Factors Influencing Mountain Biking Injuries in Australia

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ABSTRACT

Aims: Mountain biking is a rapidly growing sport in Australia with a high participation. There is a paucity of Australian information regarding injuries in this sport and limited overseas literature. Our objectives were to evaluate injury type and frequency and the factors influencing these, in Australian mountain bike riders. We hypothesized that increasing ambient temperature and track congestion would increase injury frequency.

Methods: All riders injured or unwell at the Australian 24 hour mountain biking championships from 2000- 2007 had detailed demographic and illness data recorded by St John's Ambulance. After ethics committee approval, this data was retrospectively entered into a standardized data entry form developed by the researchers. Presentations were sub classified in injury and illness subsets, and standardized as a presentation frequency. Frequency data was then correlated with weather data obtained from the Bureau of Meteorology and a track congestion figure calculated by the researchers. Gender difference in presentations was also calculated.

Results: Of the 14777 riders over the eight years, 673 required first aid treatment (4.5%). Only 37 (0.25%) required hospital treatment. There was a strong correlation between first aid presentations and increasing ambient temperature ($p<0.0001$). There was also a correlation between lower humidity and higher presentation frequency ($p=0.02$). Increasing track congestion was also found to have a statistically significant association with presentation frequency ($p=0.003$). Females were more likely to present for treatment than men ($p=0.03$).

Conclusions: Endurance mountain biking is a relatively safe sport despite the many possibilities for injury. Even a very large endurance mountain bike competition is unlikely to have a significant impact on a nearby tertiary emergency department. First aid services or small regional hospitals should prepare for more casualties for events scheduled to coincide with hot, dry weather, and for events where there is high track congestion.

Keywords: mountain biking; Australia; casualty; characteristics; frequency; mass gathering.

INTRODUCTION

Off road cycling, widely known as mountain biking, has been increasing in popularity in both recreational and competitive forms over recent years. Competitions run year round across the globe from local events to elite competitions including the World Cup and Olympics.

In 2006 over 750000 adult bicycles were sold in Australia. Of these, 70% were mountain bikes.[1] In Australia in 2003 and 2004, participation in mountain biking events increased by 150% per year.[2,3] Members of Mountain Bike Australia (MTBA), the peak governing body for competitive riding, have increased an average of 20% every year between 2000 and 2007.[4]

Despite the large numbers of both recreational and competitive mountain bikers and the increasing number of events, there is a paucity of Australian literature regarding mountain biking injuries. Previous studies, from Europe and North America, have catalogued and surveyed injuries sustained at mixed discipline mountain bike races and in elite riders out of competition. Overall the rate of injury in mountain bikers participating in events has been reported as less than 1%, or approximately one injury every 1000 bike hours. 50-90% of competitive mountain bike riders will sustain at least one injury per year, with around 20% sustaining an injury requiring medical attention.[5-15] The majority of these reports are based on data collected from surveys. Mountain bike competitions in small jurisdictions can have a significant workload impact on healthcare providers.[18]

Young males are most commonly represented, but some studies have indicated females may have a higher propensity for injury.[5,7,14] Soft tissue injuries

predominate, but of those transferred to trauma centres 46% are orthopaedic injuries, and up to 20% are 'serious' injuries.[9,12,19] Most injuries involve extremities.[17] Competition, speed and downhill racing have been identified as significant risk factors for injury.[16,17]

Research Objectives

Our objectives were to evaluate injury type and frequency and the factors influencing these, in Australian mountain bike riders. From the perspective of being both riders and health care professionals, we hypothesized that weather conditions and track congestion would alter injury frequency. Race time and gender were other factors for evaluation. Secondary aims were to evaluate the adequacy of health services provision for this event by measuring the number of hospital referrals.

METHOD

We evaluated injuries sustained at the annual Australian championships for twenty four hour mountain bike racing, which has grown to become the largest event of its type in the world. This race was selected for review because of its large participation, and its wide cross section of riders from elite professionals to novice recreational. This research used a descriptive non-experimental design utilising a cross-sectional retrospective audit of casualty report forms as a means of data collection.

Setting

Held annually in Canberra, ACT Australia, the 24 hour race begins at Midday on a Saturday in October (spring) every year. It involves cross country style endurance racing, distinct from the more dangerous downhill and jump style events. The race has been held at, Mount Stromlo nature reserve (elevation 600-760m) from 2000 to

2002 and 2007, and Kowen forest (elevation 720m) from 2003 to 2006. The two locations had comparable race tracks, which were a mixture of narrow “single track” and wider fire road, over dirt, rocks and roots in forested terrain. They undulated over 150 vertical metres for a distance of 12-21 kilometres. [20]

Population and Sample

The studied population included casualty report forms of participants who presented to St John Ambulance Australia first aid posts during the races from 2000-2007.

Riders were classified into elite or recreational, and competed as solo riders; gender separate teams of two, three, four and six; or mixed gender teams of three, four, six and ten. It is generally held that more experienced and skilful riders competed in smaller teams, whilst less experienced riders were part of larger teams.[20] Weather conditions varied considerably over the nine years, ranging from rain and sub zero temperatures to hot, dry and dusty .[21]

Data Collection

St John Ambulance Australia first aid volunteers record various casualty details on a standardised *casualty report form*. This form includes information such as, casualty demographics, nature of presentation, assessment, vital signs, treatment and a discharge referral section. An audit instrument was developed by the researchers to capture relevant information from the casualty report form. This instrument was designed based on the St John Ambulance Australia Minimum Data Set[22] and the Australian Institute of Health and Welfare Injury Surveillance National Minimum Data Set.[23] Hourly climate data for temperature, humidity and rainfall on each race weekend was obtained from the Bureau of Meteorology.[21] Competition details

including rider demographics, race length and timing data was obtained from the Canberra Off Road Cycling Club's race statistician. [20]

Validity

Content and face validity of the minimum data sets had previously been established.[22,23]

Reliability

Following the identification of the eligible casualty report forms, information was entered into SPSS for Windows 14.0®.[24] One author conducted data entry regarding the casualty demographics, presentation time and duration and the other author conducted the data entry for the nature of the presentation and casualty outcome. Interrater reliability based on a random sample of 5% of entered data was 97.7%.

Data Analysis

Simple descriptive statistics including measures of central tendency and frequency distribution were calculated using SPSS. Measures of central tendency were used to describe demographic data whilst frequency distribution was used to describe the presentation data. Gender differences were calculated with a Chi –Square test.

To accurately compare presentation frequencies between years, a standardized unit of presentations per kilometre ridden was calculated. This was derived for each year by dividing the total kilometres ridden by all participants, by the number of presentations.

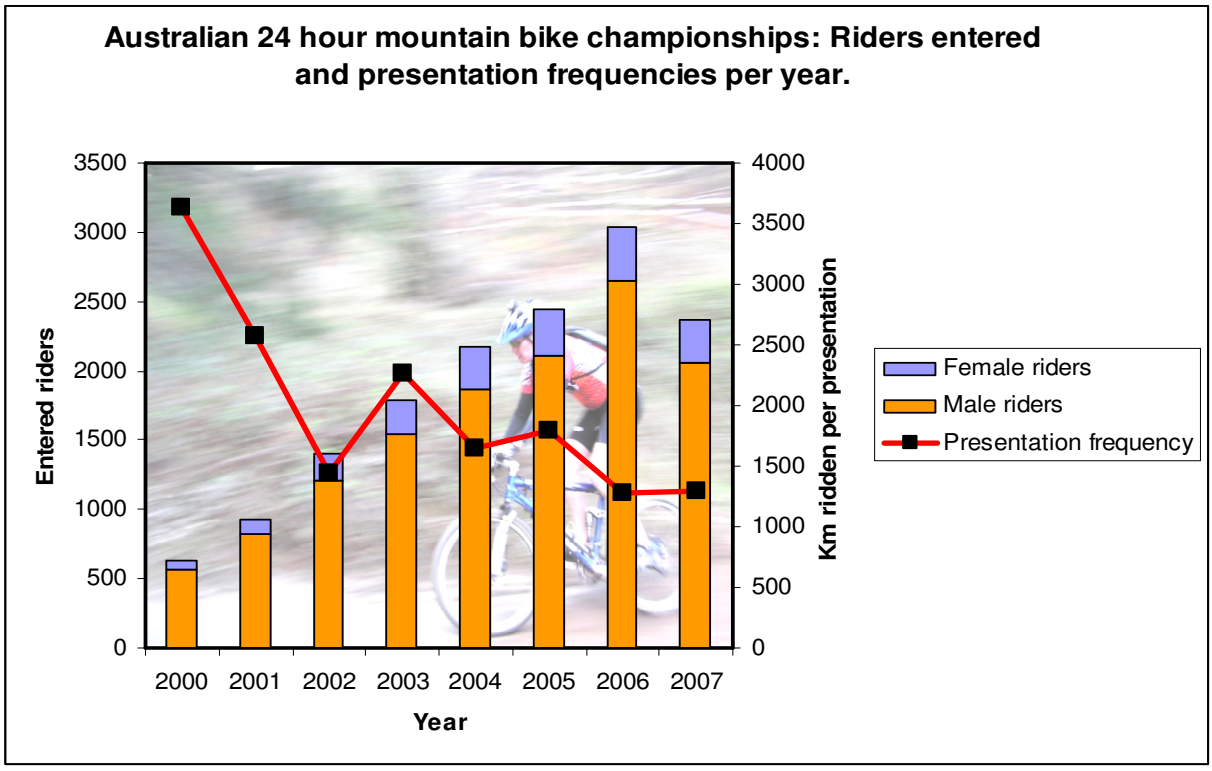
Average temperature (in degrees Celsius) and relative humidity (%) were recorded for each hour of each race.[21] A track congestion figure was derived from the track length divided by the 'rider on track' figure (each team had one rider on track at all times) giving a 'metres per rider' which could compare track congestion from year to year.[20] The congestion figures and weather data were then correlated with presentation frequencies using Pearson's R. (Microsoft excel). Significance for each R value was then calculated.

Protection of Human Participants

This research received approval from the St John Ambulance Australia Human Research Ethics Committee. All information collected from the casualty report forms were transferred to SPSS using a number coding system, therefore de-identifying individuals and individual events.

RESULTS

There was similarity of entrant demographic between the studied years of the race. Males made up 87.5% of the entrants (85.9-90.0) and females 12.5% (10.0-14.1) [Graph 1]. The average team size for all the races was 4.07 riders (3.74-4.44). The average km ridden per team was 302.8km (74km per rider), and was similar from year to year, suggesting comparable skill mix.



Graph 1: Entered rider demographics and yearly presentation frequencies

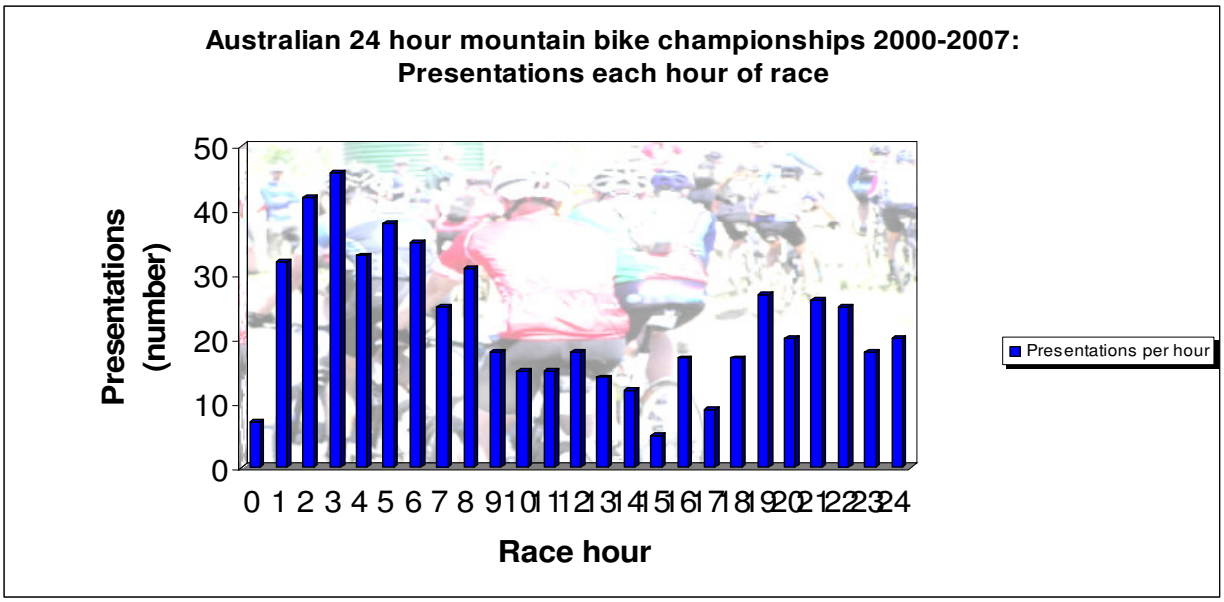
Over the eight years in which data was collected, 673 (4.55%) of the 14777 riders presented to a St John Ambulance Australia first aid post for treatment. The injury rate of females' (5.5%) was higher than the males' (4.41%) and this was significant (p=0.032).

88.3 % of presentations were injuries, 9.9% were illness, and 1.8% were environmental related. This proportion was similar across all years, and therefore injuries and presentations are used interchangeably to describe first aid events [Table 1].

Table1: Nature of casualty presentation

	f	%
Injury type	***596***	***88.3***
Fracture	9	1.5
Dislocation	2	.3
Crushing injury	3	.5
Intracranial Injury	3	.5
Sprain or strain	66	11.1
Blister	10	1.7
Abrasion	225	37.8
Superficial laceration	58	9.7
Open wound	37	6.2
Other minor wound	29	4.9
Eye injury	5	.8
Foreign body in external eye	31	5.2
Foreign body in ear canal	2	.3
Foreign body in soft tissue	5	.8
Review of injury	22	3.7
Multiple injuries	89	14.9
Injury location		
Head	8	1.3
Face	49	8.2
Neck	3	.5
Back	3	.5
Thorax	7	1.2
Abdomen	1	.2
Pelvis	8	1.3
Shoulder	16	2.7
Upper arm	4	.7
Elbow	53	8.9
Forearm	19	3.2
Wrist	14	2.3
Hand	51	8.6
Thigh	15	2.5
Knee	120	20.1
Lower leg	37	6.2
Ankle	13	2.2
Foot	10	1.7
Multiple locations	164	27.5
Illness	***67***	***9.9***
Chest pain	3	4.4
Asthma	22	32.4
Other respiratory	2	2.9
Seizure		
Collapse, unspecified	2	2.9
Nausea / vomiting	7	10.3
Diabetes related	1	1.5
Headache	23	33.8
Skin/rash	1	1.5
Pain	4	5.9
Eye		
Faint	2	2.9
Other illness	1	1.5
Environmental	***12***	***1.7***
Heat exhaustion	5	41.7
Hypothermia	5	41.7
Bite or sting	2	16.7

More patients presented in the first eight hours of the race (47.3%) [Graph 2]. When separated, the injuries and medical presentations had similar patterns.

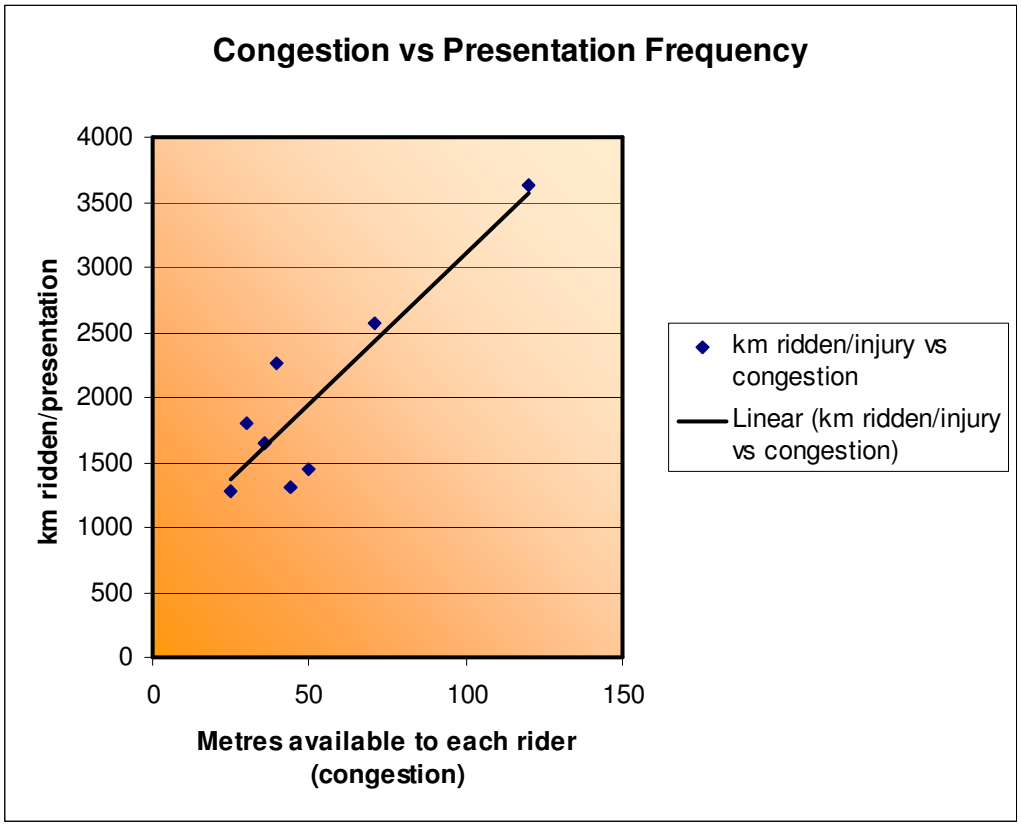


Graph 2: Cumulative presentations each race hour.

0.25% of the total rider's were referred to hospital (5.5% of total presentations). Serious presentations were uncommon, with only 0.06% of the total riders (1.3% of all presentations) transported to hospital by Ambulance. There was one presentation every 1990km ridden (151 bike hours) with a race-ending presentation (referred to hospital) occurring every 36000 km ridden (2745 bike hours).

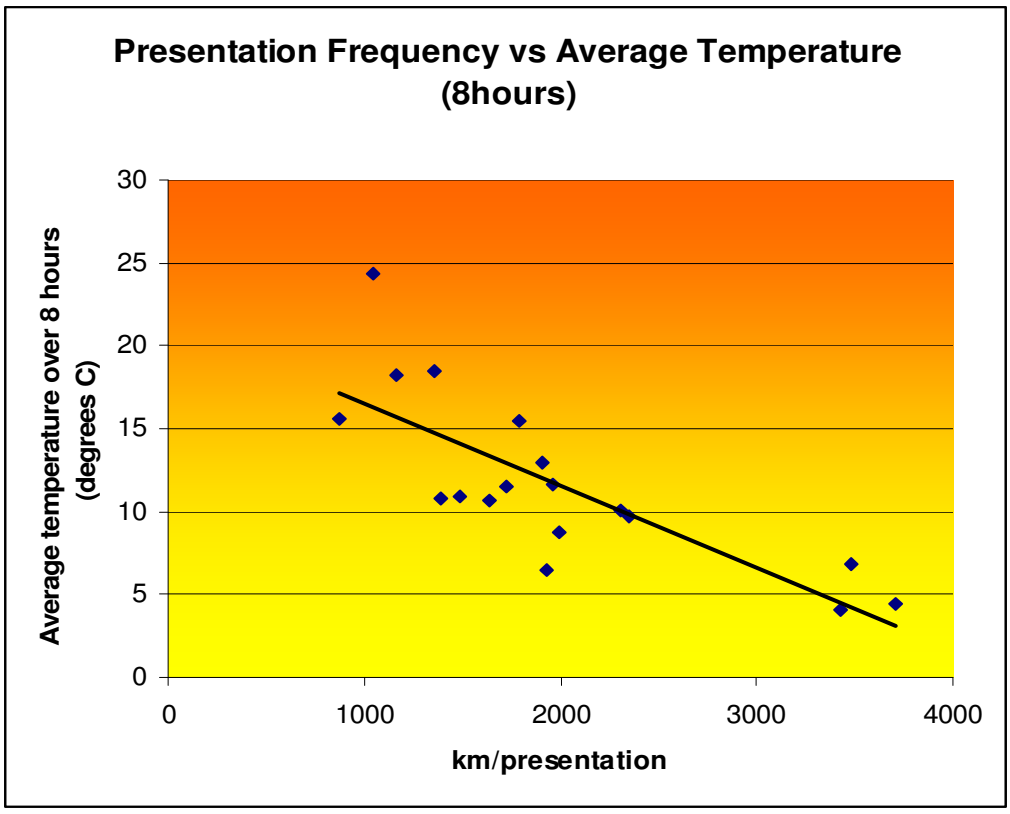
80% of injuries involved an extremity, 58% of injuries were soft tissue wounds and 5% were foreign bodies in eyes. Only 1.5% of injuries were suspected fractures, and 0.5% closed head injuries. Over 80% of the medical presentations were for asthma or headache [Table 1].

Higher track congestion was associated with a significant increase in presentation frequency (R=0.889, p=0.003). This appeared to be a linear progression with no exponential relationship found [Graph 3].



Graph 3: Effect of congestion on presentation frequency

Eight hourly blocks, corresponding to afternoon, night and morning, were used to evaluate the effect of temperature. Correlation of injury frequency with temperature averages for these periods was R=-0.78 (p<0.0001) [(Graph 4].



Graph 4: Eight hourly temperature and presentation frequencies

This effect was less strong when hourly temperatures were correlated; R= -0.35 ($p<0.0001$). Humidity had a less strong correlation with presentation frequency R=0.53 (p=0.02). Given the strong correlation between presentations and congestion, the years 2000 and 2001, which had very low entry numbers and correspondingly low congestion, were excluded from analysis of temperature and humidity effect. These two years represented only 5.49% of the total presentations.

DISCUSSION

This is the first study evaluating first aid presentations at an endurance, cross-country style mountain biking event. This is also the first large Australian study evaluating mountain bike injuries. Given that the terrain ridden includes fire road and single track (the most commonly ridden trails by recreational riders) and that the

cross section of competitors spans elite to novice, we believe it may also represent approximate injury frequencies of a large section of the Australian mountain biking public. Factors which may preclude these figures being applied to the recreational population are the established presumption that competition is a risk factor for injury, and the fact that unfamiliarity with tracks may be a risk factor for injury.

Endurance mountain biking in Australia, appears to be a relatively safe sport with generally low injury frequencies, particularly for serious injuries. Helmet use is mandatory both for competition and recreational cycling in Australia. This, combined with the relatively lower speeds of endurance racing than other mountain biking disciplines, may explain the very low serious injury rate. Given this low rate, a first aid service such as that provided by the St John Ambulance Australia, was sufficient medical coverage for this event.

The very low number of referrals to hospital would be unlikely to significantly alter the workload of a nearby tertiary hospital emergency department. However, depending on an event's location, a regional or rural health service could easily be pressured by a large mountain biking event. Ambulance services, particularly in small jurisdictions, should be forewarned of an upcoming event.[25]

In agreement with other published studies, we found a statistical difference between gender and injury frequency. These North American studies, however, were evaluating mixed discipline events including downhill racing where strength plays a more important role in bicycle control. This observation that women have a higher injury frequency may be related to a number of factors. As previously reported[7], women may have more accidents than men, they may be more likely to be injured if

they have an accident or, they may be more likely to seek first aid advice if they are injured.

It appears that injuries are more frequent when the track is congested, particularly when there is less than thirty metres of track per rider. This may seem an obvious conclusion given the technical difficulties with passing and competing on a narrow single track dirt trails. This information may serve to further guide organisers of safe levels of participation at future events.

It is apparent that more riders will require first aid support when the weather is hotter and drier. This effect is more pronounced when it is measured over the course of an afternoon, for example, than over a single hour. The eight hour period was selected because the afternoon/night/morning model is more relevant when describing weather than single hourly measurements. These eight hour periods also correspond with average shift lengths of first aid service providers.

Temperature effect may be a particular feature of endurance races such as this twenty four hour event, given the potential role of fatigue in decreasing rider strength and concentration. This fatigue effect however does not seem to be a large factor when the total presentations over time are surveyed. Hot dusty conditions also change the track surface, particularly in Australia, where mountain bike trails are generally composed of loose soil and rocks. There was an increase in injuries such as foreign bodies in the eye during the hottest and driest year, which suggests loose particles play a role.

The majority of injuries were soft tissue wounds of the extremities. Gloves have near universal uptake amongst the mountain bike fraternity. There is other protective clothing (body armour) available, however cross country riders avoid wearing this due to weight and heat considerations. Future development of lightweight, breathable, abrasion resistant clothing may prevent many of these injuries. The routine wearing of protective eye glasses may prevent foreign body injuries to eyes.

LIMITATIONS

It was impossible from the data collected to generate some important figures which may have helped to better differentiate the size of the effect that congestion and weather has on presentation frequency.

Hourly summed analysis of presentations over all races, reveals more presentations occurred during the first eight hours of the race (afternoon/evening) than the middle eight hours (overnight) or the final eight hours (morning). This observation initially seems unexpected given that night riding is generally considered more difficult and dangerous, and fatigue was thought to have been a significant factor. There was no data collected on riders' reasons for injury in this study, which may have helped differentiate causation further. It may be that riders ride more slowly and conservatively at night time, thus limiting both number of crashes and injuries sustained from these crashes.

This event by its nature was more congested in the first few hours because riders of all skills start at the same time, and then spread themselves out over the entire track length during the course of the race. There was no method, from the data available,

to calculate the variation in congestion that occurs in these first few hours. It was only possible to calculate the metres available to each rider over the entire race. Due to there being prizes for fastest lap times, there is often more intense competition between riders in the first part of the race. This increased race speed and presumed increased risk taking would also favour injuries occurring in the first few race hours. Again, there was no data collected from the riders themselves about mechanism of crash.

The hottest part of the event is also generally during the first few hours, making it difficult to differentiate between the competing factors. The strength of the associations, however, suggests both temperature and congestion influence injury frequency to some extent. In the next phase of this study, the authors will use life table methods to produce injury probabilities to attempt to standardize the injury patterns over time and better overcome this limitation.

Data was not collected by St John Ambulance Australia regarding the skill level of the injured riders. This may also be a significant factor in injury patterns. There was not, however a large difference in the teams sizes and distances ridden per team, from year to year. It is probable, therefore that the skill mix of entered riders was comparable between years, allowing comparison between years.

Due to the nature of this study, referrals to hospital were not able to be followed up, limiting the information on diagnoses and injury severity, and thus impact on the accepting hospitals.

Conclusion

Mountain biking during an endurance cross country competition is a reasonably safe sport, with only a small percentage of entrants receiving serious injuries requiring hospital care. In this research factors influencing presentations included proximity to race start, female gender, congestion of the track, and hot, dry weather conditions.

A first aid service provider, such as St John Ambulance Australia, with an ambulance- accessed nearby hospital is adequate health services for an event of this nature.

Future study should include prospective collection of data to include skill levels of injured riders, rider reports of injury mechanism and additional congestion modelling. The authors will be performing further research at mixed discipline events, specifically evaluating the impact of the event on local emergency departments.

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