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Characteristics of lane deviation accidents seen from micro investigations

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1. Introduction

In recent years, the number of fatal traffic accidents in Japan has been declining, yet the number still remains high at 3,449 such accidents that occurred in 2018. Of these, lane deviation accidents in which a driver deviated from their own lane that resulted in a collision with an oncoming vehicle, roadside structure, or other object, accounted for half of all fatal accidents while riding in a four-wheel vehicle. The hope is that these can be reduced in the future. ITARDA has reported on the results of analyses on lane deviation accidents in aiming to reduce them by focusing attention on them (2012, 2016). In 2012, macro data and micro data were used to analyze the characteristics of lane deviation incidents, and matters like analyses of the causal factors and patterns and types of vehicle deviation behavior were reported on. Moreover, in 2016 a deeper analysis of lane deviation characteristics was undertaken, and countermeasures to avoid lane deviations and estimates for the reduction in the number of casualties achievable from these were reported.

For this study, an analysis of the characteristics of lane deviation accidents was performed by using data like the results of reconstructing accidents through the use of ITARDA's micro case studies. The objective with this was to aggregate basic data conducive to advancing preventive safety systems, particularly lane deviation prevention systems, which are expected to become more widespread in the future.

2. Background and objectives

2-1. Number of lane deviation accidents and their fatality rate

The number of fatal accidents by type of accident while riding in a four-wheel vehicle are shown in Fig. 1. Here, accidents while riding in a four-wheel vehicle refer to single vehicle accidents and vehicle-vehicle accidents where the primary party was driving a four-wheel vehicle. The number of accidents represents the total number between the years 2014 and 2018. What is more, lane deviation accidents were aggregated as a total of the number of single vehicle accidents (excluding collisions with parked vehicles and overturn accidents) and head-on collision accidents.

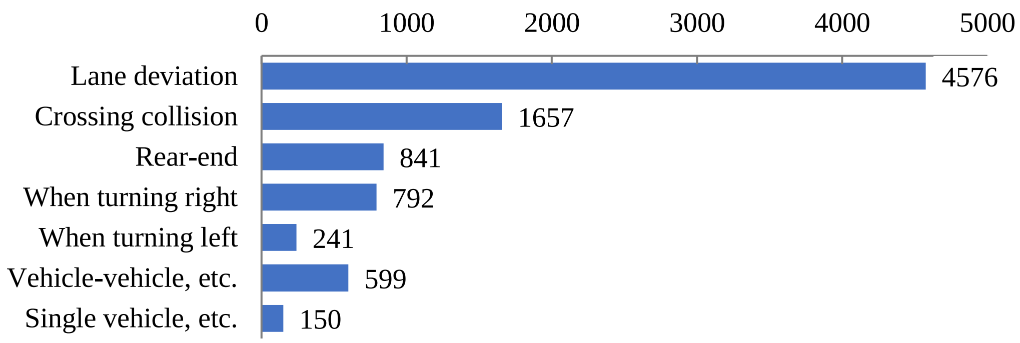

Fig. 1. Number of fatal accidents by type of accident while riding in a four-wheel vehicle

This reveals that lane deviation accidents account for the greatest share of the number of fatal accidents while riding in a four-wheel vehicle. The recognition obtained from this is that reducing lane deviation accidents will pose a major challenge moving forward.

In addition, a comparison of the fatality rates by type of accident for fatal accidents while riding in a four-wheel vehicle is shown in Fig. 2. Here, the fatality rate indicates the ratio of the number of fatal accidents to the total number of casualty accidents for each type of accident.

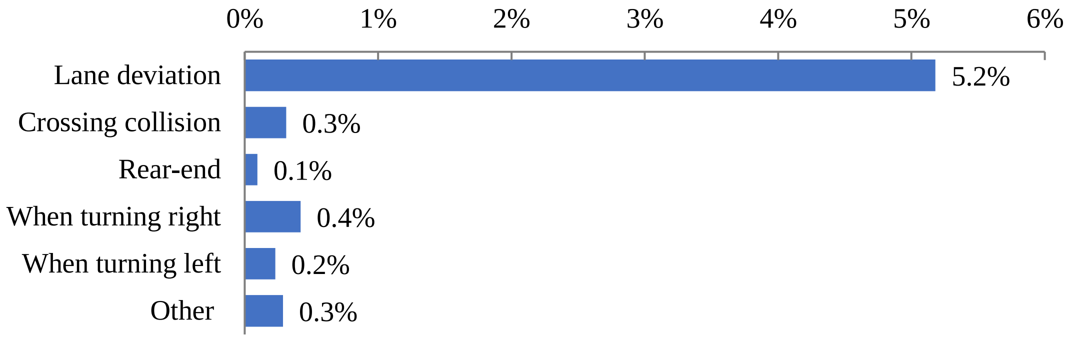

Fig. 2. Fatality rate by type of accident while riding in a four-wheel vehicle

From this, we can see that the fatality rate from lane deviation accidents is the highest by far compared with other types of accidents. In other words, the large number of fatal accidents indicated in Fig. 1 is estimated to be a contributing factor to the elevated risk of death from lane deviation accidents, and ideally such accidents should be reduced in the future.

2-2. Lane deviation prevention systems

In recent years, lane deviation prevention systems have become widespread as a type of preventive safety system designed to prevent lane deviation accidents by vehicles. These have been added as an evaluation item by the J-NCAP conducted by NASVA as well as by Euro-NCAP which is carried out in Europe, with high hopes for both their effectiveness and further advancement in the future.

These systems can be broadly categorized into two types: one type that sounds a warning to alert the driver of danger, and another type where the system takes control of the steering wheel to prevent the vehicle from deviating from its lane.

Moreover, these systems are not constantly active, but rather their activation / non-activation is governed by conditions such as the running speed, weather, and so forth. Regarding the running speed, it is generally assumed that they will be used on expressways, and while there are differences based on the car manufacturer and model, they are designed to activate at around appr oximately 50 - 100km/h (Fig. 3; Source: Various company homepages).

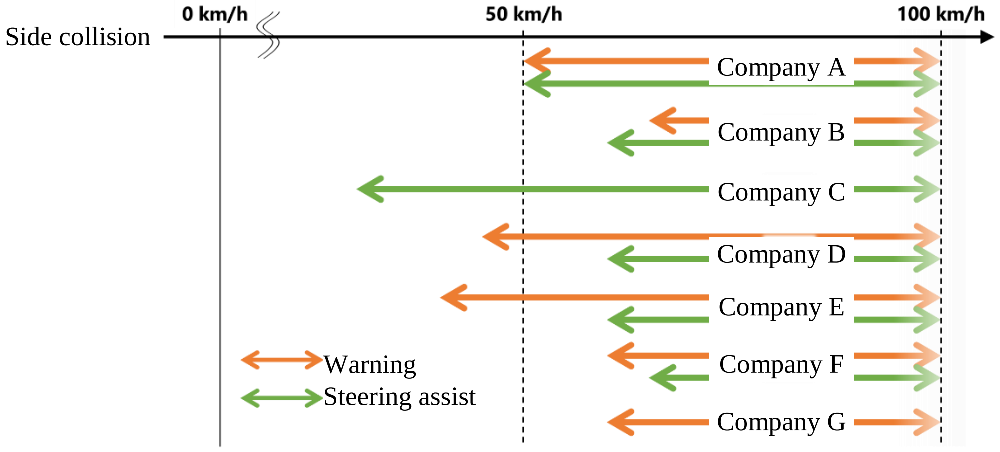

Fig. 3. Activation speed ranges for lane deviation prevention systems

3. Analytical method

3-1. Selecting the micro data

The micro data used for the analysis consisted of data from the five-year period from 2013 - 2017.
This included investigations that had been performed into 181 lane deviation accidents, the breakdown for which included 125 single vehicle accidents and 56 head-on collision accidents.

3-2. Reconstructing lane deviation accidents through the use of micro data

ITARDA creates detailed road diagrams for all of the accidents that it investigates. In addition to these road diagrams, it also uses a combination of interviews with the parties to the accident, the extent of the damage to the vehicles, and other factors to make it possible to estimate the running trajectory and trends in the speed of the vehicles in the accident from before and after the collision.
With this study, accident reconstructions were conducted on 81 of the 181 lane deviation accidents (46 single vehicle accidents and 35 head-on collision accidents). This was done in order to be able to obtain the information needed to estimate the running trajectory of the vehicles, as well as to limit this to accident types involving gentle deviation rather than types where the vehicle deviated due to slips or abrupt steering.
The following two points were verified based on the results of these accident reconstructions.

(1) The time from the lane deviation to the collision

(2) The deviation angle (the angle formed by the vehicle trajectory and the lane when the vehicle veered from its lane)

With respect to (1), the distance between the point of the lane deviation and the point of the collision was found by dividing by the collision speed. For (2), the angle was found by tracing the vehicle trajectory over top the road diagram. The lane deviation point was defined as the point where the exterior of the deviating vehicle intersected with the lane.

4. Analyzing the characteristics of lane deviation accidents

4-1. Types of road lanes

Based on the results of investigations of the scenes of accidents from the micro investigations, the number of lane deviation accidents by type of road lane are shown in Fig. 4 and Fig. 5. According to this, accidents on straight segments account for the greatest share of single vehicle accidents, while many head-on collision accidents occur on both straight segments and left-hand curves.

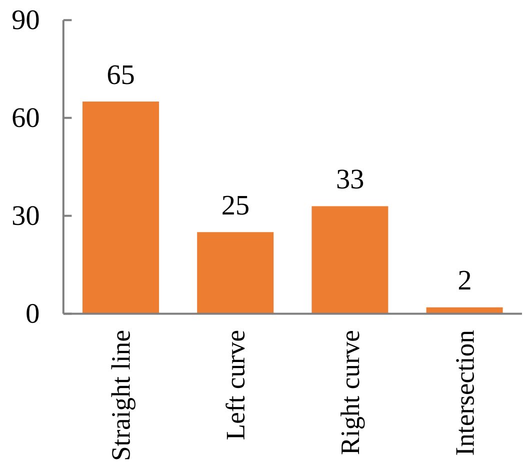

Fig. 4. Number of accidents by type of road lane (single vehicle)

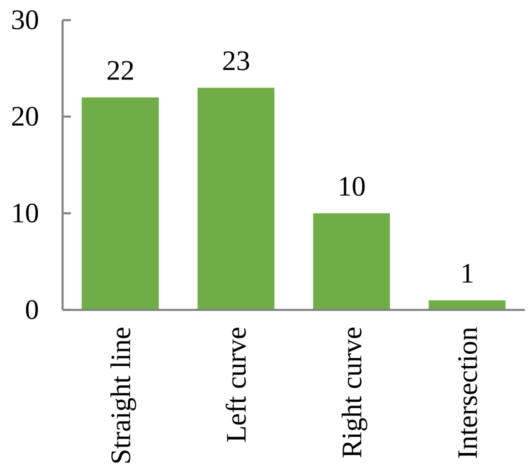

Fig. 5. Number of accidents by type of road lane (head-on collisions)

4-2. By type of deviation

Based on the results of investigations at the scene of accidents, interviews with the parties to the accidents, and so forth from the micro investigations, the number of lane deviation accidents by type of deviation are shown in Fig. 6 and Fig. 7. These reveal that accidents due to gentle deviations accounted for the majority of both single vehicle accidents and head-on collision accidents.

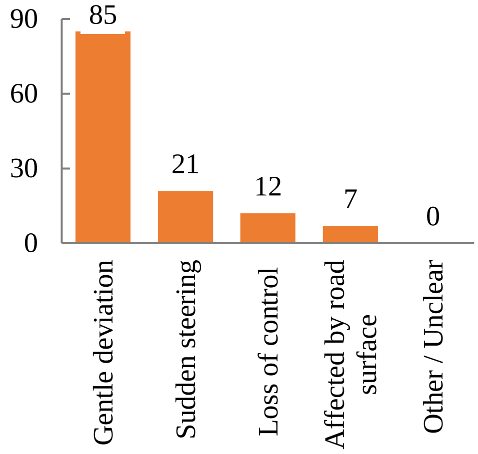

Fig. 6. Number of accidents by type of deviation (single vehicle)

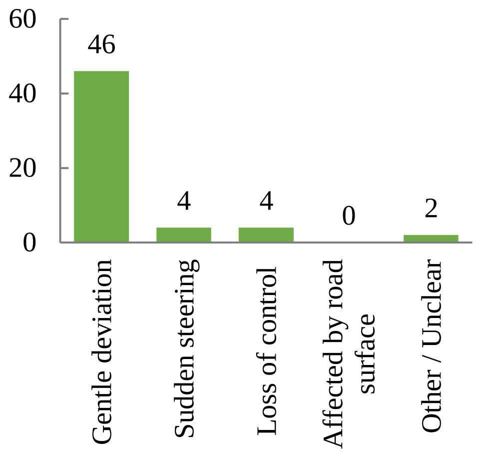

Fig. 7. Number of accidents by type of deviation (head-on collision)

4-3. By human factor

When it comes to the "gentle deviation" accidents from “4.2. By type of deviation,” the number of lane deviation accidents by human factor are shown in Fig. 8 and Fig. 9 based on the interviews with the accident parties (excluding cases where this was unknown). This reveals that the majority of accidents were caused by dozing off, absent-minded driving, and distracted driving, in that order. Absent-minded driving and distracted driving accounted for the greatest share of head-on collision accidents, followed next by dozing off. When lane deviation accidents are considered as a whole, the three factors of dozing off, absent-minded driving, and distracted driving can be considered to be the main human factors at play.

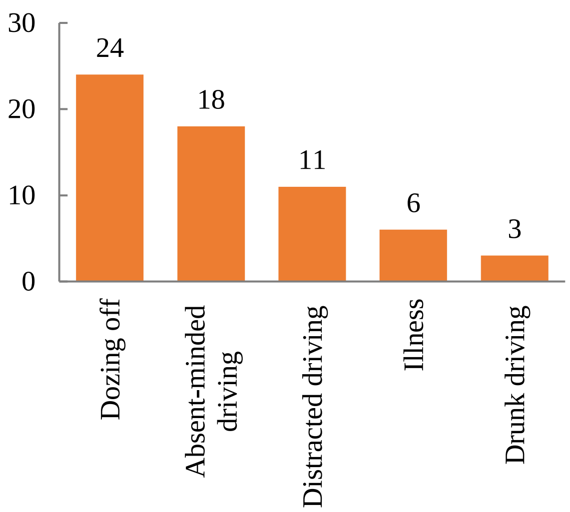

Fig. 8. Number of accidents by human factors (single vehicle)

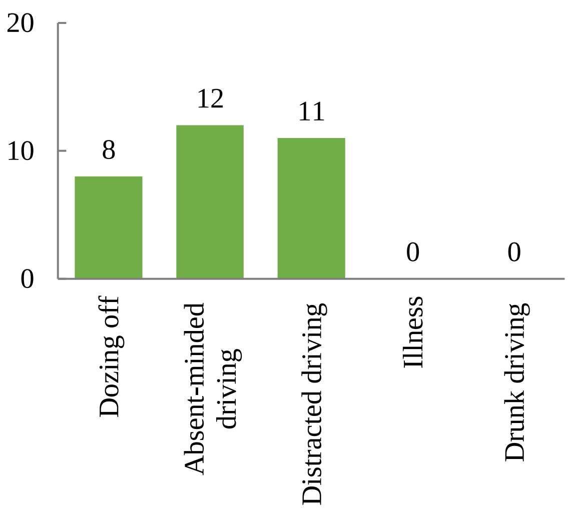

Fig. 9. Number of accidents by human factors (head-on collisions)

4-4. By danger perception timing

When it comes to the "gentle deviation" accidents from “4.2. By type of deviation,” the number of lane deviation accidents by danger perception timing are shown in Fig. 10 and Fig. 11 based on the interviews with the accident parties (excluding cases where this was unknown). This reveals that the majority of single vehicle accidents consisted of accidents where the driver was unaware of the other object at the time of the collision, or in other words, up until the collision occurred. The same holds true for head-on collision accidents, in that most accidents involved the driver only perceiving danger at the time of the collision.

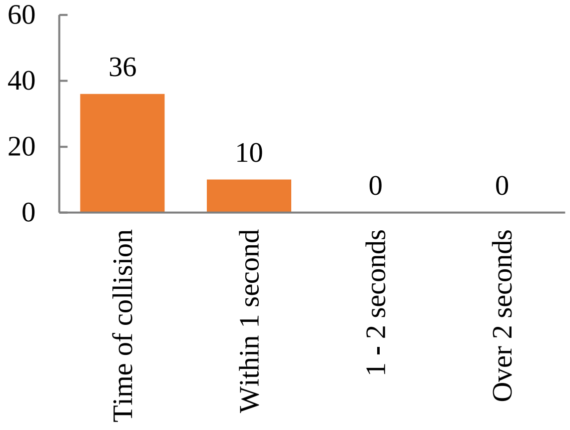

Fig. 10. Number of accidents by danger perception timing (single vehicle)

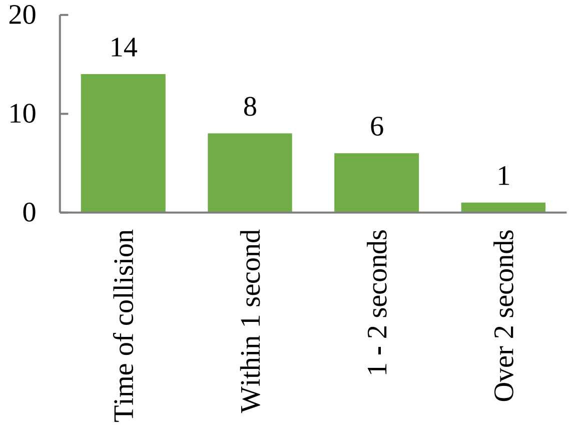

Fig. 11. Number of accidents by danger perception timing (head-on collisions)

4-5. By danger perception speed

Based on the macro data from the five-year period of 2014 - 2018, the number of lane deviation accidents by danger perception speed of the primary party are shown in Fig. 12 and Fig. 13 (excluding cases where this was unknown). This indicates that the majority of accidents occurred at a danger perception speed of between 30km/h and 40km/h for both single vehicle accidents and head-on collision accidents. The trend observed from this is that a large share of such accidents occur at speeds of no more than 50km/h.

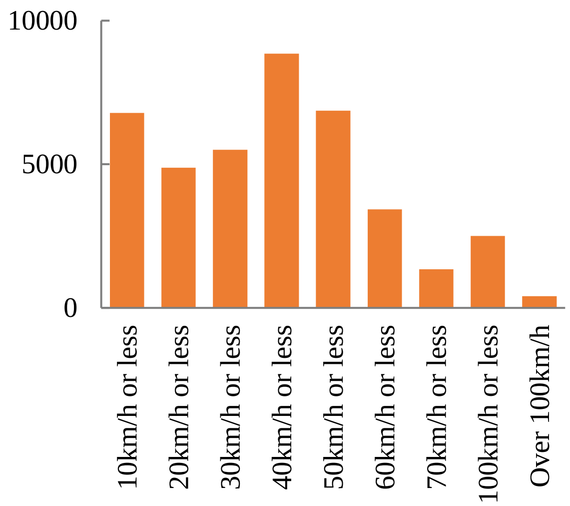

Fig. 12. Number of accidents by danger perception speed (single vehicle)

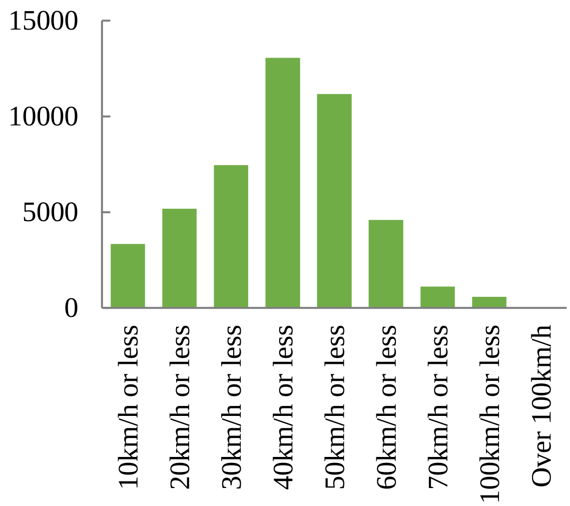

Fig. 13. Number of accidents by danger perception speed (head-on collisions)

4-6. Time from the lane deviation until the collision

For the 35 head-on collision accidents out of the 81 cases of accident reconstructions performed that are shown in 3-2., the number of lane deviation accidents by time from the lane deviation until the collision are shown in Fig. 14 (excluding cases where this was unknown). With single vehicle accidents, most collisions occur with roadside structures such as guardrails to the side of the road, and so due to their short interval of time from the deviation until the collision, they were excluded from this verification. According to this, most head-on collision accidents had a time of two seconds or less from the lane deviation until the collision occurred.

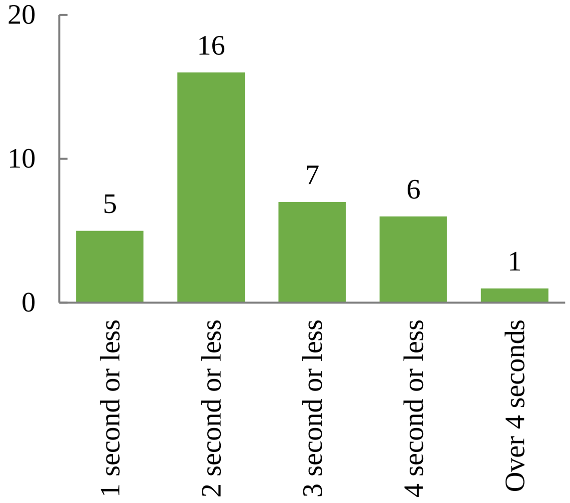

Fig. 14. Number of accidents by time from the deviation until the collision (head-on collisions)

4-7. Lane deviation angle

Of the 81 cases of accident reconstructions performed that are shown in 3-2., the number of lane deviation accidents by lane deviation angle are shown in Fig. 15 and Fig. 16 (excluding cases where this was unknown). From this, a trend was observed whereby most accidents occurred between angles of 1° and 4° for both single vehicle accidents and head-on collision accidents.

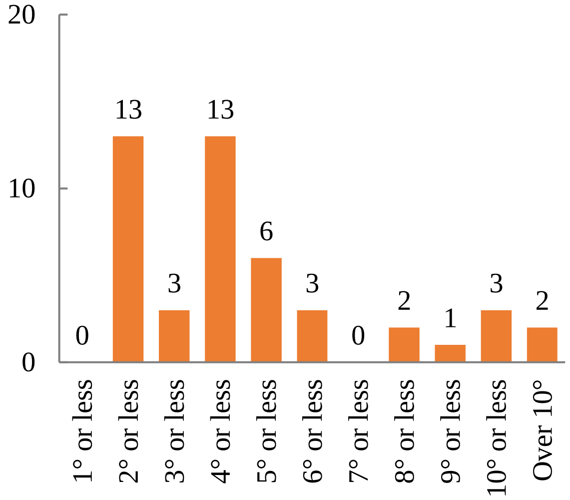

Fig. 15. Number of accidents by deviation angle (single vehicle)

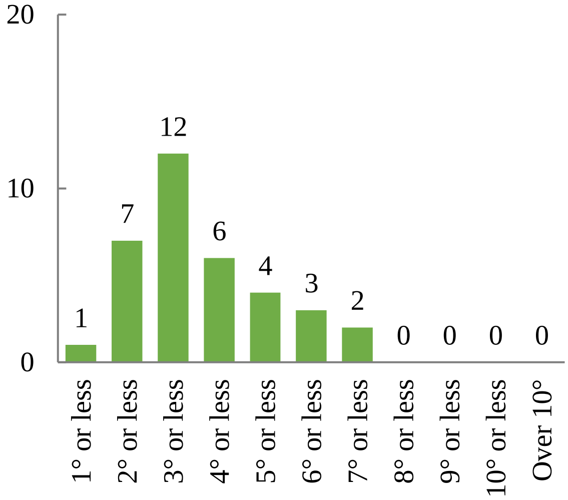

Fig. 16. Number of accidents by deviation angle (head-on collision)

5. Considerations and recommendations

5-1. Speed range in which lane deviation prevention systems activate

The actual conditions of accidents by speed shown in 4-5 are indicated in Fig. 17 as a share of accidents by speed. As was mentioned in 2-2., current lane deviation prevention systems activate at approximately 50 - 100km/h. When this is factored into consideration, we see that the accident coverage rate by such systems would be 18% for single vehicle accidents and 14% for head-on collision accidents, for 16% for lane deviation accidents as a whole. Yet conversely, 52% of single vehicle accidents and 68% of head-on collision accidents, for a total of 61% of all lane deviation accidents, occur within a speed range of 21 - 50km/h which accounts for the largest share of accidents.
For the future, being able to expand the speed range in which lane deviation prevention systems activate to 20km/h or more would lead to coverage of roughly 77% of all lane deviation accidents, which would presumably contribute enormously to reducing accidents.

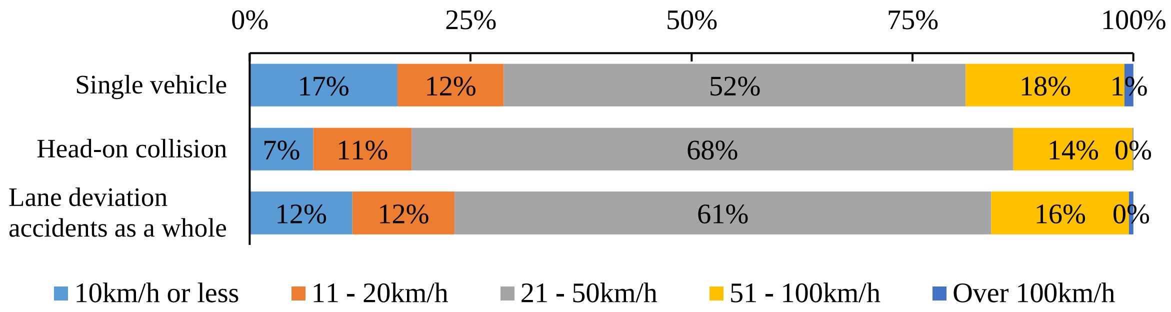

Fig. 17. Share of lane deviation accidents by speed

5-2. Lane deviation prevention systems (warning)

As indicated in 4-6, most accidents had a time from when the deviation occurred until the collision of two seconds or less. For this, if we consider a person's reaction time (time from when they notice the warning until they can actually set their body in motion) to be approximately one second, then even when a warning sounds when the driver deviates from their lane prior to a collision, they only have a brief window of time in which to avoid said collision.
Warnings are a useful way to prevent inattentive or distracted driving. However, when the verification results from this study are taken into consideration, such warnings should not be overly relied upon. Drivers must still drive in a state of readiness whereby they are prepared to take action at a moment's notice.

5-3. Lane deviation prevention systems (steering assist)

As indicated in 4-7, the most commonly seen deviation angle when vehicles deviated from their lane was between 1° and 4° versus the lane. The number of accidents and their total share for lane deviation accidents as a whole are shown in Fig. 18. This reveals that accidents with a deviation angle between 0° and 5° account for approximately 80% of the total.
If in the future lane deviation prevention systems can cover lane deviations with an angle of 5° or less, then this would cover approximately 80% of lane deviation accidents as a whole, and would presumably contribute enormously to reducing accidents.

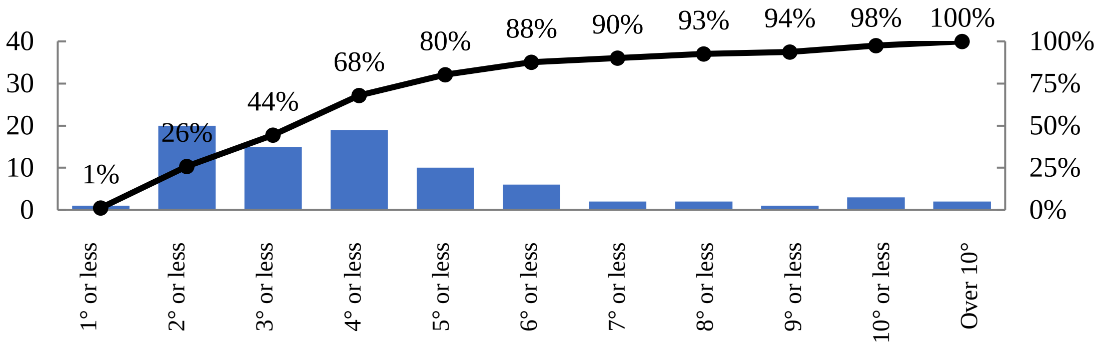

Fig. 18. Number of accidents by deviation angle and their total share

6. Conclusion

The following lessons were learned from this study as a result of analyzing lane deviation accidents through the use of information like micro data from ITARDA.

- Accidents frequently occur along straight segments, with "gentle deviation" a common type of deviation.
- The most common human factors included dozing off, absent-minded driving, and distracted driving, with many people only becoming aware they were in danger of causing an accident once the collision occurred.
- Most accidents occurred within a danger perception speed of 21 - 50km/h, with this range accounting for approximately 60% of all accidents.
- The most common time from when the vehicle deviated from its lane until it collided with an oncoming vehicle was approximately one - two seconds.
- The most common lane deviation angle was between 1° and 4°, with accidents at an angle of 5° or less accounting for approximately 80% of the total.

Based on these characteristics, the hope is that further advances will be achieved in lane deviation prevention systems. Yet even so, there will still be a need for drivers to concentrate on safe driving without becoming overly reliant on such systems.

＜引用・参考文献＞

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