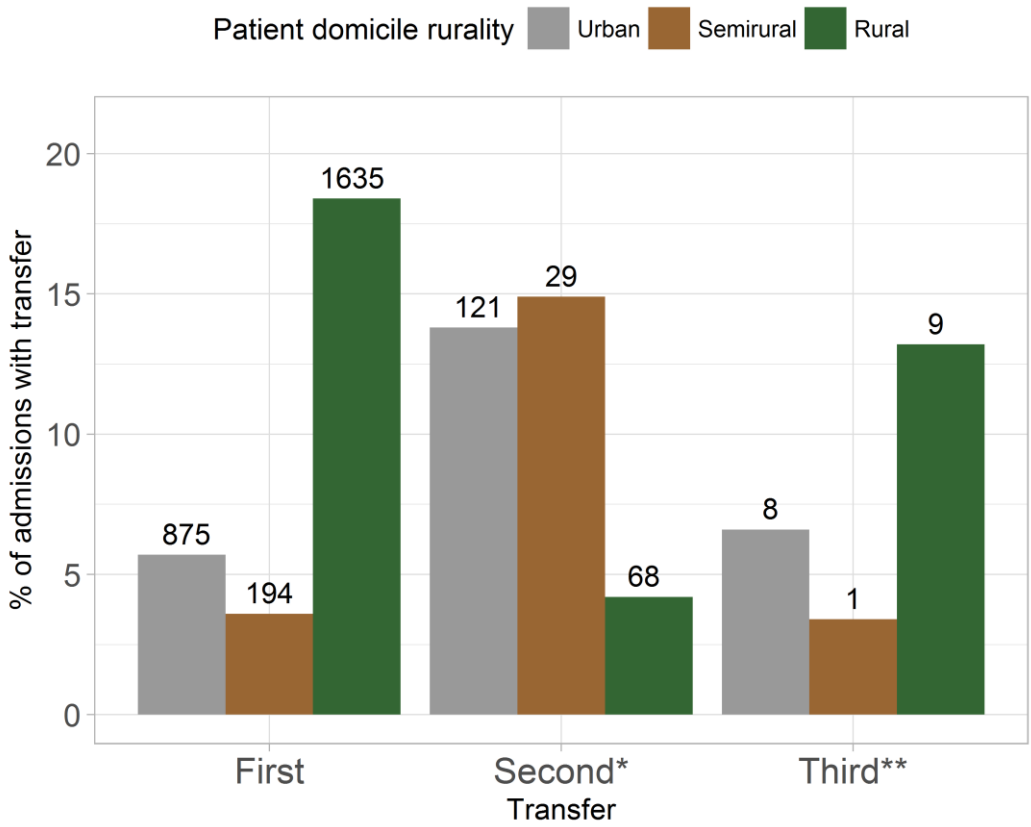
	Patient domicile rurality			
	Urban	**Semirural**	**Rural**	**Total**
Events (%)	15,364 (51.9%)	5,411 (18.3%)	8,820 (29.8%)	29,595 (100%)
Total admissions (%)	17,519 (49.7%)	5,872 (16.6%)	11,879 (33.7%)	35,270 (100%)
Ratio admissions/event	1.14	1.09	1.35	1.19

The ratio of admissions to events was higher for rural resident patients compared to either urban or semirural patients. However, a majority of rural resident patient events which involved an onward transfer from their first arrival facility tended to remain in that second facility.

Figure 3 shows trauma transfer from first arrival facility onwards to a second acute care facility, and then percentage with an additional onward transfer, according to patient domicile rurality.

Approximately 18.5% (1,635/8,820 events) of rural resident patients had a transfer from their first arrival facility onwards to a second acute care facility, for urban and semirural resident patients this was 5.6% (875/15,364 events) and 3.6% (194/5,411 events) respectively.

Figure 3. Total trauma events in Midland Region (Excl. Tairāwhiti DHB) domiciled patients, 2012-2017, with transfers from first arrival facility to a further acute care facility by rurality of patient domicile. *% with second transfer subsequent to first transfer, **% with third transfer subsequent to second transfer.



Of the 1,635 rural resident patients with a first initial transfer, 4.1% (68/1,635) of these had an additional transfer, for urban residents with a first initial transfer, 13.8% (121/875) of these had a second onward transfer (Figure 3).

Discussion

Disparities in trauma hospitalisation rates

The current study has shown substantial differences in the rates of hospitalisation due to trauma in the Midland region according to the rurality of patient domicile. Males in the 15-34 year age range, living in rural and semirural areas in particular, are at extreme risk. This finding is in agreement with a study of injury risk in urban and rural areas of Australia during 2000-2004 which identified rural resident males aged 15-29 years as having the highest injury hospitalisation and mortality rates compared to other rurality and gender groups. A similar US study during 1997 to 2001 also found young rural males to have higher injury rates than urban males or females (Tiesman, Zwerling, Peek-Asa, Sprince, & Cavanaugh, 2007).

In the current study, causes of injury including motorcycle and other road traffic crashes were found to be of particular concern for at risk young males living rurally. Studies in Australia and North America have also found motor vehicle crashes, traumatic occupational injuries, and residential fires, to increase with increasing rurality (Peek-Asa, Zwerling, & Stallones, 2004). One Australian study found that rural males were almost twice as likely to be involved in motor vehicle crashes resulting in hospitalisation than urban residents (Mitchell & Chong, 2010). A Norwegian study comparing urban and rural counties also showed that rural trauma patients were younger, died mainly at the site of injury, and most commonly from road traffic accident injuries (Bakke et al., 2013). Factors such as travel distance, vehicle speed, lighting conditions, and a lack of road safety and have all been put forward as contributing factors among rural motor vehicle and motorcycle crashes (Boland, 2005; Kmet, 2006).

The relative risk for Māori living in each of the three rurality groups was approximately ~1.5 times higher than for other non-Māori. This increased risk agrees with a previous study in the largely urban Auckland District Health board area which reported a relative risk for Māori of 2.38 (Creamer et al., 2010). However, the study conducted in the Auckland District Health Board only considered severely injured trauma patients (ISS>15), which may partly help to explain the difference in relative risk between this study and ours. Furthermore, our study is based on seven years of data while the Auckland DHB only considered data for 2004. Although the current study found a range of injury mechanisms were involved among Māori patients, no single cause of injury accounted for the overall difference between Māori and non-Māori. Our finding of high numbers of assault related injury among Māori agrees with the Auckland DHB study which also found assault to be a common cause of injury (Creamer et al., 2010). Our study also found no distinct differences among Māori when compared between the three rurality groups except for young rural resident Māori where road traffic crash injury is of concern.

Semirural populations include a mix of both rural and smaller urban areas. The overall incidence of trauma for semirural residents seen here appears to represent a combination of a peak in injury rates among young (19-34 Year old) semirural resident males, together with the steep increase in injury rates among female semirural residents aged 70 years onwards. While the present study has identified road and motorcycle crashes as being of concern in young rural and semirural males, among older persons, falls are well known as a primary cause of injury (O'Leary, Kool, & Christey, 2017). In the Norwegian study cited previously, falls was the only category of injury where the gradient increased towards urban areas and were generally older than rural trauma patients (Bakke et al., 2013). This might suggest a complex mix of injury causes among semirural populations which may provide challenges in terms of care facility planning and designing prevention campaigns, particularly where resources are limited.

Care processes and outcomes

Access to health care such as specialized trauma care facilities is an important determinant of health outcomes. In the present study we found little evidence of effects of patient residence rurality on outcomes. One Australian study has also shown that despite longer pre-hospital times and comparable patient populations, health outcomes for rural patients were no different to those for urban trauma patients (Danne, 2003). One US study further showed no difference in health outcomes even for rural patients requiring treatment for traumatic brain injury (Coward, 1990). Our study has highlighted a more frequent use of helicopter ambulances for transporting rurally resident patients. A majority of these involved motor vehicle and motorcycle crashes (not reported here). Further study will thus be required to assess the effect of helicopter ambulance use on patient outcomes in rural regions while accounting for the severity of road crash casualties.

Hospital length of stay is a commonly used but somewhat crude measure of patient outcomes in many studies of trauma care. In the current study, the finding of no effect of patient domicile rurality on total length of hospital stay may be the result of the differing demographics of rural and urban resident patients. The slightly longer average length of stay noted among urban resident patients may reflect higher numbers of older persons who often experience longer hospital stays due to other complications even for those older persons with non-Major (O'Leary et al., 2017). Similarly, the large number of young rural males injured may have shorter recovery times. The slightly higher case fatality rate seen among urban resident patients may also possibly be linked to the higher number of older persons (>70 years of age). Further studies will be required to assess these possible effects and whether the use of such outcome measures need to adjusted accordingly in future studies comparing trauma patient rurality.

A previous study found no effect of rurality and direct admission, or involving inter-hospital transfers, on outcomes such as length of stay, complication rates, or mortality (Wild et al., 2017). However, another study found that patients with major trauma (ISS > 12) taken directly to a trauma center had shorter hospital and intensive care unit stays and lower mortality, supporting the paradigm that when possible, major trauma patients should be sent to trauma centers directly from the injury scene (Young et al., 1998). The current study has shown that while a large number of rural dwelling injured patients do receive an initial transfer, the low rates of subsequent transfer suggest that decisions surrounding destination facility are largely appropriate.

Study Limitations

Exactly what defines 'rural' and 'semirural' populations is subject to continued debate (Fearnley, Lawrenson, & Nixon, 2016; McGrail & Humphreys, 2009). The definition used here was one

selected as being meaningful within the context of this study and the geographical distribution of the Midland region population (Fearnley et al., 2016), Appendix I. A further limitation is that the MTS trauma registry only includes those who are admitted to hospital or died in the emergency department. It does not include those who died at scene, it is therefore possible that serious trauma such as road crashes resulting in death at scene are underestimated for rural populations as seen in Norway (Bakke et al., 2013).

Poorer health differentials in rural and remote areas often reflect a higher proportion of people who experience socioeconomic disadvantage. A recent study in Scotland found that relative risk of trauma was independent of rurality and that at least penetrating injury was strongly linked to low socioeconomic status (Morrison, McConnell, Orman, Egan, & Jansen, 2013). The Scottish study noted however that while approximately 72% of trauma in Scotland occurs in urban areas, many such urban areas also include many people with socioeconomic disadvantage. While penetrating trauma may be linked to socioeconomic status, such penetrating injuries only accounted for 2.5% of all injuries in the Midland region. However, given the high number of penetrating and assault related injuries among urban Aucklanders (Creamer et al., 2010), future studies concentrating on potential links to NZ Deprivation (Atkinson, Salmond, & Crampton, 2014) may be worthwhile.

Conclusion

Within the Midland region there are differences in rates of trauma according to the rurality of where patients live. These disparities are strongest among young males who live rurally, and among older persons who live in urban and semirural areas, as well as overall higher rates among Māori versus non- Māori. Distinct causes and circumstances of injury underlie each of these at-risk groups. Semirural populations reveal an interesting pattern of injury incidence. They appear to align with urban or rural risk profiles dependent on age and cause that may reflect an urban migration of older persons from rural to urban settings. Conversely, risk profiles in 15-35 year olds appear to be similar. Rates for Māori are high across all rurality groups and appear to be less influenced by rurality than previously thought: this requires further analysis. We have shown that it is inadequate to rely on rurality to explain the variability in risk profiles and outcomes, but that there are complex interplays between social, ethnic and age groups, and their related activities that are influencing incidence rates. It is clear that deeper knowledge concerning population groups at risk that we have identified is required in order to accurately direct care planning and design of prevention campaigns into these communities.

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Appendix I. Rurality groupings and corresponding profiles referenced (Statistics NZ)

Rurality group (this study)	Rural profiles referenced* (Statistics NZ)
Urban	• **Main urban:** The same as the standard 2006 definition for main urban centres and includes centres with populations of 30,000 or more. • **Satellite urban:** Towns and settlements with strong links to main urban centres. Satellite urban communities are defined as urban areas where 20% or more of the usually resident employed population's workplace address is in a main urban area. • **Independent urban:** Towns and settlements without significant dependence on main urban centres. Independent urban communities are urban areas where less than 20% of the usually resident employed population's workplace address is in a main urban area.
Semirural	• **Rural with high urban influence:** Rural areas that form a transition between the main urban areas and rural areas. A significant proportion of the resident employed population work in a main urban area. • **Rural with moderate urban influence:** Rural areas with a significant, but not exclusively, main urban area influence. A large percentage of the resident employed population works in a minor or secondary urban area, or a significant percentage work in a main urban area. However, if the percentage working in a main urban area is too substantial, the area will be included in the high urban influence category.
Rural	• **Rural with low urban influence:** Rural areas with a strong rural focus. The majority of the population in these areas works in a rural area. • **Highly rural/remote area:** Rural areas where there is minimal dependence on urban areas in terms of employment, or where there is a very small employed population.

*http://archive.stats.govt.nz/BROWSEFORSTATS/population/Migration/internal-migration/mobility-urban-rural-areas.aspx