Analysis on Characteristics of Traffic Accidents in Nagano
- Statistical Accident Data Analysis for Accidents in Hilly and Mountainous Area -

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Received on June 12, 2018

ABSTRACT: In Nagano prefecture, fatal traffic accidents and fatalities have not decreased for these days compared to the whole of Japan. Especially, the number of fatalities increased in 2016 from the previous year by 76%. Nagano is one of local prefectures, which have mountainous area, cold and snowy district in Japan. It’s sure that a lot of traffic accidents occurred by remarkable local causes. Therefore, it is an imperative issue to analyze these real accident causes. This paper analyzed characteristics of traffic accidents in Nagano using statistical accident data by comparing Nagano with the whole of Japan. The data indicates Nagano has lots of vehicle alone fatal accidents, and accidents in hilly and mountainous area, where lots of roads have up-down slope and curve. Moreover, the cluster analysis using the rate of fatalities or fatal accidents shows that Wakayama, Yamanashi, Nara and Shiga prefecture have same statistical characteristics of traffic accident as Nagano. It is essential approach to analyze the common causes in these local prefectures to reduce fatal accidents in Japan effectively toward zero accidents.

KEY WORDS: safety, statistical accident analysis, accident investigation and analysis / Hilly and mountainous area [C1]

1. Introduction

The number of fatalities of traffic accidents in Japan in 2017 was 3,694, which was 5.4% reduction compared to the previous year. It starts to show steady trend of reduction in the whole of Japan (1). On the contrary, the number of fatalities in Nagano prefecture was 79 in 2017, which was 41.2% reduction compared to the previous year when the fatalities increased by 75.4%, but it has been almost constant since 2012 (shows in Figure 1) (2). The number of fatalities in Nagano is worst 17th in the whole of Japan, and the fatalities per 100,000 people is the worst 22nd (calculated originally by traffic accidents in 2014 to 2016 using references (3) (4) (5)). It can be said that Nagano makes the position of the middle class in the whole of Japan; however, the number of accidents cannot be neglected in Japan. In addition, Nagano prefecture is the region with the highest altitude in Japan (6), it is considered that the traffic situation is different from the metropolitan area where the number of fatalities is large. For example, hilly and mountainous area such as pass road, snowed and freezed road, and high dependence on transport by vehicles in their lives are characteristic situations. In order to aim for zero fatalities and zero traffic accidents, analyzing statistics of traffic accident for local area and investigating each accident case can grasp their real causes and take appropriate measures in the future.

In this study, I selected Nagano as a representative of local area of Japan, and extracted their remarkable characteristics of traffic accidents by analyzing statistical analysis as first step. The purpose of this study is to lead to measures by a new approach which investigates concretely accident cases from their characteristics and analyzes their real causes.

2. Analysis Method

2.1. Flow of this study

The flow of the study is shown in Figure 2. In order to analyze remarkable accidents, their causes and countermeasures, three major steps are framed in this study. The first step is Macro analysis. Macro analysis is the research using traffic statistical data to find out the whole situation, remarkable accidents and their priority. In this step, also statistical analysis methods such as cluster analysis are adopted originally. Moreover, by comparing with the other prefecture, their characteristics can be brought out to the tore.

The second step is Micro analysis. Micro analysis is the investigation in real accident field to find out real causes for each accident. Their causes are different from each other; therefore, it
2.2. Objects of analysis

All traffic accidents in Japan were investigated by each prefectural police, and the National Police Agency compiled and managed as traffic accident statistical data. The Institute for Traffic Accident Research and Data Analysis (ITARDA) accepts, analyzes and tabulates the data, and publishes an annual report of traffic accident research and data analysis (first step) was done for the accidents in Nagano prefecture as the first report.

The third step is countermeasure. Causes of accidents consist of human, road and vehicle factors. In order to reduce accidents or injury risk, countermeasures are proposed from these points of view. Moreover, this study aims at specifying hazard factors to prevent the future accidents. In this report, Macro analysis (first step) was done for the accidents in Nagano prefecture to find out hazard factors.

is necessary to analyze each accident one-by-one. In this step, traffic accident simulation is operated to reconstruct accidents. I especially focus on their road factors and human factors under the situation to find out hazard factors.

The results of Macro analysis of Nagano prefecture and the whole of Japan are shown for each item classified in the previous chapter.

3. Results of Analysis

3.1. Macro data analyzed

The results of Macro analysis of Nagano prefecture and the whole of Japan are shown for each item classified in the previous chapter.

3.1.1. Accident type

Figures 3 and 4 show comparisons of accidents involving fatal accidents and all traffic accidents by accident type, respectively. Compared to the whole of Japan, person to vehicle and vehicle to vehicle accidents in Nagano prefecture are fewer, and vehicle alone accidents, which occur about 34%, are more than that in the whole of Japan. In the all traffic accident, the difference of the composition is not seen, and vehicle to vehicle accidents account for about 87% in both.

In the comparison of the number of fatalities and casualties by road user type, as shown in Figures 5 and 6, fatalities of vehicle drivers and passengers in Nagano prefecture occupy a large proportion, on the contrary, cyclists and pedestrians are fewer. In casualties, vehicle drivers and passengers are many, accounting for about 80%.

| Classification Items                      | Type            | Human              | Road              | Vehicle           |
|------------------------------------------|-----------------|--------------------|-------------------|-------------------|
|                                          | Accident type, Road user type, Day and night, Month | Age, Gender, Purpose of traffic, Violation(1st party, 2nd party) | Road type, Width, Shape, Alignment | Vehicle type, Seat belt use |

Fig.2 Flow of this study

Fig.3 Percentage of fatal accidents

Fig.4 Percentage of traffic accidents

Fig.1 Classification

3.2. Contents of analysis

The number of traffic accidents and the number of casualties in the whole of Japan and in Nagano prefecture were compared based on the objects that were written in previous section. In this time, in order to pay attention to serious accidents, I focused on fatal accidents and fatalities. The comparison was done by classifying into accident type, date and time of occurrence, location, parties and accident causes so that the accident situation can be arranged from human, road and vehicle point of view. The investigated items are shown in Table 1.

| Classification | Items     |
|----------------|-----------|
| Type           | Accident type, Road user type, Day and night, Month |
| Human          | Age, Gender, Purpose of traffic, Violation(1st party, 2nd party) |
| Road           | Road type, Width, Shape, Alignment |
| Vehicle        | Vehicle type, Seat belt use |

Table1 Macro data analyzed

3.3. Objects of analysis

Accident content: Fatal accidents (include some injury accidents)

Accident occurrence year: 2014 – 2016

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Nagano prefecture has many sightseeing spots, it is estimated that Nagano are more than those in the whole of Japan. Because proportion of accidents in August, October and December in the same way in Nagano as in the whole of Japan, but the difference of night rate this research literatures. The monthly fluctuation can be seen in Nagano prefecture, vehicle occupants, especially while vehicle alone accidents are one of principal issues.

3.1.2. Date and time of occurrence

Figures 9 and 10 show comparisons of fatal accidents and traffic accidents between day and night. Although fatal accidents tend to have a higher proportion of accidents at night, the proportion of accidents at night in Nagano prefecture is smaller than that in the whole of Japan. The difference of night rate between Nagano and the whole of Japan in fatal accidents is greater than that in all traffic accidents. It is assumed that the volume of traffic affects the proportion of day to night in accidents.

Figure 11 shows a comparison of monthly traffic accidents. In addition, fatal accidents are not analyzed because of no data in these research literatures. The monthly fluctuation can be seen in the same way in Nagano as in the whole of Japan, but the proportion of accidents in August, October and December in Nagano are more than those in the whole of Japan. Because Nagano prefecture has many sightseeing spots, it is estimated that there will be more occurrences of accidents during summer vacation, excursion season and winter vacation. Furthermore, there is concern about the influence of snowfall and road freezing in December.
3.1.3. Location of occurrence

In order to investigate the characteristics of accident occurrence location, macro statistical items on roads were compared. A comparison of road type in fatal accidents is shown in Figure 12. In Nagano prefecture, there is a large proportion of municipal road. Furthermore, a comparison of road shape in fatal accidents is shown in Figure 13. Fatal accidents in Nagano prefecture account for more than 60% on non-intersection roads. In addition, fatal accidents at intersections where there are no signal also account for much. It seems to indicate the provincial tendency in the local areas. The fatal accident by road width is shown in Figure 14. In Nagano prefecture, it can be seen that there are many fatal accidents on non-intersections having a road width of less than 13 m (about 66%). Furthermore, in Figure 15 compared by road alignment, many fatal accidents occurred on roads with up and down slopes in Nagano, the proportion of accidents on updown with curve roads and updown without curves roads are twice as much as those of the whole of Japan, and those occupy about 38%. Nagano prefecture has much hilly and mountainous area. It is estimated that the road characteristic peculiar to the local areas in Nagano prefecture causes the remarkable accidents.

3.1.4. Parties and accident causes

Figure 16 shows the percentage of fatalities by gender and age group. In Nagano Prefecture, the proportion of male fatalities accounts for about 71% and it is higher than that of the whole of Japan. Furthermore, in the age group, the proportion of male elderly who are 65 years old or older is large, accounting for about 38%. That shows prevention for traffic accidents of male elderly is one of important issues.

Figure 17 shows the results of comparison by the first party's purpose of road use. In Nagano Prefecture, accidents at private use such as sightseeing, entertainment, driving and shopping are more frequent than in the whole of Japan. Also, the proportion of accidents at the time of business purpose is seen abundantly. It is necessary to look at causes of accidents from not only sightseeing parties but business use parties, respectively.

Furthermore, law violation types at accidents are investigated. Figure 18 shows the ratio of death accidents by the first party's violation of laws and regulations, and Figure 19 shows the ratio of fatal accidents by violation of laws and regulations of the second party.
The violation of laws of the first party accounts for a large proportion such as careless driving, failure to make safety check and driving at unsafe speed. It is assumed that many drivers neglecting safety confirmation put on speed on hilly and monotonous road. On the other hand, looking at the second party, although it is a party with less negligence, many pedestrian’s violations of crossing road etc. are seen in Nagano prefecture. Pedestrian’s factor inducing accidents is also concerned.

Figure 20 shows a comparison of rate of un-belted occupants in four-wheeled vehicles accidents. The proportion of un-belted occupants in Nagano prefecture is not high relative to the whole of Japan; however, the un-belted rate is high in K-commercial cars. The number of fatalities in K-commercial car (small commercial car) in 2014 to 2016 is 28 occupants (about 10% of all fatalities). Because of the high death rate in case of un-belted (9), this difference is one of the local specific issues.

3.2. Summary of Macro analysis for Nagano

Based on the Macro analysis results above, the characteristics of fatal accidents in Nagano prefecture are characterized by many vehicle accidents and many fatal accidents occurred on up and down roads with or without curves. Therefore, a scenario of characteristic fatal accidents is estimated in Nagano Prefecture as follows. In the future, it is necessary to analyze factors in detail and to consider countermeasures together with verification of the assumed scenario.

- Four-wheeled vehicle alone accidents such as collision with structures due to lane departure from curving road in hilly and mountainous area
- The causes are excessive speed and careless driving.

4. Cluster Analysis

In order to clarify the characteristics of the traffic accidents in Nagano prefecture, hierarchical cluster analysis was performed on all prefectures by selecting indicators that differed from the whole of Japan in Macro analysis.

4.1. Hierarchical cluster analysis method

Hierarchical cluster analysis is a method of collecting clusters in order from most similar individuals based on similarity or dissimilarity (distance) between individuals (10). It is also used for characteristic analysis of prefectures as a group classification method (11). In this analysis, the Ward method using the Euclidean distance commonly used as a hierarchical approach was adopted. For the analysis, the R statistical program (ver. 3.4.3) was used. As the indicator belonging to each prefecture, 14 distinctive differences which were largely different between the whole of Japan and Nagano prefecture, were selected from the accident statistical data items organized in Table 1. As the analysis index, each constituent ratio was calculated by means of dividing by the number of all fatalities or all fatal accidents. The selected items are shown in the result of analysis. As for purpose of road use, it was excluded from the analysis index because accident statistical data for each prefecture could not be obtained.
4.2. Results of analysis and discussion

Results of hierarchical cluster analysis for all prefectures by the method written in the previous section are shown as dendrogram in Figure 21. Here, in order to make it easier to extract the features of each cluster, the number of clusters is set to 10 so that about 5 prefectures per a cluster are included, and features are compared and analyzed. A standardized average for each indicator is shown in Figure 22. I considered the typical traffic accident scenario inferred from features of each cluster as follows.

Cluster 1: Hokkaido, Miyagi, Yamagata, Fukushima, Gifu
The percentages of four-wheeled vehicle accidents, head-on collisions, and careless driving are high. Accidents in the vast plain area represented by Hokkaido are presumed. The accident scenario was set as “head-on collision accidents of four-wheeled vehicles caused by careless driving”.

Cluster 2: Aomori, Akita, Hiroshima, Yamaguchi, Nagasaki, Miyazaki, Kagoshima
The percentage of up and down with curve road alignment, head-on collision and elderly persons are high. The northern and the southern tip of Honshu belong to this cluster, which is presumed to be affected by aging in local areas. The accident scenario was set as “head-on collision accidents by elderly persons in hilly and mountainous area.”

Cluster 3: Iwate, Tottori
The percentage of pedestrian accident, head-on collision, and speeding are high. The proportion of fatalities against casualties is very high. The accident scenario was set as “four-wheeled vehicle accidents and pedestrian accidents caused by speeding”.

Cluster 4: Tokyo, Saitama, Chiba, Kanagawa, Aichi, Osaka
The percentage of accidents on municipal road, collision while crossing, pedestrian and cyclist accidents are high. Metropolitan areas belong to this cluster, which occupies a large number of fatalities. As mixed transportation areas, the accident scenario was set as “urban type accidents of collisions while crossing”.

Cluster 5: Ibaraki, Tochigi, Shizuoka, Toyama, Mie, Kyoto, Hyogo, Ehime, Fukuoka, Saga
Although the percentage of collisions while crossing accidents is large, other indicators are almost average. "Nationwide average-type accidents of collisions while crossing” was taken.

Cluster 6: Gunma, Niigata, Ishikawa, Kagawa
The percentage of careless driving, elderly persons, pedestrian accidents and crossing violations by pedestrian are high. The accident scenario was set as "pedestrian accidents caused by elderly persons with careless driving”.

Cluster 7: Yamanashi, Nagano, Shiga, Nara, Wakayama
The percentage of vehicle alone, up and down with curve road alignment, speeding and male are high. Nagano prefecture belongs to this cluster. Same as the Macro analysis result of Nagano prefecture, vehicle alone accidents in hilly and mountainous area are remarkable. The accident scenario was set as...
as "vehicle alone accidents in hilly and mountainous road".

Cluster 8: Fukui, Okayama, Tokushima, Kochi

The percentage of elderly, vehicle alone accidents and cyclists are high. Many prefectures in Cyugoku and Shikoku area belong to this cluster. Accident scenario was set as "vehicle alone accidents and cyclist accidents by elderly persons".

Cluster 9: Shimane, Kumamoto, Oita

The percentage of pedestrian accidents caused by violation of speeding and pedestrian’s crossing violation, pedestrian accidents and accidents in hilly and mountainous area are high. Accident scenario was set as "elderly pedestrian accidents with speeding and pedestrian’s crossing violation".

Cluster 10: Okinawa

The indicators differ greatly from other prefectures, and Okinawa became independent clusters without belonging to others. The percentages of men and vehicle alone accidents are high, and the proportion of elderly persons is very low. The accident scenario was set as "vehicle alone accidents by male".

The estimated accident scenario cannot be concluded because it is not from the results directly analyzed from the Macro analysis. Therefore, it is necessary to verify from Micro analysis in the next step.

Nagano prefecture belongs to cluster 7. Similarly to the results obtained by Macro analysis, it can be seen that accidents on hilly and mountainous road (up and down slope, and left and right curve) and vehicle alone accidents are characterized. Wakayama, Yamanashi, Shiga, and Nara prefecture belong to the same cluster, and it is presumed that hilly and mountainous areas are predominantly occupied same as Nagano prefecture. It is expected that new direction of accident countermeasures in Nagano prefecture will be obtained from the detailed comparison of traffic accident situations, road situations etc. of these similar areas in future.

New initiatives that cooperate beyond prefectural boundaries are one of the important measures for the ultimate zero traffic accidents.

5. Conclusion

In this study, Nagano prefecture was taken up and analyzed using the traffic accident statistics tabulated by the National Police Agency as the first step of a new approach to extract remarkable traffic accidents and these factors. The conclusions obtained are as follows.

1. Fatal accidents in Nagano prefecture are vehicle alone accidents. Especially, accidents on the hilly and mountainous road which has up and down slope, and left and right curve, are remarkable for accident factors.

2. As the result of cluster analysis, Nagano prefecture belongs to the same cluster as Wakayama, Yamanashi, Shiga and Nara prefecture. In these prefectures it is presumed that they share regional features and issues of Nagano prefecture; therefore, it is required to clarify these common factors effectively toward zero accidents.

Acknowledgement

The author would like to thank Nagano Prefectural Police Agency for providing Nagano accident data.

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