イタルダ インフォメーション

ITARDA INFORMATION

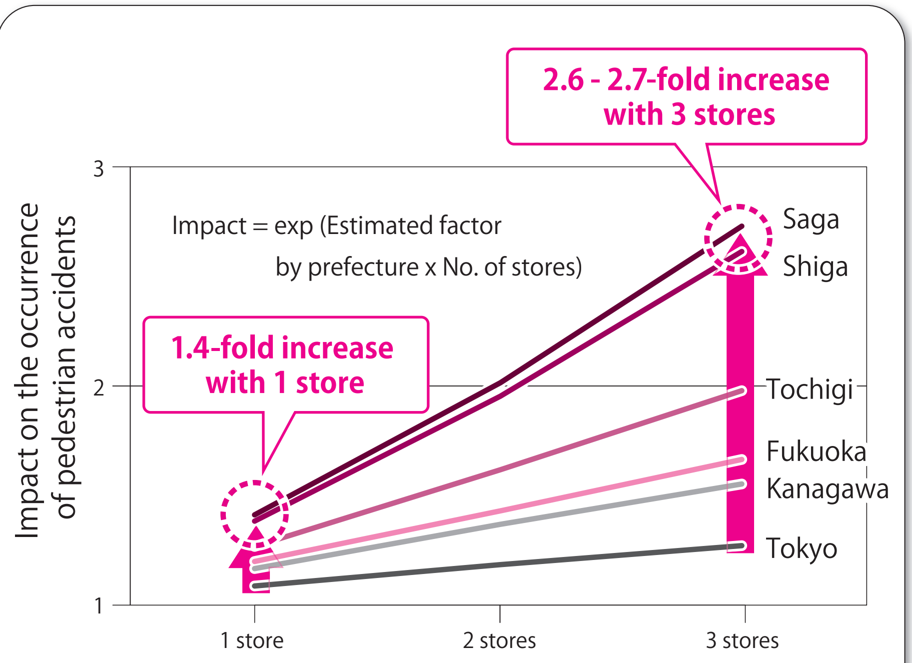
交通事故分析レポート No.120

Special feature

Correlation analysis between land use characteristics and pedestrian accidents

~ Caution is needed in sections with convenience stores, particularly in rural areas! ~

The probability of a pedestrian accident occurring increases in sections with convenience stores



Estimated results of the impact that the number of convenience stores has on the occurrence of pedestrian accidents

1 Introduction

As Fig. 1 indicates, 1,534 of the 4,117 fatalities from traffic accidents in 2015 were from accidents that occurred while the person was walking, with this accounting for roughly 40% of the total. Fig. 2 shows the percentages of casualty accidents that occurred while walking, while riding a bicycle, or by other type. Accidents while walking constitute a high percentage of fatal and serious injury accidents compared with the other types, with this being roughly double those of accidents while riding a bicycle. This shows the extent to which accidents while walking tend to lead to serious accidents. It will be important to reduce accidents while walking (hereafter referred to as "pedestrian accidents") by as much as possible in order to reduce the number of traffic accident fatalities resulting from them.

Therefore, this issue focuses on the characteristics of regions that are strongly correlated with the occurrence of pedestrian accidents in order to calculate the impact on accident occurrence as a statistical probability.

In addition, based on this impact, we performed an analysis on the degree of risk within sections (in units of 500m²) by estimating the number of pedestrian accidents that occurred within each section.

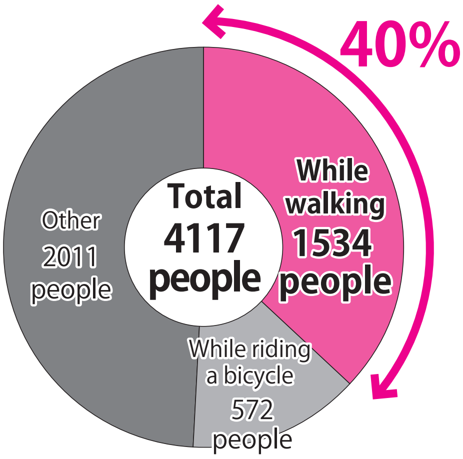


Fig. 1. Number of fatalities by type (2015)

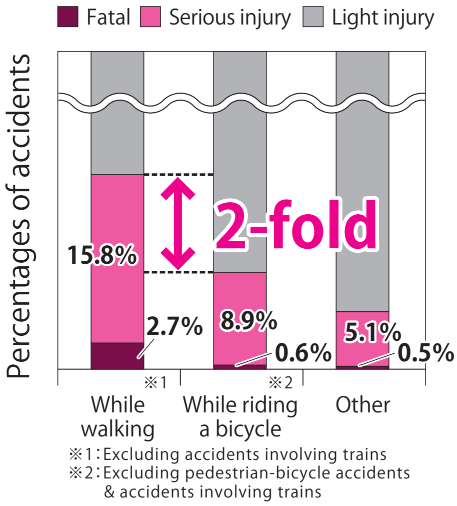


Fig. 2. Percentage of fatal and serious injury accidents (2015)

2 Characteristics of regions that are strongly correlated with the occurrence of pedestrian accidents

Fig. 3 shows the relationship between the number of pedestrian accidents per 100,000 people versus the population of each of the 47 prefectures throughout Japan. Tokyo, Kanagawa Prefecture, and Fukuoka Prefecture were selected from the group with populations that are higher than the national average, and Tochigi Prefecture, Shiga Prefecture, and Saga Prefecture were selected from the group with populations lower than the national average as subjects for analysis. They were selected so as to produce variance in terms of the number of accidents per 100,000 people.

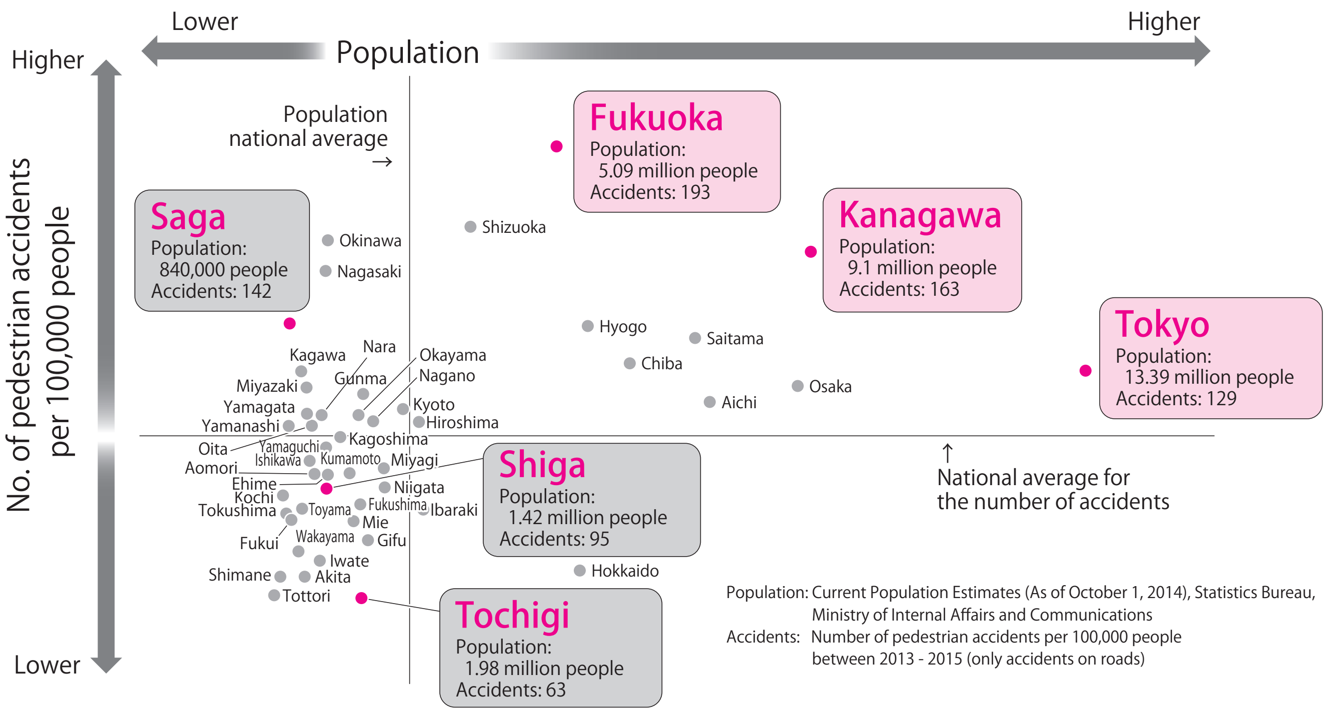


Fig. 3. Comparison chart of the population per prefecture and the number of pedestrian accidents per 100,000 people

The first thing we focused on to derive the characteristics of regions that are strongly correlated with the occurrence of pedestrian accidents was population. Fig. 4 shows the correlation between the number of pedestrian accidents and population by area classification. The graph divided up by 10km^2 units in (1) reveals that the number of accidents is very highly correlated with population, with more pedestrian accidents occurring the more people there are in a section. However, as (2) and (3) show, the smaller these area classifications are, the weaker this correlation becomes and the more the variance increases. This indicates that the correlation with the number of pedestrian accidents in the 500m^2 units of (3) cannot be explained solely by population.
The population data used here is data on the resident population, and therefore the amount of pedestrian traffic cannot be expressed solely through this data. For example, one would expect to see a great deal of pedestrian traffic even in sections with a small population, so long as there are a large number of shops located there.

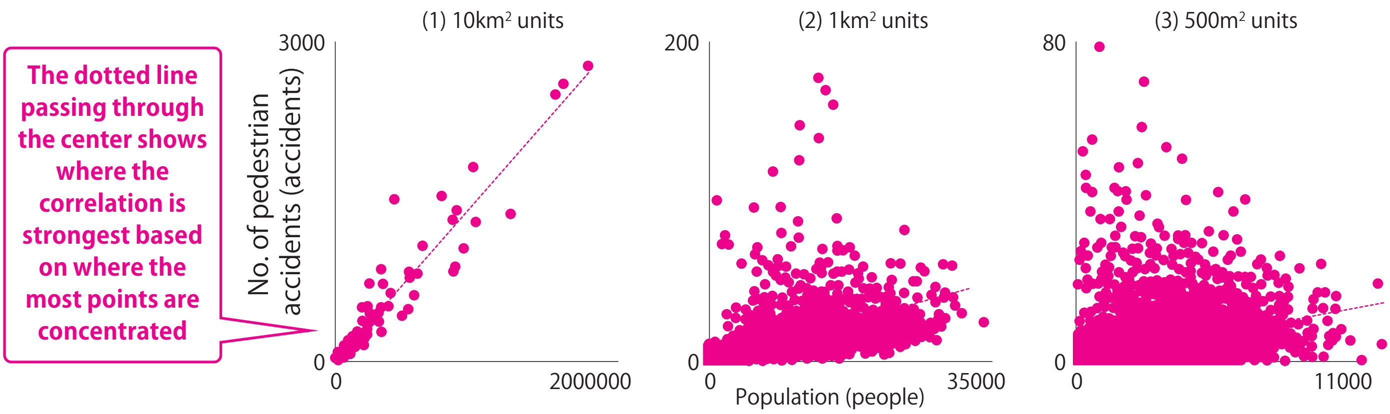


Fig. 4. Correlation between the number of pedestrian accidents and population by area classification

Therefore, we felt that we needed items other than population that would express the amount of pedestrian traffic. So for our analysis of 500m^2 units we added information on the following 17 items in order to perform a detailed analysis. We performed a number of analyses in order to deduce which of these were particularly strongly correlated with the occurrence of pedestrian accidents. Of these, here we will introduce the results of a correlation analysis and a decision tree analysis.

- Area by type of land usage [(1) Area of residential districts, (2) Area of commercial districts, (3) Area of industrial districts, (4) Other]
- (5) Building site area (area of places where buildings are tightly packed in residential areas and urban areas)
- The number of stores and facilities [(6) Convenience stores, (7) Department stores and supermarkets, (8) Hospitals, (9) Fast food restaurants, (10) Banks, (11) Gas stations, (12) Schools]
- (13) Road length (14) Number of intersections (15) Distance from station
- Population [(16) Net population, (17) Population whose only means of transport is walking to work / school]

The results of the correlation analysis are shown in Fig. 5. A correlation analysis is a technique for expressing the strength of the correlation between two items. The closer the correlation coefficient, which expresses the depth of the connection between the two items, is to 1 (when one item increases the other one also increases), the stronger the correlation. This was performed first in order to verify the extent to which it contributed to the occurrence of accidents. According to this analysis, 11 of the 17 items mentioned above had a correlation coefficient of 0.5 or greater.

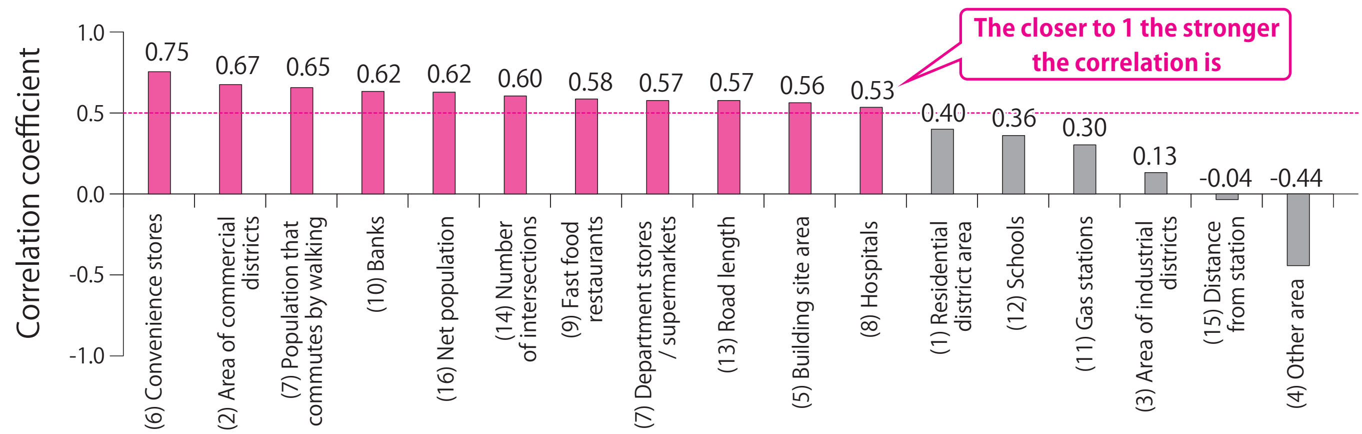


Fig. 5. Correlation coefficient between the number of pedestrian accidents and the related items for 500m^2 units

Next, we performed a decision tree analysis on the 11 items. A decision tree analysis is a technique for effectively dividing data up into groups. By analyzing which items are optimal to use in dividing up those sections with lots of pedestrian accidents and those sections with few accidents into groups, we were able to select the items that are strongly tied to the occurrence of pedestrian accidents.

Fig. 6 shows the results of this for Shiga Prefecture as an example. From this we learned that a combination of the number of convenience stores, the area of commercial districts, and the building site area allowed us to sort this most neatly. In other words, sections where the values for these three types of land use characteristics are larger, are more prone to the occurrence of pedestrian accidents. Similar results were found for the other five prefectures besides Shiga Prefecture.

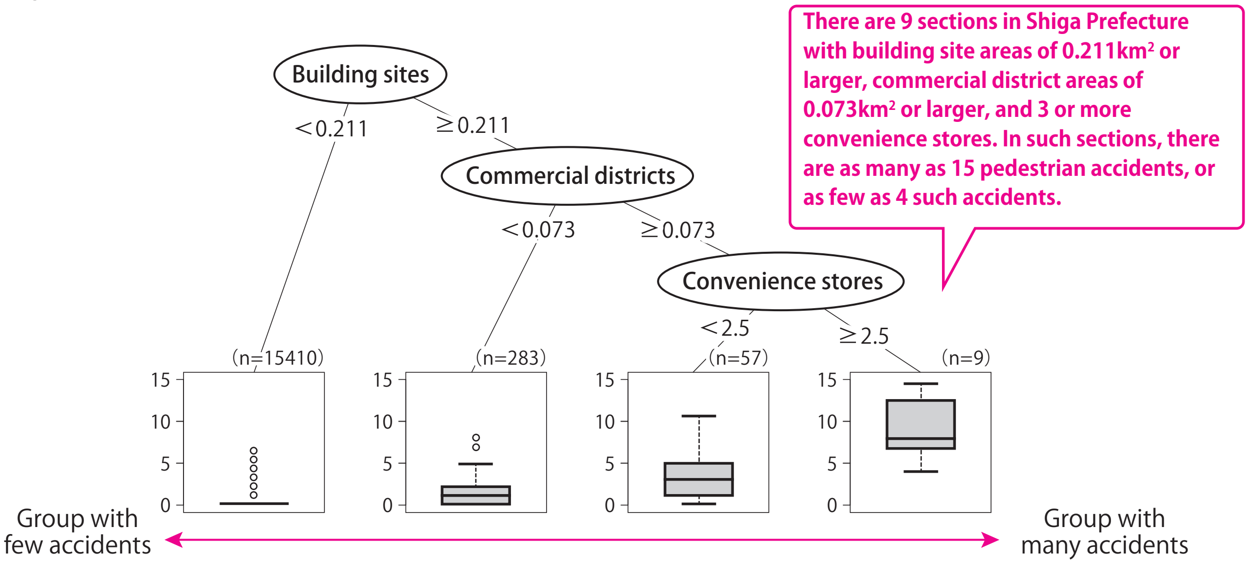


Fig. 6. Results of the decision tree analysis based on the number of convenience stores, area of commercial districts, and building site area in Shiga Prefecture

3 Impact on the occurrence of pedestrian accidents

We used a statistical model to calculate the impact that the three land use characteristics derived in the previous section have on the occurrence of pedestrian accidents.

■ Impact that the number of convenience stores has on the occurrence of pedestrian accidents

Fig. 7 shows the calculation results for the impact that the number of convenience stores has on the occurrence of pedestrian accidents. In Tokyo, the number of convenient stores does not have that great of an impact on the number of accidents, regardless of whether there is one store or three stores. Yet conversely, the results for Saga Prefecture and Shiga Prefecture show that sections with one convenience store saw a 1.4-fold increase in accidents, while sections with three convenience stores saw a 2.6 - 2.7-fold increase.

It is conjectured that since convenience stores are built in areas with a great deal of pedestrian traffic, pedestrian accidents tend to occur in the areas around them. But from just looking at the results from these six prefectures, we see that the impact this has on the occurrence of traffic accidents is greater in rural areas. In urban areas where there are numerous convenience stores the people are dispersed, whereas in rural areas with a few convenience stores the percentage of people that gather together at each store increases. Therefore, this increases the probability that a vehicle will collide with a pedestrian.

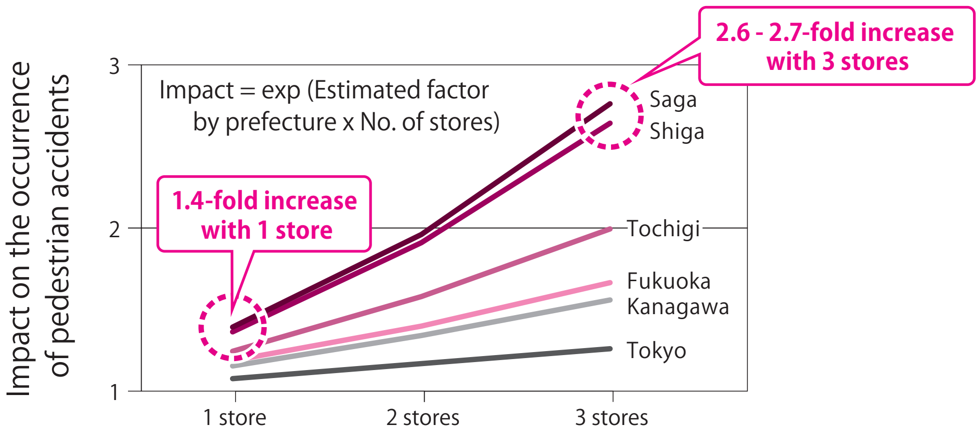


Fig. 7. Estimated results of the impact that the number of convenience stores has on the occurrence of pedestrian accidents

■ Impact that the area of commercial districts has on the occurrence of pedestrian accidents

Fig. 8 shows the calculation results for the area of commercial districts. The estimated results obtained were largely identical everywhere, except for Tochigi Prefecture. Since the area of a single section is about 0.26km², sections that primarily consist of commercial districts in the five prefectures are roughly three-times more prone to accidents than sections that do not contain these.

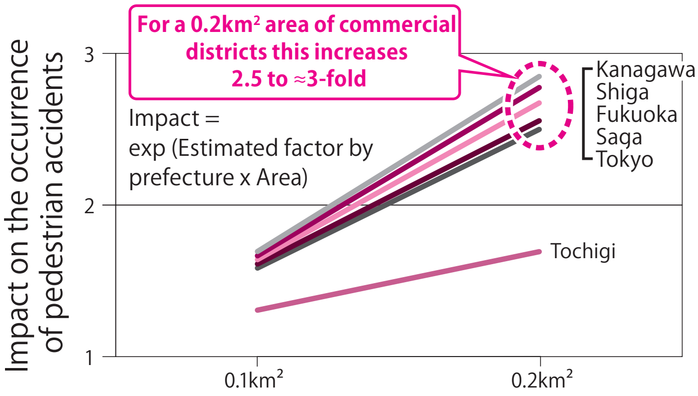


Fig. 8. Estimated results of the impact that the area of commercial districts has on the occurrence of pedestrian accidents

■ Impact that the building site area has on the occurrence of pedestrian accidents

Fig. 9 shows the calculation results for the building site area. Apparently, the greater the building site area is in a section the more prone to accidents the section will be, which is true everywhere except for in Tokyo. This tendency appears to be particularly strong in Saga and Tochigi Prefectures.

In regions where buildings are closely packed, not only are there numerous pedestrians, there are also numerous blind spots due to the buildings. As a result, as the area of these regions grows larger it is believed that accidents become more likely to occur. The impact from this overall tendency does not appear to be all that strong in Tokyo.

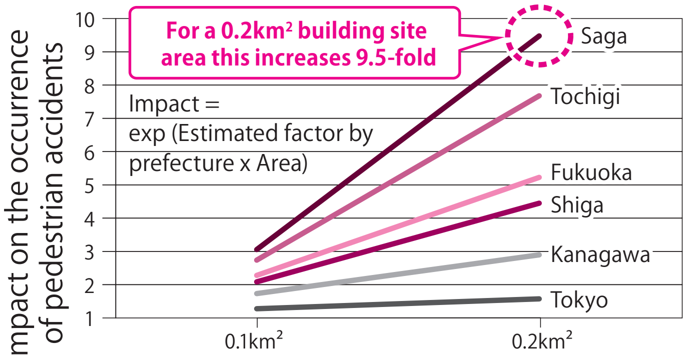


Fig. 9. Estimated results of the impact that the building site area has on the occurrence of pedestrian accidents

4 Estimates of the number of pedestrian accidents

Based on the impact on the occurrence of pedestrian accidents that was calculated, we calculated estimated figures for the number of accidents in each section (500m² units). Fig. 10 shows an image of four sections in Shiga Prefecture that were selected as examples, while Fig. 11 shows the estimated results for these same sections. For example, in the section in the top right, 14 pedestrian accidents occurred over a three-year period. This section has three convenience stores, a building site area of 0.25km², and an area of commercial districts of 0.24km². Since a single section has an area of roughly 0.26km², more than 90% of this section consists of building sites and commercial districts.

The estimated results for the number of accidents calculated by plugging the actual measurement results for these three land use characteristics (number of stores, area), and each impact on the occurrence of pedestrian accidents, into a model equation resulted in a median value (most highly probable number of accidents) of 16 accidents. This result is most likely within the range of 10 - 24 accidents, with a probability of 95%.

In this manner, we calculated the estimated values for the number of accidents in every section. The results we obtained showed that the actual number of accidents was within ±2 accidents of the median values for the estimated number of accidents in more than 90% of the sections.

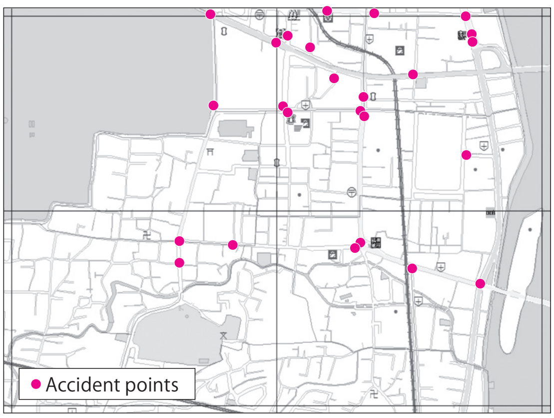


Fig. 10. Image of the four sections in Shiga Prefecture

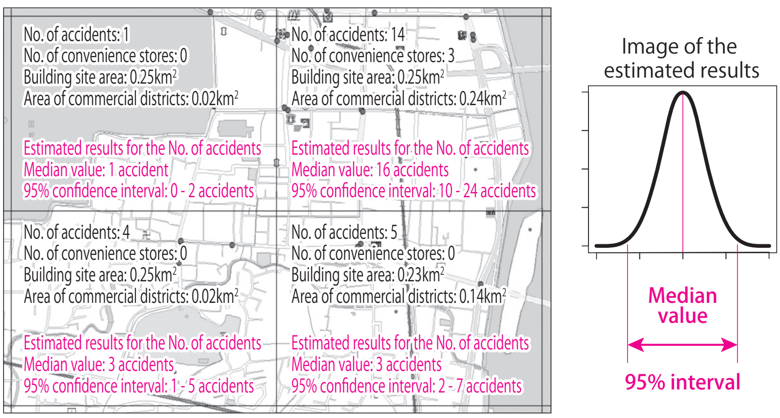


Fig. 11. Estimated results for the number of pedestrian accidents in the same sections from Fig. 10

5 Introducing sections where the actual number of accidents vastly exceeds the estimated number of accidents

For the comparison, we will start by introducing a section where there is no difference between the actual number of accidents and the estimated number of accidents. Fig. 12 shows a section located in Ota Ward, Tokyo as an example. It has four convenience stores, a building site area of 0.25km^2, and a commercial district area of 0.09km^2. Five pedestrian accidents occurred over a three-year period, with the median value for the estimated number of accidents at five. The majority of sections with five pedestrian accidents in Tokyo are these sorts of comparatively bustling areas with a large number of buildings.

Fig 12. Sample section with no difference between the actual number of accidents and the estimated number of accidents (Ota Ward, Tokyo)

Next we will introduce a section where the actual number of accidents vastly exceeds the estimated number of accidents.

Fig. 13 shows a section located in Ome City, Tokyo. It has zero convenience stores, a building site area of 0.1km^2, and a commercial district area of 0km^2. Given the odds, it would be reasonable to assume that there would be one accident there, but in actuality five pedestrian accidents have occurred there. Four of the five accidents occurred at intersections surrounded by corners. Based on a reading of the accident data, it is believed that three of these accidents were between pedestrians and vehicles making right turns from north to west. The photograph on the bottom right-hand side shows the central intersection as seen from north to south.

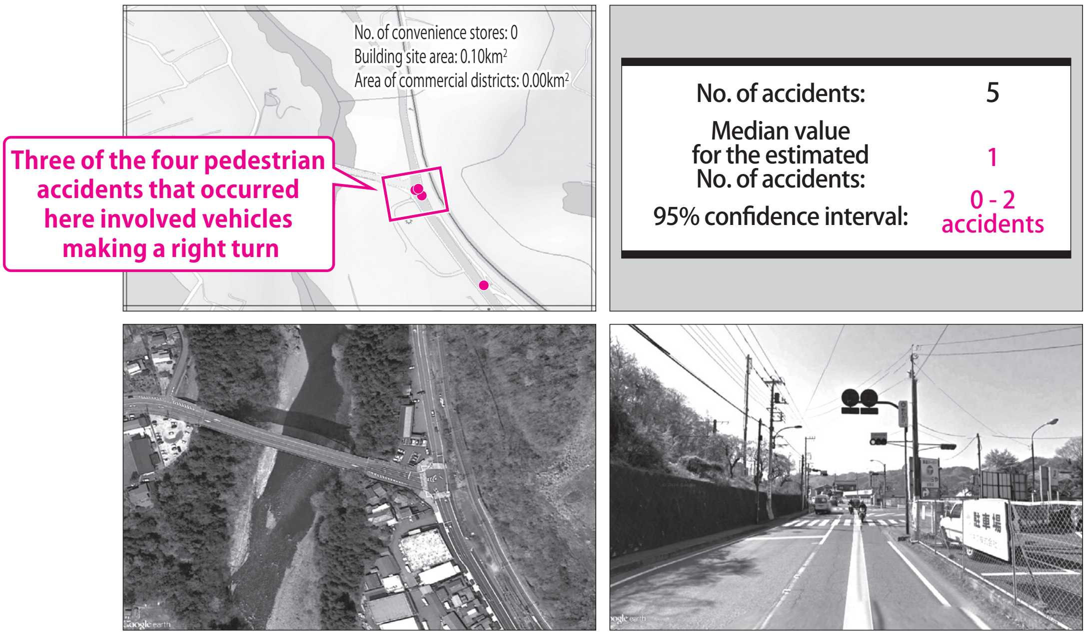


Fig. 13. Sample section where the actual number of accidents vastly exceeds the estimated number of accidents (Ome City, Tokyo)

There are a number of these sections where the actual number of accidents vastly exceeds the estimated number of accidents, including those in the other prefectures as well. With respect to the causal factors behind this, since the circumstances differ in each respective section, we feel that a detailed analysis would be needed for each section. But a tendency for there to be a high percentage of accidents involving vehicles making a right turn stood out as an overall characteristic. Fig. 14 shows the percentage of the number of pedestrian accidents involving a vehicle making a right turn in sections where the actual number of accidents vastly exceeds the estimated number of accidents, versus those in sections where this was not the case. From this we learned that in every prefecture, in those sections where the actual number of accidents vastly exceeded the estimated number there was a higher percentage of accidents involving vehicles making right turns.

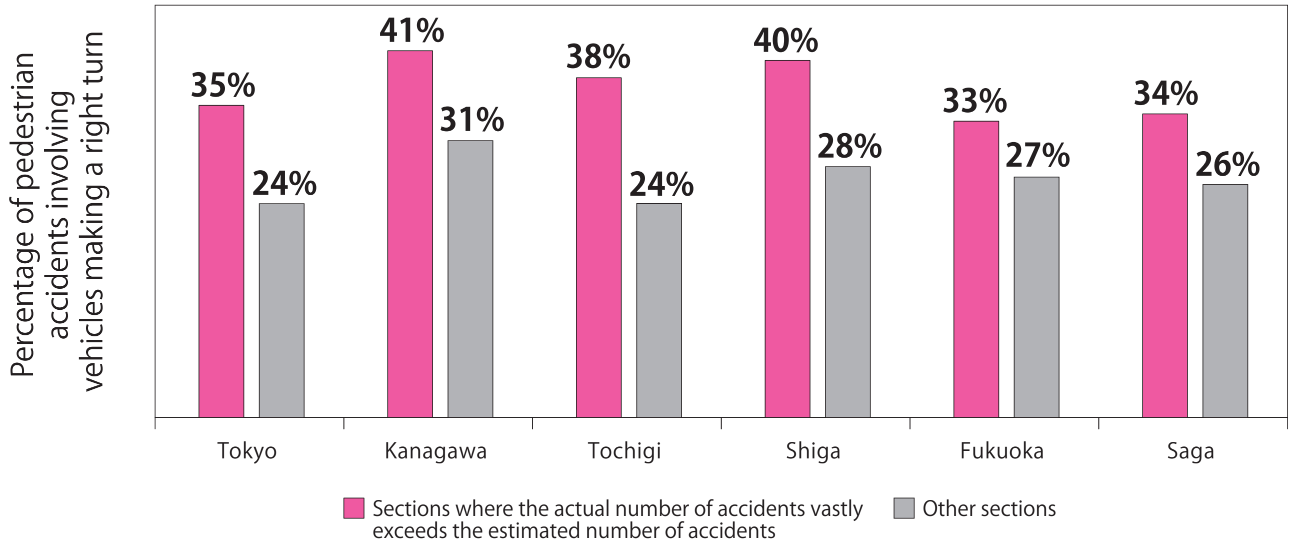


Fig. 14. Percentage of pedestrian accidents involving vehicles making a right turn

There is one other hypothesis to explain this. In those sections where the actual number of accidents vastly exceeds the estimated number of accidents, accidents tend to occur when the actual measured values for the three land use characteristics, such as the number of convenience stores, is lower. Therefore, while they tend to have less pedestrian traffic, many sections with less pedestrian traffic have a comparatively lower overall traffic volume. Regarding the intersection in Tokyo introduced in Fig. 13, to the extent that one checks the photographic image there does not appear to be much traffic volume. This intersection features a blind spot created by a sign on the right-hand side and other obstructions.
When this is expressed in the schematic diagram in Fig. 15, at the point in time in (1) it is thought that the driver entered the intersection without being aware of the pedestrian, who was behind a blind spot. If there had been a large volume of traffic, they would have come to a temporary stop at the point of time in (2). But in this situation they would not stop unless there was a car coming at them from head-on, and would have turned the wheel while paying attention to what was up ahead. It is possible that they were delayed in confirming the presence of the pedestrian due to the difficulty in looking backwards and to the right while turning the wheel.

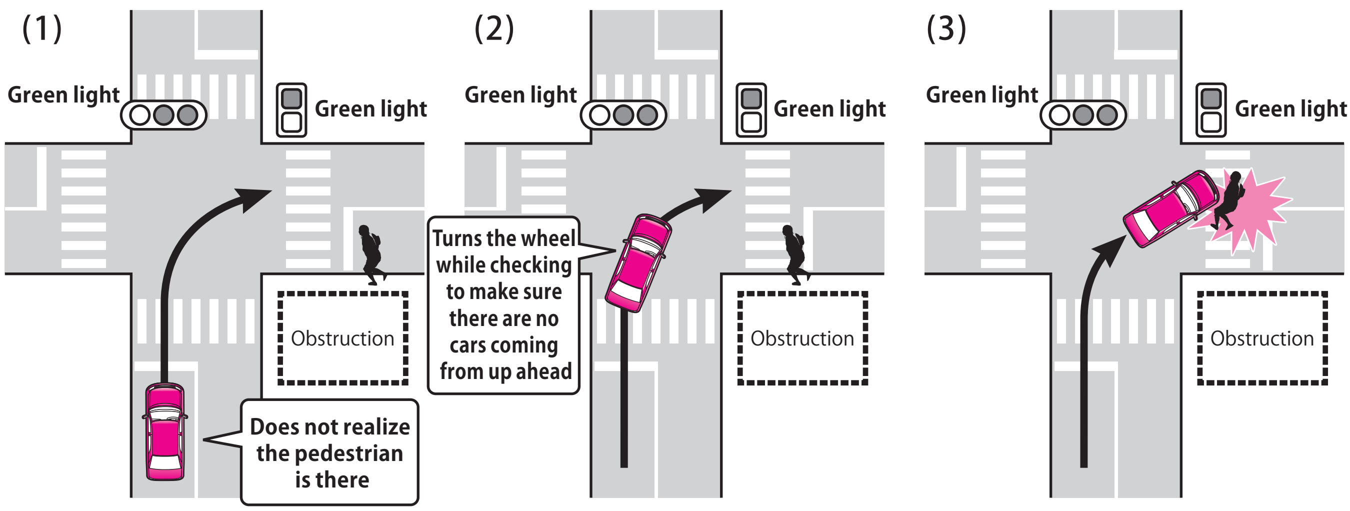


Fig. 15. Schematic diagram showing the (hypothetical) conditions at the intersection in Fig. 13

6 Conclusion

This analysis revealed that there is a strong connection between the number of convenience stores, area of commercial districts, and building site area with the number of pedestrian accidents that occur. Drivers, particularly those in rural areas, must make an effort to drive carefully in sections with convenience stores. In addition, they must drive cautiously while keeping in mind that there is a higher probability of colliding with pedestrians in sections where commercial districts and buildings are tightly packed.
Even in regions with little pedestrian traffic, there is the possibility that they will be delayed in confirming the presence of pedestrians, especially when turning right. Therefore, drivers must must reduce their vehicle's speed and thoroughly check to make sure there are no crossing pedestrians.

(Tomoko Kitano)

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For details regarding the contents herein, please refer to the materials from the 19th ITARDA Research Presentation Session (on the ITARDA homepage (address below)).

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