Comparing Cause Factors in Thailand & USA Motorcycle Crashes[1]

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Abstract

The comparison of accident cause factors in Los Angeles and Thailand accidents revealed both similarities and great differences. Both studies were dominated by multiple vehicle accidents, but in Los Angeles they were mostly due to car driver failure to see the motorcycle. In Thailand rider error caused multiple vehicle crashes as often as car driver error. Many car drivers in Los Angeles, but very few in Thailand, said they had failed to see the motorcycle. Alcohol consumption before riding was far more frequent in Thailand than in Los Angeles (37% vs. 12%). In both studies, drinking riders had similar problems: inattention and running off the road. The great differences in the two studies, therefore, involved non-drinking riders. The reason Thai drivers see motorcycles more often may not be conspicuity but the far higher frequency of motorcycles in traffic in Thailand (about 1 vehicle in 3) compared to Los Angeles (about 1 in 200).

Abstrakt

Bei zwei gründlichen Untersuchungen von Motorradunfällen am Unfallort – eine in Los Angeles und eine in Thailand – stellten sich in Bezug auf Unfallursache sowohl Ähnlichkeiten als auch grosse Unterschiede heraus.

Beide Untersuchungen betrafen vor allem multiple Fahrzeugunfälle. In Los Angeles wurden sie jedoch meistens durch Autofahrer hervorgerufen, die das Motorrad nicht rechtzeitig wahrnahmen. In Thailand wurden multiple Fahrzeugunfälle genauso oft durch Versagen des Motorradfahrers hervorgerufen wie auch durch Autofahrerversagen. In Los Angeles sagten viele Autofahrer, aber in Thailand sehr wenige, aus, dass sie das Motorrad nicht gesehen hätten.

Alkoholverzehr vor der Fahrt geschah weitaus häufiger in Thailand als in Los Angeles (37% vs. 12%). In beiden Untersuchungen hatten die Motorradfahrer mit Alkoholgehalt ähnliche Probleme: Unaufmerksamkeit, und Verlust der Strassenspur. Daher lag der grosse Unterschied in den beiden Untersuchungen bei den nicht-trinkenden Motorradfahrern.

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Der Grund, dass die Thai Autofahrer die Motorräder öfters sehen, liegt unter Umständen nicht an der Auffälligkeit, sondern daran, dass in Thailand weitaus mehr Motorräder im Verkehr sind (etwa 1 Gefährt zu 3) als in Los Angeles (etwa 1 zu 200).

Résumé

Deux études en profondeur *in situ* sur les accidents de motocyclettes, l'une à Los Angeles, l'autre en Thaïlande, ont révélé des similarités et des différences en ce qui concerne les causes des accidents. Les deux études étaient dominées par des accidents à véhicules multiples. A Los Angeles cependant, la majorité de ces accidents étaient provoqués par le fait que l'automobiliste ne pouvait pas voir la motocyclette. En Thaïlande les erreurs des motocyclistes ont provoqué de multiples accidents. Plusieurs automobilistes à Los Angeles, par rapport au très petit nombre en Thaïlande, ont dit qu'ils n'ont pas vu la motocyclette. La consomption d'alcool avant les sorties en moto était beaucoup plus commune en Thaïlande qu'à Los Angeles (37% contre 12%). Dans les deux études les motocyclistes qui ont bu avaient des problèmes similaires : un manque d'attention, et des écarts de la route. Les plus grandes différences entre les deux études résultent donc, des motocyclistes qui n'ont pas bu. Il se peut que les motocyclistes/automobilistes thaïlandais s'aperçoivent plus souvent des motocyclettes, non à cause de la visibilité de la motocyclette, mais du fait qu'il y a plus de motocyclettes sur les rues en Thaïlande (1 véhicule sur 3) par rapport à Los Angeles (environ 1 sur 200).

Introduction

Motorcycle accident causation is widely variable and sometimes very complicated. Individually, some accidents are simple, straightforward events with a single cause such as a rider who misjudges how fast to enter a curve or a car driver who fails to see a readily visible motorcycle in traffic and violates its right-of-way. Other crashes may involve complex interactions, such as a car driver and motorcyclist who see each other, react to each other, but each incorrectly predicts what the other will do next. Still other crashes may involve the interaction of one or more environmental problems and errors by the rider and perhaps the driver of another vehicle. Statistical analyses of accident populations inevitably overlook unique differences in the causes of individual accidents yet reveal overall trends in the most frequent sorts of problems in a way that allows those problems to be addressed. At yet another level, comparing accident causation in two (or more) different motorcycle accident studies – especially where essentially similar methodology has been used – can provide insights into accident causation that cannot be obtained from a single study by itself.

Early motorcycle accident research [1, 2] identified the high frequency of multiple vehicle intersection crashes, particularly crashes in which a car turned across the path of a motorcycle approaching from the opposite direction. (By comparison, the most common car-versus-car crash involved one car striking the rear end of another.) Most car drivers who caused a crash by violating the motorcycle right-of-way explained that they never saw the motorcycle before the crash. As a result, "motorcycle conspicuity" was identified as a serious problem and research was undertaken to find ways to make motorcycles more conspicuous in traffic [e.g., 3, 4].

Hurt et al. [5] confirmed the problem of motorcycle conspicuity in their on-scene, in-depth investigation of 900 motorcycle accidents in Los Angeles. They reported that two-thirds of all crashes involved a motorcycle colliding with another vehicle and nearly two-thirds of those multiple-vehicle crashes occurred when the car driver violated the motorcycle right-of-way. Hurt et al. reported that most motorcycles involved in daytime crashes were relatively inconspicuous. The motorcycle headlamp was usually turned off during daytime and most riders were wearing low-contrast upper torso coverage such as a military camouflage jacket.

When the Thailand Motorcycle Accident Research project began, it was expected that the same accident cause factors that dominated previous studies would dominate crashes in Thailand also. Those expectations were dashed as the Thailand data were collected. This paper will highlight some of the major differences and some of the similarities between the motorcycle accidents in Los Angeles from data collected by Hurt and his associates [5] compared to the Thailand motorcycle accident research recently done by Kasantikul [6, 7]. The two Thailand databases – one for Bangkok [6] and one for "upcountry" Thailand [7] are combined here into a single database.

Methods

<u>Accident investigation</u> – The Thailand and USC studies used essentially identical methods to obtain data. In both, teams of investigators traveled to an accident scene immediately after notification in order to conduct a detailed research investigation and analysis independent of the police investigation. The investigators were university graduates who had undergone extensive training (nine weeks in Los Angeles, 12 weeks in Thailand) in motorcycle accident investigation and reconstruction, interviewing, injury analysis, motorcycle design and stability, helmet design and analysis, etc.

Investigation teams obtained crash notifications from police or ambulance communication centers. Once on-scene, investigators photographed the motorcycle(s) and other vehicles involved as well as skids, scrapes, "people marks" (such as blood, cloth marks, "soft" dents in vehicles), pre-crash paths of travel, etc. Investigators also measured and diagrammed the physical evidence as well as obtaining driver and witness interviews and injury information. The information was used to reconstruct the crashes and determine how and why the crash occurred and how the injuries occurred.

The Thailand study investigated a total of 969 collisions involving 1082 riders and 399 passengers in six different regions within Thailand over a twenty-month period. About one-fourth of the Thailand multiple-vehicle collisions involved two motorcycles colliding with each other, so that there were more motorcycles than collisions. The first twelve months of the Thailand study (all of 1999) were devoted to accident investigation in Bangkok (723 cases). In the remaining months (March – September, 2000) another 359 cases were investigated in "upcountry" sampling regions of Thailand (i.e., the provinces of Phetchburi, Trang, Khon Kaen, Saraburi and Chiang Rai), which were located 150 to 700 km from Bangkok. The USC study involved 900 accidents at all levels of severity in the City of Los Angeles in 1976-77. Only a few of the Los Angeles crashes were motorcycle-versus-motorcycle.

The crash investigation and reconstruction methodology used in the Thailand study was the same as that used in the USC studies, and has been described elsewhere in more detail [5-9]. In Thailand, over 2000 data elements were recorded, using the OECD data form [10]. Some data elements were simple items such as weather, roadway type, motorcycle manufacturer or rider gender. Other items were complex factors that required considerable analysis and integration of accident evidence, such as precrash and crash speeds, injury mechanisms and accident cause factors. Although the data forms differed, the Thailand data form was based on the Los Angeles data form and many similar or identical questions appeared on both.

Investigation teams were on scene while vehicles, parties and eyewitnesses were still present in over 93% of the Thailand cases and two-thirds of the Los Angeles cases reported here. In Thailand, the rest were investigated within a few hours after occurrence; in L.A., cases were investigated up to 24 hours after the crash. The only criterion for inclusion was whether the team was able to collect enough information about the crash to have a complete investigation. There was no pre-selection for any particular accident or injury characteristic.

<u>Alcohol determination</u> – In both studies, BAC was measured whenever possible. In Thailand, blood (or, in a few cases, urine) was obtained either during transport, at the emergency room or at autopsy. The Thailand samples were submitted to the Department of Forensic Medicine, Chulalongkorn University. Testing was limited by a variety of factors including rider cooperation, the availability of personnel to draw blood if the rider did not go to the hospital, and the expense of blood testing. Breath analysis was performed by the investigation team using an Alcolmeter SD 400 portable breathalyzer. The breathalyzer was obtained midway through the project, after the high frequency of alcohol involvement became apparent. In Los Angeles, BAC data was collected in a variety of ways. Police sometimes collected breath samples shortly after the crash, while in other cases blood samples were taken in the emergency room or during autopsy.

If BAC measurement was impossible, the subjective judgment of the on-scene interviewer, police officer or EMS personnel was used to determine whether the rider had been drinking or not. The investigator's judgment was based on a face-to-face interview with the rider shortly after the crash. For this study, drinking riders are treated as a single category – "had been drinking" (HBD) regardless of BAC – for comparison to riders who had not been drinking.

<u>Accident causation</u> – The primary cause of the accident was the action (or failure to take ordinary control action when necessary – such as stopping at a stop sign) that led immediately to the crash. In Los Angeles, the primary cause was called the precipitating event. The cause factors were grouped under general categories such as "rider error," "car driver error," "vehicle failure" etc., without specifying the exact nature of the error or failure. For example, a typical case of "OV driver error" involved a car driver who entered the path of an approaching motorcycle when the motorcycle was so close that the rider would have to take emergency evasive action to avoid a crash.

In Thailand accidents, as many as three cause factors could be ranked in order of their contribution; the first was considered the primary cause factor. If no second factor was listed then the primary cause was considered to be the sole cause of the accident. The codes "rider error" and "OV driver error" were the two most frequent and could cover multiple mistakes in the same crash. For example, if a rider was drunk, speeding and turned around talking to his passenger when he ran a red light and crashed, "rider error" was coded only once. In the U.S. accidents, only a primary cause factor could be cited. Judgments about accident causation were based on the *actions* that led to the crash, not on alcohol involvement.

Rider attention was evaluated in a number of ways, most often by interview with the rider, passenger or eyewitnesses or by physical evidence. Riders who were unable to give any explanation of how the crash occurred or what they were doing just before the crash were usually coded as inattentive, provided there was no evidence of traumatic amnesia. Evidence of continuing steady-state vehicle operation when control actions were required – for example, running off the side of the road for no apparent reason and with no evasive action – was taken as an indicator of inattention. Information about attention diverted (to passengers, vehicle operation, etc.) usually came from rider, passenger or eyewitness interviews. Riders who could give an accounting of precrash events that corresponded to physical evidence or who left physical evidence of precrash evasive action were usually considered to have been attentive.

After the Thailand team completed its investigation and reconstruction of each crash, the case file was sent to the Head Protection Research Laboratory (HPRL) in California. At HPRL, every case was reviewed and reconstructed again and changes recommended as needed. The Los Angeles cases were reviewed and corrected by the principal investigator.

Results

In both Los Angeles and Thailand, human error – by the motorcycle rider or the OV driver – was the primary cause in about 91% of crashes. The precipitating event that led to the accident (in Los Angeles) and primary, secondary and third cause factors (in Thailand) are shown in Table 1.

Table 1: Percent distribution of cause factors in Los Angeles and Thailand cases

Factor	Precipitating event Los Angeles (N = 900)	Thailand (N = 1082)		
		Primary cause	2nd cause	3rd cause
MC rider error	40.8	54.2	25.9	1.7
OV driver error	50.8	37.2	19.3	1.4
Vehicle failure/defect	2.8	0.3	0.9	1.7
Roadway defect	2.0	0.9	3.0	1.6
Traffic control problem	NA	0.9	1.2	0.9
Animal, pedestrian, etc.	1.8	3.6	5.6	2.0
Weather	0	0.0	1.0	0.5
Non-contact OV	0.4	2.0	2.0	0.5
98 - Other	1.4	1.0	5.0	3.5
No 2nd or 3rd cause	NA	NA	36.0	86.3
Total	100.0	100.0	100.0	100.0

There were important differences, however. Rider error was much more likely to cause a crash in Thailand than in Los Angeles (54% vs. 41%). In multiple vehicle crashes, OV driver error was far more common than rider error in Los Angeles compared to Thailand (64% vs. 45%). In both studies, about 70% of motorcycle-solo crashes were the result of rider error, with vehicle failures as the 2nd most common cause. The data are shown in Table 2.

The Los Angeles data form allowed investigators to list only a single precipitating event, but it was often clear during the reconstruction that multiple factors contributed to some crashes. The Thailand data form remedied this shortcoming by asking for the three most important cause factors. Nearly two-thirds (64%) of Thailand cases had only a single cause, 22% had two causes and about one in seven had at least three cause factors.

Table 2: Primary cause of single and multiple vehicle crashes in Los Angeles and Thailand.

Primary cause of crash	Los Angeles		Thailand	
	MC Solo (N = 180)	At least 1 OV (N = 718)	MC Solo (N=172)	At least 1 OV (N = 878)
	Percent	Percent	Percent	Percent
Rider error	70.6	33.4	72.1	52.6
OV driver error	-	63.6	-	45.8
Roadway defect	7.8	0.6	1.2	0.1
Pedestrian	2.8	0.1	5.2	0.1
Animal	5.0	0.1	1.7	0.8
Vehicle failure	11.7	0.6	19.8	0.6
Other	2.8	1.5	-	-
Total	100.0	100.0	100.0	100.0

Table 3: Crosstabulation of primary and secondary cause factors in Thailand. Second contributing factors are numbered the same as primary cause factors.

Primary cause	Second contributing factor								Total
	No 2nd factor	1	2	3	4	5	6	7	
1 MC rider error	241		199	7	22	45	8	64	586
2 OV driver error	130	222		1	10	16	1	22	402
3 Vehicle failure/defect	1		1					1	3
4 Roadway defect	1	8		1				2	10
5 Pedestrian, animal, etc.	3	32	1	1					39
6 Weather									0
7 All other causes	13	18	8				2	1	35
Total	389	280	209	10	32	61	11	90	1082

Table 3 shows a cross-tabulation of the primary and secondary cause factors in Thailand. Four cells in Table 3 account for 73% of the cases: 1) Rider error-only (22.3%), 2) OV driver error + contributing error by MC rider (20.5%), 3) Rider error plus contributing error by OV driver (18.4%), and OV driver error only (12%). Vehicle-mechanical problems were the primary cause

in three crashes and a contributing cause in another 28 cases (a total of 3% of all 1082 cases). Environmental problems such as weather, pavement irregularities, inadequate signing and debris in the roadway were rarely the primary cause of a crash, but often contributed as second or third factors. It is worth noting in Table 3 that only 26 of the Thailand crashes (2.4%) did NOT list human error as either of the first two causes.

Accident configuration - Table 4 compares the most common accident configurations in Thailand and Los Angeles. The upper half of the table shows those crashes caused by rider error, while the lower half shows crashes in which OV driver error was the primary cause. In both study areas, the same configurations tended to dominate.

Table 4: Top five accident configurations, Thailand & Los Angeles

Crashes due to rider error				
Rank	Los Angeles (N = 367)		Thailand (N = 586)	
	Configuration*	Percent	Configuration	Percent
1	18, 19	26.2	18, 19	17.2
2	13	11.7	13	15.7
3	20, 21	10.4	2, 3	9.4
4	15	9.0	15	6.5
5	16	6.3	14	4.4
	Subtotal	63.5	Subtotal	53.2
Crashes due to OV driver error				
Rank	Los Angeles (N = 457)		Thailand (N = 402)	
	Configuration	Percent	Configuration	Percent
1	6, 7	38.7	16	14.7
2	2, 3	21.9	6, 7	12.2
3	15	7.7	5	9.5
4	12	5.9	2, 3	9.2
5	14	5.5	15	9.0
	Subtotal	79.6	Subtotal	54.5

* 2, 3 Both vehicles going straight on perpendicular paths
4 MC & OV on perpendicular precrash paths, then OV turns right in front of MC
5 MC & OV on perpendicular precrash paths, then OV turns left in front of MC
6, 7 MC approaching OV from opposite direction, OV turns across MC path
12 OV strikes rear of MC
13 MC strikes rear of OV
15 Sideswipe, MC & OV on parallel paths going same direction
16 OV making U-turn or Y-turn in front of approaching MC
18, 19 MC fell on road or ran off road, no OV
20, 21 MC fell on road or ran off road while trying to avoid OV

However, Thailand accident types tended to be more broadly distributed; those in Los Angeles were dominated by fewer types. Crashes in which the OV driver turned across the path of a motorcycle approaching from the opposite direction were three times as common in Los Angeles as in Thailand, and perpendicular intersection crashes were more than twice as common in Los Angeles. Those two configurations accounted for 60% of OV driver error crashes in Los Angeles but only 21% of Thailand crashes. In Thailand, the top five configurations accounted for just over half of the crashes. In Los Angeles, the top five accounted for nearly two-thirds of rider error crashes and nearly 80% of OV driver error crashes.

Alcohol - Alcohol use was significantly more common in Thailand than in Los Angeles (37% vs. 12%) and drinking riders were significantly more likely to be the primary cause of their crash than riders who had not been drinking. These data are shown in Tables 5 and 6, which compare only riders whose alcohol/drug use status was known. Table 6 excludes those crashes whose primary cause was something other than rider or OV driver error.

Table 5: Alcohol use in Thailand and Los Angeles

Rider alcohol or drug use	Los Angeles		Thailand		Total
	n	Column %	n	Column %	
Not used	773	88.2	683	63.5	1456
Alcohol or drugs used	103	11.8	393	36.5	496
Total	876	100.0	1076	100.0	1952
$\chi^2 = 156.3$, $p < .0001$, df = 1					

Table 6: Alcohol/drug use and primary cause factors in Los Angeles and Thailand

Rider alcohol or drug use	Los Angeles				Total
	Rider error		OV driver error		
	n	Row %	n	Row %	
Not used	280	39.7	425	60.3	705
Alcohol or drugs used	70	72.2	27	27.8	97
Total	350	43.6	452	56.4	802
$\chi^2 = 35.5$, $p < .0001$, df = 1					

Rider alcohol or drug use	Thailand				Total
	Rider error		OV driver error		
	n	Row %	n	Row %	
Not used	300	49.4	307	50.6	607
Alcohol or drugs used	285	75.6	92	24.4	377
Total	585	59.5	399	40.5	984
$\chi^2 = 66.1$, $p < .0001$, df = 1					

In both Los Angeles and Thailand, approximately 75% of drinking riders were the primary cause of the crash in which they were involved.   By comparison, non-drinking riders were the primary cause of 40% of crashes in Los Angeles and 50% in Thailand.

Rider error crashes were dominated by riders running off the road or falling on the road absent any threat by another vehicle, striking the rear of another vehicle (both of which are typical alcohol-involved crash scenarios), and same-direction sideswipe crashes. Crashes caused primarily by OV driver error in both study areas were dominated by three configurations: crashes in which the car turned across the path of a motorcycle approaching from the opposite direction, perpendicular intersection collisions and same-direction sideswipe crashes.

Drinking riders tended to get into different kinds of accidents than non-drinkers, especially running off the road. In Los Angeles running off the road or falling on the road in the absence of threat from any OV jumped from 9% of non-alcohol crashes to 39% of alcohol-involved crashes. Similarly, in Thailand, 21% of drinking riders simply ran off the road, compared to only 5% of non-drinkers. The data are shown in Table 7.

Table 7: Five most common accident configurations for drinking and non-drinking riders in Los Angeles and Thailand.

Rank	Non-drinking riders			
	Los Angeles (n = 773)		Thailand (n = 683)	
	Configuration*	Percent	Configuration	Percent
1	6+7	23.0	13	11.1
2	2+3	14.0	2+3	9.2
3	18+19	9.2	15	8.3
4	20+21	8.7	16	8.3
5	15	8.2	6+7	7.5
Rank	Alcohol / drug using riders			
	Los Angeles (n = 102)		Thai (n = 393)	
1	18+19	38.8	18+19	21.4
2	6+7	13.6	13	15.0
3	2+3	10.7	2+3	7.9
4	15	4.9	20+21	6.4
5	20+21	3.9	6 + 7 & 15	5.1 (tie)

* 2, 3 Both vehicles going straight on perpendicular paths
6, 7 MC approaching OV from opposite direction, OV turns across MC path
13 MC strikes rear of OV
15 Sideswipe, MC & OV on parallel paths going same direction
16 OV making U-turn or Y-turn in front of approaching MC
18, 19 MC fell on road or ran off road, no OV
20, 21 MC fell on road or ran off road while trying to avoid OV

Table 8 summarizes the percent distribution of rider attention for impaired and non-impaired riders in Los Angeles and Thailand. In both study areas, non-drinking riders were far more likely than drinkers to pay attention to the driving task, and in both areas, only about 40% of drinking riders appeared to be paying attention just before they crashed. In both study areas, drinking riders were as likely to be distracted from the driving task as non-drinkers. Therefore, the primary effect of alcohol in both study areas was that drinking riders shifted from the "attentive" category to the "inattentive" category.

Table 8: Rider attention in Los Angeles & Thailand as a function of alcohol/drug use

Rider attention	Alcohol or drug use			
	Los Angeles		Thailand	
	No (n = 745)	Yes (n = 84)	No (n = 666)	Yes (n = 353)
Inattentive	16.5%	38.1%	3.0%	53.8%
Distracted	22.0%	21.4%	9.2%	8.2%
Attentive to task	61.5%	40.5%	87.8%	38.0%
Total	100.0%	100.0%	100.0%	100.0%

Inattention to the driving task was the most frequent cause of rider error crashes in Los Angeles (70%), but not in Thailand (46%). However, in both study areas, the great majority of inattentive/distracted riders (72% in Los Angeles, 87% in Thailand) were the primary cause of their crash. In contrast, 78% of attentive riders in Los Angeles were in crashes precipitated by the driver of the other vehicle. In Thailand, attentive riders were about as likely to cause their own crash as to be in a crash caused by the other driver. The data are shown in Table 9.

<u>Motorcycle loss of control</u> - Loss of control differed considerably between Los Angeles and Thailand. For example, 40% of Los Angeles crashes involved some sort of loss of control, compared to only 20% of Thailand crashes. Slide-out crashes were much more common in Los Angeles than in Thailand (22% vs. 7%). The difference in this single category accounted for most of the higher rate of loss of control in Los Angeles, as shown in Figure 1.

Loss of control also varied partly as a function of alcohol, as shown in Figure 2. The most notable results in Figure 2 are: 1) drinking riders in both Los Angeles and Thailand were far more likely to lose control by running off the road than non-drinkers and, 2) Los Angeles riders were much more likely than their Thai counterparts to lose control of the motorcycle by sliding out, regardless of alcohol use.

<u>Speed</u> – Motorcycle precrash and crash speeds were higher on average in Los Angeles than in Thailand. The median precrash speeds and crash speeds were 48 and 35 km/hr (30 and 21 mph) in Los Angeles and 38 and 30 km/hr (23 and 18 mph) in Thailand. The differences were statistically significant ($t > 5.5$, $df > 1785$, $p < .0001$). The cumulative percent distributions of precrash and crash speeds of both study areas are shown in Figure 3.

Figure 1: Loss of control mode, USC vs. Thailand

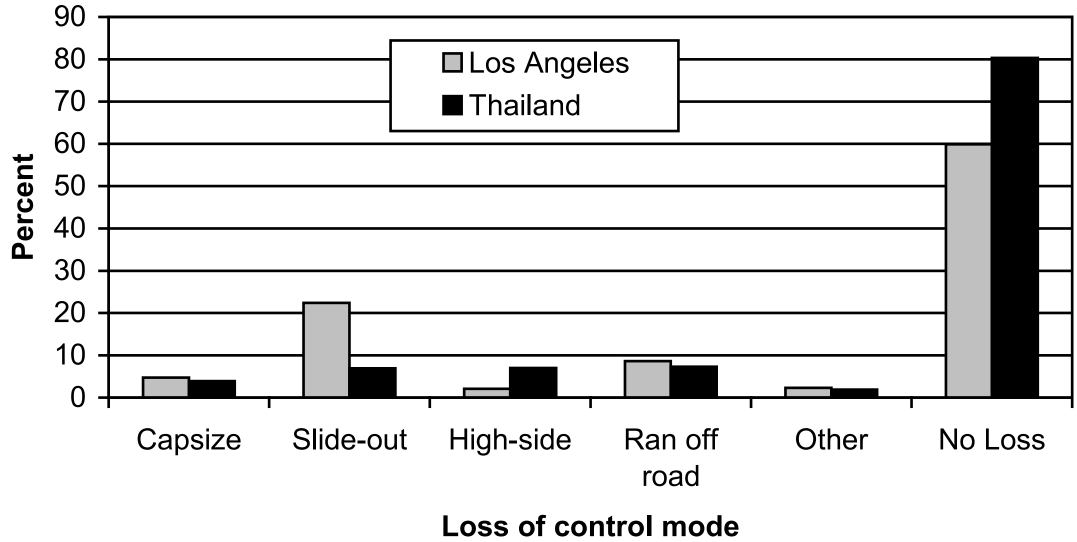


Figure 2. Loss of control mode as a function of alcohol use, Los Angeles and Thailand

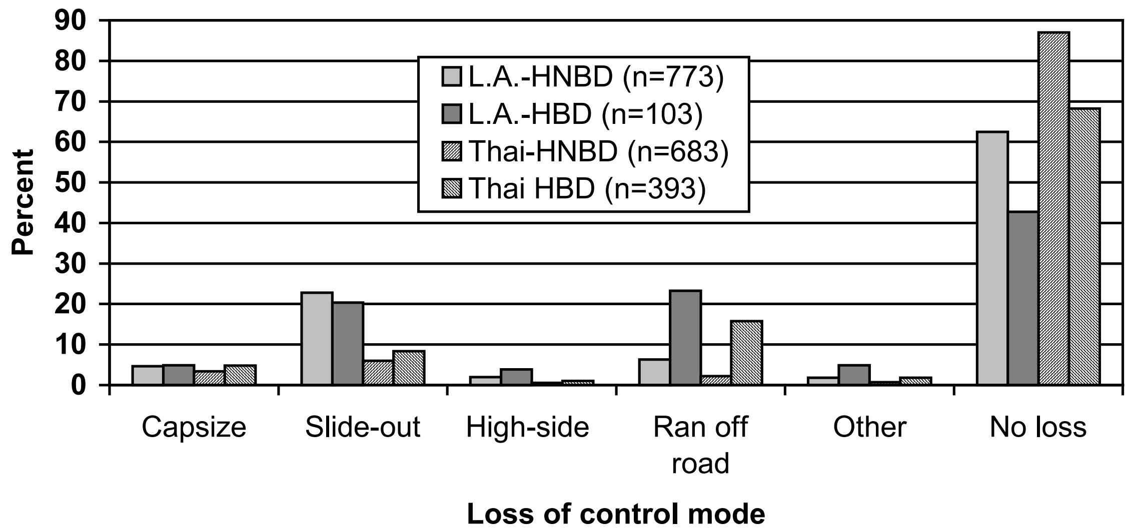
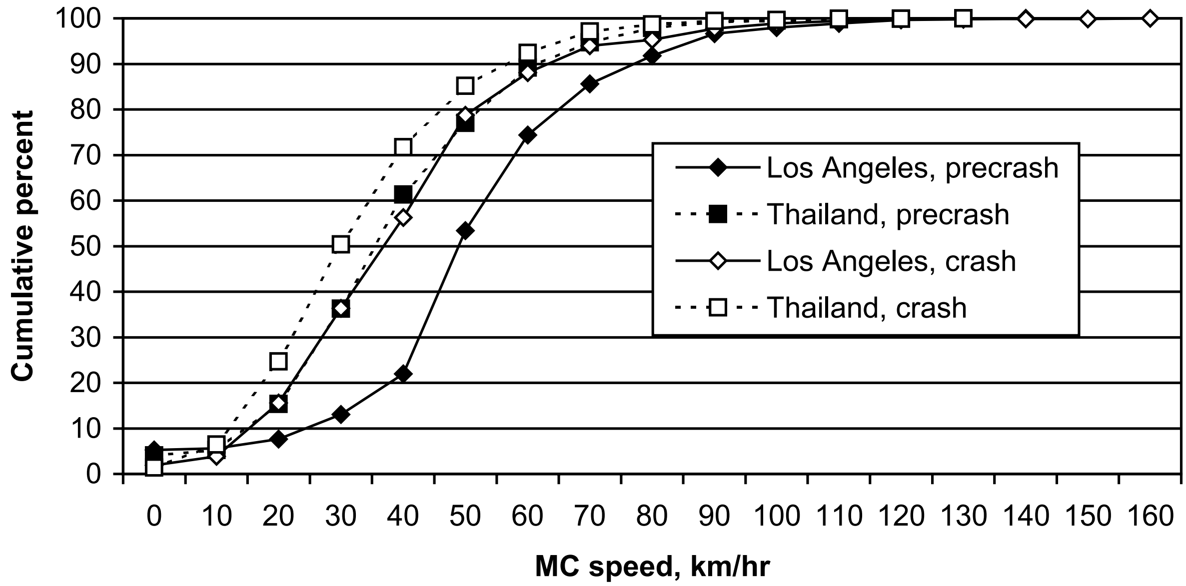


Figure 3: Cumulative percent distribution of motorcycle precrash and crash speeds in Los Angeles and Thailand



Speed and engine size - In Thailand, motorcycle engine displacement was uncorrelated with precrash and crash speeds (Pearson $r_{precrash}$ = .036, N = 1028, p = .244; Pearson r_{crash} = .019, N = 1070, p = .530). However, this may be the result of a narrow range of engine sizes. Due to tariff restrictions, only 13 motorcycles in Thailand (1.2%) exceeded the 150cc limit and 86% of Thai motorcycles were in the 100-150cc range. In Los Angeles, where engine size was unrestricted (and only 14% of motorcycles were 150cc or less), engine displacement did correlate significantly with precrash and crash speeds (Pearson $r_{precrash}$ = .292, N = 890, $p < .01$; Pearson r_{crash} = .252, N = 898, $p < .01$). However, precrash speed may also be related to the speed limits of the roadway. In order to test this hypothesis for the Los Angeles study, the speed limit was subtracted from the motorcycle precrash speed and the resulting values were then correlated with engine size. When this was done, the correlation was positive and statistically significant but much lower (Pearson r = .126, N = 874, $p < .01$). That is, engine size appeared to account for about 2% of the variation in precrash speed relative to speed limit. Figure 4 shows a scatter plot of engine size versus the motorcycle speed relative to the speed limit. Values on the y-axis below zero indicate the motorcycle was going under the speed limit; values greater than zero indicate the motorcycle was going faster than the speed limit.

Time - Figure 5 shows the cumulative percent distributions of time from precipitating event to impact in Los Angeles and Thailand. Median times were approximately similar in both study areas: 1.9 seconds in Los Angeles vs. 1.7 seconds in Thailand. The distribution in Thailand was more widely variable than in Los Angeles. However, in both study areas, approximately 75% of crashes occurred less than 2.5 seconds after the precipitating event. The luxury of three seconds or more in which to perceive, decide and execute an evasive action was available to only 10% of riders in Los Angeles and 18% in Thailand.

Figure 4: Scatter-plot of motorcycle engine size versus motorcycle precrash speed relative to speed limit. Speed values below zero indicate the motorcycle was traveling below the speed limit; values above zero the motorcycle was traveling faster than the speed limit.

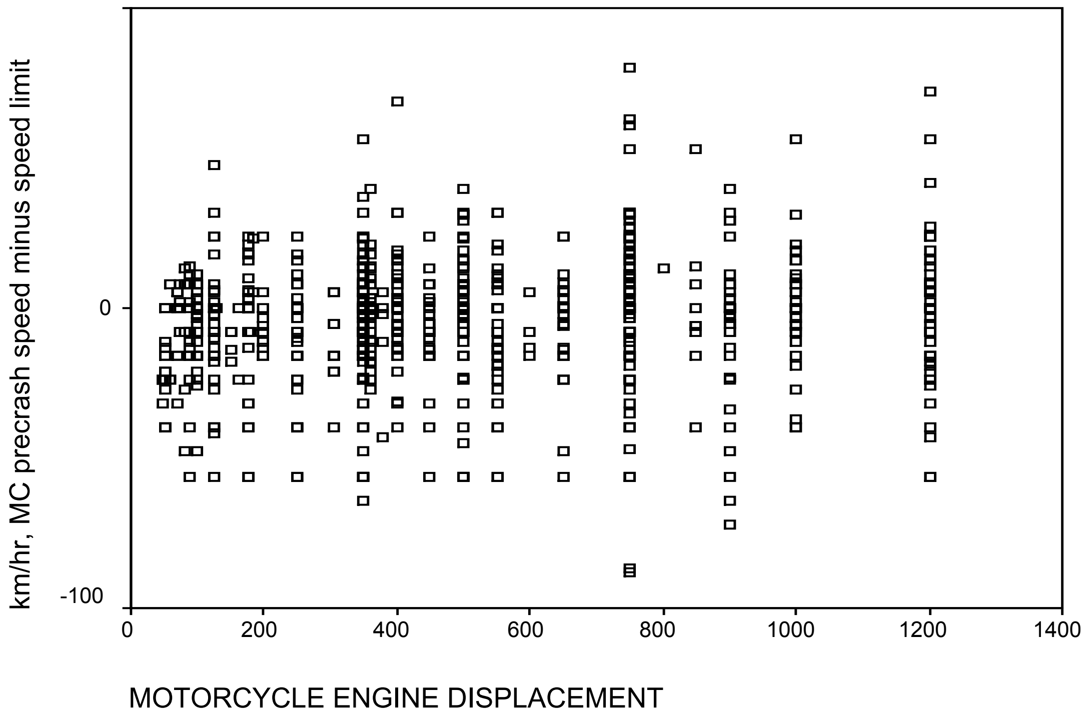
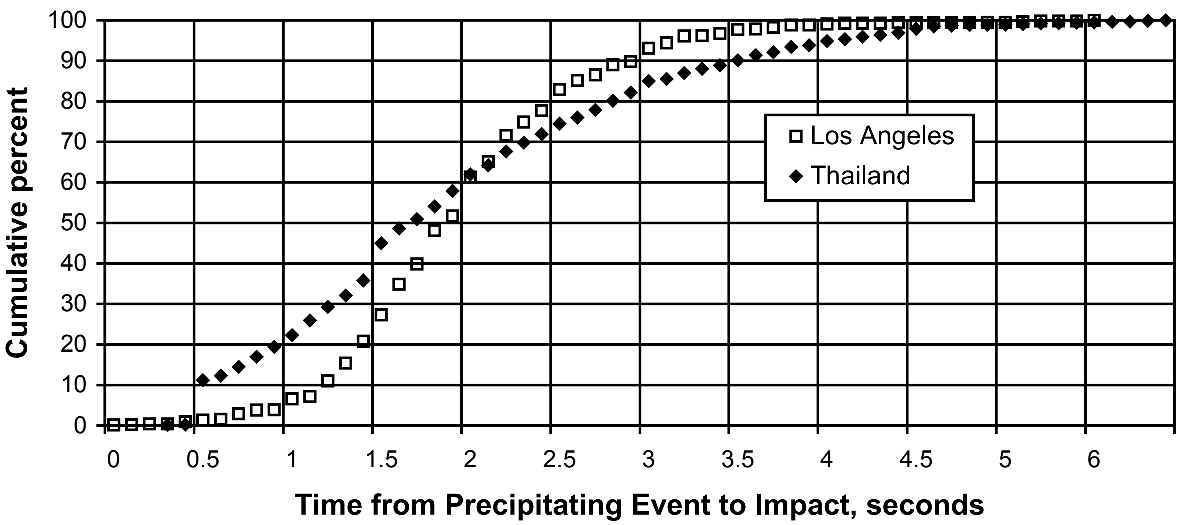


Figure 5: Cumulative percent distribution of time from precipitating event to impact, Los Angeles and Thailand



Discussion

Differences - The most significant finding in this study is the relative lack of OV driver error in Thailand (46% of multiple vehicle crashes) compared to Los Angeles (64%). Roughly half this difference was the result of the high rate of alcohol involvement in Thailand compared to Los Angeles (37% vs. 12%) and the fact that about three-fourths of drinking riders in both locations were the primary cause of the crashes they were in. But half the difference was due to other factors that are more difficult to quantify because they were not recorded.

Neither the Los Angeles nor the Thailand data forms asked car drivers *why* they collided with the motorcycle even though drivers often told investigators what they had seen – or not seen – just before the crash. Hurt et al. [5, p. 45] reported that a typical statement by an OV driver was, "I signaled to turn left and started out when it was clear. Then something hit my car and later I saw the motorcycle and the guy lying in the street. I never saw him! Look what he did to my car." Drivers in Los Angeles made variations of this sort of statement over and over. The research experience of interviewing many of these drivers would suggest that 90-95% of car drivers whose error caused the crash failed to see the motorcycle at all or saw it just an instant before impact, when it was too late to avoid a collision. The remainder of at-fault drivers said they had seen the motorcycle but misjudged its speed or distance and mistakenly thought they had enough time to complete their maneuver.

By comparison, car drivers in Thailand who violated the motorcycle right-of-way often insisted that "the motorcycle rider should have yielded to me" or that they thought the motorcycle would stop for them. Obviously, this points to a great need for more effective driver training, particularly in right-of-way issues. However, the interesting thing was that drivers in Thailand almost never said they hadn't seen the motorcycle in cases where it was in plain sight. Of course, there were cases where the motorcycle was not readily visible, such as when a view obstruction blocked the view of the motorcycle or when the motorcycle was riding at night without a headlamp or tail lamp.

Conspicuity probably does not account for this difference because motorcycles in Thailand were, if anything, *less* conspicuous than those in Los Angeles. Daytime headlamp use in Thailand multiple vehicle crashes was about 25% compared to 30% in Los Angeles crashes. Thai riders were no more likely to wear highly conspicuous clothing than their Los Angeles counterparts, and Thai motorcycles as a group were much smaller than those in Los Angeles. So why do Thai drivers so consistently see motorcycles while drivers in Los Angeles just as consistently fail to see motorcycles?

The answer may lie in a hypothesis advanced by Hancock et al. [11], who suggested that detection of motorcycles in traffic depends partly on how frequently an "event" (in this case a motorcycle) appears amid the "noise" (other vehicle traffic on the street). Hancock cited research in sustained attention that suggests that when the event-to-noise ratio is less than about one in six, or the total number of events per unit time increases beyond the observer's capacity, the probability of detection declines. In Los Angeles, motorcycles accounted for about one in every 200 (0.5%) vehicles passing by exposure sites. In Thailand, motorcycles were 29% of the vehicle traffic passing the exposure sites in Bangkok and 49% of the traffic in "upcountry" areas [6, 7]. Hancock's hypothesis suggests that Thai drivers were more likely to see approaching motorcycles because they are so common on the road, while drivers in Los Angeles failed to see the motorcycle they struck because they rarely saw a motorcycle in traffic.

The frequency of motorcycles in traffic appears to shape car driver expectations as well as affecting visual search patterns and failures to detect traffic conflicts with motorcycles.

A second major difference between Thailand and Los Angeles was the significant amount of alcohol involvement in Thailand (37% vs. 12%). Despite the differences in the *frequency* of alcohol involvement, the problems created by alcohol appeared to be the same in both areas. These will be discussed shortly.

Riders in Los Angeles were much more likely than those in Thailand to lose control of the motorcycle in either low-side or high-side slide-out crashes (25% vs. 7%). The great majority of slide-out crashes in Los Angeles (20% of all crashes) occurred during collision avoidance braking maneuvers. In fact, 176 of 603 Los Angeles riders (29%) who took precrash evasive action suffered some kind of slide-out loss of control compared to only 48 of the 553 Thai riders (9%) who took avoidance action. The reasons for the difference are not obvious, and more research is needed.

Similarities – The effects of alcohol on crashes were remarkably similar in Los Angeles and Thailand. About three-fourths of drinking riders in both locations were the primary cause of their crash. Attention to the riding task plummeted among drinking riders while distraction and outright inattention just before the accident increased. Many drinking riders in both Los Angeles and Thailand simply could give no explanation of what happened just before they crashed. In both study areas, the accident configuration most “favored” by drinking riders involved running off the road or falling on the road in the absence of a threat from any other vehicle. These characteristics of alcohol-involved crashes, along with a predominance of alcohol crashes occurring at night, seem to be quite consistent, as they have been reported in Los Angeles [12], Hawaii [13], Australia [14] and the United States generally [15].

Speeds were very similar in both Thailand and Los Angeles. Precrash speeds were about 10 km/hr higher in Los Angeles than in Thailand and crash speeds about 5 km/hr higher. While these differences were statistically significant, it is not clear that they had any practical significance since injury severity is only mildly correlated with crash speed.

This report fails to find any support for the popular notion that large displacement motorcycles are more dangerous because they go faster than small motorcycles. The great majority of crashes occur at relatively low speeds – more than three-quarters were going less than 50 km/hr (~30 mph) when they crashed. In Los Angeles only 2% of motorcycles had a precrash speed of 100 km/hr or faster, while only 0.8% in Thailand were going that fast – and almost any motorcycle can reach speeds of 100 km/hr. In Los Angeles, motorcycles with larger engines tended to be going faster when they crashed, but it appears this was largely because they crashed on roads with higher speed limits. When motorcycle precrash speed was compared to the speed limit, larger displacement motorcycles were only slightly more likely to be exceeding the speed limit than smaller motorcycles.

Both the Los Angeles and Thailand studies showed that accident-involved riders had extremely short times to react to traffic conflicts. When a traffic conflict occurs, the motorcycle rider must detect the hazard, decide on a course of action, apply the proper control actions, and then monitor the motorcycle as it responds to those control actions. The great majority of riders (90% in Los Angeles, 82% in Thailand) had less than 3 seconds between the precipitating event and the collision impact for all these mental and physical processes.

The success or failure of the collision avoidance action depends upon adequate time to react to the traffic conflict and upon rider skill. Collision avoidance skills are more complex and difficult to execute properly for motorcycles than for cars and most motorcycle riders have not developed the necessary skills. The rider's detection process can be improved with experience and training to reduce the amount of time required to respond to a traffic hazard. However, decision and control application always consume valuable time and many riders make significant errors of judgment and execution.

Accident research has shown problems with both swerving and braking as ways of avoiding a collision [5-7]. Ouellet [16] analyzed braking performance in typical traffic conflict situations and proposed that a strategic choice of lane position can allow the rider more time to respond and delay his arrival at the conflict point than highly skilled braking. The requirement for "counter-steering" the motorcycle to turn or swerve is unique to the single track vehicle and many riders - even experienced and trained motorcyclists - demonstrate dangerous errors as well as significant delays in control actions [5, 17]. Counter-steering absorbs both space and time – about one-half second – while the motorcycle front wheel "tracks out" and the motorcycle begins to lean before the motorcycle changes direction [18]. Finally, when swerving is combined with excessive braking, the usual result is a slide-out loss of control.

If lack of time for collision avoidance action is a major determinant of crash involvement, then it may be useful to teach riders strategies for traffic conflict avoidance that would allow riders to avoid some risky situations and respond much sooner in other potential threat situations. The teaching and practice of braking and swerving is useful, but development of traffic conflict avoidance skills surely has at least equal importance. The fact that 30% of the Los Angeles riders who took evasive action lost control and slid out suggests serious limitations in relying on collision avoidance skills as a way of preventing accidents. Unfortunately, these errors of collision avoidance persist in current motorcycle accidents, even for trained and experienced riders.

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