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Institute for Traffic Accident
Research and Data Analysis
(財)交通事故総合分析センター
ITARDA INFORMATION
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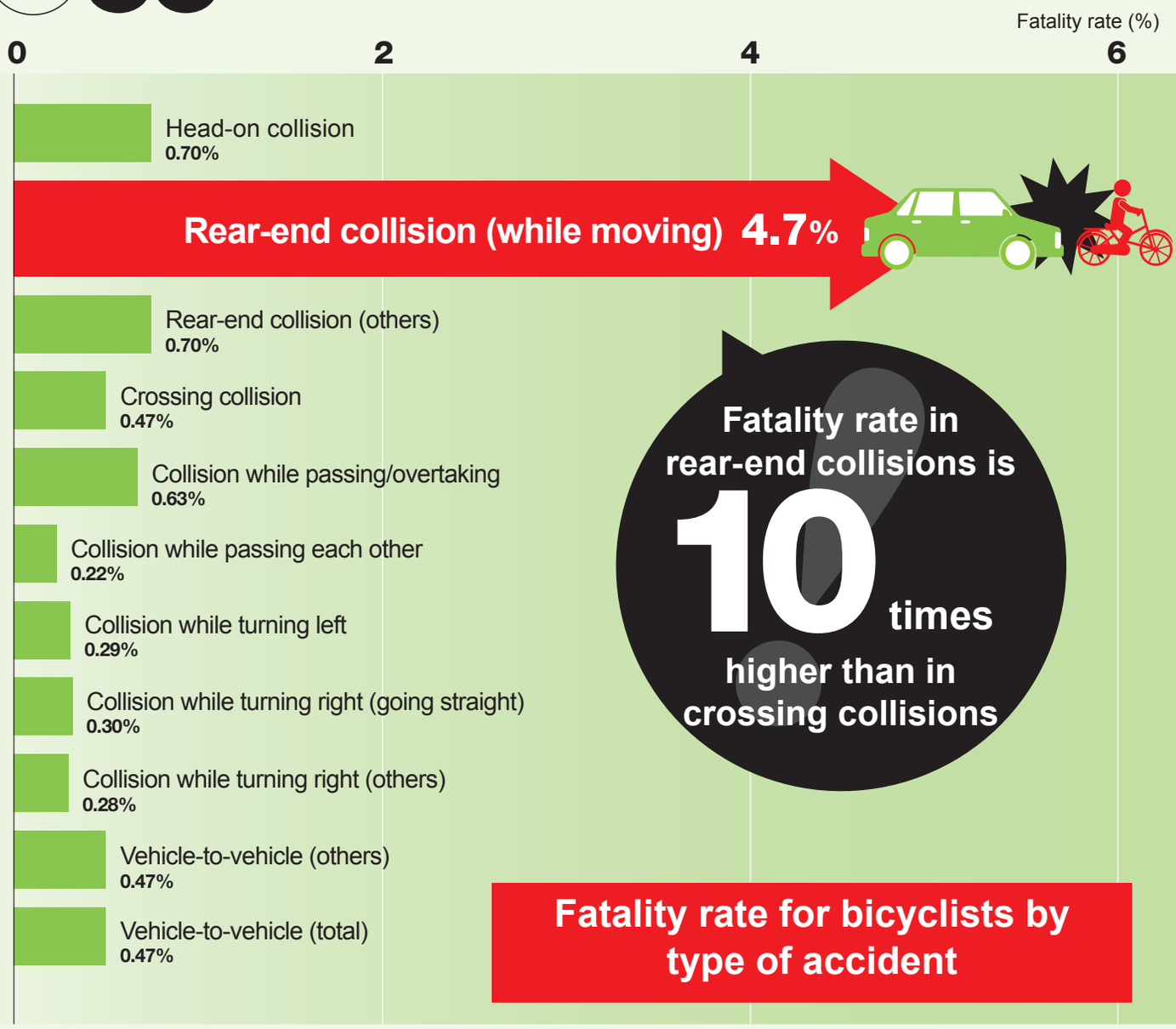

Special feature

Rear-end collisions with a moving bicycle—posing a high risk of death

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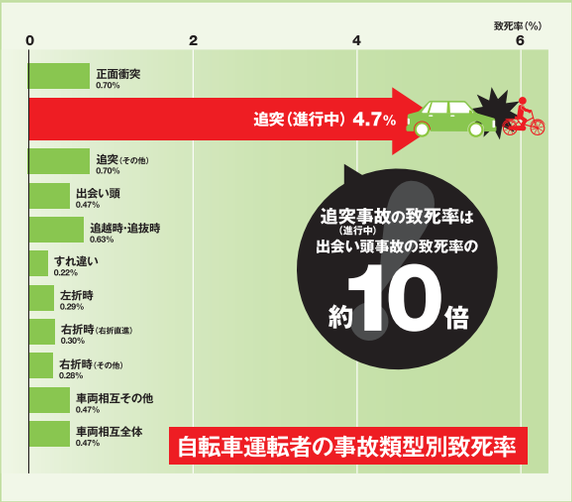


Special feature

Rear-end collisions with a moving bicycle—posing a high risk of death

According to statistics, when a bicycle is involved in a traffic accident, it is typically hit by a car at an intersection (crossing collision). However, a rear-end collision, i.e., one in which a moving bicycle is hit from behind by a car, is much more life-threatening than any other type of accident, despite its low incidence rate. (Throughout this analysis, "rear-end collision" refers to crashing into a bicycle that is traveling and does not include bicycles that are stationary.)

While bicycle riders are often found to be responsible for collisions with a car in general, rear-end collisions are mostly attributable to car drivers. In many cases, this type of accident can be prevented by always trying to predict and avoid possible dangers while driving. In this issue of ITARDA Information, we explore effective ways to drive in order to achieve this objective.

CONTENTS

SECTION 1

Overview of bicyclists in rear-end collisions

(1) Fatality rate and number of bicyclists involved

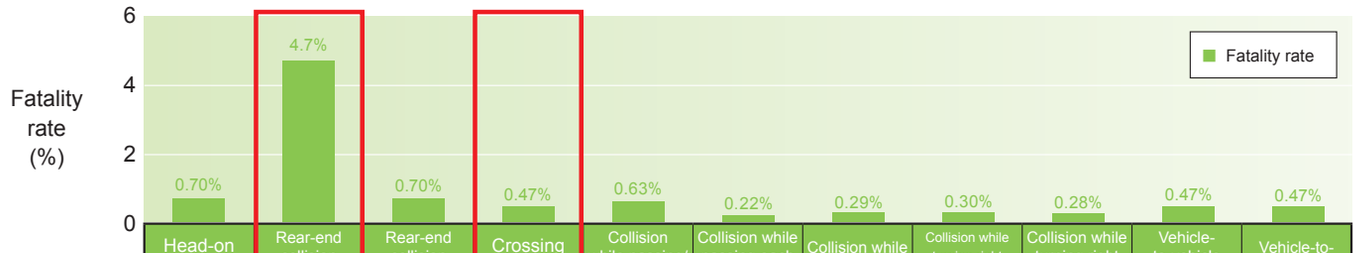
For all bicycle riders involved in traffic accidents, both as the primary party ("Party 1") and the secondary party ("Party 2")*, the fatality rate and the number of casualties are shown in Fig. 1 by accident type and degree of injury. The traffic accident data used in this analysis is the total number of casualties recorded between 2001 and 2009.

$$\text{Fatality rate} = \frac{\text{Number of deaths}}{\text{Number of casualties}} \times 100(\%)$$

The category "Crossing collision" presents the highest number of deaths and casualties, but focusing on the fatality rate, there is a remarkably high rate of 4.7%, or 1 in 20, for rear-end collisions. The rate for "Crossing collision" is only 0.47%, or 1 in 200, meaning that the risk of death is 10 times higher when a bicycle is struck from behind.

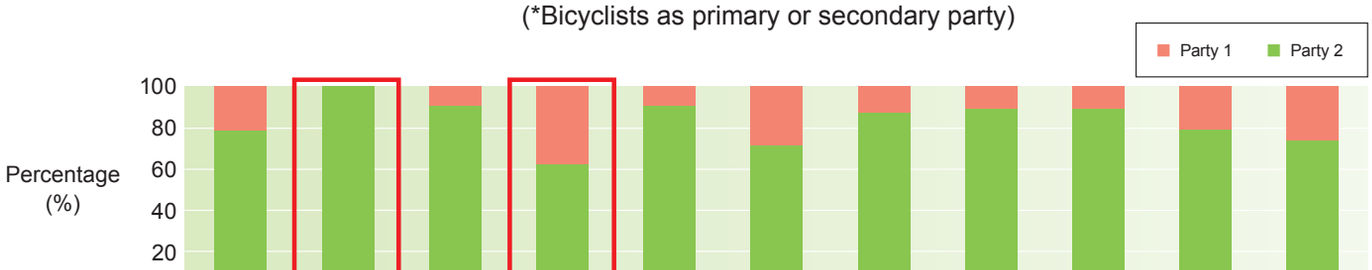
According to Fig. 2 illustrating whether the bicycle was Party 1 or Party 2 in each type of accident, bicycles are most likely to be Party 2 in rear-end collisions, compared to the case of crossing collisions in which a certain percentage is Party 1.

*Of the two parties directly involved in a traffic accident, the more negligent one is designated as the primary party and the other one the secondary party. If the level of negligence is almost the same, the less injured party is regarded as the primary party.



	Head-on collision	Rear-end collision (while moving)	Rear-end collision (others)	Crossing collision	Collision while passing/ overtaking	Collision while passing each other	Collision while turning left	Collision while turning right (going straight)	Collision while turning right (others)	Vehicle-to-vehicle (others)	Vehicle-to-vehicle (total)
Fatality rate	0.70	4.7	0.70	0.47	0.63	0.22	0.29	0.30	0.28	0.47	0.47
Fatalities	264	611	53	3,877	236	63	473	219	297	957	7,050
Serious injuries	3,666	2,156	553	60,428	3,915	1,822	7,669	5,200	7,070	13,735	106,214
Minor injuries	33,819	10,186	6,968	763,666	33,353	26,765	154,295	68,166	99,404	186,935	1,383,557
Casualties	37,749	12,953	7,574	827,971	37,504	28,650	162,437	73,585	106,771	201,627	1,496,821

Fig. 1: Fatality rate for bicyclists by type of accident (vehicle-to-vehicle accidents)
(*Bicyclists as primary or secondary party)



		Head-on collision	Rear-end collision (while moving)	Rear-end collision (others)	Crossing collision	Collision while passing/ overtaking	Collision while passing each other	Collision while turning left	Collision while turning right (going straight)	Collision while turning right (others)	Vehicle-to-vehicle (others)	Vehicle-to-vehicle (total)
Fatalities	Parties 1+2	264	611	53	3877	236	63	473	219	297	957	7,050
	Party 1	56	4	5	1,466	22	18	6	24	32	200	1,833
	Party 2	208	607	48	2,411	214	45	467	195	265	757	5,217
Casualties	Parties 1+2	37,749	12,953	7,574	827,971	37,504	28,650	162,437	73,585	106,771	201,627	1,496,821
	Party 1	5,500	430	1,279	106,072	2,246	2,450	1,925	1,842	3,653	17,116	142,513
	Party 2	32,249	12,523	6,295	721,899	35,258	26,200	160,512	71,743	103,118	184,511	1,354,308

Fig. 2: Number of fatalities for bicyclists as primary or secondary party by accident type (vehicle-to-vehicle accidents)

(2) Breakdown of Party 1 in rear-end collisions

The primary party hitting a bicycle from behind in general includes motorcycles and bicycles (Fig. 3). However, regarding only fatal accidents, the blame is almost always placed on the four-wheeled vehicle (hereafter "car"). Therefore, we deal exclusively with car (as Party 1)-to-bicycle (as Party 2) accidents in this analysis. Also, since bicycle riders are almost always the most severely injured party in this type of accident, we focus on the number of accidents rather than casualties.

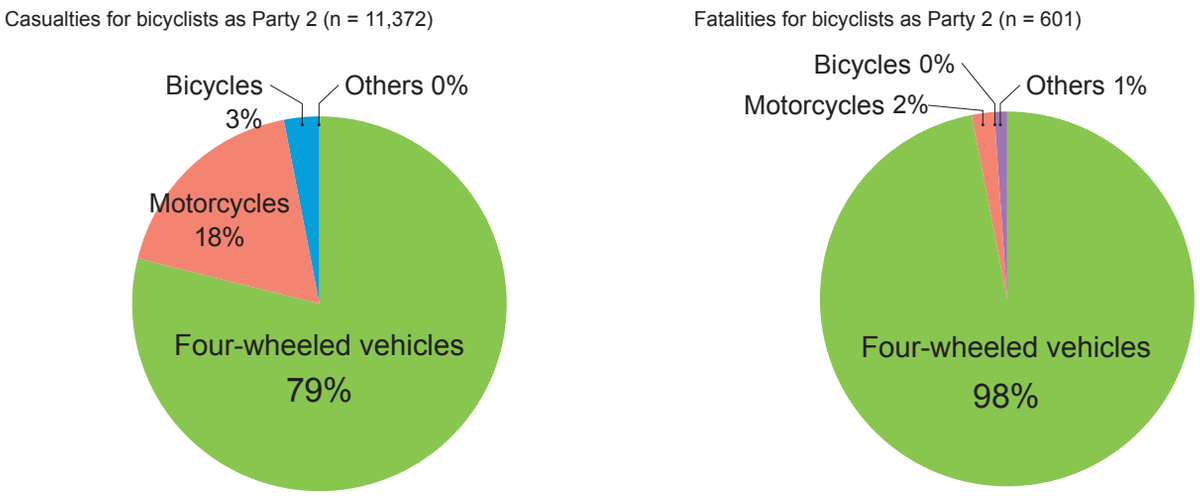


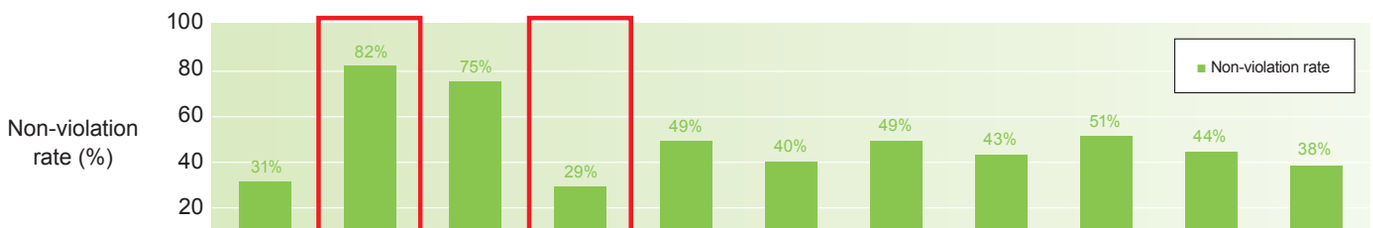
Fig. 3: Vehicle type of primary party in rear-end collisions (while moving)
(*Excluding hit-and-run accidents where the primary party is unknown)

(3) Traffic violations on the part of bicyclists

Figure 4 shows how many bicycle riders as Party 2 did not commit a traffic offense, along with the "non-violation rates".

$$\text{Non-violation rate} = \frac{\text{Number of non-violative cases}}{\text{Number of total accidents}} \times 100(\%)$$

In rear-end collisions, the rate goes up to 82% in comparison to 29% in the case of crossing collisions. In other words, 82% of the car drivers were responsible for the rear-end collisions, which means that this type of accident can usually be prevented by always trying to predict and avoid possible dangers while driving.



	Head-on collision	Rear-end collision (while moving)	Rear-end collision (others)	Crossing collision	Collision while passing/ overtaking	Collision while passing each other	Collision while turning left	Collision while turning right (going straight)	Collision while turning right (others)	Vehicle-to-vehicle (others)	Vehicle-to-vehicle (total)
Non-violation rate (%)	31	82	75	29	49	40	49	43	51	44	38
Non-violative cases	5,980	7,450	3,639	187,536	12,472	7,339	74,599	28,835	49,599	70,168	447,617
Total accidents	19,099	9,054	4,823	640,686	25,219	18,475	150,710	66,759	96,951	161,050	1,192,826

Fig. 4: Non-violation rate for bicyclists by accident type
(*Primary party = car, secondary party = bicycle)

SECTION 2

Characteristics of rear–end collisions

To understand the characteristics of rear-end collisions, we regard all types of collisions involving cars (Party 1) and bicycles (Party 2) as "Total accidents" for easy comparison in this section. The figures include all accidents causing fatalities and injuries unless otherwise stated, since the number of fatal accidents alone is too low to obtain a clear general trend.

(1) Speed immediately before accident

The graph below (Fig. 5) shows the vehicle speed immediately before the crash, taken from our traffic accident database and originally categorized as the danger recognition speed (i.e., the speed when the driver recognized the danger of an accident).

While more than half the "Total accidents" comprise "Stopped or under 10 km/h", higher speed ranges such as "Over 40 km/h" (29%) are dominant in rear-end collisions instead of the lowest speed range, which is the least frequent in this type of accident. It can be concluded that cars tend to be traveling fast at the time of a rear-end collision.

(2) Type of road

The type of road most likely to induce a collision (Fig. 6) is the intersection in the case of "Total accidents" (72%), whereas a large proportion of rear-end collisions happened on stretches of road where there is no intersection (78%).

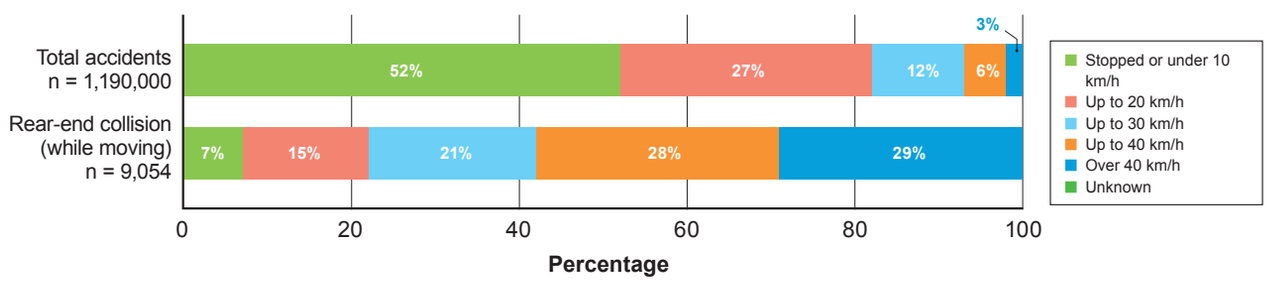


Fig. 5: Car speed immediately before crash

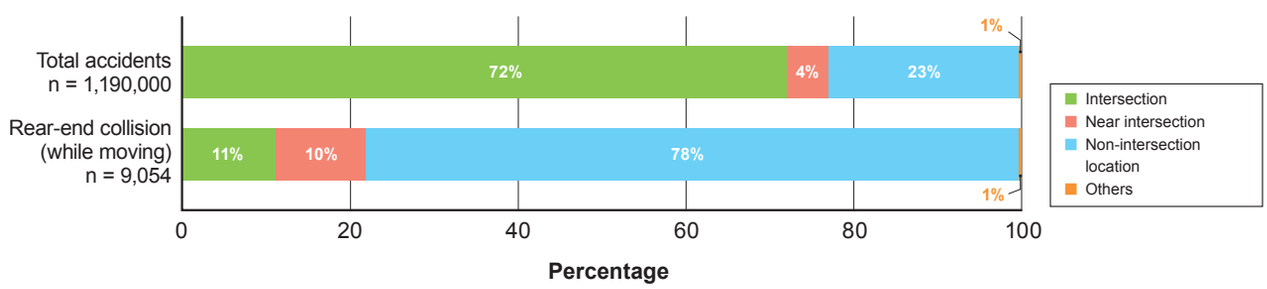


Fig. 6: Type of road at accident site

(3) Time of day

Nighttime accidents account for nearly half the rear-end collisions, compared to a low incidence rate for "Total accidents" (Fig. 7). When restricted to fatal accidents, the incidence rate of 39% for "Total accidents" jumps to 72% for "Rear-end collisions" (Fig. 8).

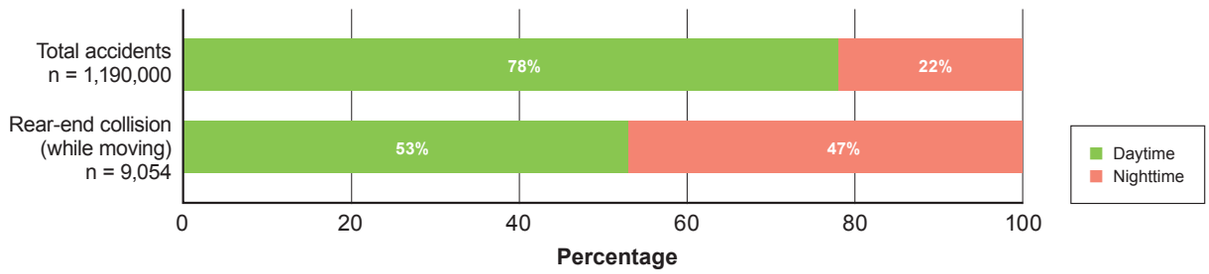


Fig. 7: Time of accident involving fatalities and injuries by time of day

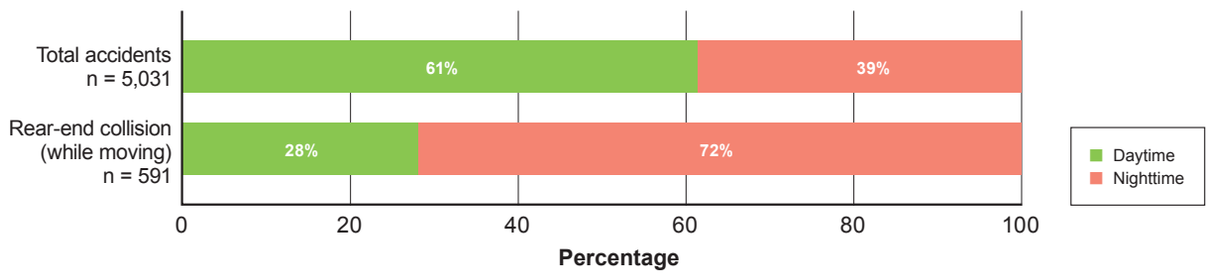


Fig. 8: Time of accident involving fatalities by time of day

(4) Human factors on the part of car drivers

With respect to the causes of accidents classified in Fig. 9 in terms of human factors on the part of the car driver (Party 1), a delay in noticing the bicycle ahead is the major cause for both rear-end and all types of collisions.

The main cause of the delay is failure to check safety for "Total accidents", but in rear-end collisions drivers typically overlooked the bicycle ahead by looking elsewhere or being inattentive, adding up to 82% (Fig. 10). Drivers tend to be less attentive at night than during the day according to Fig. 11, suggesting that bicycles are more easily overlooked in the dark.

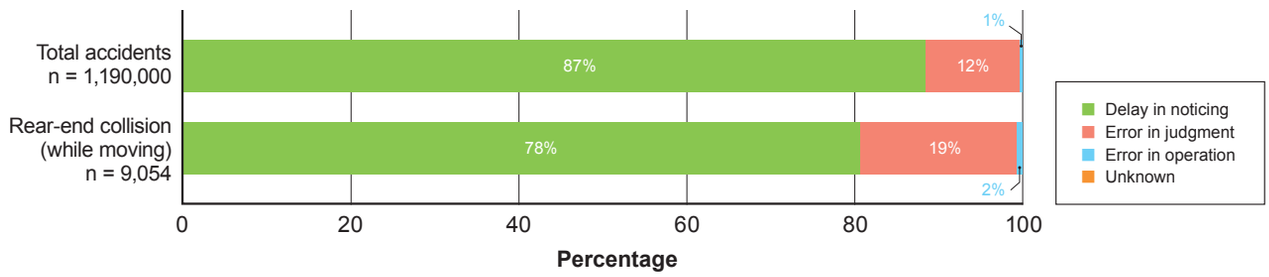


Fig. 9: Human factors in accidents for car drivers

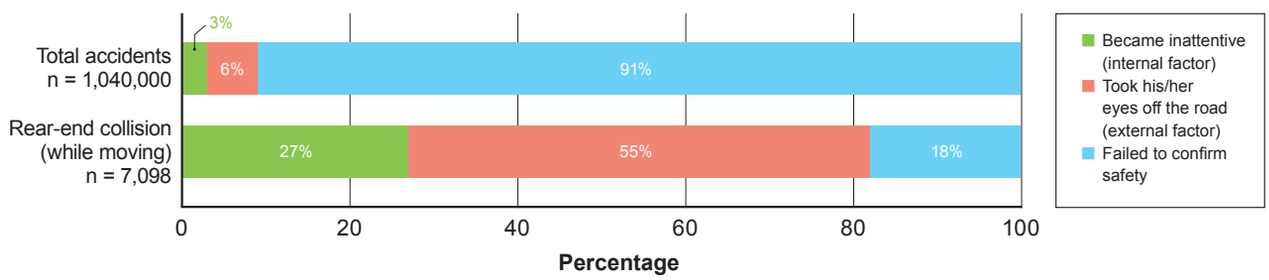


Fig. 10: Breakdown of the factor "Delay in noticing"

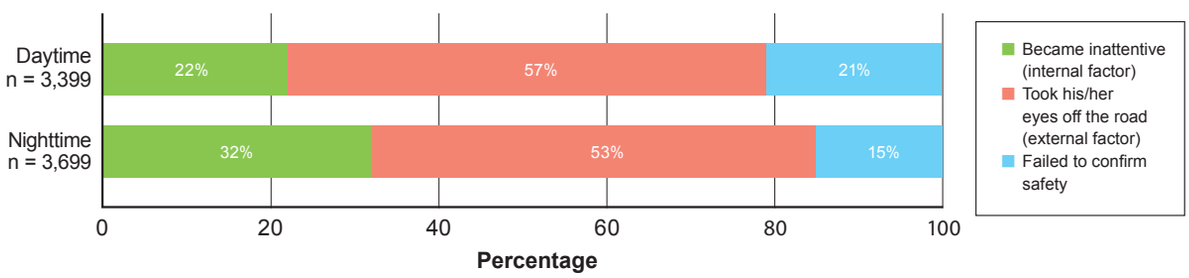


Fig. 11: Breakdown of the factor "Delay in noticing" in rear-end collisions by time of day

(5) Traffic violations committed by bicyclists

Looking at the causative factors on the part of the bicycle riders (Fig. 12), apart from the largest category "No violations", 6% is "Failure to confirm safety behind them" when changing lanes, turning right or left, or crossing the road. Other offenses include "Incorrect use of roadway" (not traveling on the far left side of the road, two bicycles traveling side by side, etc.) and "Incorrect manner of riding", constituting 2% each.

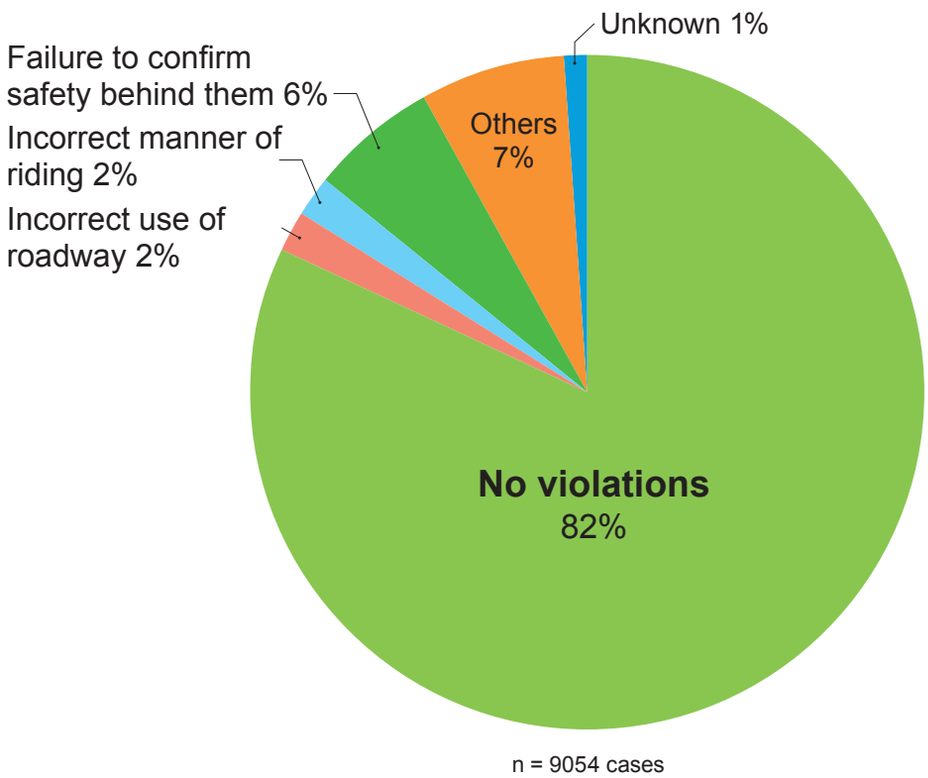


Fig. 12: Details of violations by bicyclists

To sum up, rear-end collisions while the bicycle is moving exhibit the following characteristics:

1. The speed of the car immediately before the crash is usually over 40 km/h (in the medium- to high-speed range),
2. These accidents occur more often on stretches of road where there is no intersection and at nighttime,
3. The major human factor on the part of the car driver is the delay in noticing the bicycle (about 80%), more than 80% of which is due to "Took his/her eyes off the road" and/or "Became inattentive", particularly at nighttime,
4. Bicycle riders sometimes fail to fully check the traffic behind them when changing lanes, turning right or left, or crossing the road.

Based on the above human factors and the daytime/nighttime data, rear-end collisions are more likely to happen at night presumably because the car driver is less attentive and the shape of the bicycle is difficult to see from behind.

SECTION 3

Factors for looking away from the road or becoming inattentive while driving

We don't know from the above data why car drivers look away from the road or become inattentive while driving. This section explores the factors leading to these conditions based on ITARDA's in-depth study database.

From all the traffic accidents involving cars and bicycles covered by our database, 31 cases can be extracted as rear-end collisions, many of which occurred at nighttime (Table 1). As to whether or not the car drivers had noticed the bicycle, 24 of them did not see the bicycle until it was too late, mostly at nighttime, whereas 7 drivers noticed the bicycle in advance, especially in the daytime.

(1) Factors for the delay in noticing the bicycle

The direct factors for the delay in the 24 cases above can be roughly classified into "visibility", "conspicuity", and "traffic conditions":

❶ Visibility: Of the 22 nighttime accidents, 18 cases occurred on roads with no streetlamps. Other factors affecting the delay were driving with low beams despite no oncoming cars (3 cases) and driving with reduced visibility due to rain (3 cases).

❷ Conspicuity: Of the 11 cases in which the color of the bicyclist's clothes was known, 9 were wearing dark-colored clothes. There was also a case in which the driver noticed a bicycle on the far side of the road in advance, but only recognized the presence of another bicycle traveling alongside near the middle of the road just before the crash.

❸ Traffic conditions: In 5 cases, the driver was distracted by oncoming cars on roads of 4.7 to 5.6 meters wide. Other traffic conditions affecting the delay were little/no traffic (4 cases) and the provision of a wide sidewalk that the driver thought the bicycle would use (1 case).

(2) Background of delay in noticing the bicycle

It is believed that these drivers were inattentive because they should have been able to see the bicycle from a sufficient distance to avoid a collision if they had been paying attention. The underlying premise was "there must be no bicycles here" on the grounds that:

❶ It's the middle of the night and raining hard,
❷ There are usually no bicycles here at this time of day (night),
❸ There is hardly any traffic now so I can look away from the road for a little while (daytime),
❹ I'm sure all the bicycles are riding on the wide sidewalk here (daytime).

These are the only four clearly stated comments from interviews that we conducted with the drivers involved in the above accidents. Although several factors may directly cause a delay in noticing the bicycle, the assumption that "there must be no bicycles here" may be the biggest contributory factor to drivers losing their concentration. This assumption is more prevalent at nighttime.

(3) Causes of accidents even after noticing the bicycle in advance

The following are the causes of 7 accidents in which the car driver noticed the bicycle in advance:

❶ The driver looked away from the road after catching sight of the bicycle (4 cases),
❷ The bicycle changed lanes without looking back (1 case),
❸ The bicycle crossed the road diagonally from the right at an intersection (1 case),
❹ The driver took a certain action to avoid danger (1 case).

In many cases, the driver did not keep his/her eyes on the road even after noticing the bicycle.

	Daytime	Nighttime	Total
Delay in noticing	2	22	24
Noticed	5	2	7
Total	7	24	31

Table 1: Number of accidents by early/late notice and time of day for car drivers
(*Primary party = car, secondary party = bicycle)

Factor	Daytime	Total
Visibility	Dark road	18
	Low beams	3
	Rain	3
Conspicuity	Dark clothes	9
	Traveling side by side	1
Traffic conditions	Distracted by oncoming cars	5
	Little/no traffic	4
	Provision of wide sidewalk	1

Table 2: Number of accidents by factor in "Delay in noticing" for car drivers
(multiple answers)

SECTION 4

Examples of accidents

Below is a detailed description of one accident case from our database analyzed in the previous section.

Situation

A man in his 40s was driving a standard-sized cargo van (A) on a dark two-lane road with no streetlamps shortly after 11 pm in a heavy rain. There were no oncoming cars ahead, but he used low beam to avoid having to switch high/low beams according to the traffic in the opposite lane. While driving on a familiar road at about 45 km/h as usual, absentmindedly looking ahead in a relaxed mood after work, he suddenly heard a crash and realized that the left front corner of his car had struck a bicycle (B) from behind. He said that he did not notice the bicycle because he never thought that a bicycle or pedestrian would be on the road in such heavy rain in the middle of the night.

The bicycle rider sustained serious injuries in the crash.

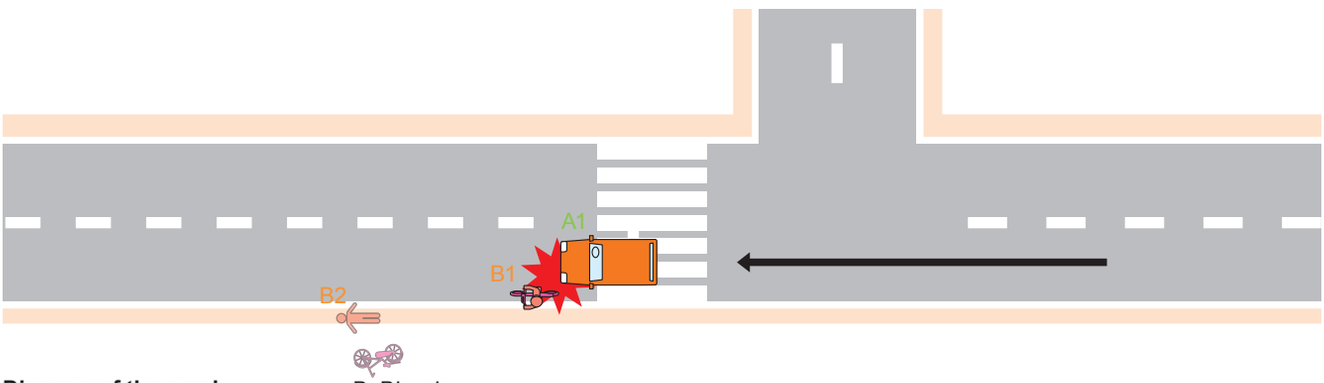
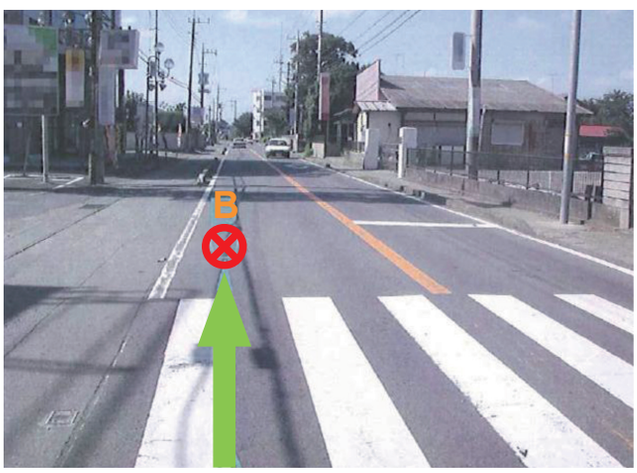


Diagram of the crash B: Bicycle



Accident site
Bicycle B traveling on the left-hand side of the road was struck by Car A.

Accident site seen from 30 m away
There were, presumably, no objects blocking the field of vision at the time of accident and therefore the driver would have noticed Bicycle B if he had considered that there might be a bicycle on the road.

SECTION 5

Conclusion

(1) Characteristics of rear-end collisions

The analysis of the accident data revealed the following characteristics of rear-end collisions, the most fatal among all types of collisions involving cars and bicycles:

1. The speed of the car immediately before the crash is usually over 40 km/h (in the medium- to high-speed range),
2. These accidents occur more often on stretches of road where there is no intersection and at nighttime,
3. The major human factor on the part of the car driver is the delay in noticing the bicycle (about 80%), more than 80% of which is due to "Took his/her eyes off the road" and/or "Became inattentive", particularly at nighttime,
4. Bicycle riders sometimes fail to fully check the traffic behind them when changing lanes, turning right or left, or crossing the road.

(2) Findings from our database

The analysis of our in-depth study database identified several different factors directly causing the delay in noticing the bicycle ahead:

1. Visibility : Dark roads, low beams, rain
2. Conspicuity : Bicyclist wearing dark clothes, two bicycles traveling side by side
3. Traffic conditions : Distracted by oncoming cars, little/no traffic, assumption that bicycles would ride on the sidewalk

It is considered that the drivers were inattentive largely due to their incorrect assumption that "there must be no bicycles here".
In many cases, the driver did not keep his/her eyes on the road even after noticing the bicycle.

(3) Precautions against rear-end collisions

The precautions from the above analysis are as follows:

1. For car drivers
   - ⓐ To notice the bicycle as soon as possible,
     - Assume that bicycles are everywhere at any time,
     - Assume that bicycles are basically on the roadway, not the sidewalk, as prescribed in the law,
     - When turning your attention to oncoming cars in the opposite lane, continue to pay attention to the bicycle in your lane,
     - Try switching to high beams whenever there are no oncoming cars.
   - ⓑ After noticing the bicycle,
     - Reduce the vehicle speed to maintain a safe distance from the bicycle ahead, paying close attention until you have passed it.
2. For bicycle riders
   - ⓐ To protect yourself,
     - Wear bright-colored clothes, reflectors at nighttime, etc., to be more visible to car drivers,
     - Be sure to check the traffic behind you before changing lanes.

In analyzing the traffic accidents, both car drivers and bicycle riders exhibited dangerous behavior that resulted in an accident. However, even in similar situations, most drivers and bicyclists avoid an accident by taking preventive action. It is essential for both parties to obey traffic rules and proper driving manners and to slow down to a safe speed.
Since bicycle riders are usually not held responsible in rear-end crashes, car drivers are strongly urged to always try to predict and avoid possible dangers while driving, to reduce the number of fatalities and the number of accidents itself.

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