2021
The 24th Traffic Accidents Investigation Analysis Research Presentation Meeting

Tendency and Features of Vehicle Rollover Accidents
~ Analysis Based on Micro Data ~

Hiroki Kobayashi
Investigator, Tokyo Traffic Accident Investigation Office

1. Introduction

The research conducted by our center in 2003 shows a tendency that occupant's injuries become more serious in vehicle rollover accidents. (ITARDA, 2006). However, due to the change of vehicle model constitution and environmental changes such as spread of safety equipment and advance of aging population, situations may have been changed from that time. Therefore, we analyzed rollover accidents based on the latest accident data and compared the results with past research and studied changing points and their factors.

2. Analysis method

2.1 Use data

If the Road Traffic Accident Statistics (macro data) of the National Police Agency is used, it is difficult to perform detailed analysis of rollover accidents due to constraints of tabulation items. Therefore, we performed analysis using "micro data", which are data of accidents investigated and tabulated by our center. The targets in the analysis are single vehicle accidents and vehicle-vehicle accidents of four-wheeled vehicles that occurred from 1993 to 2003 (old data) and from 2010 to 2020 (new data) with the vehicle models classified into ten kinds, mainly medium sized vehicles and small sized vehicles (Fig.1).

	Popular name (example)	Remarks
Truck, etc.	Land cruiser, CS-X, Juke	
SUV	Alphard, Selena, Freed	
Minivan (mV)	High ace, Town ace	
Van	Camry, PRIUS, Fit	
Ordinary sedan car (Car)	N-BOX, Tanto	
Super tall wagon (SHk)	N-WGN, Move, Dayz	Overall height 1,700 mm or more
Tall (light wagon)	Alto, Mira	Overall height 1,600 mm or more
Light sedan car (k)	High Z, Every	
Light van (kV)	Carry, Acty	
Light truck (kT)	Land cruiser, CS-X, Juke	

Fig.1 Classification of vehicle models

2.2 Comparison between micro data and macro data

Whereas the macro data recorded all casualty accidents in Japan, micro data mainly collected the data of serious accidents that occurred around Tsukuba City, Ibaraki Prefecture and may not represent accidents that occurred in Japan. Therefore, we made a comparison by focusing on "overturn accidents", which are the only common denominators of micro data and micro data in relation to rollover accidents. Overturn accidents refer to rollover accidents without a collision that becomes a cause of accident. The overturn ratio of both data (Fig.2) show that, although the overturn ratio of micro data is generally high, both data has the same tendency as to comparison between vehicle models (medium sized and small sized) and time series (old and new data). Therefore, we determined that the micro data can be used for relative comparison between vehicle models and new and old data and an analysis of occurrence factors.

Overturn ratio (number of overturned units / number of units of single vehicle accidents)

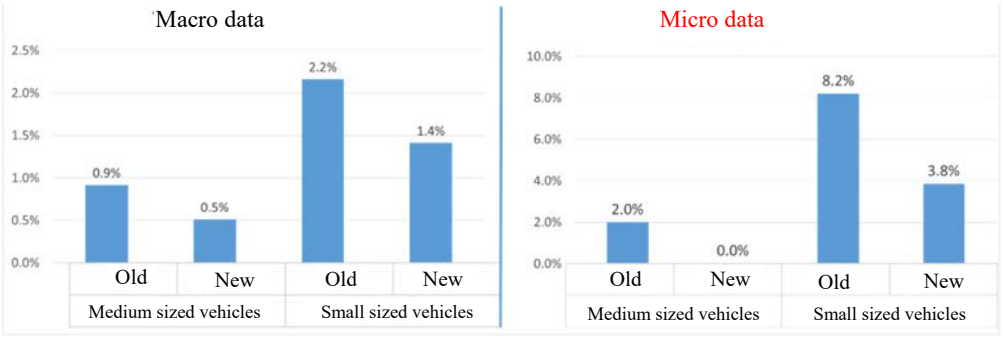

Fig.2 Comparison of overturn ratio between macro data and micro data

3. Present state of rollover accidents

Fig.3 shows the variation with time of rollover ratios of small sized vehicles, medium sized vehicles, and all vehicle models (small sized and medium sized) obtained from the micro data. The rollover ratio that added up single vehicle accidents and vehicle-vehicle accidents of all vehicle models increases to double. By vehicle model, the rollover ratio of small sized vehicles increases more than that of medium sized vehicles. In the case of small sized vehicles, vehicle-vehicle accidents increased 2.5 times and single vehicle accidents increased 1.2 times from old to new data, which shows that an increase of the rollover ratio of single vehicle accidents is lower than that of vehicle-vehicle accidents.

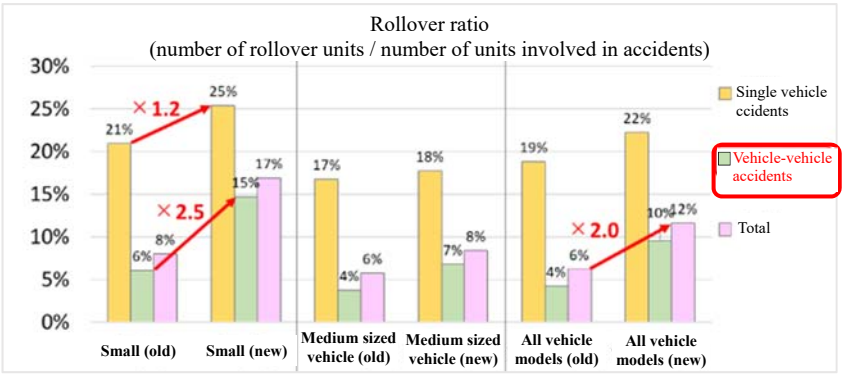

Fig.3 Variation with time of the rollover ratio by vehicle model

4. Study

We focus on the tendencies found in Chapter 3 - "the tendency that the rollover ratio of all vehicle models increased from old data to new data" and "the tendency that an increase in rollover ratio of single vehicle accidents is lower than that of vehicle-vehicle accidents" and perform an analysis of factors from the perspective of vehicles and persons.

4.1 Factors of vehicles (for the tendency that the rollover ratio of all vehicle models increased from old to new data)

4.1.1 Change on the other vehicle side

At first, we studied a possibility that the rollover ratios increase due to the effects of the other vehicle side in the

case of vehicle-vehicle accidents (increase of new vehicle models such as SUV and minivan). The component rates of vehicles involved in vehicle-vehicle accidents in the case of old data and new data respectively are shown in Figs.4 and 5. The figures show that there is a difference of component rate between all vehicles and rollover vehicles while the component rates between the other vehicles and rollover vehicles has a similar distribution. Therefore, it can be considered that an increase in rollover ratio is not the problem on the other vehicle side but the problem on the rollover vehicle side.

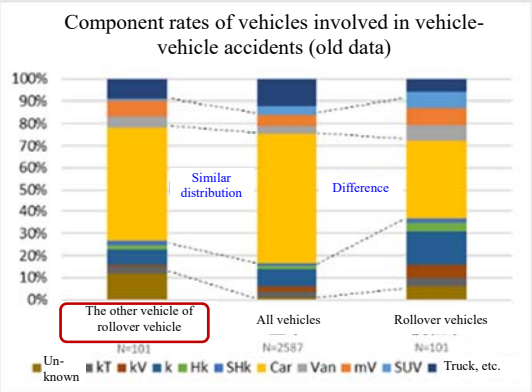

Fig.4 Component rates of vehicles involved in vehicle-vehicle accidents (old data)

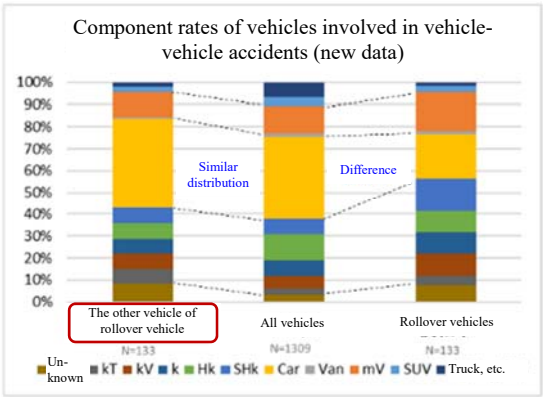

Fig.5 Component rates of vehicles involved in vehicle-vehicle accidents (new data)

4.1.2 Change on the rollover vehicle side

Next, to examine the features of rollover vehicle side, we focused attention on SSF (Static Stability Factor), which is the rollover evaluation index of U.S. NCAP (Fig.6). SSF is a value which divides 1/2 of tread width by vehicle gravity center height. However, since the data of gravity center height is difficult to obtain, we made calculation as simple SSF by approximating gravity center height as vehicle height x 0.38 (Euro NCAP, 2011).

The relation of rollover ratio in the case of all vehicle models which added up old and new data, and simple SSF is shown in Fig.7. The component rate of vehicle models in the case of rollover vehicles is shown in Fig.8. Fig.7 shows that there is a strong correlation (R=-0.72) between simple SSF and rollover ratio and the lower simple SSF becomes, the higher rollover ratio becomes. Also, Fig.8 shows an increase in the component rate of vehicle models with low SSF. Therefore, such change of vehicle model constitution is considered as a cause of increase in the rollover rate.

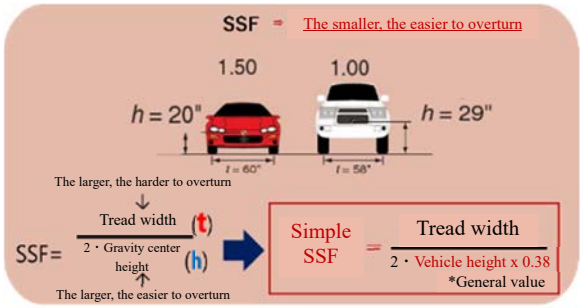

Fig.6 SSF and simple SSF

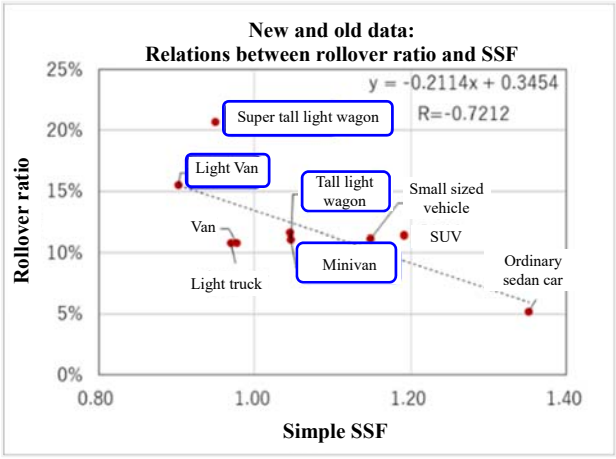

Fig.7 Relations between rollover ratio and simple SSF by vehicle model

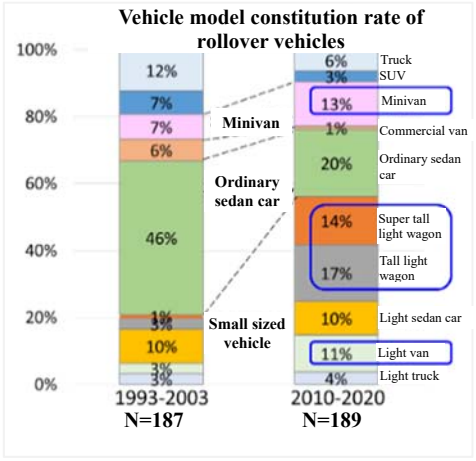

Fig.8 Vehicle model constitution of rollover vehicles

4.2 Factors of vehicles (for the tendency that an increase in rollover ratio of single vehicle accidents is lower than that of vehicle-vehicle accidents)

4.2.1 Relations between ESC and single vehicle rollover

As a factor that an increase in the rollover ratio of single vehicle accidents is low, we focused attention on in ESC (Electronic Stability Control). The rollover ratios of vehicle-vehicle accidents and single vehicle accidents classified according to the presence of ESC is shown in Fig.9. Although effects of ESC are not seen in vehicle-vehicle accidents, the rollover rate decreased in the case of vehicles equipped with ESC, indicating that ESC contributes to suppress an occurrence of rollover.

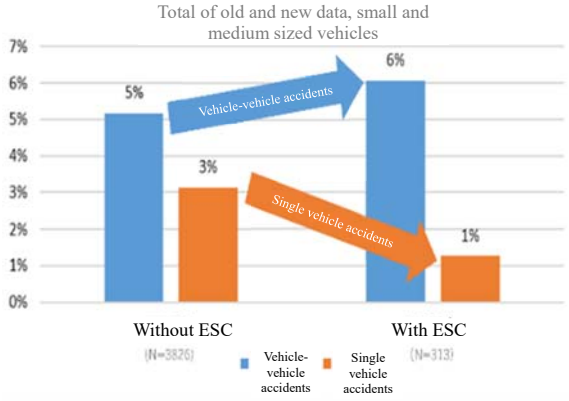

Fig.9 Presence of ESC and rollover ratio of accidents

4.2.2 Change of the number of units equipped with ESC

Since vehicles made in Japan in 2002 and before were not equipped with ESC, the number of ESC-equipped vehicles was 0 in old data. In new data, the ratio of ESC-equipped vehicles reaches 15% (small sized vehicle) and 38% (medium sized vehicle) of ESC-unequipped vehicles (Fig.6) and it can be considered that ESC affects the rollover ratio of single vehicle accidents. As shown in Fig.3, the tendency to increase the rollover ratio of single vehicle accidents for medium sized vehicles is lower than that of small sized vehicles, which matches the ratio of ESC equipment mentioned above.

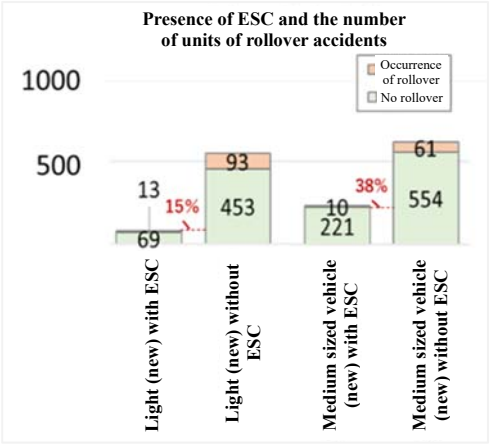

Fig.10 Presence of ESC and the number of units of rollover accidents (new data)

4.3 Factor of persons (for the tendency that the rollover ratio of all vehicle models increased from old to new data)

4.3.1 Change of age composition of drivers

To analyze factors of persons, we examined the component rate of drivers by age. (Fig.11). Age groups were classified into young group (24 years old or younger), middle-aged group (25 to 64 years old), and elderly group (65 years old or older). The ratio of elderly drivers in rollover accidents is higher for small sized vehicles compared with medium sized vehicles, and the ratio increased from old data to new data.

Fig.11 Variation with time of the component rate of drivers by age (rollover vehicles)

4.3.2 Relations between rollover ratio and elderly drivers

Next, we examined the relations between elderly drivers and rollover ratio. In Figs.12 and 13, the component rate and rollover ratio of elderly drivers are plotted by vehicle model on the graphs. Although the correlation between elderly drivers and rollover ratio was weak in old data, strong positive correlation (R=0.81) was found in new data. There is a possibility that, with the change of times, behavioral characteristics of elderly people has some kind of effect on rollover of vehicles.

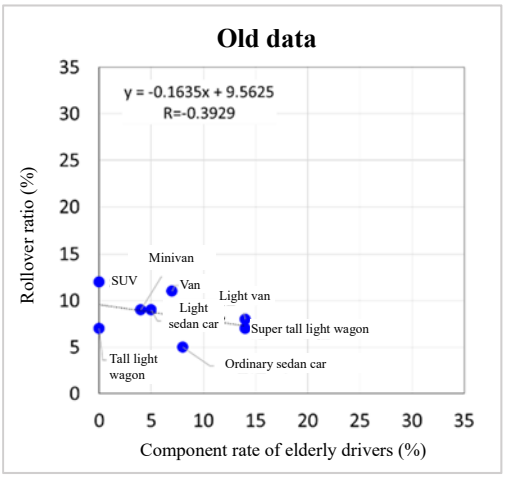

Fig.12 Relations between elderly drivers and rollover ratio (old data)

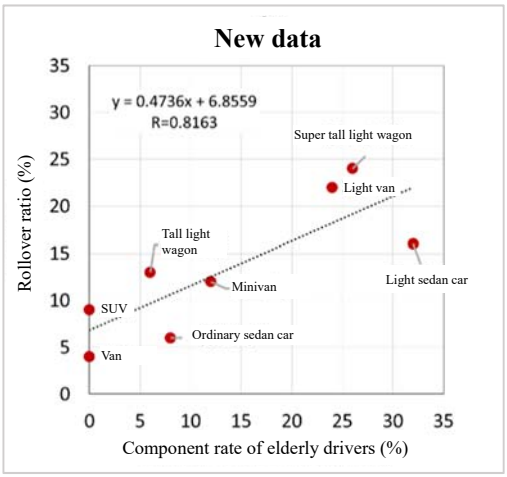

Fig.13 Relations between elderly drivers and rollover ratio (new data)

5. Summary

As a result of examining the change of rollover accidents using new and old micro data, the following was found in the examples used this time.

- The vehicle rollover ratio increased. The change of vehicle model constitution can be considered as main factor for such increase.
- The tendency to increase the rollover ratio is smaller in single vehicle accidents than that of vehicle-vehicle accidents. There is a possibility that the obligation to equip vehicles with ESC will be more effective for suppressing the occurrence of rollover accidents of single vehicles.
- Simple "SSF", which is rollover evaluation index of U.S. NCAP, has strong correlation with rollover ratio and can be used for evaluating easiness of rollover of vehicles.
- There is a possibility that the aging of drivers has affected an increase in the rollover ratio.

<References/Sources>

1) ITARDA(交通事故総合分析センター), 2006 年, 予防安全に関する調査研究車両の転覆及び走行レーンに関する事故実態研究, 引用 116 ページ-引用 127 ページ

2) Euro NCAP, 2011 年, THE DYNAMIC TEST OF CAR ELECTRONIC STABILITY CONTROL (ESC) SYSTEMS PROTOCOL, 引用 1 ページ-引用 3 ページ

3) 本宮　嘉弘, 高塚　尚和, 2017 年, 軽微な事故で横転する軽ハイトワゴンの危険性, 日本交通科学学会誌, 第 17 巻(第 2 号), 引用 34 ページ-引用 41 ページ

4) S.P.Santosa, A.Jusuf, L.Gunawan, K.A.Abu Kassim, M.L.Hakim, and B.P.E.Wiranto, 2018 年, Rollover Risk Probability Analysis for SUVs and MPVs in the ASEAN Market, 自動車技術会マレーシア支部誌, 第 2 巻(第 3 号), 引用 279 ページ-288 ページ

5) Jia-Ern Pai, 2017年, Trends and Rollover-Reduction Effectiveness of Static Stability Factor in Passenger Vehicles, DOT HS 182 444, 引用62ページ-引用132ページ