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Pedestrian Accident Analysis Focusing on Vehicle Evolution and Human Age —Taking Population Aging Into Account—

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1. Introduction

For the first time, a target for reducing serious injuries[a] was set forth in the 11th Basic Plan for Traffic Safety formulated in March 2021. The target set for serious injuries is 22,000 or less by 2025 which, when combined with the target for fatalities of 2,000 or less, results in a combined target of 24,000 or less for fatal and serious injuries.

In 2020, the number of fatal and serious injuries was 30,613. Of these, 8,000 were suffered while walking, which was higher than the 7,895 suffered while riding a vehicle and is the highest number in a single year. For these reasons, this paper focused on fatal and serious injury accidents suffered by pedestrians. By looking at the trend in numbers of pedestrian fatal and serious injuries involving small- and medium-sized passenger vehicles, although some years show a slight fluctuation, it can be seen that these numbers are decreasing long-term and that frontal impact crashes involving pedestrians are high in number (see Fig. 1).

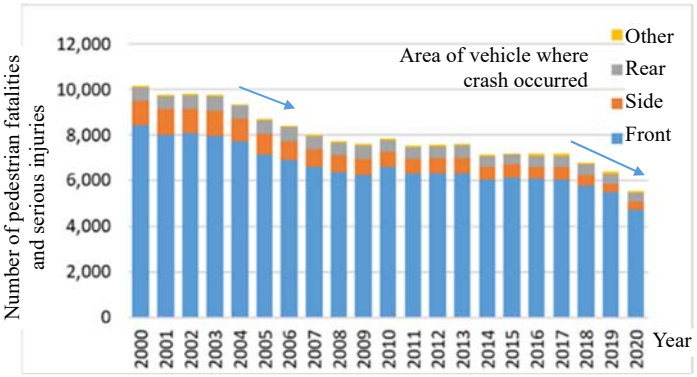


Fig. 1. Trend in numbers of pedestrian fatal and serious injuries (involving small- and medium-sized passenger vehicles)

In an attempt to reduce pedestrian accidents and injuries, both improvements in vehicle crash safety performance and the adoption of various types of preventive safety systems are being promoted. For example, in terms of crash safety performance, the JNCAP (Japan New Car Assessment Program), which evaluates the safety performance of new vehicles, began evaluating pedestrian head protection performance in 2003 and leg protection performance from 2011 in an attempt to improve vehicle performance in these areas. JNCAP has also made steps in terms of preventive safety, such as starting evaluations of damage mitigation brakes for pedestrians (daytime) from 2016. Although it is assumed that the effects of these improvements are included among the reductions shown in Figure 1, the bars above the accident years show totals that combine those for both old vehicles and new vehicles, preventing the effects of these enhancements from being clarified.

In this paper, vehicles were categorized by the year of full-model change (Mo.CY) and an attempt was made to quantitatively clarify whether numbers of pedestrian accidents are decreasing for newer vehicle groups. Furthermore, remaining issues for the newest vehicle types were elaborated on by taking the ages of drivers and pedestrians into account.

[a] "Serious injury" refers to an injury requiring 30 or more days of treatment.

2. Analysis subjects and evaluation indicators

2-1. Grouping of vehicle classes

Vehicle classes as defined by the Japan Automobile Manufacturers Association (JAMA) are as shown in Table 1[b]. These are based on a list from the end of 2019 in which vehicles are classified as belonging to one of three groups: small-sized passenger vehicles (or K-cars), medium-sized sedan-type passenger vehicles (total height of less than 1,600 mm), and SUVs (total height of 1,600 mm or more).

Table 1. Vehicle classes

	Class	Definition
Small-sized passenger vehicles	Small-sized sedan	Two- or three-box with overall height of 1,400 mm or more
	Small-sized sports	Two- or three-box with overall height of less than 1,400 mm
	Small-sized one-box	One-box
	Small-sized SUV	Two-box with overall height of 1,600 mm or more Minimum ground clearance of 180 mm or more
Medium-sized passenger vehicles	Sedan M1	Sedan three-box with overall height of 1,400-1,600 mm Engine displacement of 2,000 cc or less or max. output of 120 kw or less
	Sedan M2	Sedan three-box with overall height of 1,400-1,600 mm Engine displacement above 2,000 cc or max. output above 120 kw
	SUV	Two-box with overall height of 1,600 mm or more Minimum ground clearance of 180 mm or more
	Sedan S1	Sedan two-box with overall height of 1,400-1,600 mm Engine displacement of 2,000 cc or less or max. output of 120 kw or less
	Sedan S2	Sedan two-box with overall height of 1,400-1,600 mm Engine displacement above 2,000 cc or max. output above 120 kw
	Sporty	Two- or three-box with overall height of less than 1,400 mm
	Station wagon	Two-box with overall height of 1,400-1,600 mm, luggage room of 1 m^2 or more in principle
	Tall wagon	Two-box with overall height of 1,600 mm or more
	Minivan A	Two-box with overall height of 1,400-1,600 mm, three rows of seats
	Minivan B	Two-box with overall height of 1,600 mm or more
	One-box A	One-box with overall height of 1,600 mm or more
	One-box B	One-box with overall height of 1,600 mm or more

2-2. Groupings by year of full-model change and number of vehicle registrations

Groupings by year of full-model change or year of new model introduction (Mo.CY) were segmented across three years (2003, 2011, and 2016) based on the information explained in the previous section "1. Introduction".

The number of vehicle registrations was calculated by first obtaining information on the number of registered vehicles by model name at the end of each year from (1) end of 2016 to (5) end of 2020 using a formula such as that below.

Example: Number of vehicle registrations in 2017 = (end of 2016 +end of 2017)/2

Total number of vehicle registrations for 4 years = 2017 + 2018 + 2019 + 2020 (number of vehicle registrations in each year)

By calculating in this manner, the total number of vehicles of a particular model name (by Mo.CY) owned over a four-year period was obtained. Table 2 shows a summary for the total number of vehicle types and total number of registered vehicles for each group.

	Small-sized passenger vehicles		Medium-sized passenger vehicles			
			Sedan		SUV	
Mo.C Year	No. of vehicle types	Total number of registered vehicles	No. of vehicle types	Total number of registered vehicles	No. of vehicle types	Total number of registered vehicles
2000-2002	12	6,273,131	52	7,870,861	34	8,306,732
2003-2010	47	36,455,164	99	36,032,654	65	27,724,360
2011-2015	38	29,783,397	61	23,646,674	37	15,962,985
2016-2019	20	4,981,993	39	3,531,140	25	4,552,585
Total	117	77,493,684	251	71,081,328	161	56,546,660

Table 2. Number of vehicle types in each group and total number of vehicle registrations
(for 4 years from 2017 to 2020)

[b] Although each class has its own definition, the class applied by the automobile manufacturer is ultimately prioritized when determining individual vehicle types.

3. Analysis of reductions in pedestrian fatal and serious injury accidents due to vehicle evolution

3-1. Accident data

Accident data subjected to analysis is as follows:

Type of accident: Pedestrian accidents

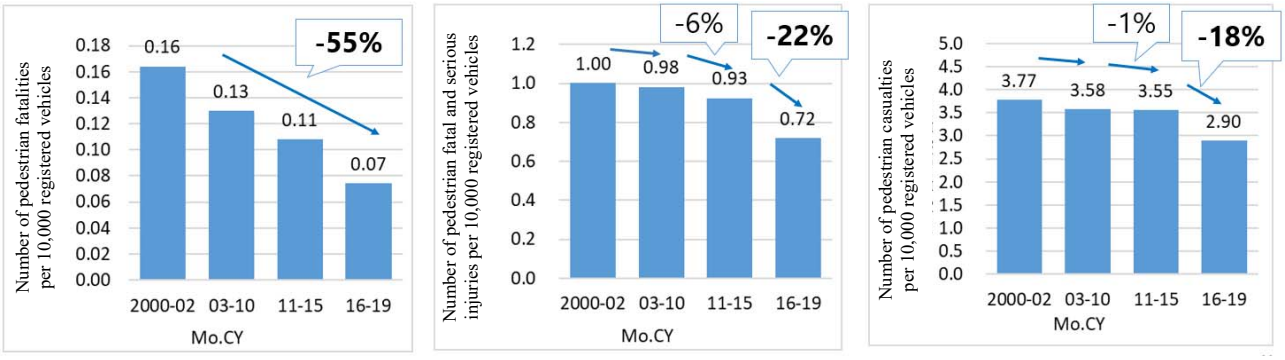
Area of vehicle where crash occurred: Front (front + right-front + left-front)

Accident years: 2017 to 2020 (4 years in total)

Here, the number of accidents in each group from Table 2 was totaled, divided by the number of registered vehicles, and then analyzed by the indicator "per 10,000 registered vehicles".

3-2. Analysis results

Analysis results for small-sized passenger vehicles are shown in Figure 2. Using data for the same period over the four years from 2017 to 2020, fatalities, fatal and serious injuries, and casualties (fatalities + serious injuries + slight injuries) were compared based on Mo.CY group. Fatalities are decreasing the newer the group, with a 55% decrease being seen when comparing the periods 2000 to 2002 and 2016 to 2019. Although fatal and serious injuries and casualties are not decreasing at the rate of fatalities, a 22% decrease in fatal and serious injuries and an 18% decrease in casualties can be seen when comparing the periods 2011 to 2015 and 2016 to 2019.



Fatalities　　Fatal and serious injuries　　Casualties

Fig. 2. Number of people by degree of injury per 10,000 registered vehicles by Mo.CY for small-sized passenger vehicles (or K-car) (2017 to 2020)

4. Issue analysis

4-1. Analysis items

In order to identify issues for which initiatives should be undertaken in the future, general trend analysis was performed on the items shown in Figure 3 and on the differences between Mo.CY groups.

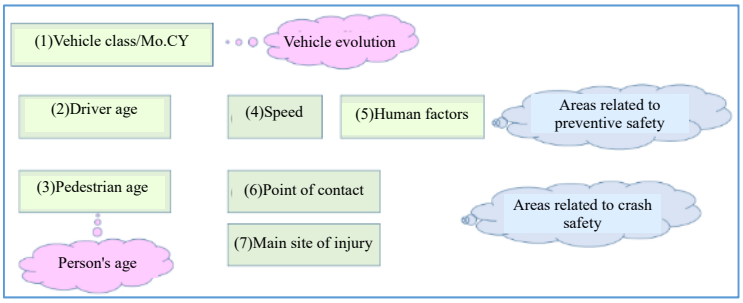


Fig. 3. Overall view of analysis items

4-2. Changes in speeds and driver age groups

Figure 4 shows the number of pedestrian fatal and serious injuries in 2000 and 2020 distributed by danger perception speed. Although the percentage of accidents in 2000 that occurred at 20 km/h or less was 34%, by 2020, because of significant decreases in the number of accidents at medium and high speeds, the percentage of accidents that occurred at 20 km/h had risen to 53%, indicating the increased importance of addressing low-speed accidents.

Also, as shown by the color-coded driver age groups in the graph, the percentage of drivers in the age groups of 24 and under and 25 to 34 had decreased significantly in 2020 compared to their relatively large percentage in 2000, indicating that the number of pedestrian fatal and serious injuries caused by elderly drivers and occurring at low speeds is increasing.

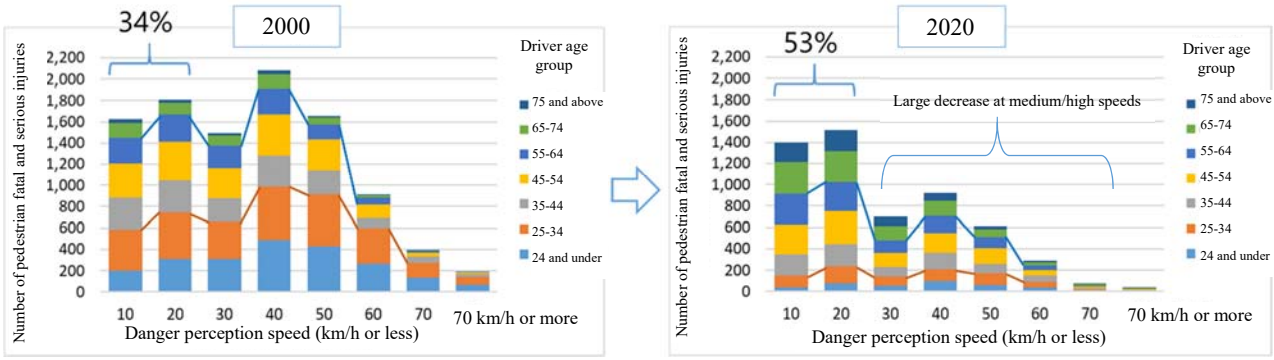
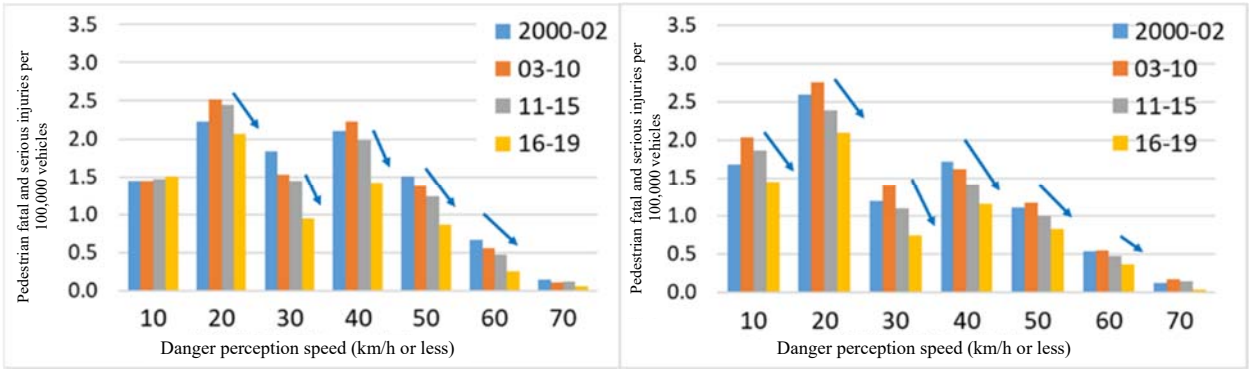


Fig. 4. Danger perception speed and driver age group in accidents resulting in pedestrian fatal and serious injuries (2000 and 2020) and caused by drivers of medium- and small-sized passenger vehicles

4-3. Reductions by Mo.CY by speed

Figure 5 shows numbers of pedestrian fatal and serious injuries compared by Mo.CY groups of small- and medium-sized sedan-type passenger vehicles and distributed by speed, with the vertical axis representing the number of fatal and serious injuries per 100,000 registered vehicles. In the case of small-sized passenger vehicles, although there was no decrease at speeds of 10 km/h or less, speeds above that showed a decreasing trend. In the case of sedan-type vehicles, decreasing trends could be seen across all speed ranges. In both cases, there were a large number of pedestrian fatal and serious injuries at a speed of 20 km/h or less.



Small-sized passenger vehicles Medium-sized sedan-type passenger vehicles

Fig. 5. Comparison of pedestrian fatal and serious injuries by Mo.CY by danger perception speed (totals for 2017 to 2020)

4-4. Human factors

Figure 6 shows human factors in pedestrian fatal and serious injury accidents broken down by driver age group. Although cognition errors were highest for all age groups, the percentage of operational errors was high in the case of drivers aged 75 and above. In 2020, there were 44 instances of operational errors committed by drivers aged 75 and above. Looking at a detailed breakdown, 31 of these, or roughly 70%, were caused by misapplication of the brake and accelerator pedals.

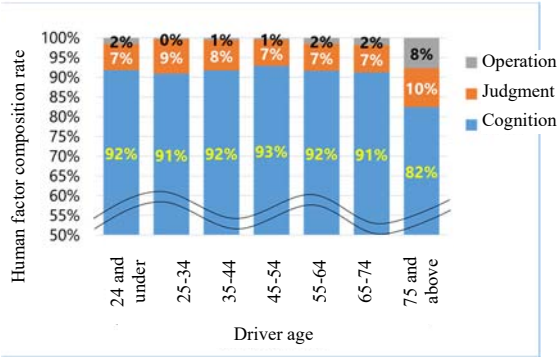


Fig. 6. Human errors in pedestrian fatal and serious injuries caused by drivers of medium- and small-sized passenger vehicles in 2020

4-5. Point of contact and injury site

Figure 7 shows rates of pedestrian fatal and serious injuries by age group for vehicles with a Mo.CY between 2016 and 2019. As shown in Figure 4, this shows that more than half of fatal and serious injury accidents occur at a danger perception speed of 20km/h or less. In the case of small-sized and sedan-type passenger vehicles, it is starting to be seen that more than 10% of fatal and serious injury accidents involve pedestrians aged 55 and older, or pedestrians of 45 and older in the case of SUVs. Although the number of pedestrians aged 12 and under also appears high, because the number of fatal and serious injuries is low at 5 or less, it was not discussed here.

Rate of fatal or serious injury	2016 to 2019 Mo.CY, Point of contact: Vehicle body		
Pedestrian	Small-sized	Sedan	SUV
6 and under	38%	0%	0%
7-12	13%	10%	13%
13-24	5%	6%	0%
25-34	7%	2%	4%
35-44	8%	6%	3%
45-54	9%	7%	13%
55-64	13%	14%	7%
65-74	18%	23%	16%
75-84	32%	38%	21%
85 and above	48%	29%	57%

Fig. 7. Rates of pedestrian fatal and serious injuries by age group in accidents that occurred between 2017 and 2020
at a danger perception speed of 20 km/h or less

When analyzing injury sites, in the case of small-sized and sedan-type passenger vehicles, it can be seen that the chest and abdomen were the main sites that suffered the most injuries among pedestrians aged 65 and older. In the case of SUVs, pedestrians aged 45 to 54 also suffered serious injuries to the chest, back, and legs. For the elderly, multiple cases were observed in which arms suffered the most serious injuries.

5. Summary

5-1. Findings

(1) Through this research, it was confirmed that grouping vehicles by year of full-model change showed that the newer the vehicle, the lower the number of pedestrian accidents.

(2) As for long-term changes, it was clarified that a high percentage of pedestrian fatal and serious injury accidents are caused by elderly drivers, and that the high percentage of low-speed accidents was due to decreases in accidents occurring in the middle- and high-speed ranges.

(3) The percentage of pedestrian fatal and serious injuries caused due to operational errors committed by drivers aged 75 and above was high, with accelerator and brake pedal misapplication making up a large percentage

of such errors.

(4) Serious injuries are even occurring at low speeds of 20 km/h or less, and middle-aged and elderly pedestrians are at a particularly high risk.

5-2 Future issues for research

Future issues for research derived through this research are as follows:

(1) Research aimed at low-speed pedestrian accident avoidance

(2) Research on accident-avoidance support systems for elderly drivers
(Ex.: Acceleration control devices for preventing pedal misapplication that also detect pedestrians)

(3) Research to investigate the mechanism of serious injuries that occur to the chest, abdomen, back, and legs at low speeds of 20 km/h or less, as well as research to determine whether countermeasures for such injuries are possible

<Sources>

(1) 近藤直弥、2020 年、「軽乗用車の衝突被害軽減ブレーキ(AEB)の効果分析」、イタルダインフォメーション(No.133)