Cycling-related injuries and cycling promotion: a trauma service perspective

Neerja Singh, Natalie Joe, Janet Amey, Alastair Smith, Grant Christey

ABSTRACT

AIM: Current policy direction seeks to promote participation in both recreational and active transport cycling. We evaluate cycling-related injuries resulting in hospital admission across the Midland Region of New Zealand to establish injury trends.

METHOD: A retrospective review of anonymised prospectively-collected trauma registry data from 1 June 2012 to 31 July 2016 in the Midland Region. Cases include patients hospitalised with cycling-related injuries.

RESULTS: Nine hundred and ninety-eight cyclists were admitted to hospital (2012–2016). Admission volumes increased approximately 16.8% per year, major trauma by 11.9% and non-major trauma by 17.8%. Overall, 66.7% of admissions were for people aged over 20 years and 73.4% were for males. The participation-adjusted annual injury rate was 78.4 per 100,000. This masked considerable variation by gender, age group and injury severity.

CONCLUSION: Hospital admission volumes and rates are rising with underlying variation in patient demography, place and severity of injury. Current policy direction to grow cycling participation based on the health, environmental and economic benefits is ahead of the implementation of safer cycling infrastructure, creating a timing lag. From a regional hospital-based trauma service perspective, this timing lag needs due consideration if the full benefits of increasing participation are to be realised.

The popularity of recreational cycling is increasing in New Zealand, both on- and off-road, while evidence shows that cycling as a means of active transport has decreased over time.[1–3] These diverging trends are occurring in an increasingly supportive policy environment at the national, regional and local government level, with the aim of better integrating recreational and active transport into planning processes.[4,5]

Government aspirations to increase active transport were clear in the 2008 New Zealand Transport Strategy [4] and making cycling a more attractive choice is now a strategic priority of the New Zealand Transport Agency.[6] In 2018 the Labour-led Government announced the development of a replacement road safety strategy, including further investigation of the 'Vision Zero' philosophy, which aims to achieve a transport system with no fatalities or serious injuries involving road traffic.[5]

Owing to the fragility of the unprotected human body,[8] cyclists are vulnerable to injury compared to those in motorised vehicles[9,10] and are likely to sustain injuries to more than one body area.[8] Crashes involving collisions with motor vehicles are associated with more severe injuries[11] and males often have higher cycling-related morbidity and mortality than females.[12] The most common cause of death is from major trauma events involving blunt multi-system trauma, and brain injuries.[13] Although the majority of injuries are non-major in nature, a large portion of patients continue to suffer physical symptoms for more than six months following injury.[14]

In New Zealand, the Ministry of Health acknowledges that cyclists are at increased risk of death or injury per hour spent travelling.[10] In 2016, 958 cyclists were hospitalised in New Zealand for a total of 4,596 bed days.[3] In that year five cyclists died, 169 were seriously injured and 560 suffered

non-major injuries in police-reported road crashes—about 6% of the total number of casualties from police-reported crashes.[15] However, police-reported crashes involving cyclists are under-reported[16] and police-assessed injury severity can also be discordant with subsequent medical assessment.[17]

Methods

The study criteria included domiciled patients admitted to hospital as a result of an injury sustained while cycling on a non-motorised two-wheeled bicycle in four of the five district health boards (DHBs) in the MTS, between 1 June 2012 and 31 July 2016 (excluding Tairawhiti DHB). Consistent with international trauma registries,[18] patients were excluded if they sustained injury as a direct result of pre-existing medical conditions, late effects of injury, if the injury occurred more than seven days prior or if the patient was deceased prior to hospital admission.

Severity and pattern of injury diagnoses were quantified using the Abbreviated Injury Scale (AIS), an anatomical scoring system that ranks injuries from '1' (minor) to '6' (non-survivable). The Injury Severity Score (ISS) is also an anatomical scoring system using a 0–75 scale. The highest AIS scores in each body region are the basis of the ISS, with injuries then categorised as non-major (ISS ≤ 12) and major (ISS ≥ 13).[19] For patient ethnicity we used that recorded on the patient's National Health Index number and categorised according to the 2005 Ethnicity New Zealand Standard Classification. Publicly available data from the Ministry of Transport's 'Cycling New Zealand Household Travel Survey' were used to calculate participation-adjusted injury rates. Population data for the Midland region were obtained from Statistics New Zealand's online portal. Statistical analyses were performed in Microsoft Excel 2010.

Results

Between 1 June 2012 and 31 July 2016, a total of 998 events that met the inclusion criteria resulted in hospital admission (Table 1), with an increase in the volume of injuries of approximately 18% per year (Table 2). As in other areas of New Zealand there was a significant seasonal component, with higher numbers of cyclists in the warmer months and a corresponding decrease over winter.[20]

The majority of injuries occurred on road (37.7%), followed by the countryside/beach (22.9%) (Table 1, Table 4). For females, 47.4% of cycling injuries were on road, 19.9% at the countryside/beach and 10.2% at a sports area. For males, injuries were more spread between environments with 34.2% occurring on road followed by countryside/beach locations and sports areas (23.5% and 20.5% respectively). The highest volume of road injuries occurred in the Waikato DHB area, and this was expected given it is the most populated DHB. The highest volume of injuries occurring at the countryside/beach were in the Lakes DHB, with injuries for this category contributing 45.4% of all injuries, suggesting the importance of recreational mountain biking in this district.

A total of 2,097 AIS diagnoses were observed with the majority of injuries having an AIS score of 1 or 2 (42.2% and 47.6%, respectively) (Table 3). Our study found that males had significantly more injuries (Chi Square goodness of fit, χ^2=115, df=1, P<0.0005) than females, consistent with other studies.[1,21] The most common body region injuries were upper extremity injuries (642), lower extremities (438), face (266) and head (228) (Table 3). This is similar to other studies and mainly involved superficial injuries such as abrasions, contusions and lacerations.[8] We found that patients with an AIS severity score of 3+ were more likely to have injuries to the head, thorax, spine and abdomen/pelvis regions than to the extremities. With AIS diagnoses translated to ISS, overall 91.9% of injuries were categorised as non-major (Table 4). The volume of non-major injuries increased from 173 in the 2012/13 year to 281 in 2015/16. In contrast, major injury volumes fluctuated over time; averaging 20 per year (range 17–25). Driven by the volume increase seen for non-major injures, the total admission volume (major and non-major injuries) increased from 190 patients in 2012/13 to 302 in 2015/16.

The higher volume of injuries in males translated into higher participation-adjusted injury rates, with higher rates for males across all age groups and injury severity categories (Table 5). Non-major injury rates increased for all population groups with the

Table 1: Demography of cycle injuries by place of injury in Midland Region (excluding Tairawhiti District) 2012–2016.

	Road	Countryside/ beach	Sports area	Cycleway/ sidewalk	Home/ farm	Other	Total
Total	376 37.7%	225 22.5%	177 17.7%	78 7.8%	70 7.0%	72 7.2%	998 100%
Major/non-major							
Major	50 61.7%	14 17.3%	10 12.3%	2 2.5%	1 1.2%	4 4.9%	81 100%
Non-major	326 35.6%	211 23.0%	167 18.2%	76 8.3%	69 7.5%	68 7.4%	917 100%
Gender							
Female	126 47.4%	53 19.9%	27 10.2%	23 8.6%	16 6.0%	21 7.9%	266 100%
Male	250 34.2%	172 23.5%	150 20.5%	55 7.5%	54 7.4%	51 7.0%	732 100%
Age group							
0–14 years	60 25.3%	24 10.1%	58 24.5%	29 12.2%	46 19.4%	20 8.4%	237 100%
15–19 years	21 22.1%	36 37.9%	23 24.2%	7 7.4%	3 3.2%	5 5.3%	95 100%
20+ years	295 44.3%	165 24.8%	96 14.4%	42 6.3%	21 3.2%	47 7.15%	666 100%
Ethnicity							
NZ European	274 34.1%	213 26.5%	138 17.2%	61 7.6%	59 7.3%	58 7.2%	803 100%
Māori	75 50.0%	11 7.3%	32 21.3%	12 8.0%	9 6.0%	11 7.3%	150 100%
Pacific	7 43.8%	1 6.3%	4 25.0%	1 6.3%	1 6.3%	2 12.5%	16 100%
Other	20 69.0%	-	3 10.3%	4 13.8%	1 3.4%	1 3.4%	29 100%
DHB of domicile							
Waikato	173 45.2%	55 14.4%	70 18.3%	33 8.6%	26 6.8%	26 6.8%	383 100%
Bay of Plenty	105 41.2%	50 19.6%	40 15.7%	16 6.3%	27 10.6%	17 6.7%	255 100%
Lakes	43 18.9%	103 45.4%	34 15.0%	15 6.6%	12 5.3%	20 8.8%	227 100%
Taranaki	55 41.4%	17 12.8%	33 24.8%	14 10.5%	5 3.8%	9 6.8%	133 100%

Table 2: Number of hospital admissions each year by injury severity, in Midland Region (excluding Tairawhiti district) 2012–2016.

	Non-major (ISS ≤ 12)		Major (ISS ≥ 13)		Total	
Year	Events	%	Events	%	Events	%
2012/13	173	91.1%	17	8.9%	190	100.0%
2013/14	204	89.1%	25	10.9%	229	100.0%
2014/15	259	93.5%	18	6.5%	277	100.0%
2015/16	281	93.0%	21	7.0%	302	100.0%
Total	917	91.9%	81	8.1%	998	100%

exception of females aged 15–19 years. For females, the highest rates are for those aged over 20 years, being broadly similar to those for males aged 0–14 years. Major injury incidence rates for males across all age groups fluctuated over the period and were highest for males aged over 20 years, with a high of 21.1 per 100,000 in 2013/14. There were no major trauma injuries requiring hospital admission for female cyclists aged 0–14 or 15–19 years.

Table 3: Cycling injuries in Midland Region 2012–2016, number of AIS diagnoses by body region and severity score.

	AIS Severity Score			
AIS Body Region	1	2	3+*	Total
Upper extremity	216 33.6%	420 65.4%	6 0.9%	642 100.0%
Lower extremity	169 38.6%	210 47.9%	59 13.5%	438 100.0%
Face	234 88.0%	32 12.0%	-	266 100.0%
Head	69 30.3%	105 46.1%	54 23.7%	228 100.0%
Thorax	40 22.5%	75 42.1%	64 36.0%	178 100.0%
Spine	23 13.2%	131 75.3%	20 11.5%	174 100.0%
External	88 100.0%	-	-	88 100.0%
Abdomen/pelvis	42 54.5%	24 31.2%	11 14.3%	77 100.0%
Neck	4 80.0%	2 20.0%	-	6 100.0%
Total	885 42.2%	999 47.6%	213 10.2%	2,097 100.0%

Table 4: Cycling trauma events, by place of injury and injury severity, in Midland Region 2012–2016 (excluding Tairawhiti District).

	Non-major (ISS ≤ 12)		Major (ISS ≥ 13)		Total	
Place of injury	**Events**	**%**	**Events**	**%**	**Events**	**%**
Road	326	86.7%	50	13.3%	376	100.0%
Countryside/beach	211	93.8%	14	6.2%	225	100.0%
Sports area	167	94.4%	10	5.6%	177	100.0%
Cycleway/sidewalk	76	97.4%	2	2.6%	78	100.0%
Home/farm	69	98.6%	1	1.4%	70	100.0%
Other	68	94.4%	4	5.6%	72	100.0%
Total	917	91.9%	81	8.1%	998	100%

Table 5: Cycling injury rate per 100,000 participating population, by age group and sex in Midland Region 2012–2016 (excluding Tairawhiti District).

	Non-major injury (ISS ≤ 12)		Major injury (ISS ≥ 13)		Total	
Age group, sex	**Rate**	**CI 95%**	**Rate**	**CI 95%**	**Rate**	**CI 95%**
Males 0–14						
2012–2013	49.3	34.1–69.1	1.6	0.1–7.8	50.9	35.4–71.0
2013–2014	54.2	38.1–74.8	-	-	54.2	38.1–74.8
2014–2015	87.6	66.6–113.2	1.6	0.1–7.9	89.2	68.0–115.5
2015–2016	83.9	63.4–108.9	-	-	83.9	63.4–108.9
Males 15–19						
2012–2013	73.4	40.9–122.4	-	-	73.4	40.9–122.4
2013–2014	122.8	78.9–182.8	11.2	1.9–36.9	133.9	87.8–196.3
2014–2015	126.6	82.2–186.9	-	-	126.6	82.2–186.9
2015–2016	108.0	67.8–163.8	5.4	0.3–26.6	113.4	72.1–170.4
Males 20+						
2012–2013	77.9	61.9–96.8	11.1	5.9–19.3	89.0	71.8–109.2
2013–2014	96.5	78.6–117.2	21.1	13.4–31.7	117.5	97.7–140.4
2014–2015	109.7	90.7–131.6	13.8	7.9–22.7	123.5	103.3–146.7
2015–2016	120.9	101.0–143.5	12.6	7.0–21.0	133.4	112.5–157.2
Females 0–14						
2012–2013	22.3	12.1–37.9	-	-	22.3	12.1–37.9
2013–2014	33.5	20.5–51.9	-	-	33.5	20.5–51.9
2014–2015	26.0	14.8–42.6	-	-	26.0	14.8–42.6
2015–2016	29.3	17.5–46.9	-	-	29.3	17.5–46.9

Table 5: Cycling injury rate per 100,000 participating population, by age group and sex in Midland Region 2012–2016 (excluding Tairawhiti District) (continued).

Females 15–19						
2012–2013	34.0	10.8–81.9	-	-	34.0	10.8–81.9
2013–2014	25.3	6.4–68.8	-	-	25.3	6.4–68.8
2014–2015	25.0	6.3–73.0	-	-	25.0	6.3–73.0
2015–2016	16.5	2.8–54.6	-	-	16.5	2.8–54.6
Females 20+						
2012–2013	50.0	35.6–68.5	6.9	2.5–15.4	57.0	41.4–76.5
2013–2014	42.7	29.5–59.9	2.8	0.5–9.1	45.5	31.8–63.1
2014–2015	72.0	54.5–93.5	4.1	1.0–11.1	76.1	58.1–98.1
2015–2016	73.5	55.9–94.9	9.4	4.1–18.5	82.8	64.1–105.5

Discussion

The New Zealand policy and funding environment has seen considerable change over the last 20 years. Policy makers have increasingly looked to enable active transport, particularly for short-distance trips,[15] and to increase multi-modal trips for longer commutes.[4] Alongside this has been the growing importance of both on-road and off-road recreational cycling. Regional tourism and local cycle trail organisations have actively targeted recreational cyclists.[22] Within the Midland Region there are now a number of cycle trails and mountain biking destinations, the genesis of some being the 2009 Prime Ministers job summit aimed at boosting regional economic development during the global financial crisis.

This increase in recreational cycling raises the question of whether recreational cycling can influence active transport uptake. A small 2013 Wellington study found that recreational cyclists were more open to moving into active transport (than non-cyclists), but were concerned about sharing the road with motor vehicles.[23] A study of cyclists participating in the Lake Taupo Cycle Challenge suggested the importance of separated cycle paths as an encouraging factor.[7] The new national road safety strategy, for consultation in 2019, will include the possibility of further adopting 'Vision Zero' principles. The vision includes the physical separation of cyclists from motor vehicles travelling above 30km/h.[5]

Regional and local government authorities now have dedicated cycle plans aiming to make cycling a safer and more attractive commuting option. These plans are often referred to as 'sustainable' initiatives, aimed at increasing the liveability of communities, improving health and wellbeing, ameliorating road traffic congestion to lowering carbon emissions.[4,24,25] It is at this local level that implementation issues may arise. There is a timing lag between the more 'now' promotion of cycling participation and actual implementation resulting in safer cycling environments. This study has shown increasing volumes and rates of trauma, particularly non-major trauma, which while not categorised by the ISS scale as 'major' can be significant in terms of impacts on injured individuals and their families. The MTS, as the regional hospital-based trauma service aims to reduce this burden of trauma, while still supporting the wider health benefits of increased participation.

Obviously not all cycling trauma involves a motorised vehicle. From an awareness raising and prevention perspective a sustained emphasis on cycle skills training (and cycle maintenance) for both young and older cyclists is needed. A higher level of riding skill should result in less 'loss of control' incidents.[26] A more contested area perhaps is that of attitudes to cycling and the sharing of physical space on the road (in the absence of safer infrastructure), where a look through the comments section

of any online article about cycling shows the polarised views of road users. The 2013 Chief Coroners report,[25] 2014 Cycling Safety Panel report[24] and the 2015 interim evaluation of Safer Journeys report[27] all consider improving both cyclist and motor vehicle driver behaviour in mixed traffic, including giving more space, cycle placement at intersections and slower speeds.

The Safer Journeys Strategy evaluation report also stated that focus must remain on cycling-related trauma while promoting cycling as a transport mode where "a lot of benefit will be lost if greater activity simply results in additional trauma".[26] Progress towards achieving a safer cycling environment was rated as 'insufficient' in the context of most safety benefits to date having been accrued to motor vehicle occupants.[26]

So, while cycling has documented health, environmental and economic benefits[1] there remains a tension between these benefits and safety concerns, particularly for cycling that involves sharing physical road space. At all government levels, cycling promotion often appears well ahead of implementation. The resulting timing lag could contribute to an increasing number of injuries, adding to the trauma burden in the community and to costs across the health system.

Strengths and weaknesses

One strength of this study is the MTS registry data, which captures both major and non-major trauma. The inclusion of non-major trauma allows the trauma burden to be better quantified. The registry allows analysis of injury events, patient factors and processes in care and outcomes. However, the registry does not include data for injured persons who died prior to hospital admission, where the injury did not result in an admission, those cyclists only treated in primary care facilities, and those who sought no treatment at all.

Conclusion

We acknowledge the health, environmental and economic benefits of increased cycling participation but advocate there is a tension requiring greater acknowledgement—in that the promotion of cycling is generally ahead of safety improvement initiatives. From our perspective this timing lag has consequences, for all cyclists injured and for health system costs. Due consideration of these consequences is needed if the full range of cycling benefits are to be realised.

Competing interests:
Nil.

Acknowledgements:
We want to acknowledge the ongoing commitment of the clinical staff across the Midland Trauma System to collecting the base trauma data, and the hub staff for data entry and quality checks on the Trauma Registry. We also thank Professor Shanthi Ameratunga for reviewing an early draft.

Author information:
Neerja Singh, Midland Trauma System, Waikato Hospital, Hamilton; Natalie Joe, Midland Trauma System, Waikato Hospital, Hamilton; Janet Amey, Midland Trauma System, Waikato Hospital, Hamilton; Alastair Smith, Midland Trauma System, Waikato Hospital, Hamilton; Grant Christey, Midland Trauma System, Waikato Hospital, Hamilton; Waikato Clinical School, University of Auckland, Auckland.

Corresponding author:
Dr Grant Christey, Midland Trauma System, Waikato Hospital, Hamilton 3204.
grant.christey@waikatodhb.health.nz

URL:
http://www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2019/vol-132-no-1494-3-may-2019/7868

REFERENCES:

1. Tin ST, Woodward A, Ameratunga S. Injuries to pedal cyclists on New Zealand roads, 1988–2007. BMC public health. 2010 Dec; 10(1):655.
2. Tin ST, Woodward A, Thornley S, Ameratunga S. Cycling and walking to work in New Zealand, 1991–2006: regional and individual differences, and pointers to effective interventions. International Journal of Behavioral Nutrition and Physical Activity. 2009 Dec; 6(1):64.
3. Ministry of Transport. Cyclists 2017. Wellington: Ministry of Transport; 2017. Available from: http://transport.govt.nz. Accessed on 17 October 2018.
4. Ministry of Transport. Raising the profile of walking and cycling in New Zealand: A guide for decision-makers. Wellington: Ministry of Transport; 2008.
5. Genter JA. Improving road safety in New Zealand. Wellington: Office of the Associate Minister of Transport; 2018. Available from http://transport.govt.nz. Accessed on 17 October 2018.
6. Mackie H, Hawley G, Scott R, Woodward A. Towards a safe system for cycling. Wellington: New Zealand Transport Agency; 2017.
7. Tin Tin S, Woodward A, Thornley S, Langley J, Rodgers A, Ameratunga S. Cyclists' attitudes toward policies encouraging bicycle travel: findings from the Taupo Bicycle Study in New Zealand. Health Promotion International. 2009 Oct 22; 25(1):54–62.
8. Sikic M, Mikocka-Walus AA, Gabbe BJ, McDermott FT, et al. Bicycling injuries and mortality in Victoria, 2001–2006. Med J Aust. 2009 Apr 6; 190(7):353–6.
9. Manson J, Cooper S, West A, Foster E, et al. Major trauma and urban cyclists: physiological status and injury profile. Emerg Med J. 2013 Jan; 30(1):32–7.
10. Woods K. Annual Report for the year ended 30 June 2013. Wellington: Ministry of Health; 2013.
11. Abu-Zidan FM, Nagelkerke N, Rao S. Factors affecting severity of bicycle related injuries: The role of helmets in preventing head injuries. Emerg Med Australas. 2007 Aug; 19(4):366–71.
12. Olds K, Byard RW, Langlois NE. Injury patterns and features of cycling fatalities in South Australia. J Forensic Leg Med. 2015 Aug; 34:99–103.
13. Gopinath B, Jagnoor J, Craig A, Kifley A, et al. Describing and comparing the characteristics of injured bicyclists and other injured road users: a prospective cohort study. BMC Public Health. 2016 Apr 14; 16:324.
14. Rivera FP, Thompson DC, Thompson RS. Epidemiology of bicycle injuries and risk factors for serious injury. Inj Prev. 2015 Feb; 21(1):47–51.
15. Turner S, Francis T, Roozenburg A. Predicting accident rates for cyclists and pedestrians. Wellington: Land Transport New Zealand; 2006.
16. Langley JD, Dow N, Stephenson S, Kypri K. Missing cyclists. Inj Prev. 2003 Dec; 9(4):376–9.
17. McDonald G, Davie G, Langley J. Validity of police reported information on injury severity for those hospitalized from motor vehicle traffic crashes. Traffic Inj Prev. 2009 Apr; 10(2):184–90.
18. Nwomeh BC, Lowell W, Kable R, Haley K, et al. History and development of trauma registry: Lessons from developed to developing countries. World J Emerg Surg. 2006 Oct 31; 1:32.
19. Baker S, O'Neill B, Haddon W, Long WB. The injury severity score: A method for describing patients with multiple injuries and evaluating emergency care. J Trauma Acute Care Surg.1974; 14(3):187–96.
20. Tin Tin S, Woodward A, Robinson E, Ameratunga S. Temporal, seasonal and weather effects on cycle volume: An ecological study. Environ Health. 2012 Mar 8; 11:12.
21. Beck B, Stevenson M, Newstead S, Cameron P, et al. Bicycling crash characteristics: An in-depth crash investigation study. Accid Anal Prev. 2016 Nov; 96:219–227.
22. Cycling and Mountain Biking. 2017. Available from: http://www.tourismnewzealand.com/markets-stats/sectors/special-interest/cycling-and-mountain-biking/ Accessed on 22 November 2018.
23. Randal E. What makes a commuter cyclist? A mixed methods study of behavioural antecedents and perceptions of commuter cycling in the Wellington region. Victoria University of Wellington; 2013.
24. Cycling Safety Panel. Safer journeys for people who cycle: Cycling safety panel final report and recommendations. Wellington; 2014.
25. Koorey G. Investigating common patterns in New Zealand cycling fatalities. IPENZ Transportation Group Conference, 23–26 March 2014; Wellington.
26. Small M, Howard E, Moore R. Safer journeys interim evaluation: Report for the Ministry of Transport. Martin Small Consulting, 2015.
27. Ekegren CL, Beck B, Simpson PM, Gabbe BJ. Ten-year incidence of sport and recreation injuries resulting in major trauma or death in Victoria, Australia, 2005–2015. Orthop J Sports Med. 2018 Mar 5; 6(3):2325967118757502.