Effects of Advanced (Anti-lock) Braking Systems (ABS) On Motorcycle Crashes

A Survey of 61 motorcyclists who crashed between 2010 and 2015

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February 2017

Abstract

An online survey was carried out in 2016 focussing on motorcyclists who had crashed while riding a motorcycle fitted with Advanced (anti-lock) Braking Systems (ABS).

The survey was a pilot study to identify specific issues relating to crashes involving motorcycles fitted with ABS. The objective of the survey was to find out from riders, their experiences which will be used to provide information to improve training and the technical development of future ABS, the wealth and depth of information provided by the motorcyclists who participated allows for a wide range of analysis of the details that resulted from the questionnaire and the responses.

Riders from Australia, South Africa and Europe replied.

They overwhelmingly recognised the risk of injury if they are involved in a crash and thus wore highly protective clothing and helmets. The typical speed of 32% of the riders was between 41 to 60 kilometres per hour (kph), while 13% indicated that their speed prior to braking was between 61 to 70 kph. Only four (7%) indicated that their speed was more than 100 kph prior to braking. In terms of how the speed before braking affected the injury severity, the evidence in this study suggests that the injury outcome appears to be nearly random, or rather it is dependent on circumstances other than speed.

In order to have a more valid understanding of the dynamics of motorcycle crashes with ABS brakes, further research is required to extend and expand the survey to cover different languages to get a more global response which would thus offer governments, trainers and motorcycle manufacturers an opportunity to improve the quality of motorcycle training and technology in order to reduce potentials risks that riders may face.

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Introduction

An online survey was carried out focussing on motorcyclists who had crashed while riding a motorcycle fitted with Advanced (anti-lock) Braking Systems (ABS). The survey was a pilot study to identify specific issues relating to crashes involving motorcycles fitted with ABS. The survey took place between October 2016 and December 2016. The motorcyclists participating in the survey came from a variety of countries including Australia, Sweden and the United Kingdom. In total 61 motorcyclists replied to the survey. In three cases the motorcyclists only partially replied, but there was sufficient information regarding the dynamics of the crashes to be including in the analysis. The limited number of responses is partly due to two reasons: 1) the survey was limited in time, distribution and language (only English); 2) the availability of ABS on motorcycles has been restricted partly due to cost and because the manufacturers had offered ABS as an option mostly for the bigger engine size motorcycles, which has thus limited the pool of riders using these motorcycles.

Aims

The study aims to identify the dynamics of crashes between Powered Two Wheelers (PTWs: motorcycles or scooters) that have Advanced (Anti-lock) Braking Systems (ABS) - and another vehicle, object or road/side between January 2010 and December 2015. To understand the specifics of the impact of the motorcycle with ABS and how this affects the rider in terms of the trajectory of the rider post-impact and the type of possible injuries sustained by the rider. (Throughout the survey we used the generic term "motorcycle" for convenience.)

Objective

The objective of the survey was to find out from riders, their experiences which will be used to provide information to improve training and the technical development of future ABS.

Methodology

An online survey was disseminated through magazines, Facebook, motorcycle forums and web sites. A total of 36 questions were asked. As the survey was a pilot study, the questions were asked based on knowledge of the issues and to identify possible weaknesses or omissions in order to prepare a more in-depth and larger multi-lingual questionnaire.

The first section covered requests for information about their personal details including age, gender, country of residence (and crash). Questions included the type of clothing and whether it had armour protection, as well as gloves, boots and the type of helmet worn. A further section requested information about the motorcycle e.g. make, model, year of manufacture, style and type of braking technology. The next section required information about the circumstances of the crash including location, type of road, conditions, weather and the circumstances of the incident. Finally the rider was asked for information in relation to potential injuries – whether they were minor or serious and the extent of the injuries.

The respondent was also asked to provide comments and further details if required (see Annex one). All information is confidential and no personal identifying questions regarding the rider or the motorcycle/scooter was asked. The analysis of the survey was carried out using SPSS software and Microsoft Excel. See Annex two for details of the questionnaire.

Personal Information

1. **Age**
   The average (mean) age of the riders who answered the survey was 43.8 years; the youngest was 21 years and the oldest 69 years.

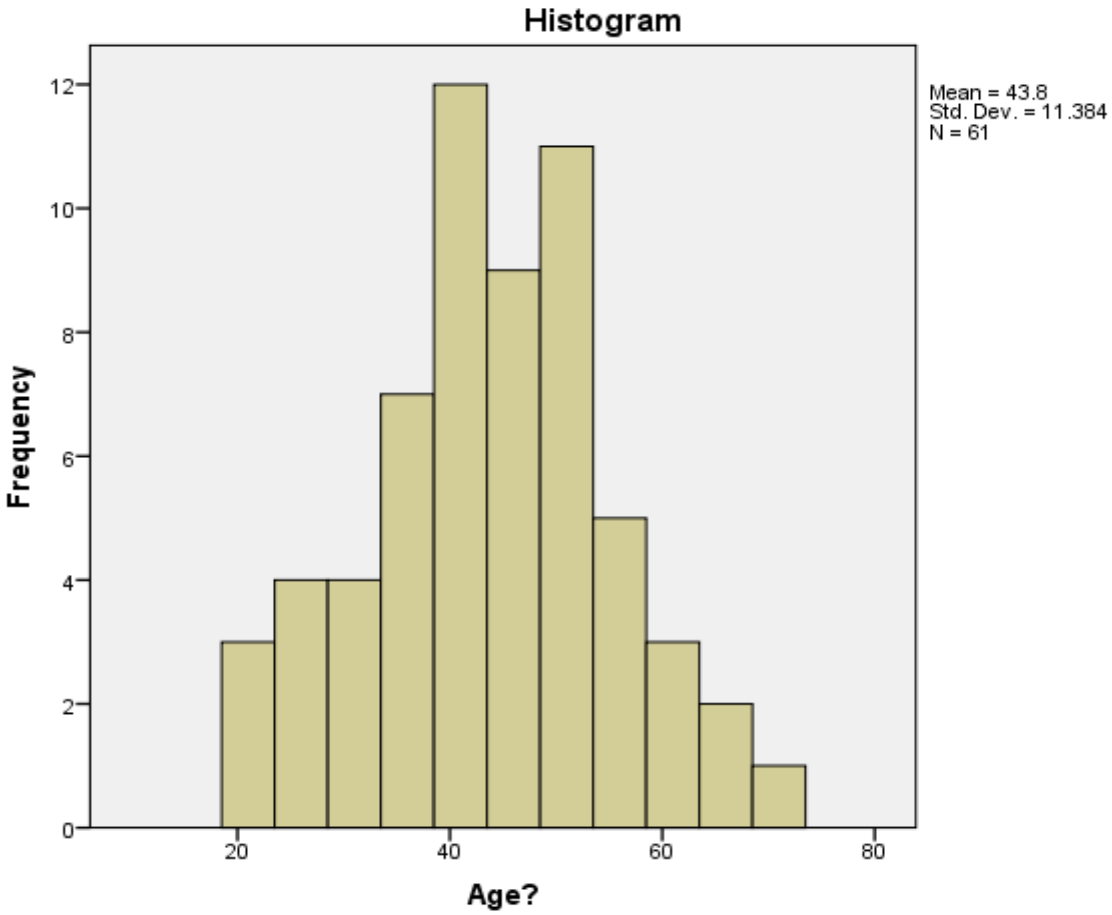

Figure 1: Age of motorcyclist

2. **Gender**

   Only one female replied to the survey the remaining 60 (98.4%) were male.

3. **Licence**

   Sixty riders replied to this question of which 56 (93%) had a full licence; one had an A2 licence (NB: A2 licence is a category of licence for European motorcyclists, a full licence is categorised as an A licence), one had a provisional licence and one had a learner licence, the remaining rider replied “other”.

4. **Type of Helmet Worn**

   There were n.59 responses to this question of which n.41/59 (69.5%) wore a full face helmet; n.17/59 (29%) wore a flip front helmet and only one wore an open face helmet. There were no other responses.

5. Type of Clothing

a. *Jacket with armour*
There were n.58/61 responses to this question of which n.56/58 (96.5%) replied that they wore jackets with armour.
b. *Trousers with armour*
There were n.54/61 responses of which n.41/54 (76%) stated that they wore trousers with armour.
c. *Boots*
There were n.59/61 (96.7%) riders who wore boots and one who wore shoes.
d. *Gloves*
There were n.59/61 (96.7%) riders who wore gloves; one did not answer.

6. Consecutive Riding Prior to Crash

There were n.59/61 responses to this question and 32.2% of riders (n.19) had ridden for more than 20 years; while 16.9% (ten) had ridden between 3 and 5 years; followed by 11.9% (seven) for both groups of 11 to 15 years and two years; 10.2% (six) for the six to ten year group. Finally 8.5% (five) replies for both the 16 to 20 year and only one year groups.

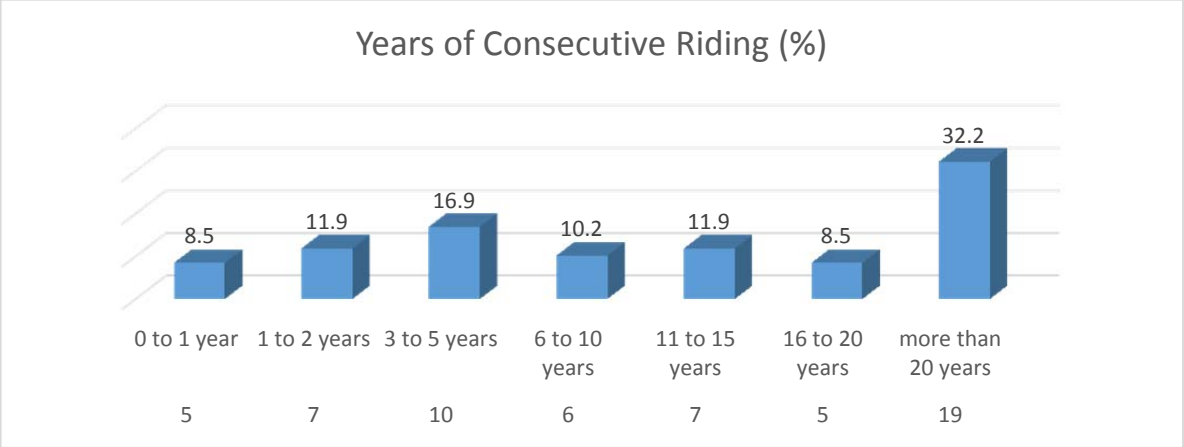

Figure 2: Years of Consecutive Riding

7. Post Test Training

There were n.34 (55.7%) riders who confirmed that they had done post-test training. (Post-test = voluntary training beyond the obligatory motorcycle test to obtain a licence).

8. Specific Training for ABS

There were n.60 responses to this question. Only ten (16.7%) had participated in training specifically focussing on the use of ABS. According to a study carried out on behalf of the European Parliament's Internal Market and Consumer Protection Committee (IMCO) in relation to experience and training, with regards overconfidence of riders of ABS-equipped motorcycles. *"The risk of accidents could be increased due to overconfidence of riders of motorcycles fitted with ABS or a misunderstanding of the capabilities of ABS (substitute for CBS)[1]. An underestimation of stopping distance at a given speed or misconceptions about the set of situations in which ABS is effective might lead individual riders to adopt a less safe riding style.*

[1] CBS = Combined Braking Systems – this comment in the IMCO report is inaccurate because CBS and ABS are different systems. They can be fitted together on the same bike but can also be fitted separately.

While plausible, this effect can be mitigated through education measures and can be expected to be temporary. Inexperienced riders are more likely to suffer from overconfidence, but at the same time new riders will be trained on ABS-equipped motorcycles (sic), which results in a better understanding of the capabilities of ABS. Moreover, no plausible evidence has been found documenting such an effect for other safety measures (obligatory wearing of helmets, seatbelt laws for cars, etc.), which might be expected to have fostered over confidence in a similar way".[2]

9. Country

There were n.25/61 (41%) riders from Australia; n.20/61 (32.8%) from the United Kingdom; n.12/61 (19.7%) from Sweden, the remaining two were from South Africa and two from the Netherlands.

Accordingly, the majority of the crashes occurred in Australia (39.3%), followed by the U.K. (29.5%) then Sweden (19.7%). There were two crashes in South Africa, and one each in France, Germany, Netherlands and New Zealand.

Table 1: Country where crash occurred

Country	Frequency	Percent
Australia	24	39.3
France	1	1.6
Germany	1	1.6
Netherlands	1	1.6
New Zealand	1	1.6
South Africa	2	3.3
Spain	1	1.6
Sweden	12	19.7
UK	18	29.5
Total	**61**	**100.0**

Information about the Motorcycle

The German manufacturer BMW had the highest proportion of makes in this survey, equal to 29.5% (n.18/61) which would be expected as it represents one of the most popular types of motorcycle with ABS. This is followed by the Japanese manufacturer(s) Honda (23%), Kawasaki (11.5%), Yamaha (9.8%) and Suzuki (8.2%). The proportion of motorcycles in this study appears to be a reflection of the popularity of the makes rather than their performance.

Table 2: Make of motorcycle

Make	Frequency	Percent
N/a	1	1.6
Aprilia	1	1.6
Bigboy (Sth African Scooter)	1	1.6
BMW	18	29.5
Ducati	1	1.6
Harley Davidson	1	1.6
Honda	14	23.0
Indian	1	1.6
Kawasaki	7	11.5
KTM	1	1.6
Moto Guzzi	1	1.6
Suzuki	5	8.2
Triumph	3	4.9
Yamaha	6	9.8
Total	**61**	**100.0**

[2] http://www.europarl.europa.eu/document/activities/cont/201202/20120220ATT38592/20120220ATT38592EN.pdf Page 17 Approval and market surveillance of two- or three-wheeled vehicles and quadricycles -Impact Assessment of IMCO Compromise Amendments

10. Year of Manufacture

As the figure below demonstrates, the majority (77%) of the motorcycle models were manufactured between 2007 and 2015 (n.47/61)

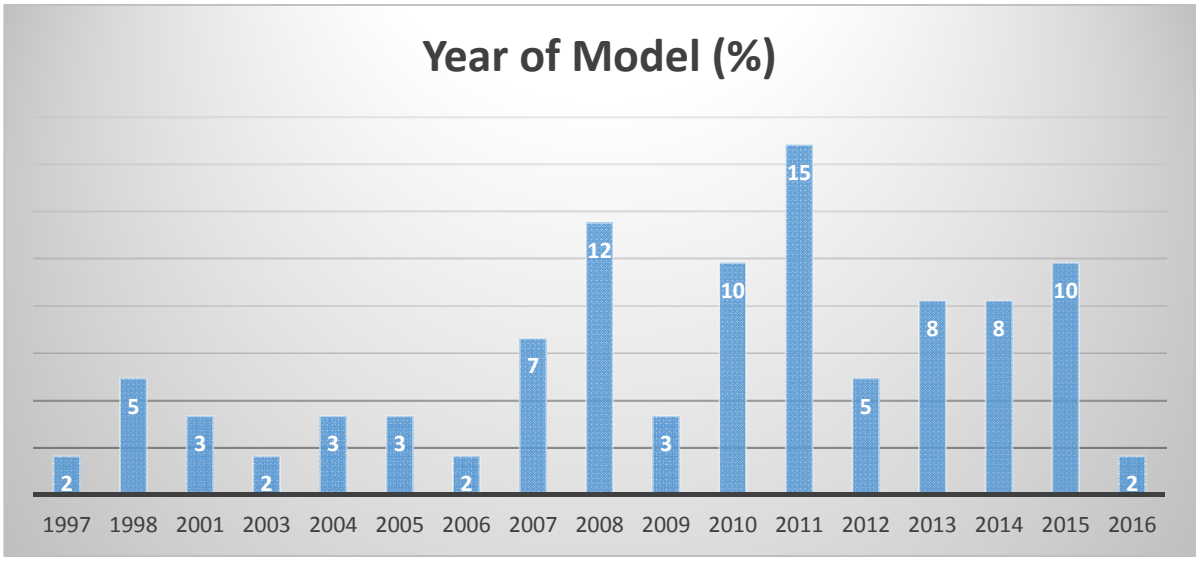

Figure 3: Year of Model

11. Style of Motorcycle

The most popular styles of motorcycle in the survey were the Adventure (26.2%) followed by the Sport Tourer (21.3%) and the Tourer (16.4%), totally 63.9% (n.39/61) of the motorcycles in this survey. These are typically used for long distance travel.

Table 3: Style of Motorcycles

Style	Frequency	Percent
No response	1	1.6
Adventure	16	26.2
Adventure Tourer	2	3.3
Cruiser	3	4.9
Naked	6	9.8
Scooter	2	3.3
Sport	5	8.2
Sport Tourer	13	21.3
Super Sport	3	4.9
Tourer	10	16.4
Total	**61**	**100.0**

12. Engine Size of Motorcycle

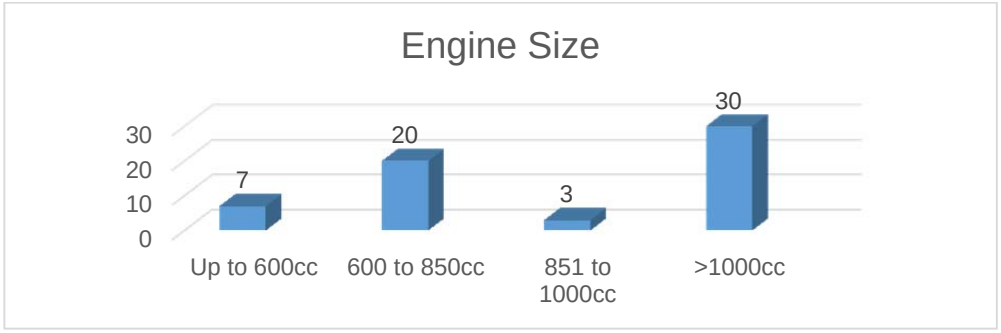

Figure 4: Engine Size of motorcycle

The majority (n.30/61) 49.2% of the motorcycle had engine sizes over 1000 cc, followed by motorcycles with engine sizes between 600 to 850 cc, (n.20/61) equal to 32.8% of those surveyed.

13. Type of Brakes

Of the respondents who answered this question, n.60/61 replied that the brakes on their motorcycles were disc brakes. N.20/61 (32%) replied that their motorcycles had traction control. Three riders indicated that they had their ABS switched off while a fourth rider stated that there was a mechanical defect which caused the system to be switched off at the time of the crash. Only one had specific ABS training and this rider and another had also done post test training. The remaining two had not. However, the rider that had done both training courses (post test and ABS) had not turned off the system, it was a technical fault.

A more detailed account of the differences between ABS and non ABS time and distance for motorcycles will be expanded In the Discussion section.

Conditions and Scenario of Crash

14. Speed of motorcycle prior to crashing

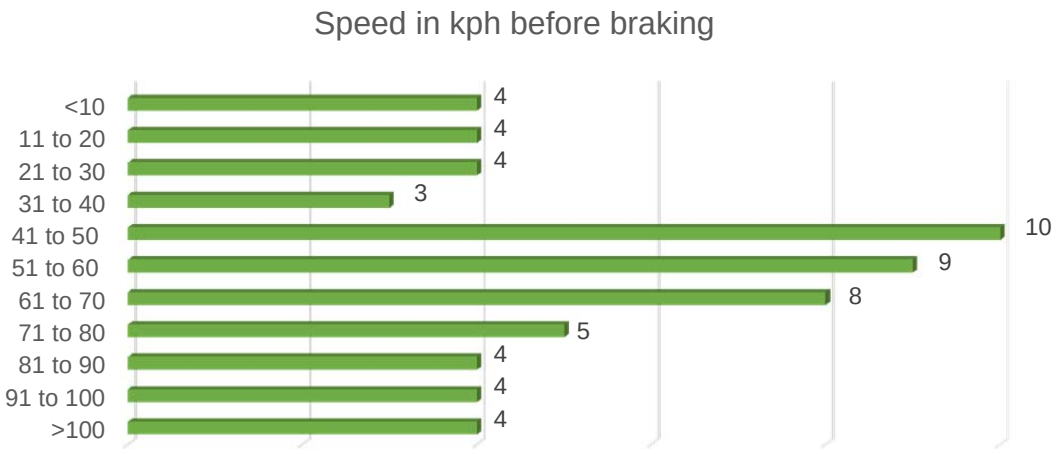

Figure 5: Speed in kph before braking

Most riders (32%) reported speeds between 41 to 60 kph, while 13% indicated that their speed prior to braking was between 61 to 70 kph. Only four (7%) indicated that their speed was more than 100 kph prior to braking. Eight (14%) were travelling at speeds up to 20 kph prior to braking. When asked whether the riders applied their brakes prior to crashing, n.52/61 (85.2%) replied that they did.

In order to understand whether the rider was impaired prior to crashing, the question of whether the rider had consumed alcohol or drugs (prescribed or not) prior to crashing was asked. All n.60 riders who replied to this question stated that they had not consumed alcohol or drugs.

Table 4: Weather

Weather	Frequency	Percent
No response	2	3.3
Dry and sunny	37	60.7
Dry and cloudy	11	18.0
Light rain	9	14.8
Raining heavily	1	1.6
Snow and/or ice	1	1.6
Total	**61**	**100.0**

Table 5: Time of Day

Time of Day	Frequency	Percent
No response	2	3.3
Early morning (5 am to 8 am)	4	6.6
Morning (8.01 am to 11 am)	10	16.4
Midday (11.01 am to 2 pm)	14	23.0
Early afternoon (2.01 pm to 4 pm)	17	27.9
Late afternoon (4.01 pm to 6 pm)	8	13.1
Early evening (6.01 pm to 8 pm)	5	8.2
Night time (Midnight to 5 am)	1	1.6
Total	**61**	**100.0**

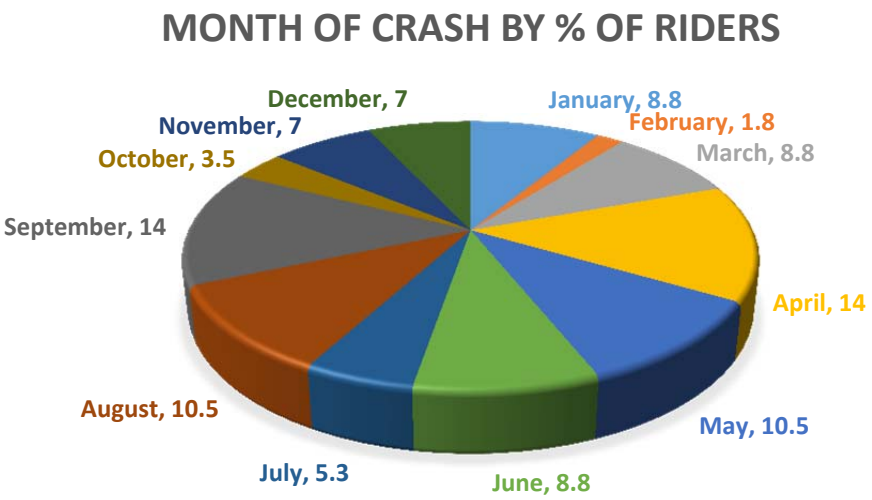

Figure 6: Month of Crash

Overall there were n.34 riders from the Northern Hemisphere and n.27 riders from the Southern Hemisphere. Overall the highest proportion of crashes occurred in September and April (14% respectively). However, in order to have a clearer understanding of the seasons when the riders crashed, because of the variation of seasons between the Northern and Southern Hemispheres, the following figure highlights that the majority of crashes occurred in Summer and Autumn, 30% respectively.

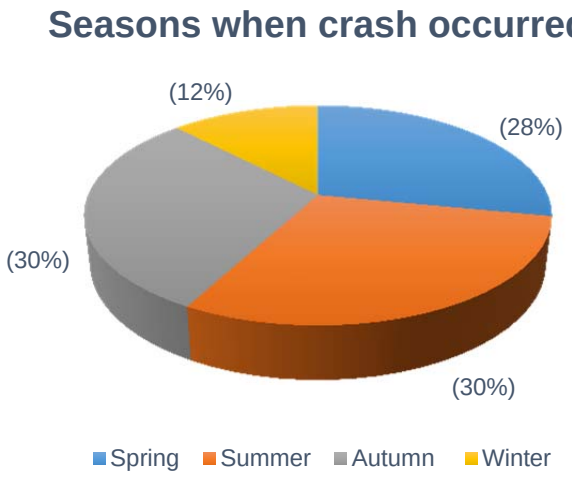

Figure 7: Seasons when crash occurred

15. Crash Outcome

When asked whether the rider had separated from their motorcycle at impact, n.37/61 (60.7%) replied that they had. When asked in which direction the rider was projected if separated, n.11/61 replied that they fell sideways to the left, n.10/61 replied that they fell sideways to the right, n.12/61 replied that they went over the top in a forwards direction. Of these, n.3 riders indicated that they had stopped and were hit from behind by a car and one rider indicated that he ran into a car that had stopped with no brake lights. The remainder did not indicate the circumstances. One rider indicated that he fell rearwards over the back of the motorcycle to the right. By observing the direction compared to the country (i.e. whether left or right hand drive) there was no indication that this was significant when falling sideways (either right or left), see table below.

Table 6: Direction of Fall Compared to Left or Right Hand Drive Countries

Direction of fall	Australia (LHD)	France (RHD)	Germany (RHD)	NZ (LHD)	South Africa (LHD)	Spain (RHD)	Sweden (RHD)	UK (LHD)	Total
Fell sideways left	5	0	0	1	0	0	2	3	11
Fell sideways right	3	0	0	0	0	1	4	2	10
Other (e.g. backward)	1	0	1	0	0	0	0	1	3
Over the top of the motorcycle, in a forwards direction	2	0	0	0	2	0	3	5	12
Remained upright on motorcycle when colliding	2	0	0	0	0	0	0	1	3
Total	**13**	**0**	**1**	**1**	**2**	**1**	**9**	**12**	**39**

NZ = New Zealand

Of those that had traction control (n.20/61), six indicated that they fell sideways left, two fell sideways right, five went over the top in a forwards direction and three remained upright. The remainder did not indicate the circumstances.

With regards to whether post-test training[3] or specific training with ABS motorcycles mattered to the outcome of the direction of separation – the responses from n.44/61 of those surveyed indicated that the direction was not significantly different proportionately, than the overall replies above. N.17/44 fell sideways and n.9/44 either went forward over the top or remained upright.

When asked what the motorcycle collided with, n.23/55 (41.8%) replied that the crash was single vehicle and that they had collided with the road: of which five due to gravel, six due to road contamination and one due to potholes. N.22/55 (40%) had collided with another vehicle: of which n.17/55 with a car, three with another motorcycle and two with a van. Respectively, one collided with railings, one with a post, one with a tree, one with a large animal. Five indicated "other".

[3] Post-test training refers to voluntary training courses after the rider had obtained a motorcycle licence.

Table 7: What the motorcycle crashed with

	Frequency	Percent
Car	17	30.9
Road only	11	20
Other (Fence, trench, High side wobble, wall)	6	10.9
Road contamination (e.g. wet leaves, diesel spillage, ice)	6	10.9
Gravel	5	9.1
Motorcycle	3	5.5
Van (3.5 tonnes or less)	2	3.6
Electricity post, lamppost	1	1.8
Large animal (e.g. deer, cow, horse, moose)	1	1.8
Pothole(s)	1	1.8
Railings	1	1.8
Tree	1	1.8
Total	**55**	**100**

The following table highlights the type of road and location of impact for n.60 riders. The table highlights that a straight road was the most common type with 15% impacting on an urban (straight) road and 13.3% impacting on a rural (straight) road. Right bends on a rural road indicated that 13.3% of the riders had an impact at these locations, while 8.3% of riders collided on a left hand bend on a rural road.

Table 8: Type of road and location at impact

Straight road	**Frequency**	**Percent**
Major Highway or motorway	2	3.3
Rural Road	8	13.3
Trail riding - e.g. unmetalled roads	1	1.7
Urban Road	9	15
Left hand bend		
Major Highway or motorway	4	6.7
Rural Road	5	8.3
Urban Road	3	5
Right Hand bend		
Off road e.g. garage forecourt, driveway, race-track, training centre	2	3.3
Rural Road	8	13.3
Urban Road	3	5
Junction (intersection)		
Major Highway or motorway	1	1.7
Rural Road	1	1.7
Urban Road	4	6.7
T-junction		
Rural Road	1	1.7
Urban Road	1	1.7
Cross roads		
Major Highway or motorway	1	1.7
Urban Road	2	3.3
Staggered junction		
Major Highway or motorway	1	1.7
Roundabout		
Major Highway or motorway	1	1.7
Urban Road	1	1.7
Rail crossing		
Rural Road	1	1.7

16. Damage to motorcycle

When asked if the rider had claimed insurance for the crash, 37 of 59 riders (63%) stated that they had filed an insurance claim.

Riders could report multiple areas of crash damage on their motorcycle. Damage to the front parts of the motorcycle was the most common: two-thirds reported damage to fairing or handlebars, half to the turn indicators. The data are shown in Figure eight and Table ten.

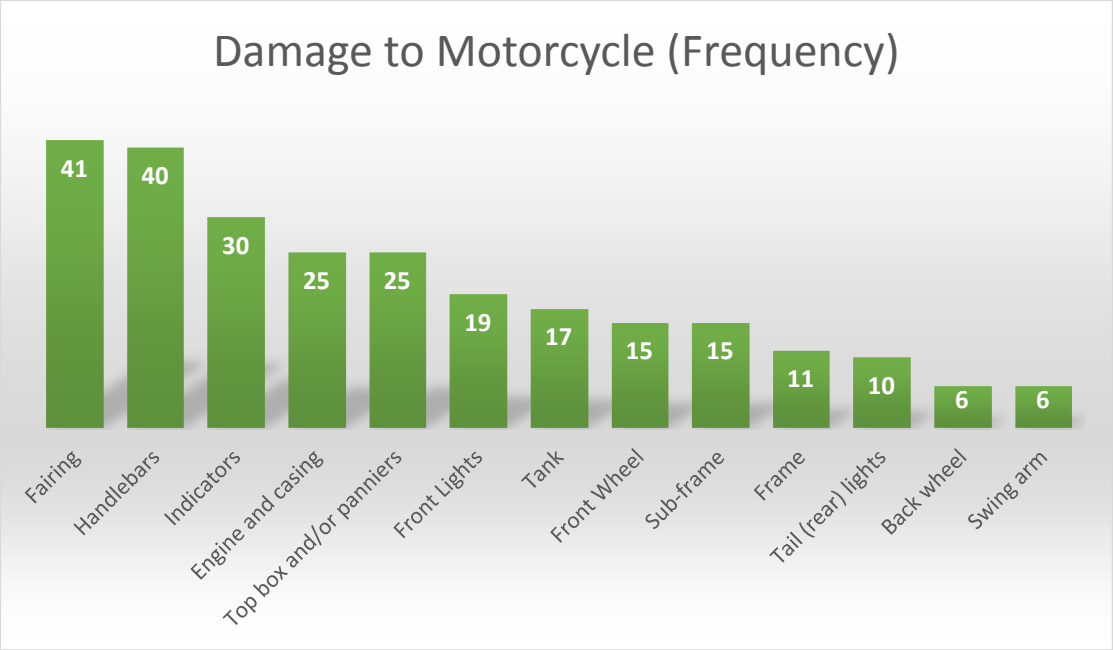

Figure 8: Part of motorcycles damaged

Table 9: Part of motorcycles damaged (%)

Damage to Motorcycle	Percent
Fairing	67.2
Handlebars	65.6
Indicators	49.2
Engine and casing	41.0
Top box and/or panniers	41.0
Front Lights	31.1
Tank	27.9
Front Wheel	24.6
Sub-frame	24.6
Frame	18.0
Tail (rear) lights	16.4
Back wheel	9.8
Swing arm	9.8

17. Personal Injuries

N.31/61 indicated that they had been injured either slightly (minor) or seriously. The biggest proportion of injuries was to the lower limbs – 26.2% of minor injuries, then 14.8% for upper limbs. This was followed by minor injuries to shoulders (9.8%) Overall the riders who suffered serious injuries were far less with a maximum of four riders (6.6%) claiming serious injuries to lower limbs and chest. Of those that commented about their "other" injuries, these ranged from "pride" to back pain, bruising and discomfort. In the case of the rider with serious injuries, he

stated that this was a fractured spine. Those with serious injuries were mainly to the shoulders (8.2%) lower limbs and internal chest injuries – respectively (6.6%).

Overall injuries to the shoulders was the most predominant (18%)

Table 10: Injuries minor or serious

Lower limbs	**Frequency**	**Percent**
Minor (slightly injured)	16	26.2
Serious (internal damage or broken bones)	4	6.6
Pelvic Internal		
Minor (slightly injured)	2	3.3
Pelvic External		
Minor (slightly injured)	3	4.9
Abdomen Internal		
Minor (slightly injured)	2	3.3
Abdomen External		
Minor (slightly injured)	2	3.3
Chest Internal		
Minor (slightly injured)	3	4.9
Serious (internal damage or broken bones)	4	6.6
Chest External		
Minor (slightly injured)	4	6.6
Upper Limbs		
Minor (slightly injured)	9	14.8
Serious (internal damage or broken bones)	2	3.3
Shoulders		
Minor (slightly injured)	6	9.8
Serious (internal damage or broken bones)	5	8.2
Neck		
Minor (slightly injured)	4	6.6
Serious (internal damage or broken bones)	2	3.3
Face		
Minor (slightly injured)	2	3.3
Head		
Minor (slightly injured)	3	4.9
Brain		
Minor (slightly injured)	2	3.3
Serious (internal damage or broken bones)	1	1.6
Other		
Minor (slightly injured)	6	9.8
Serious (internal damage or broken bones)	1	1.6

18. Speed versus Injuries Sustained

In table eleven below, the comparison between speed and injuries demonstrates that the outcome appears to be random. In the case of serious injuries where the speed was under ten kilometres per hour (kph), the rider was hit from behind by a car travelling at a much higher speed. The same collision happened to another case where the rider was travelling at a speed between 31 and 40 kph. In the second case where the rider was travelling between 31 and 40 kph and was seriously injured, he was the victim of a hit and run by a van.

This suggests that collisions are dependent on a number of circumstances which include what the rider hits and how the rider falls as highlighted in the Discussion section by Kevin Williams and the video presentation by Dr John Hinds. In other words, speed is just one of many components which may influence the series of events leading to a crash and subsequent injuries.

As table eleven demonstrates, riders with serious injuries, compared to those with minor injuries were as follows: 0-40 km/hr: 3 of 6; 40-60 km/hr: 6 of 15; 61-80 km/hr: 5 of 9; >80 km/hr: 1 of 6.

Table 11: Comparison of Speed before Braking and Injuries Sustained

speed before braking Kph	Lower limbs	Pelvic inter.	Pelvic exter.	Abdo. Inter.	Abdo. Exter.	Chest inter.	Chest exter.	Upper limbs	Shoulders	Neck	Face	Head	Brain
<10	Minor					Minor	Minor	Minor	Minor	Minor		Minor	Serious
<10	Minor												
31-40	Minor												
31-40	Minor												
31-40	Serious								Minor				
31-40			Minor			Serious			Serious				
41-50	Minor												
41-50	Minor							Minor					
41-50									Serious	Serious			
41-50		Minor pillion						Minor pillion					
41-50								Minor					
41-50	Serious												
41-50								Minor					
41-50													
51-60								Serious			Minor		Minor
51-60	Minor			Minor		Serious		Serious					
51-60			Minor					Serious			Serious		
51-60								Minor					
51-60	Minor								Minor				
51-60	Minor				Minor	Serious		Serious	Minor				
51-60	Minor												
61-70									Minor	Minor		Serious	
61-70	Serious								Serious				
61-70										Minor			
61-70	Serious								Minor	Minor		Minor	
61-70													
61-70													
71-80							Minor						
71-80						Serious			Serious				
71-80	Minor												
71-80	Minor									Serious			
81-90							Minor						
91-100								Minor					
91-100	Minor		Minor					Minor					
91-100	Minor												
101-110	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor
111-120	Minor					Serious			Serious				

Conclusions

Although this pilot survey is a small sample, the wealth and depth of information provided by the motorcyclists who participated allows for a wide range of analysis of the details that resulted from the questionnaire and the responses.

The typical speed of 32% of the riders was between 41 to 60 kph, while 13% indicated that their speed prior to braking was between 61 to 70 kph. Only four (7%) indicated that their speed was more than 100 kph prior to braking. Eight (14%) were travelling at speeds up to 20 kph prior to braking. In particular, the riders overwhelmingly recognised the risk of injury if they are involved in a crash and thus wore highly protective clothing and helmets. In terms of how the speed before braking affected the injury severity, table 11 suggests that the injury outcome appears to be nearly random, or rather it is dependent on circumstances other than speed.

When asked whether the riders applied their brakes prior to crashing, n.52/61 (85.2%) replied that they did. This response is possibly the most important and relevant question and answer in the survey. The reason is that the focus of this survey and its response regards advanced (anti-lock) braking systems and whether the dynamics of the outcome of the crashes matters or whether there is something else that requires attention. For example does ABS affect injury severity? Does ABS affect collision motions, which in turn affect injury severity? Does ABS matter in collision dynamics? Does something other than ABS or speed affect injuries? More research is required to answer these questions.

With regards the assumption that specific training is required to understand how ABS functions, for example, in 2011 the Third European Driving Licence Directive was introduced throughout Europe which set out conditions and categories for motorcyclists to attain a licence based on age. The Directive allowed through derogation, the Member States (MS) to determine the age range for commencing to learn to ride a PTW (Powered Two Wheeler), but possibly the most important derogation that was allowed, was to leave the MS to decide whether to move the riders through the categories either by testing or training[4].

Overwhelmingly the MS chose testing – most probably for financial reasons. Testing to acquire a licence for a novice rider means that he/she would need training – although it is not obligatory. However the consequences of the testing regime for the Third EU driving licence is that in the majority of Member States, typically novice riders would be trained to pass the test and not necessarily trained to survive, nor indeed understand the dynamics of ABS.

Australia has a federal government and the licencing system for motorcyclists is dependent on the legislation of each of the six states and territories (Northern Territory and Canberra – Australian Capital Territory).

Whether the European Union extends ABS to smaller PTWs or not and whether this will matter in terms of the reduction of casualties is a moot point. What is possibly more important is whether the rider actually understands how to use this system of braking, or simply whether the rider has sufficient knowledge of emergency braking and hazard awareness so as to prevent a crash in the first place.

In order to have a more valid understanding of the dynamics of motorcycle crashes with ABS brakes, the plan for further research, depending on the level of funding, is to extend and expand the survey to cover different languages, e.g. French, German, Spanish, Italian and English to get a more global response which would thus offer governments, trainers and motorcycle manufacturers an opportunity to improve the quality of motorcycle training and technology in order to reduce potentials risks that riders may face.

[4] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:403:0018:0060:EN:PDF Page 4.

Discussion

a) Reaction of riders in crash scenarios

According to a study carried out by the European Parliament's Internal Market and Consumer Protection Committee (IMCO Impact Assessment) with regards ABS in certain motorcycle-specific accident configurations, the study states that *"ABS potentially has a negative impact on rider safety in certain accident configurations that are specific to motorcycle accidents: in certain accident situations, falling off and being separated from the motorcycle results in less severe injuries than impacting an obstacle while still in control of the vehicle, albeit at reduced speed. However, such 'downfall' accidents have been shown to result in greater casualties overall, which suggests that the number of cases in which the absence of ABS would have increased rider safety is very limited"*.[5]

In response to the IMCO Impact Assessment comment above, Kevin Williams Survival Skills Trainer argues that:

"First thing, there is no guarantee that a rider in an emergency will actually apply the brakes at all. So in an extreme case, it's possible that a rider on a machine with ABS might simply ride straight into the crash.

I can suggest two circumstances:

- either the rider was so close to the collision site when the emergency developed that there was no time to apply the brakes;
- or the rider had time to apply the brakes but froze.

In either case, I can't see that ABS / non-ABS equipped machines make any difference, and nor does training in the USE of ABS. In the first case, the only viable solution is improved situation awareness so that the rider isn't in the 'killing zone' when the emergency develops. In the second, the solution is 'No Surprise' style awareness training, so that the rider is aware of the POTENTIAL of the situation to develop before it does, and goes into a pre-planned routine to take emergency action - ABS would assist the rider in braking hard but only if the rider can respond rapidly enough - reference James Ouellet's work on the 'at risk' zone which he puts at three seconds back from junctions. This is more than enough time / distance to stop, yet his research suggests many riders fail, and the reason is nothing to do with the mechanical abilities of the machine but human factors - specifically, surprise.

Second, the authors of the impact assessment need to define what they are talking about. Are they suggesting that if you take two machines travelling at the same speed towards the same emergency, then "in certain accident configurations" a rider who falls off, slides and then impacts the obstacle will suffer less severe injuries than a rider who stays aboard the machine and brakes effectively but doesn't have time to completely stop?

If they are, that sounds horribly like the old 'laid it down' myth resurfacing. (..) I very much doubt that a sliding rider decelerates at anything even close to the deceleration rate at which a rider braking hard (which ABS of course allows).

There are now two possibilities:

- the sliding rider slides clear of the collision and suffers only abrasion injuries (or impacts something else further off and much slower);
- the sliding riding impacts the obstacle - and if that happens, the implication is that the sliding

[5] http://www.europarl.europa.eu/document/activities/cont/201202/20120220ATT38592/20120220ATT38592EN.pdf

rider MUST impact the obstacle at a considerably higher speed than the rider atop the machine hits it.

What happens next? There are some well-known injuries that result from T-boning a car sat on a bike, including broken wrists / injuries to the upper leg (typically fractured femur) resulting from the rider sliding forward into the handlebars, a fractured pelvis from sliding into the tank (potentially fatal) and head injuries from the rider pivoting forward into whatever they are hitting.

What happens to the rider sliding and impacting? Good question (…) but once on the deck your motion will be more or less random and a matter of luck what hits first. And then I suspect injuries very much depend on how you hit something; head-first vs foot-first, or side on.

But given that you're likely to be hitting at a much higher speed than the rider atop the machine, then it's likely that some impact injuries are fatal, and thus being missed if they are doing a straight comparison of injuries alone".

"However, such 'downfall' accidents have been shown to result in greater casualties overall, which suggests that the number of cases in which the absence of ABS would have increased rider safety is very limited" (ref IMCO Impact Assessment).

"Once again, what do they mean by 'greater casualties'? Are they talking numbers or severity? Riders who fall and slide typically suffer abrasion injury. Given the poor performance of most motorcycle kit when abrasion resistance is required, that's not a surprise. But of course, it requires sufficient distance to slide clear of the obstacle. What's needed here is more detail than traditional KSI information (…)".

These comments are supported by Dr John Hinds Motorcycle Trauma Specialist[6] in his presentation on the work carried out by his team at Irish road racing events where he demonstrates the type of injuries are dependent on the way in which the rider falls post-crash. What is evident in the following video is that the motorcyclists are all travelling at very high speeds and during the video, Dr Hinds highlights the importance of the way the rider falls and the possible outcome due to where the rider lands and which part of the body hits the ground or object first.

He comments that "the mechanism is important, speed isn't" (3.40 mins into the video). He then continues to explain possible injury scenarios depending on the type of action the motorcycle may take. For example he explains what may happen when the motorcycle "High-sides" and he points that the crash is dependent on the height of the fall rather than the speed – which in the case of his presentation – the speeds are significantly higher than normal road riding e.g. 150 to 200 mph.

Video presentation: "More Cases from the Races"
https://www.youtube.com/watch?v=ocHeJG5o8N0

b) Braking Time and Distance

To better understand the variation in terms of time and distance with the motorcycle having ABS fitted compared to those that do not, the following table gives a comparison of these variations based on mph speed and highlights a breakdown of time and distance for braking with ABS and without ABS – note that the distances are in miles (1 mile = 1.60934 kilometres and one foot = .03048 metres).[7] The table twelve demonstrates the efficacy of ABS in terms of stopping times and distance compared to motorcycles without ABS fitted.

[6] Dr John Hinds died in July 2015 at a road race course in Ireland
[7] http://www.bikesafer.com/detail/braketime.html

Table 12: ABS braking time and distance

Speed – MPH*	Braking Time (seconds)		Braking and reaction time		Distance to Stop (feet)	
	ABS	non ABS	ABS	non ABS	ABS	non ABS
5	0.26	0.29	0.88	0.91	5.51	5.63
10	0.52	0.59	1.14	1.21	12.94	13.41
15	0.79	0.88	1.41	1.5	22.3	23.36
20	1.05	1.18	1.67	1.8	33.57	35.46
25	1.31	1.47	1.93	2.09	46.78	49.73
30	1.57	1.77	2.19	2.39	61.9	66.15
35	1.84	2.06	2.46	2.68	78.95	84.73
40	2.1	2.36	2.72	2.98	97.92	105.48
45	2.36	2.65	2.98	3.27	118.82	128.38
50	2.62	2.94	3.24	3.56	141.64	153.44
55	2.89	3.24	3.51	3.86	166.38	180.66
60	3.15	3.53	3.77	4.15	193.05	210.05
65	3.41	3.83	4.03	4.45	221.64	241.59
70	3.67	4.12	4.29	4.74	252.15	275.29
75	3.93	4.42	4.55	5.04	284.59	311.15
80	4.2	4.71	4.82	5.33	318.95	349.16
85	4.46	5.01	5.08	5.63	355.23	389.34
90	4.72	5.3	5.34	6.92	393.44	431.48
95	4.98	5.6	5.6	6.22	433.57	476.18
100	5.25	5.89	5.87	6.51	475.62	522.84

*MPH = miles per hour

To complement the above data, motorcycle trainer Kevin Williams, Survival Skills believes that the following should be considered in making any evaluation regarding distance and time:

“There is the mechanical stopping distance the bike actually needs to stop from the moment the brakes are applied - that's based on the effectiveness of the braking system, the coefficient of friction of tyres / road surface, and how hard / how quickly the rider actually squeezes the brakes. It would help to discuss just how many G the rider is able to pull when braking to get some feel for what this means. Typically riders manage no better than 0.5 to 0.6G when braking in an emergency. As a typical motorcycle can actually approach 1G (and even slightly exceed it on a half-decent surface) that means anything from 30-50% of the available braking force is simply not being used. If training means that riders with ABS are more confident to brake harder, then stopping distances will be accordingly reduced - potentially very significantly.

Also there's the 'muscle twitch' reaction time - this is the delay from the moment the brain sends the signal to the muscles to brake, to the moment the lever moves. This is typically in the region of 0.5 to 0.7 seconds. Older riders tend to have slower reactions. This is built-in human physiology, and not something that can be changed.

Finally there's the cognitive delay which constitutes what I call 'recognition time' - this is the delay from the moment the emergency reveals itself to the moment the brain's cognitive systems actually detect the emergency and send a 'need to take evasive action by braking' message. This can be anything from near-instantaneous to two to three seconds. ABS won't do anything for this - this is No

Surprise? No Accident territory[8]*.*

With regards the braking distance table above, it is also necessary to consider impact speeds IF the rider fails to stop. This is in many ways more important than absolute stopping distances.(…) SPEED is not linear with time / distance when braking - because of the square term in the equation relatively little speed is lost initially, but speed falls rapidly at the end - this means that small savings in overall stopping distances have MUCH bigger implications for reducing the impact of a collision or even avoiding the collision altogether.

This could be achieved by modest reductions of speed before braking (situation awareness) or modest increases in the rider's braking efficiency. When I demonstrate emergency stops, I do the demo at 25mph and the bike stops in around three bike lengths - 6 metres / 22ft - which is much less than the table suggests because a) I know I'm going to stop but I'm also braking to the limit of adhesion. When I add just 5mph to my speed it adds another bike length - an extra 2 metres approximately - but where I could JUST stop at 25, my impact speed from 30 would be about 10mph".

Based on the evidence from the cases of motorcycle fatalities in Northern Ireland, the Investigators from the Forensic Science Northern Ireland Road Traffic Investigation Unit have commented that *"Before the motorcyclist applies braking and begins to leave a tyre mark, there is a time period during which the rider perceives there to be a hazard ahead and then, typically reacts to that perceived hazard. The length of this perception/reaction time depends on a number of factors and cannot be known. However, a probable range of perception/reaction times of 0.75 to 1.5 seconds can be assumed".*[9]

Furthermore they state that: *"The deceleration rate of the motorcycle is dependent on a number of factors, one of which is the braking technique employed by the motorcyclist i.e. the severity of braking applied and the ratio of front/rear brake distribution. Unlike a car, the front and rear brakes of the motorcycle <u>without</u> ABS are separate systems and the rider can vary the ratio of braking applied to each wheel.*

Under severe braking, the minimum deceleration is achieved with rear wheel only braking and a value of approximately 0.4g (3.92 m/s2) can be considered. A deceleration of 1g (9.81 m/s2) can be considered representative of strong braking by a skilled motorcyclist on, f-or example, a 1000cc engine Super Sports motorcycle using both front and rear brakes. Following examination of the motorcycle, considering the nature of the tyre mark and considering the friction surface dressing on the road surface, the investigators are thus able to determine a range of possible deceleration rates. These calculations for braking, deceleration and perception/reactions time are considered by the investigators when preparing the reports of the scientific examination of the material relating to the collision scenes."[10]

In the study carried out on behalf of the European Parliament's Internal Market and Consumer Protection Committee (IMCO Impact Assessment) by London Economics[11], with regards the avoidance or mitigation of accidents and Casualties, the study states that "*ABS is the only technical solution that directly monitors and prevents wheel-locking. In certain emergency situations, ABS can help motorcycle riders to achieve faster deceleration. In particular, the braking performance of inexperienced riders can be raised to that of experienced riders*".

[8] https://nosurprise.org.uk/predicting-surprises/
[9] Forensic Aspects of Driver Perception and Response, Paul Olsen, Lawyers and Judges Publishing Company Inc. 1996. ISBN 0-913875-22-8
[10] http://www.righttoride.org.uk/documents/Northern_Ireland_Motorcycle_Fatality_Report_2012.pdf page 17
[11] http://www.europarl.europa.eu/document/activities/cont/201202/20120220ATT38592/20120220ATT38592EN.pdf
Approval and market surveillance of two- or three-wheeled vehicles and quadricycles -Impact Assessment of IMCO Compromise Amendments Page 18

c) ABS Technology – how it works[12]:

James Ouellet explains: "*When any vehicle is coasting, neither speeding up nor slowing down, the "tire speed" and the vehicle speed are the same. If the vehicle applies the brakes the "wheel speed" slows, becoming slower than the speed the vehicle is moving. The difference between the speed the tire is rotating and the vehicle moving is called "slip" because small portions of tire tread actually slip slightly across the pavement as the tire rotates. The difference between slip and skid is that in a skid the tire stops rotating and the entire contact patch skids and slides across the pavement. Maximum slip is dynamically unstable, so that a very minute increase in slip can almost instantly turn into a fully locked skid. Anti-lock braking systems are designed to allow high levels of slip just below a level that would cross the boundary into full skid".*

ABS typically allows as much as 20% "slip", before ABS control kicks in. The two ABS wheel speed sensors send their speed signal to the ABS modulator, which determines the Vehicle Reference Speed (VRS). When braking, during any event when a tire "slips" to a speed less than the VRS, the ABS modulator kicks in and modulates that brake until that wheel speed sensor signal is within the 20% slip threshold. During any ABS-controlled stop, you will hear some tire squeal and see tire marks on the pavement. Maximum braking is achieved at the 20% slip ratio.

All ABS systems are set up based on a preset "modulation" rate, usually about 5 cycles per second (cps). Lessor systems may be only 3 cycles per second. The early Delco ABS systems on Chevrolet cars had pronounced less ABS performance because the 3 cps rate could not match the performance of the 5cps common to Bosch and Wabco systems. Delco has since improved to beyond the 5cps rate. I believe most motorcycle ABS systems function at no less than the 5cps rate, and probably at a higher cycle rate.

Inherent in any ABS brake system, is natural wheel/brake hysterisis. Hysterisis is a fancy word to describe the rotational natural dynamics of a braked wheel system. As wheel mass increases, the hysterisis of that wheel also increases. The hysterisis of a wheel assembly also affects how well an ABS system can control that wheel. An ABS system on a Victory Hammer would require different algorithms to control the skinny front tire versus the giant rear tire. The type of brake system also affects hysterisis. But since all ABS braked bikes are disc braked we can treat them all the same. The hysterisis of the braked wheel determines the minimum speed thresehold at which ABS cannot modulate the wheel because even if the ABS releases the brake pressure, the latent "lag" in the brake system maintains braking effort on that wheel.

On many ABS equipped bikes, the low-speed threshold of ABS operation is below 10mph. Below 10mph, the ABS cannot release the braked wheel fast enough to overcome the hysteresis in the system at the preset cycle per second rate. So at slow speeds the wheels can lock up. This is also why on off-road applications the wheels can "lock up", because the loose dirt/gravel surface can "dam up" in front of the tires and actually cause enough drag to slide a wheel even though the ABS is working. This can also occur on grass, for example going downhill.

One thing about ABS is practice to get used to the feeling i.e. initial practice at about 20mph on a straight dry paved surface. Some suggest to practice on a low traction surface like a thin coating of gravel on a hard-packed surface. One caution about testing ABS equipped bikes on gravel surfaces: The "damming" effect of gravel in front of the tire contact patch can and will cause momentary lockup of the tire due to a response lag after the ABS has released the brake and the tire has "plowed through/over" the piled up gravel. Just be aware that the tire, especially the front, can still "lock up" on gravel if the gravel is deep/loose enough that the damming effect happens.

[12] Source: AVH: http://forum.motorcycle-usa.com/default.aspx?f=22&m=314718 with additional comments and input from James V Ouellet.

Acknowledgements

James V. Ouellet, Motorcycle Accident Analyst from California USA for his thorough critique of this report and for his assistance with the survey questionnaire.

Kevin Williams, Motorcycle Survival Skills Trainer for his comments and input into this study. Further information here: https://nosurprise.org.uk/

References

1. Approval and market surveillance of two- or three-wheeled vehicles and quadricycles -Impact Assessment of IMCO Compromise Amendments http://www.europarl.europa.eu/document/activities/cont/201202/20120220ATT38592/20120220ATT38592EN.pdf

2. Forensic Aspects of Driver Perception and Response, Paul L. Olsen, Lawyers and Judges Publishing Company Inc. 1996. ISBN 0-913875-22-8

3. Hardy E et al: Northern Ireland Motorcycle Fatality Report 2012 http://www.righttoride.org.uk

4. Hinds J: More Cases from the Races, Presentation at the SMACC *(*Social Media and Critical Care*)* conference Chicago 2014. https://www.youtube.com/watch?v=ocHeJG5o8N0

5. Notes about ABS Technology AVH: http://forum.motorcycle-usa.com/default.aspx?f=22&m=314718

6. Stopping Distances Revisited http://www.bikesafer.com/detail/braketime.html

Annex One: Comments from n.28 riders about the circumstances of their crash

	Post test training?	Training ABS	Traction control	ABS switch off?	Direction of fall?	Comment
1	Yes	Yes			Over the top, forwards	ABS made no difference in this accident use case.
2	Yes					ABS saved my life
3	Yes		Yes		Fell sideways left	ABS, even if brakes were applied in this instance would not have assisted. E.g. leaning around left hand corner, wet road, diesel spill. Police attributed no blame to me.
4					No fall/ injuries	Blind junction with a green light, hit by police car with lights and sirens coming from the right through their red light. Did not hear or see them because of the blind junction (bridge pillar).
5					Over the top, forwards	Car skipped a stop sign and crossed the road. ABS worked fine, but didn't reduce speed enough. I aimed for the cars back wheel, hit the car at just enough speed for the bike to go over its front wheel, but not fast enough to throw me. Still remember the sqk-sqk-sqk of ABS
6	Yes			Yes	Fell sideways right	Doing a U turn on a gravel driveway under 10kph. ABS turned off, front slid out
7	Yes	Yes			No injuries	Front washed out under very light braking on very slight LH bend. The road was very damp and I hit a particularly slippy patch, which may have been an oil deposit, which I did not spot in time. This incident this was the first bike I have ever owned with ABS. I learnt many years ago to modulate braking and deal with any wheel locking automatically, so ABS - for me at least makes no difference to my riding. I now have a BMW S1000XT SE Sport, with full lean sensitive ABS, Traction Control (all the electronics), but the only times I have noticed any effect is when I have very deliberately used them during test & training sessions, where I also learnt that I could in fact stop in a shorter distance using trained in progressive braking action, (on a dry road at least), without inducing the ABS. At all other times, my natural trained instincts have forced reversion to manual adjustment of braking pressures (front and rear) and throttle and they have not yet engaged under any circumstance.

Comments from n.28 riders about the circumstances of their crash…cont.

	Post test training?	Training ABS	Traction control	ABS switch off?	Direction of fall?	Comment
8	Yes				Remained upright on motorcycle when colliding	Had just returned to riding after 15 year break. Was pulling over before a corner immediately before a T-intersection. Sealed road was dry but hit mud and leaves that had been washed onto the edge of the bitumen. ABS activated and I went straight ahead and hit a road sign. Sign already damaged and fell over. Stayed upright. No injuries, minor scratches to fairing which were barely noticeable. First bike with ABS. I attribute accident to being out of practice. Without abs I'm convinced the bike would've gone down, been severely damaged and I would've been injured. Big fan of ABS!
9	Yes				Remained upright on motorcycle when colliding	Hit and run, van cut left across lane travelling in same direction.
10	Yes		Yes		Fell sideways right	In this particular circumstance, thought the bike is fitted with ABS., it had nil bearing on the accident in my opinion, I had braked lightly before the curve (a hairpin curve) to reduce my speed to about 20kph. I did not brake at all through the curve but believe the rear lost traction either on fine gravel, or simply I leaned too far. I did not account adequately for the road conditions (lowest point of the road, in a hilly area, with a gravel road joining the road at a tangent, and the surface of the asphalt not being in particularly good condition, on a cold day, so not as "grippy" as I expected (though I should have been more aware of this). No injuries at all, not even a bruise. Very slow low side, gear protected as designed to do.
11					Fell sideways left	I crashed due to general understeer, which occurred do to loose stones being left on the road after resurfacing works. I don't think I braked hard enough for the ABS to activate, even though I braked as hard as I felt I could, given the gravel surface.
12			Yes		Gravel	I had to swerve to avoid a car that came over to my side of the road in a left hand curve. I drove into a ditch by the road.
13	Yes	Yes	Yes		Fell sideways left	I know that if I see an eminent danger I can apply my brakes as hard as I like and not risk a skid has saved me on more than one occasion with Kangaroos.

Comments from n.28 riders about the circumstances of their crash… cont.

	Post test training?	Training ABS	Traction control	ABS switch off?	Direction of fall?	Comment
14	Yes	Yes		Yes	Fell sideways left	I was fortunate not to hit the barrier (wire rope type) on this Swedish three lane road. We were coming from two down to one lane our side. The rider ahead did not touch his brakes so went through unaware of my fall. I believe I fell only because I applied some light braking and the ABS was disabled at the time owing to a fault. I do not know if it had been operating whether it would have saved me from a fall or not.
15					Forwards	I was running tight at low speed when a dog with a long leash run in front of me. At the other end of the leash was a young girl WHO had no control over the dog. I applied the brakes but since I was traveling on gravel and turning at the same time the front wheel slid on the gravel and I fell inwards.
16	Yes				Fell sideways left	If it wasn't for ABS my accident would have been much worse. It kept me in control as I brought the bike to a stop
17	Yes				Fell sideways right	In this case the accident happened so suddenly that I have virtually no time to brake. I was overtaking the car as it changed lanes suddenly hitting me just forward of the foot pegs.
18					Fell sideways left	Inappropriate application of front and rear brake mid corning due to mudded road surface, inevitable crash with too much speed to be able to react/take alternative line through corner. ABS not activated as brakes were not fully applied as to allow cornering angle to be kept, however unsuccessful.
19	Yes	Yes	Yes		Over the top, forwards	Oil on road. High-sided in left turn
20			Yes		Remained upright on motorcycle	Rear ended by a car, impact crushed muffler against rear brake master, ABS stopped the rear wheel from locking which allowed me to control the bike to a stop, I was also braking at the time of impact and the shock of it made me apply more front brake, ABS activated allowing the front wheel to keep on turning, ABS saved me from falling off and allowed me to keep control in a straight line
21					Fell sideways right	Teach riders the bikes braking limit and how to respond. ABS makes you a forward flying brick as you no longer have predictable steering.

Comments from n.28 riders about the circumstances of their crash… cont.

	Post test training?	Training ABS	Traction control	ABS switch off?	Direction of fall?	Comment
22			Yes		Over the top, forwards	The ABS came in and I could not stop to avoid or softening the impact. think I would have been able to avoid the accident if the bike didn't have ABS
23	Yes	Yes				The car is front braked heavily for a kangaroo. I simply couldn't stop in time so made the decision to quick flick around it when I saw the kangaroo, which subsequently jumped out in front of me, so I quick flicked again which ran me out into the gravel... upon applying the brakes to slow in dirt I lost control. I believe had I made the decision to rely on ABS I probably wouldn't be typing this.
24	Yes				Over the top, forwards	The crash was probably due to unbalanced load on the bike and tires more suited for off-road usage than on-road usage. The ABS was probably not engaged at all during the crash since I didn't apply any hard braking.
25	Yes				Over the top, forwards	The driver who hit me "did not see me" and tried to blame me for braking too hard. The police only charged her with "Follow too closely". Motorcycle written off and her car was too.
26	Yes				Fell sideways left	The road surface was heavily corrugated. A vehicle pulled out in front of me, I applied the brakes, and as the bike rose and fell over the corrugations the ABS forced the lever back with each fall off the corrugations. It didn't allow me to slow in time. I tried to avoid the car and dropped the bike on the left side.
27					Backwards	Shunted from rear, slid up bonnet of car onto roof then forwards across open tarmac. No serious injuries. Hospital discharged me after triage saw no reason to examine me further than a verbal chat. General discomfort from the tumble. Only low speed but thrown about a cars length but no solid impact to body or limbs. Was wearing winter padded jacket, trousers and separate padded over suit so bruising of limbs etc was minimal.
28			Yes	Yes	Remained upright on motorcycle when colliding	Without ABS, I would have been hit by a bus cutting a blind corner. My crash was far more controlled.

ANNEX TWO

Dynamics of PTW crashes using ABS

PILOT STUDY

This study aims to identify the dynamics of crashes between Powered Two Wheelers (PTWs: motorcycles or scooters) that have Advanced Antilock Braking Systems (ABS) - and another vehicle, object or road/side. To understand the specifics of the impact of the motorcycle with ABS and how this affects the rider in terms the trajectory of the rider post-impact and the type of possible injuries sustained by the rider. (Throughout the survey we use the generic term "motorcycle" for convenience.)

The objective of the survey is to find out from riders, their experiences which will be used to provide information to improve training and the technical development of future ABS.

Note: *This is a pilot study and only in English, however it will eventually be translated into various languages in order to capture the opinions of riders throughout Europe and beyond.*

IMPORTANT: This survey is ONLY for riders who have been involved in a crash on a PTW (Powered Two Wheeler: Motorcycle or Scooter) with Advanced Antilock Braking Systems (ABS) between January 2010 and December 2015.

All information is confidential and no personal identifying questions regarding the rider or the motorcycle/scooter will be asked. We are not interested in who you are, we just want to know what happened and how it happened.

If you are unhappy with any question or if you don't know or are not sure of the answer, leave it and move on to the next question. Thank you for participating!

There are 36 questions in this survey

About you and your motorcycle

These questions aim to gather generic information : your age, which country you live in and riding experience. The questions about your motorcycle are to help us understand the make, model and type of ABS on your motorcycle.

Please note that the information regarding your motorcycle is specific to the one you were riding when you crashed.

1 []How old were you when the crash occurred?

Only numbers may be entered in this field.

Please write your answer here:

2 []What gender are you?

Please choose **only one** of the following:

- ◯ Female
- ◯ Male

3 []What type of licence did you have when the crash occurred?

Please choose **only one** of the following:

- ◯ A (Full)
- ◯ A1
- ◯ A2
- ◯ AM
- ◯ Provisional
- ◯ Other

4 []What type of helmet were you wearing when you crashed?

Please choose **only one** of the following:

- ◯ Full face
- ◯ Open face
- ◯ Flip
- ◯ None
- ◯ Other

5 []What type of clothing were you wearing when you crashed with your motorcycle?

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Jacket with body armour	◯	◯	◯
Jacket without body armour	◯	◯	◯
Trousers with body armour	◯	◯	◯
Trousers without body armour	◯	◯	◯
Boots	◯	◯	◯
Shoes or trainers	◯	◯	◯
Light summer clothes (e.g. shirt and light trousers or skirt)	◯	◯	◯
Winter clothes (e.g. jeans or trousers with a jacket)	◯	◯	◯
Gloves	◯	◯	◯

6 []How many consecutive years of regular riding had you done preceding the crash?

Only numbers may be entered in this field.

Please write your answer here:

7 []Did you take part in any post test training, prior to the crash?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

8 []Did you take part in a training course with specific focus on handling ABS prior to the crash?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

9 []Which country did you live in when the crash occurred?

Please write your answer here:

10 []In which country did the crash occur?

Please write your answer here:

11 []Please indicate the make of the motorcycle you were riding when the crash occurred.

Please write your answer here:

12 []Please indicate the model of the motorcycle you were riding when you crashed.

Please write your answer here:

13 []What was the model year of the motorcycle you were riding when you crashed?

Only numbers may be entered in this field.

Please write your answer here:

14 []Please indicate the style of the motorcycle you were riding when you crashed (e.g. sport, supersport, cruiser, adventure, scooter, etc)

Please write your answer here:

15 []What cc (engine size) was the motorcycle you were riding when you crashed? (e.g. 125cc, 750cc, 1200cc etc)

Please write your answer here:

16 []Did the motorcycle you were riding, have disc brakes front and back when you had a crash?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

17 []If the motorcycle you were riding when you crashed, did not have disc brakes front and back, please indicate what type of brakes (e.g. drum)

Please write your answer here:

18 []When you crashed, did the motorcycle you were riding have cornering ABS?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

19 []When you crashed, did the motorcycle you were riding, have traction control?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

Background

Could you please answer these questions in order to provide background information which would help us understand why and how the crash may have occurred.

20 []Prior to the crash, could you please indicate (approximately) your speed before any braking you may have done? (before things started to go wrong)

Please choose **only one** of the following:

- ◯ Up to 10 kilometres per hour
- ◯ between 11 and 20 kilometres per hour
- ◯ Between 21 and 30 kilometres per hour
- ◯ Between 31 and 40 kilometres per hour
- ◯ Between 41 and 50 kilometres per hour
- ◯ Between 51 and 60 kilometres per hour
- ◯ Between 61 and 70 kilometres per hour
- ◯ Between 71 and 80 kilometres per hour
- ◯ Between 81 and 90 kilometres per hour
- ◯ Between 91 and 100 kilometres per hour
- ◯ Between 101 and 110 kilometres per hour
- ◯ Between 111 and 120 kilometres per hour
- ◯ Between 121 and 130 kilometres per hour
- ◯ More than 130 kilometres per hour

Make a comment on your choice here:

21 []Prior to crashing, did you apply the brakes?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

22 []Was the ABS switch turned **off** prior to the crash?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

23 []Had you consumed alcohol or taken any prescribed or non-prescribed drugs which may have impaired your judgement prior to the crash? The reason for this question is to understand whether you were fully alert before crashing.

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

24 []What damage did your motorcycle sustain?

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Front Wheel	◯	◯	◯
Front Lights	◯	◯	◯
Indicators	◯	◯	◯
Fairing	◯	◯	◯
Frame	◯	◯	◯
Sub-frame	◯	◯	◯
Tank	◯	◯	◯
Engine and casing	◯	◯	◯
Back wheel	◯	◯	◯
Swing arm	◯	◯	◯
Handlebars	◯	◯	◯
Top box and/or panniers	◯	◯	◯
Tail (rear) lights	◯	◯	◯

25 []Did you claim on your insurance?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

26 []What part of the day or night was it when you crashed?

Please choose **only one** of the following:

- ◯ Early morning (5 am to 8 am)
- ◯ Morning (8.01 am to 11 am)

- ◯ Midday (11.01 am to 2 pm)
- ◯ Early afternoon (2.01 pm to 4 pm)
- ◯ Late afternoon (4.01 pm to 6 pm)
- ◯ Early evening (6.01 pm to 8 pm)
- ◯ Evening (8.01 pm to 9 pm)
- ◯ Late evening (9.01 to midnight)
- ◯ Night time (Midnight to 5 am)

27 []Which month of the year did you have the crash?

Please choose **only one** of the following:

- ◯ January
- ◯ February
- ◯ March
- ◯ April
- ◯ May
- ◯ June
- ◯ July
- ◯ August
- ◯ September
- ◯ October
- ◯ November
- ◯ December

28 []What was the weather like prior to the crash?

Please choose **only one** of the following:

- ◯ Raining heavily
- ◯ Light rain
- ◯ Fog or mist
- ◯ Dry and sunny
- ◯ Dry and cloudy
- ◯ Snow and/or ice

Crash Details

This set of questions is aimed to identify the dynamics of crashes for motorcycles that have ABS.

29 []Did you separate from your motorcycle at the moment of impact?

Please choose **only one** of the following:

- ◯ Yes
- ◯ No

30 []If you were separated from your motorcycle, which way did you go?

Please choose **only one** of the following:

- ◯ Over the top of the motorcycle, in a forwards direction
- ◯ Fell sideways left
- ◯ Fell sideways right
- ◯ Remained upright on motorcycle when colliding
- ◯ Other

Make a comment on your choice here:

31 []What did you crash with? Please indicate from the list below. You will have the opportunity to explain in more detail at the end of the survey, if necessary.

Please choose **only one** of the following:

- ◯ Car
- ◯ Heavy goods vehicle or bus
- ◯ Truck (over 3.5 tonnes)
- ◯ Van (3.5 tonnes or less)
- ◯ Tractor or agricultural machinery
- ◯ Motorcycle
- ◯ Parked vehicle (car, van truck, bus)
- ◯ Other vehicle
- ◯ Cyclist
- ◯ Pedestrian
- ◯ Tree
- ◯ Electricity post, lamppost
- ◯ Traffic lights
- ◯ Railings
- ◯ Bollards
- ◯ Footpath (kerbside)
- ◯ Road only
- ◯ Gravel
- ◯ Road contamination (e.g. wet leaves, diesel spillage, ice)
- ◯ Standing water on road
- ◯ Drainage covers (metal grills)
- ◯ Pothole(s)
- ◯ Large animal (e.g. deer, cow, horse, moose)
- ◯ Small animal (e.g. cat, dog, fox, sheep)
- ◯ Other

Make a comment on your choice here:

32 []Could you please indicate on what type of road and where on the road you crashed?

Please choose the appropriate response for each item:

	Straight road	Left hand bend	Right hand bend	Junction (intersection)	T-junction	Cross roads	Staggered junction	Roundabout	Pedestrian crossing	Railway crossing
Rural Road	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

	Straight road	Left hand bend	Right hand bend	Junction (intersection)	T-junction	Cross roads	Staggered junction	Roundabout	Pedestrian crossing	Railway crossing
Urban Road	○	○	○	○	○	○	○	○	○	○
Major Highway or motorway	○	○	○	○	○	○	○	○	○	○
Off road e.g. garage forecourt, driveway, race-track (training centre)	○	○	○	○	○	○	○	○	○	○
Trail riding - e.g. unmetalled roads	○	○	○	○	○	○	○	○	○	○

33 []Were you injured?

Please choose **only one** of the following:

- ○ Yes
- ○ No

34 []Could you indicate the severity of your injuries and on which part of your body you were injured?

Please choose the appropriate response for each item:

	Lower limbs, including knees, feet and/or ankles	Pelvic internal	Pelvic external	Abdomen internal	Abdomen external	Chest internal	Chest external	Upper limbs - arms, elbows, wrists, hands	Shoulders	Neck	Face	Head	Brain	Other
Minor (slightly injured)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Serious (internal damage or broken bones)	○	○	○	○	○	○	○	○	○	○	○	○	○	○

35 []Could you please give details of any other injuries not included in the question above?

Please write your answer here:

Comments

If you have any comments you wish to add, please take your time, we are very interested in your opinions.

36 []If there is any further information in relation to the collision that you feel we should know, please write here.

Please write your answer here: