Motorcyclist Injuries and Protective Clothing:

Research with TAC Clients

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Abstract

The wearing of protective clothing is one strategy used to mitigate injuries to motorcyclists. The present research project investigated the types of injuries sustained by TAC client motorcyclists and the relationships of these injuries with the wearing of protective clothing. A sample of 500 TAC client motorcyclists was interviewed about their accidents, motorcycles, wearing of protective clothing and riding behaviour. These data were linked to police reports and TAC injury data. Injuries were classified according to body region and type of injury, allowing the effect of different items of protective clothing to be explored. Participants reported high levels of helmet and protective glove wearing. Protective jackets and boots were worn by the majority, with protective pants the least likely item of clothing to be worn. Analyses showed those wearing protective clothing were less likely to sustain open wound injuries than those not wearing protective clothing. The wearing of specific items of protective clothing was associated with fewer open wound injuries to the corresponding regions of the body. There was also some evidence of the protective effect of motorcycling pants and boots on nerve injuries. A comparison of road-bike riders with off-road riders showed that road-bike riders wore fewer items of protective clothing and fared more poorly in terms of injuries sustained. The research demonstrates the benefits the wearing of protective clothing offers motorcyclists in the event of a crash.

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Introduction

In 2008, 500 TAC clients who had sustained injuries as motorcyclists were interviewed about their accidents with a particular focus on the wearing of protective clothing at the time of the accident. Findings are detailed in the original 2008 research report by *IPSOS*, including analyses of riding and crash patterns and predictors of protective clothing wearing. With respect to wearing of protective clothing, it was found that those with lower income levels, who were riding as commuters and with fewer years of experience were least likely to be wearing protective gear.

Because of the way client injuries were classified at the time of the research, conclusions about the effects of protective gear on injury outcomes were difficult to make. However, recent work has been done on the classification of injuries and improvements in how injuries are classified have been made, warranting revisiting the motorcycle client research.

The aim of the current report is to understand the types of injuries sustained by TAC motorcyclist clients and to examine the relationship of these injuries with the wearing of protective gear. This new analysis does not re-examine the issues covered by the original report; rather it aims to identify new insights based on the new method of injury classification available in the claims data.

There has been much research on injury outcomes associated with the non-wearing of motorcycle helmets and the protective effect of helmet wearing has been well established (e.g. Cochrane review, 2009). However, there is by comparison little previous research that examines the effects of protective clothing on injury outcomes for those involved in crashes as motorcyclists. Recently, de Rome et al. (in press) have shown that protective clothing offers benefits for motorcyclists in reduced risk of open wound injury and that protective clothing incorporating body armour offers significantly reduced injury risk.

In the present research protective clothing would be expected to reduce open wound type injuries, as it provides a better barrier between the skin and the road surface than everyday clothing. However, it would be expected that the impact of protective gear on more serious injuries, such as fractures, would be limited given the forces operating to result in such an injury. Injury outcomes and wearing of protective clothing among on and off-road riders were also explored.

Method

A sample of 500 TAC clients injured as motorcyclists was interviewed about their accidents and their purpose for riding at the time of their accident, the protective clothing they were wearing at the time of the accident, their motorcycles, their riding experience, license status, registration and their riding since the accident. The clients' accidents were from the years 2006 to 2008. The wearing of helmets, protective jackets, gloves, pants and boots was of particular interest.

The participants were interviewed by *iView* using CATI methodology (Computer Assisted Telephone Interview). These data from the telephone interviews were then matched with accident information from police reports and injury data from TAC claims.

The majority of the participants were male (96%) and the mean age was 35.8 years. The sample characteristics were representative of the population of TAC motorcyclist clients. The characteristics of the sample are likely to be more severe that the general population of crash involved motorcyclists, as those with very minor injuries are less likely to need extensive medical treatment and are probably less likely to make a TAC claim.

In the original research project, the ways in which injury data were recorded made it difficult to observe the impacts of the wearing of protective clothing on injury outcomes. Depending on the source of the injury data, information about injuries in the TAC's systems was coded in different formats. Hospital data was coded using ICD-10-AM classification system, while non-hospital data was coded in ICPC-2 PLUS (2002-2007) and SNOMED CD (2007 onwards). Recently, work has been done to convert all TAC injury codes to ICD-9-CM codes, which provided greater clarity about a client's injuries and allowed the region of the body injured to be examined. This work was completed in 2010. The availability of new injury data warranted revisiting the 2008 client research to explore the impacts of protective clothing on injury outcomes.

Injuries were classified in broad categories (based on ICD-9-CM codes), including fractures, open wounds, minor injuries; these could be attributed to general body regions: head, trunk, upper limbs and lower limbs. Nerve, internal injuries and intracranial injuries completed the injury categories. See the appendix for a summary of the types of injury in each category.

Results

Injury Types

The most common types of injury were fracture-type injuries and minor injuries (both of these classes of injury were present among 58% of motorcyclists). Nerve or spinal cord injuries were sustained by 39% of motorcyclists surveyed. Open wound types of injuries were sustained by 37% of those sampled.

Obviously, it is possible for a motorcyclist to sustain more than one injury type and injuries to multiple regions of the body. On average motorcyclists sustained injuries to two body regions. The lower limbs were the most common body region to be injured, with 62% of those interviewed sustaining some type of lower limb injury. About half of those interviewed sustained an injury to the trunk region (51%). Similarly half of those interviewed sustained upper limb injuries. Of all motorcyclists interviewed 14% of the sample received some type of head injury. On average motorcyclists sustained injuries in 2.7 of the 15 categories listed in the appendix, with the highest number of different injury classes being 9 for a handful of motorcyclists interviewed.

Protective Clothing

The rates of wearing of protective clothing were examined. Helmets were worn by almost all of the motorcyclists interviewed (99%), similarly the incidence of glove wearing was very high (92%). Jackets were also reasonably common (79%) and motorcycling boots (70%) and pants (59%) were the least likely of the items to have been worn at the time of the accident. On average participants wore four of the five types of protective clothing under consideration, with 47% wearing all five types of protective clothing at the time of the accident. When looking at body regions that sustained open wounds, an increase in items of protective clothing worn is associated with open wounds to fewer regions of the body, this correlation was moderate in size and significant, $r(498) = -.385$, $p<.001$.

When examining the stay in hospital immediately after the accident, analyses showed that those wearing all five items of protective clothing spent significantly less time in hospital than those wearing less than five items of clothing ($t(498)=2.21$, $p=.028$). On average, those wearing five items of clothing stayed for 5.6 days. Those wearing fewer than five items of clothing stayed, on average, for 10.5 days. This is likely to be related in part to the protective gear wearing patterns different types of riders and is discussed further later. Each body region is examined further with respect to protective gear. Simple tests for statistical significance were performed (generally Chi squared analyses or t-tests), and results of these tests are generally reported only where there were statistically significant outcomes.

Head injuries

Almost all motorcyclists injured (99%) reported wearing a helmet at the time of the crash, consequently head injuries sustained by motorcyclists were usually sustained while wearing a helmet (see table 1).

Table 1 Number of motorcyclists who sustained each type of head injury according to helmet wearing

Body Region	Injury Type	Wearing helmet - number injured	Not wearing helmet - number injured
Head	Skull fracture	14	1
	Intracranial injury	49	2
	Open wound	24	3
	Other minor	1	

Full face helmets offered some protection from open wounds in comparison to open face helmets. There was a significant association between wearing of full and open face helmets and open wounds to the head, χ^2 (1, 490) = 17.24, $p<.001$. Only 3% of motorcyclists wearing full face helmets sustained an open wound head injury compared to 14% of those wearing open face helmets.

Trunk and upper limb injuries

Jacket wearing among the sample was reasonably high, with 79% of motorcyclists surveyed reporting wearing a protective jacket at the time of their accident. The data suggests that wearing a protective jacket offers some prevention of open wounds to the trunk as there was a significant association between jacket wearing and open wounds to the trunk, χ^2 (1, 496) = 4.92, $p=.027$. Fewer of those who were wearing a jacket sustained open wounds, compared to those not wearing a jacket, see table 2.

While internal trunk injuries were generally less common, only 5% of those who wore a jacket sustained an internal trunk injury compared to 10% of those not wearing a jacket. However, this trend did not reach statistical significance, χ^2 (1, 496) = 2.77, p=.096. There was a significant relationship between jacket wearing and upper limb open wounds, χ^2 (1, 496) = 12.13, p<.001, such that fewer motorcyclists wearing a jacket sustained an upper limb open wound than those not wearing a protective jacket.

Table 2 Percentage of motorcyclists with trunk and/or upper limb injuries by injury type and the wearing of a protective jacket.

Body Region	**Injury Type**	**Wearing jacket - % injured**	**Not wearing jacket - % injured**
Trunk	Fracture	17%	15%
	Internal injury	5%	10%
	Open wound	15%	25%
	Other minor	29%	23%
Upper Limbs	Fracture	29%	23%
	Open wound	9%	22%
	Other minor	26%	25%

The majority of those interviewed were wearing protective gloves at the time of their accident (92%). Analyses show a significant association between wearing motorcycling gloves and open wounds to the upper limbs, χ^2 (1, 500) = 44.84, p<.001. Fewer of those who were wearing gloves sustained an open wound injury to the upper limbs, compared to those not wearing protective gloves, see table 3.

Table 3. Percentage of motorcyclists who sustained upper limb injuries by the wearing of protective gloves

Body Region	**Injury Type**	**Wearing gloves - % injured**	**Not wearing gloves - % injured**
Upper Limbs	Fracture	28%	25%
	Open wound	9%	45%
	Other minor	26%	20%

Lower limb injuries

Only 59% of those interviewed were wearing protective pants, with 70% wearing protective boots. Both of these items of clothing were associated with lower incidences of lower limb open wounds, χ^2 (1, 499) = 17.65, p=.001 and χ^2 (1, 495) = 9.91, p<.002 for protective pants and boots respectively (see tables 4 and 5).

Table 4. Percentage of motorcyclists who sustained lower limb injuries by the wearing of protective pants

Body Region	**Injury Type**	**Wearing pants - % injured**	**Not wearing pants - % injured**
Lower Limbs	Fracture	33%	29%
	Open wound	14%	30%
	Other minor	33%	33%

Table 5. Percentage of motorcyclists who sustained lower limb injuries by the wearing of protective boots

Body Region	Injury Type	Wearing boots - % injured	Not wearing boots - % injured
Lower Limbs	Fracture	32%	32%
	Open wound	16%	29%
	Other minor	30%	38%

Nerve injuries

Protective pants and boots were also associated with significantly lower incidences of nerve injury. A third of those wearing protective pants sustained a nerve injury, compared to 48% of those not wearing protective pants, χ^2 (1, 499) = 11.13, p<.001. The effect was even more striking with protective boots, 35% of those wearing boots sustained a nerve injury, compared to 78% of those not wearing boots, χ^2 (1, 495) = 7.05, p<.008.

On-Road and Off-Road Riding

Road bikes were the most common of any type of motorcycle ridden and accounted for 60% of cases, with trail bikes accounting for 35% and scooters only 4%.

To examine differences between on-road and off-road riders and their injuries, those who were riding a road bike on either a metro or country road were classified as 'on-road riders' and compared to 'off-road riders', those who were riding a trail bike in a state or national park or on private property. In the sample there were a total of 299 on-road riders and 78 off-road riders.

On-road riders were significantly older than off-road riders (mean = 39.84 years (SD = 12.65) for on road riders and mean = 36.28 years (SD= 9.69) for off road riders); t(375)=2.31, p=.021. There was a significant association of rider type with riding purpose (χ^2 (2, 377) = 49.18, p<.001). Off-road riders were more likely to be riding for recreational purposes; they were almost exclusively riding for recreational purposes (99%) compared to 56% of on-road riders who were recreational riders at the time of their accidents.

There was a significant association between the type of rider and types of crashes in which on-road and off-road riders were involved (χ^2 (7, 377) = 73.99, p<.001). These trends are likely to contribute to the types of injuries sustained. The most frequent types of crashes in which on-road riders were involved were single vehicle (39%), intersection (21%) and same direction (20%) crash types. In comparison, 47% of off-road riders were involved in single vehicle crashes, 21% in the miscellaneous category (this involves falling from vehicles and other crashes) and 19% in on-path crashes (of which two thirds of crashes involved riders hitting an object on the road/path).

As indicated by the crash types, there was a significant association between the two groups with the number of vehicles involved in crashes. On-road riders were more likely to be involved in crashes with multiple vehicles, than were off-road riders (62% of on-road riders versus 33% of off-road riders, χ^2 (6, 377) = 23.32, p=.001). On-road

riders were more likely to be riding in metro areas than off-road riders (65% of on-road riders compared to 13% of off-road riders, χ^2 (2, 377) = 69.42, p<.001).

A t-test was performed to examine if there were differences in the wearing of protective clothing among these two subgroups of riders. These results showed that on-road riders wore significantly fewer items of protective clothing than off-road riders (mean = 3.9 (SD=1.17) for on-road and mean = 4.4 (SD=0.97) for off-road riders; t(375)=-3.278, p=.001).

On-road riders fared more poorly in terms of injury outcomes than off-road riders (see table 6). Hospital stays were significantly longer for on-road riders than off-road riders (t(375)=2.44, p=.015) . On average off-road riders stayed 2.6 days in hospital while on-road riders stayed in 10.7 days in hospital. On-road riders had injuries to significantly more regions of the body than off-road riders, significantly more body regions sustaining open wounds and were significantly more likely to sustain nerve injuries (see table 6). In terms of the nature of injuries, on road riders sustained significantly more classes of injuries to the trunk (e.g. fracture, open wound, minor) and significantly more classes of injuries to the upper limbs (see table 6). This difference injury outcome is likely to be due to both lower levels of protective clothing wearing and the different crash profiles of on- and off-road riders.

Table 6. Injury outcomes compared for on-road riders and off-road riders.

	On-Road Riders	**Off-Road Riders**	**Significance test results**
Mean number of body regions injured (out of 5)	2.4	1.6	t(375)=5.68, p<.001
Mean body regions with open wound (out of 4)	0.7	0.2	t(375)=4.36, p<.001
Mean body regions with minor injury (out of 4)	1.0	0.7	t(375)=2.46, p=.014
Mean number of classes of trunk injury (out of 4)	0.8	0.5	t(375)=5.68, p<.001
Mean number of classes of upper limb injury (out of 3)	0.8	0.4	t(375)=3.28, p=.001
Percent who sustained nerve injury	44%	24%	χ^2(1, 377)=10.09, p=.001

Discussion

The research showed that levels of helmet wearing are high, but that there is room for improvement in the wearing of other items of protective gear, particularly pants and boots. The findings are consistent with previous research (de Rome, et al., in press) and support the idea that protective clothing is effective in reducing rates of open wound types of injuries. The key benefits identified are listed below.

- Full face helmets offer better protection from open wounds than open face helmets.
- Wearing protective jackets and gloves is associated with a lower the incidence of upper limb open wounds.

- Wearing protective jackets is associated with a fewer open wounds to the upper limbs and trunk.
- Wearing protective boots and pants is associated with fewer nerve injuries and lower limb open wounds.

While protective clothing was associated with a lower incidence of open wound injury, it did not prevent open wound injuries in all cases. Despite reporting wearing protective gear, a number of TAC clients still sustained open wound injuries. This may be due to variable quality and performance of the protective clothing or differing interpretations of what protective clothing means. In future, the types of protective clothing worn could be examined in more depth to explore which clothing offers the best protection.

There was no indication that serious injuries (fractures) might be mitigated by the wearing of protective clothing. de Rome et al. (in press) found a protective effect of body armour on fractures. The wearing of body armour was not captured in detail in the present research and the rates of wearing may have increased among motorcyclists who have crashed in more recent years. Future research with TAC clients could investigate the role of body armour and if it offers protection against fracture injuries. Factors like the nature of the objects impacted and speed at impact are likely to contribute to fracture outcomes and these were not available.

Those who wore ‘full’ protective clothing (five items) had hospital stays that were on average five days shorter than those wearing less than the five items of protective. However, this is likely to be in part due to the types of riders and their accidents as well as the protective effect of gear. It is probable that a combination of accident factors and wearing of gear contributes to the length of hospital stay.

When comparing on-road and off-road riders there were a number of differences that emerged. On-road riders had worse injury outcomes wore fewer items of protective clothing and rode in very different environments to off road riders. On-road riders stayed longer in hospital than did off-road riders. The findings about injury trends are consistent with previous research about injury associated with on-road and off-road motorcycling in Victoria (Cassell, Clapperton, O’Hare & Congui, 2006). There are a number of explanations for the poorer outcomes shown among on-road riders, apart from the level of protective clothing wearing. Due to the nature of off- road riding, travelling speeds are generally slower and tracks are more likely to be gravel rather than bitumen, and few other vehicles, it is easy to understand why the outcomes were better for off-road riders.

The following recommendations could be considered in motorcycle safety programs:

- There is room for improvement in the wearing of protective pants, boots and jackets.
- Using full face helmets should be encouraged.
- Messages about the benefits of protective clothing can specify their benefits in reducing the likelihood of open wound types of injuries and nerve injuries.
- Based on injury outcomes and protective gear wearing rates road bike riders travelling on-road should be a key target for protective clothing campaigns.

References

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Appendix: Injury Classifications

Head/Skull Injuries

- Skull Fracture - skull or face fractures, crushing of skull or face
- Intracranial injuries - concussion, cerebral lacerations and contusions, haemorrhages
- Open Head Wound - open wounds to eyes, ears or head, injuries to head or neck blood vessels, superficial injuries or burns to face, neck, scalp or eye, foreign bodies in eye, ear or nose.
- Minor head injury - dislocation of jaw

Trunk Injuries

- Fracture Trunk: fracture or crushing of vertebrae, ribs, sternum, pelvis
- Internal Trunk Injuries - injury to heart, lungs, spleen, liver, kidney, abdominal organs, pelvic organs and digestive tract, foreign bodies in digestive or genitourinary tracts
- Open Wound Trunk - open wounds to neck, chest, back, buttock and genitals, injury to blood vessels of the thorax, abdomen and pelvis, superficial injury to trunk, burns to trunk or internal organs
- Minor Trunk - back strains and sprains, dislocation of shoulder

Upper Limb

- Fracture Upper Limb - fracture or crushing of arms, shoulder, hands and fingers
- Open Wound Upper Limb - open wounds, superficial injuries, burns or traumatic amputation of upper limb which includes shoulder, arm, elbow, forearm, wrist, hand or finger
- Other Minor Upper Limb - dislocation of elbow, forearm or strains and sprains of arm, shoulder, elbow, wrist or hand

Lower Limb

- Fracture Lower Limb - fracture or crushing of leg, knee, ankle, foot and toes
- Open Wound Lower Limb - open wounds, superficial injuries, burns or traumatic amputation of lower limb which includes
- Other Minor Lower Limb - dislocation of hip, knee, ankle, foot and strains and sprains of hip, thigh, knee, leg, ankle or foot

Nerve/Other Spinal

- Injuries to optic and cranial nerves, spinal cord (excluding spinal bones), nerves of trunk, upper and lower limbs