# A STUDY ON THE EFFECT OF SAFETY PROGRAM ON TRAFFIC ACCIDENT REDUCTION


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**Abstract:** Japanese government conducted the project of empirical survey on the effect of safety programs at 3,196 sites with frequent accident occurrence for 5 years from 1996 to reduce the number of accidents. However, the effect of sort of program on the accident reduction by accident type was not analyzed deeply. This study aims at the post-evaluation of safety programs on accident reduction at 1,713 intersections. The accident factors are hypothesized though the basic data analyses. These hypotheses are verified by two statistical analyses, cross tabulation analysis and *t*-test. It is found out that the downsizing at intersection possibly reduces the number of human-vehicle type accidents, while right-turn related improvement induces this sort of accident. Besides, several trade-offs of accident reduction among safety programs are found. Finally, the mechanisms of accident occurrence under the circumstantial change by safety programs are considered by microscopic viewpoints.



**Key Words:** Accident Analysis, Effect of Safety Program, Statistical Analysis


## 1. INTRODUCTION

The numbers of traffic accident has still been increasing in Japan, while the critical safety programs to reduce accident are still sought. Japanese government conducted the project of empirical survey on the effect of safety programs at 3,196 sites with frequent accident occurrence for 5 years from 1996. Huge data set of annual accident occurrence by accident type and time of day, basic structural conditions, operation and demand valuables, and sort of improvement are obtained. However, only the effect of sort of program on the accident reduction by accident type was roughly analyzed in the process of program post-evaluation.

Only 2 % of total accidents are observed in 3,196 frequent sites, while the rest 98% occur in less-frequent sites. Authors basically think that the factors of accidents should be deeply analyzed at each site one by one, and the safety programs that are appropriate to the reduction of accidents should be implemented one by one. However, such implementation may be efficient if the factors of accidents and the effect of safety programs can be understood in the context of decomposition of common in all over Japan and specific at each site though the analysis at frequent sites.

This study aims at the post-evaluation of safety programs on accident reduction mentioned above at 1,713 intersections of 3,196 frequent sites. The major concern in the study is to consider the effect of safety programs in these 4 steps. The general trend of the accident reduction and the microscopic analysis at a few large intersections for focused 5 years are described in Chapter 2. The effect of safety programs on the accident reduction is simply analyzed by cross tabulation analysis in Chapter 3. The effect of safety programs on the number of accident reduction is analyzed statistically in Chapter 4. The mechanisms of

Table 1 Database Used in the Study

| Data | | Contents |
|---|---|---|
| Coded | Accident data | Annual number of accidents classified by 33 categories in dat/nighttime (1995-1999) |
| | Road design | Number of legs |
| | | Number of lanes |
| | | Existence of ped. way |
| | | Existence of lanes for right/left turn |
| | Traffic flow condition | Daily flow rate |
| | | Daytime flow rate |
| | Implemented safety program | Multiple checking |
| Uncoded | Drawing | Drawing contaies implemented safety programs with site information |

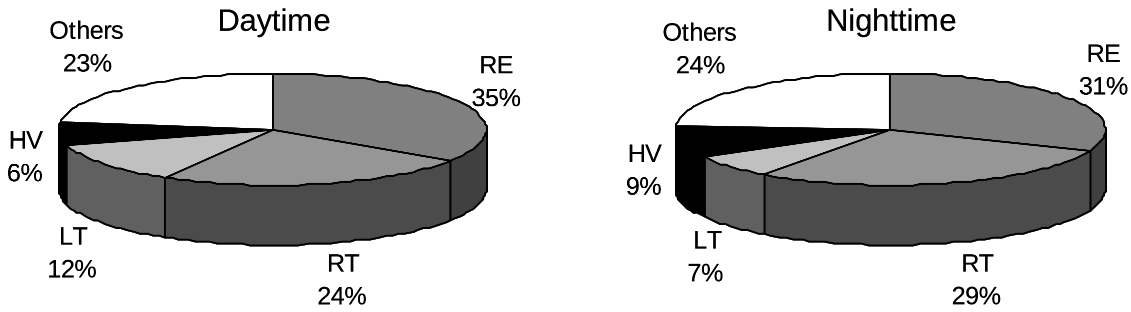


Figure 1. Proportion of Accident Type (1995-1999)

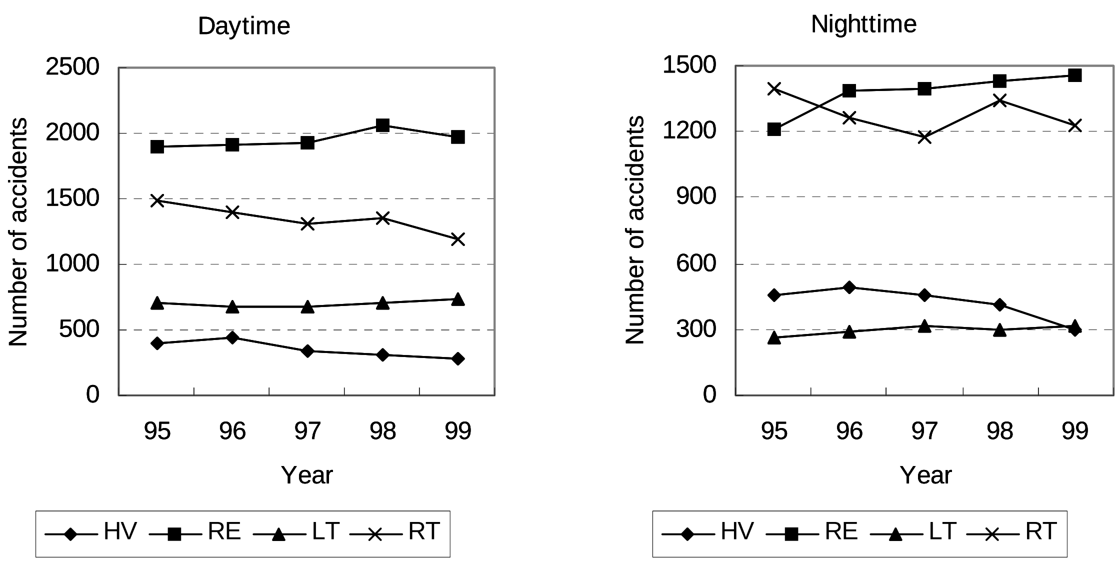


Figure 2. Trend of Number of Accident in 4 Types

accident occurrence and avoidance under the circumstantial change by safety programs are considered by microscopic viewpoints in Chapter 5. The study is summarized in Chapter 6.

## 2. GENERAL TREND OF ACCIDENT REDUCTION IN FREQUENT SITES

### 2.1 Used Data

The database used in the study includes the coded data listed in Table 1 integrated by the

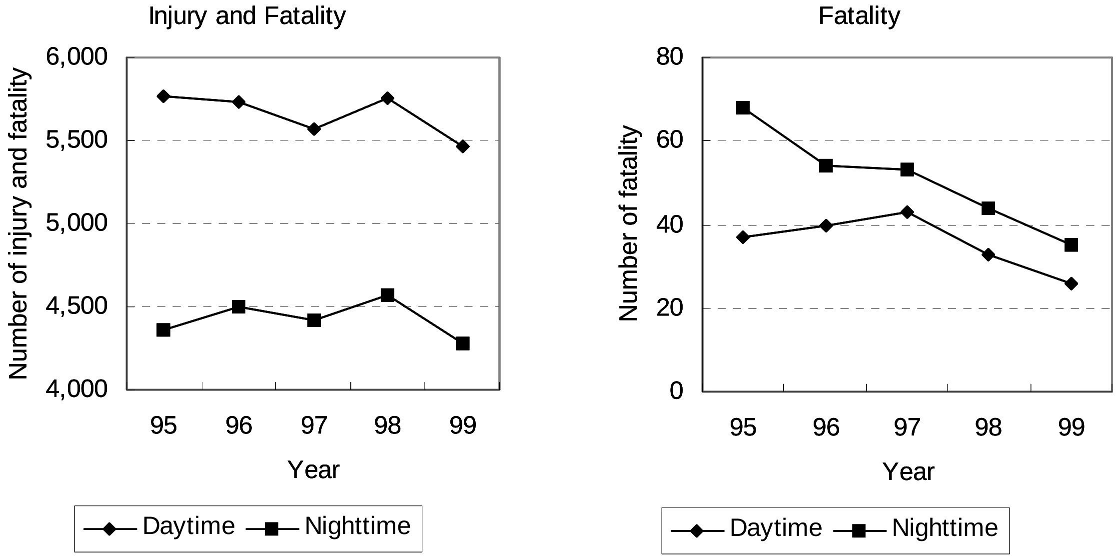


Figure 3. Trend of Number of Injury and Fatality

Japanese Ministry of Land, Infrastructure and Transport. The accident type is classified in 5 groups with 33 categories in advance, however the number of injury and fatality in each category is not available in this database, only total number of injury and fatality can be obtained. The data related to road structure and traffic flow rate are referred by the National Road Census database. All safety programs were implemented at all frequent sites up to now.

### 2.2 Trend of Standing Accident Type

Figure 1 shows the proportion of the number of accidents by their type both in daytime and nighttime for focused 5 years. Over 75% of total accidents are covered by 4 major accident types, rear-end (RE) collision, right-turn (RT) collision, left-turn (LT) collision and human-vehicle (HV) collision at pedestrian crossing. It is remarkable that the share of human-vehicle collision in nighttime is larger than that in daytime. This is because the driver tends to miss the pedestrian in low luminous intensity.

Figure 2 shows the trend of the number of accidents for 4 major types both in daytime and nighttime for focused 5 years. The number of HV and RT type accidents has been decreased year by year, on the contrary the number of RE and LT type accidents has been increased both in daytime and nighttime. It is reasonable to consider that the number of vehicle-vehicle (VV) collision (RE, RT and LT) in daytime is larger than that in nighttime because traffic volume is much larger in daytime, while the number of HV type accidents in nighttime is larger than that in daytime because of the difference of luminous intensity.

The safety programs at 1,713 intersections started in 1997. The main safety programs at intersection was the downsizing such as improvement of corner design and repositioning of pedestrian crossing to reduce the number of human-related accidents. This attempt seemed to achieve its objective, however there is possibility that such safety programs might increase the number of VV type accidents. Several analyses under this viewpoint are conducted below.

Figure 3 shows the trend of the number of injury and fatality both in daytime and nighttime for focused 5 years. It is typical that the number of fatality has been decreasing gradually just after the implementation of safety programs in 1997. This fact may be explained by the effect of many pedestrian-oriented programs.

### 2.3 Examples at Two Intersections

We focused on two large intersections (Kamiuma Underpass and Itabashi Chuo Overpass) located at the cross point of circular road and radial national road in Tokyo. Some safety programs such as reshape of design, repositioning of pedestrian crossing and improvement of

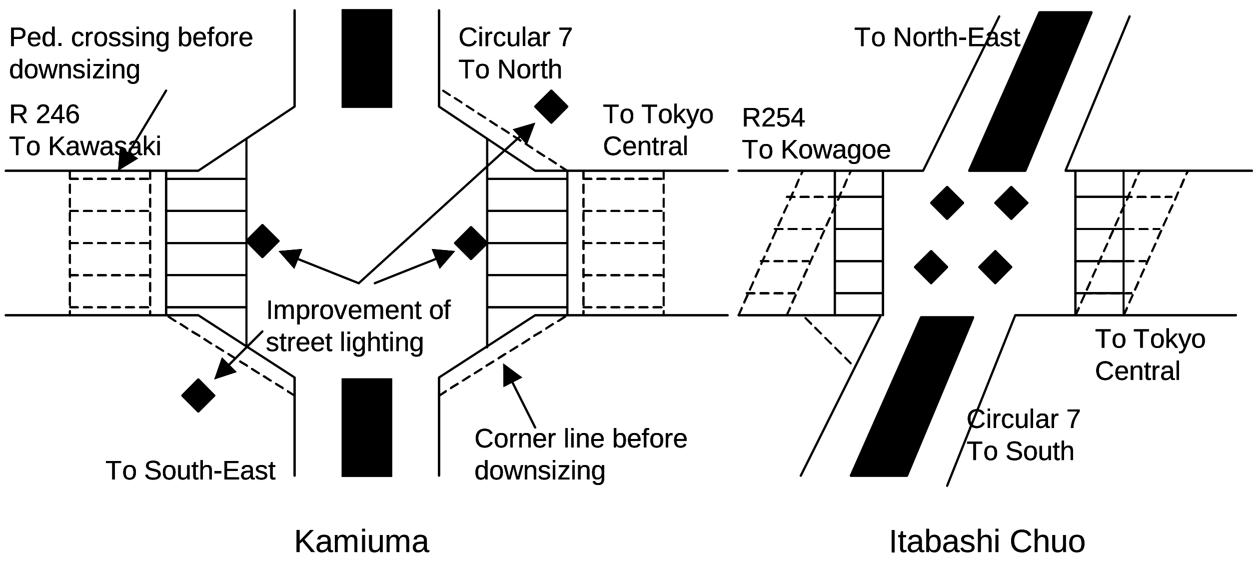


Figure 4. Contents of Safety Programs at Two Intersection

Table 2 Trend of Number of Accidents at Two Intersections

| Kamiuma | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Daytime | | | | | | Nighttime | | | | | |
| | HV | RE | LT | RT | Injury | Fatality | HV | RE | LT | RT | Injury | Fatality |
| 95 | 10 | 0 | 0 | 0 | 15 | 0 | 7 | 0 | 0 | 1 | 11 | 0 |
| 96 | 13 | 2 | 0 | 0 | 15 | 0 | 9 | 1 | 0 | 2 | 12 | 1 |
| 97 | 9 | 2 | 1 | 1 | 14 | 0 | 3 | 2 | 0 | 0 | 7 | 0 |
| 98 | 4 | 6 | 3 | 2 | 17 | 0 | 1 | 2 | 0 | 3 | 9 | 0 |
| 99 | 1 | 4 | 4 | 3 | 14 | 0 | 2 | 4 | 0 | 11 | 20 | 0 |
| Itabashi Chuo | | | | | | | | | | | | |
| Year | Daytime | | | | | | Nighttime | | | | | |
| | HV | RE | LT | RT | Injury | Fatality | HV | RE | LT | RT | Injury | Fatality |
| 95 | 7 | 0 | 0 | 0 | 7 | 0 | 4 | 0 | 0 | 1 | 5 | 0 |
| 96 | 8 | 1 | 0 | 0 | 9 | 0 | 2 | 2 | 0 | 0 | 4 | 0 |
| 97 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 3 | 7 | 0 |
| 98 | 0 | 3 | 1 | 3 | 7 | 0 | 1 | 2 | 2 | 5 | 10 | 0 |
| 99 | 0 | 1 | 1 | 0 | 4 | 0 | 0 | 4 | 1 | 3 | 9 | 0 |

street lightings (shown in Figure 4) were implemented to both intersections in 1997. Table 2 shows the annual number of accident in 4 major accident types both in daytime and nighttime. It is obviously understood that the number of HV type accidents dramatically decreased, while the number of VV type accidents increased. These phenomena indicate that the downsizing possibly induces VV type accident in spite of effectiveness to the reduction of HV type accident. This hypothesis is verified in following two chapters by statistical analyses.

## 3. ANALYSIS OF EFFECT OF SAFETY PROGRAMS USING CROSS TABULATION ANALYSIS

### 3.1 Methodology

208 intersections of 1,713 that we can reinforce more detailed information of safety programs though drawings are selected in this analysis. Focused safety programs are downsizing, repositioning of pedestrian crossing, left-turn related improvement and right-turn related improvement. Focused accident types are HV, RE, LT and RT.

We define the number of accident reduction for each accident type by safety programs at all focused intersections as follows,

$$RD_{it} = \left(ACC98_{it} + ACC99_{it}\right) - \left(ACC95_{it} + ACC96_{it}\right) \tag{1}$$

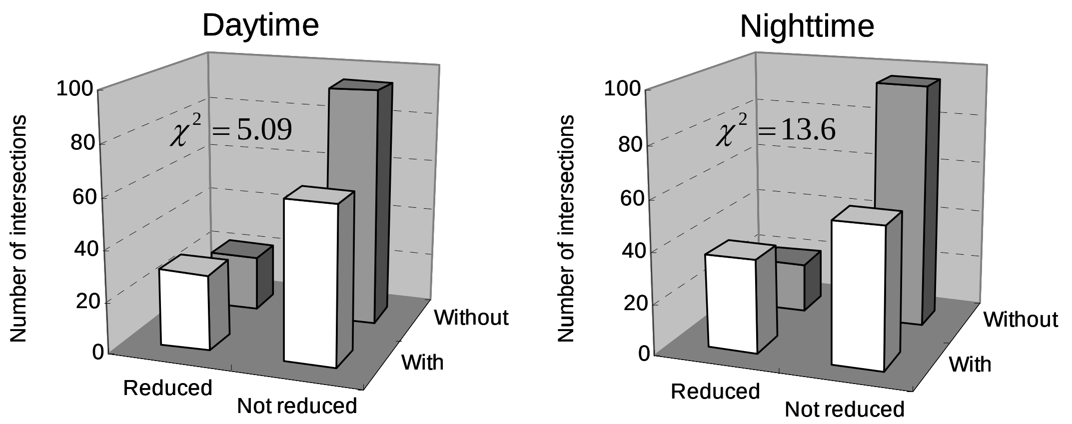


Figure 5. Relation between Accident Reduction and Safety Program (Downsizing)

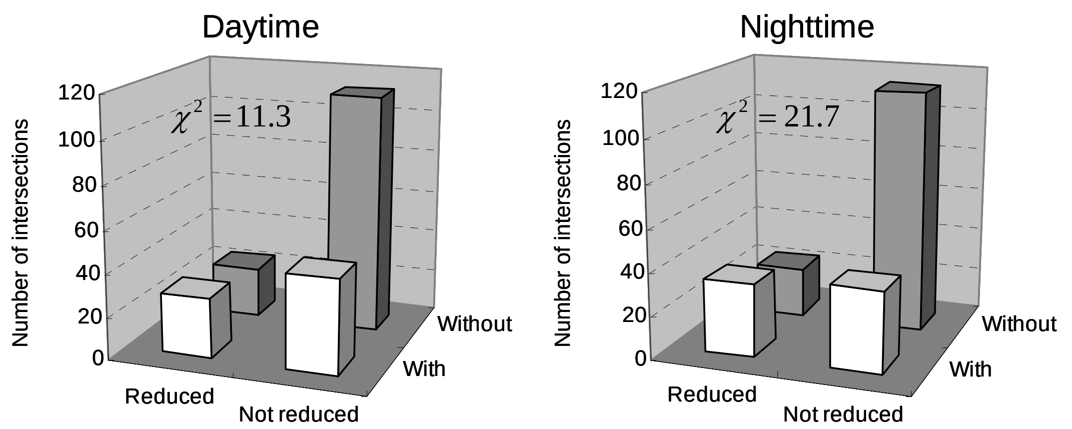


Figure 6. Relation between Accident Reduction and Safety Program (Repositioning of Pedestrian Crossing)

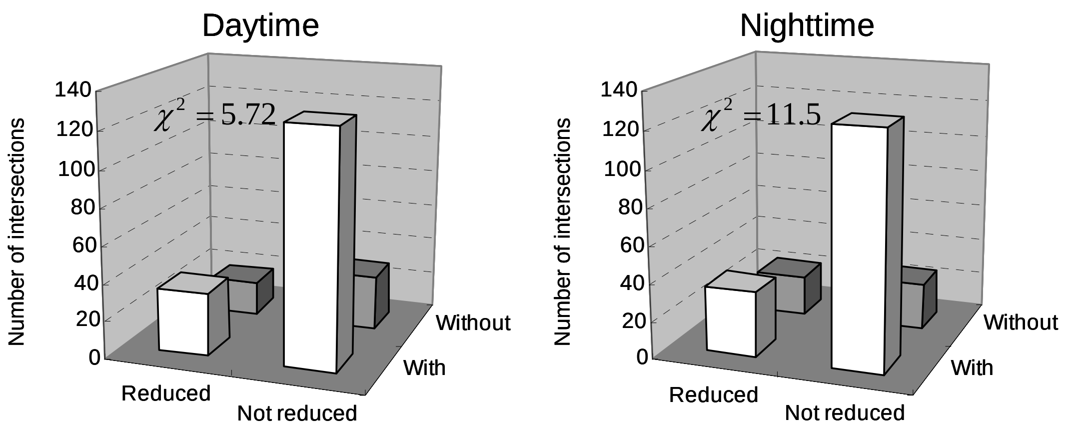


Figure 7. Relation between Accident Reduction and Safety Program (Light-turn Related Improvement)

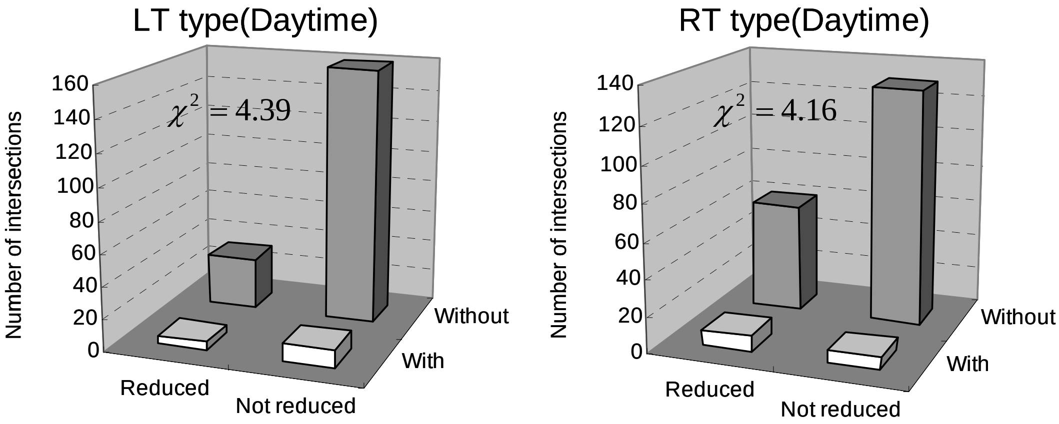


Figure 8. Relation between Accident Reduction and Safety Program (Attachment of Left-turn Lane )

where *i* is intersection, *t* is accident type, *RD* is the number of accident reduction, *ACCy* is the number of accidents in year *y*. the number of accidents in 1997 is neglected because most safety programs were implemented in 1997. In the cross tabulation analysis, we classify the whole intersections into “Reduced” (in case *RD* is negative) or “Not reduced” (in case *RD* is more than zero) groups, and “With” (in case focused program is implemented) or “Without” (in case focused program is not implemented).

### 3.2 Effect of Downsizing on Accident Reduction

Figure 5 shows the number of intersections classified by *RD* value of HV type and downsizing. The test of independence by Chi square value in cross tabulation analysis (over 3.84 for 5% significance level of d.f. 1) indicates that the downsizing is possible to reduce the number of HV type accidents both in daytime and nighttime.

As the same manner, the effect of the repositioning of pedestrian crossing is checked. Figure 6 shows the number of intersections classified by *RD* value of HV type and repositioning of pedestrian crossing. It is suggested that the repositioning of pedestrian crossing has highly potential to reduce the number of HV type accidents both in daytime and nighttime.

### 3.3 Effect of Left-turn and Right-turn Related Improvement on Accident Reduction

Figure 7 shows the number of intersections classified by *RD* value of HV type and right-turn related improvement. It is suggested that the right-turn related improvement is not possible to reduce the number of HV type accidents both in daytime and nighttime.

It is interesting that the attachment of left-turn lane affects the accident reduction in not only LT type but also RT type as shown in Figure 8. However, this consideration should be insufficient because of limited samples.

## 4. ANALYSIS OF EFFECT OF SAFETY PROGRAMS ON NUMBER OF ACCIDENT REDUCTION

### 4.1 Methodology

Here we focus on the effect of safety programs on the number of accident reduction at all intersections. 208 intersections same as Chapter 3 are picked up. The focused accident types and safety programs are also same as Chapter 3.

In the analyses, all intersections are classified into “With” and “Without” groups as a same manner as Chapter 3. A simple *t*-test of difference of average *RD* between groups is applied. However, a few mega-intersections with huge number of accidents may give larger standard deviation and result in bias, this is because such intersections are removed in advance.

Table 3 Average Accident Reduction by Downsizing

| Program | Daytime | | | | Nighttime | | | |
|---|---|---|---|---|---|---|---|---|
| | HV | RE | LT | RT | HV | RE | LT | RT |
| With | -0.416 | 0.104 | 0.078 | 0.167 | -0.411 | -0.045 | 0.206 | 0.022 |
| Without | -0.013 | 0.233 | 0.018 | 0.036 | 0.000 | -0.083 | 0.035 | -0.036 |
| Significance | # | | | | # | | & | |

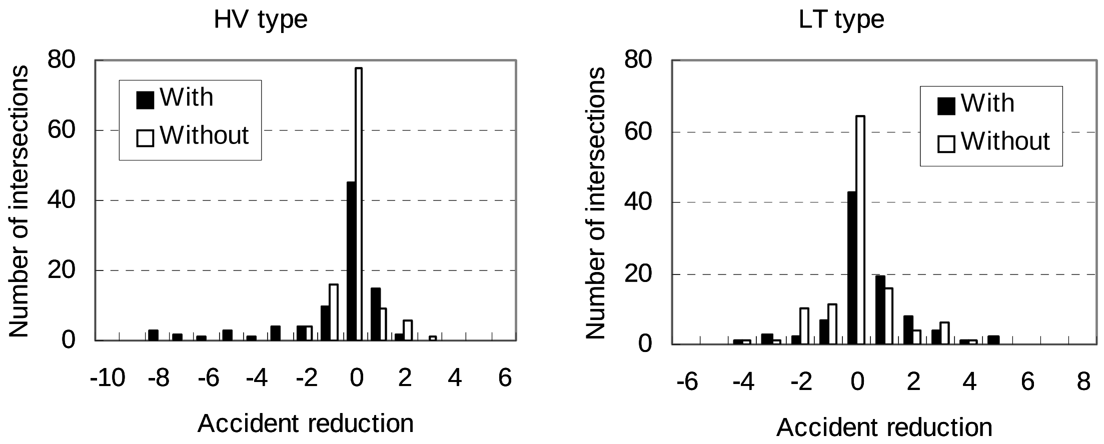


Figure 9. Distribution of Accident Reduction (Classified by Downsizing, Daytime)

Table 4 Average Accident Reduction by Repositioning of Pedestrian Crossing

| Program | Daytime | | | | Nighttime | | | |
|---|---|---|---|---|---|---|---|---|
| | HV | RE | LT | RT | HV | RE | LT | RT |
| With | -0.522 | -0.066 | 0.199 | 0.129 | -0.715 | 0.222 | 0.111 | 0.243 |
| Without | 0.019 | -0.066 | 0.066 | -0.056 | -0.036 | 0.151 | 0.011 | 0.019 |
| Significance | # | | | | # | | & | |

Table 5 Average Accident Reduction by Attachment of Guideline for Right-turn

| Program | Daytime | | | | Nighttime | | | |
|---|---|---|---|---|---|---|---|---|
| | HV | RE | LT | RT | HV | RE | LT | RT |
| With | 0.000 | 0.019 | -0.031 | -0.074 | -0.012 | 0.091 | 0.007 | 0.153 |
| Without | -0.330 | -0.059 | 0.224 | 0.033 | -0.295 | 0.206 | 0.092 | 0.085 |
| Significance | & | | # | | & | | # | |

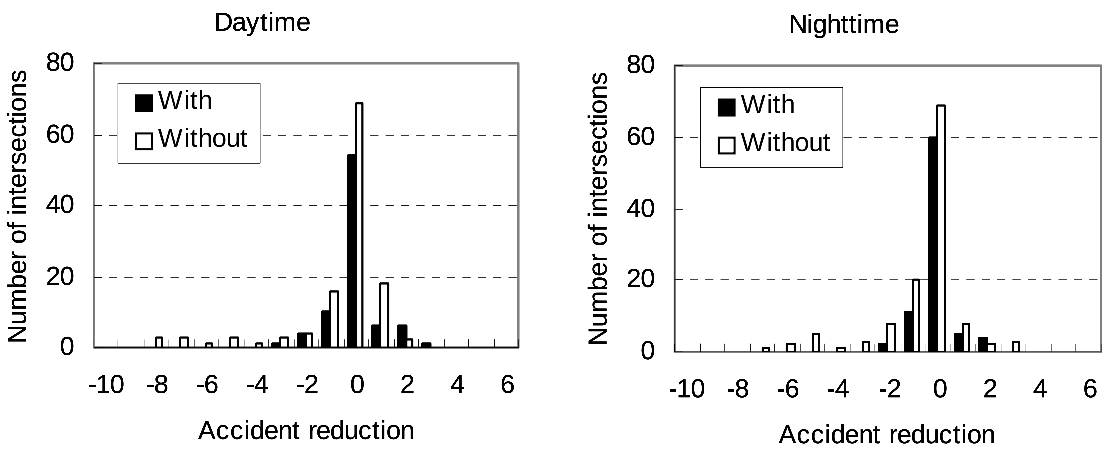


Figure 10. Distribution of Accident Reduction (Classified by Guideline for Right-turn)

Table 6 Average Accident Reduction by Attachment of Lane for Right-turn

| Program | Daytime | | | | Nighttime | | | |
|---|---|---|---|---|---|---|---|---|
| | HV | RE | LT | RT | HV | RE | LT | RT |
| With | -0.015 | -0.085 | -0.077 | -0.077 | -0.031 | 0.084 | 0.068 | -0.099 |
| Without | -0.277 | -0.057 | 0.022 | 0.022 | -0.201 | 0.172 | 0.054 | 0.238 |
| Significance | & | | | | & | | | # |

Table 7 Average Accident Reduction by Attachment of Lane for Left-turn

| Program | Daytime | | | | Nighttime | | | |
|---|---|---|---|---|---|---|---|---|
| | HV | RE | LT | RT | HV | RE | LT | RT |
| With | 0.032 | -0.188 | 0.219 | -0.500 | 0.000 | 1.094 | -0.032 | 0.063 |
| Without | -0.171 | -0.056 | 0.083 | 0.030 | -0.186 | 0.087 | 0.043 | 0.095 |
| Significance | & | | | # | & | & | | |

### 4.2 Effect of Downsizing on Number of Accident Reduction

Table 3 shows the result of *t*-test for average annual accident reduction (negative value means "reduced") by the downsizing in daytime and nighttime. The mark # in table 3 and following tables means that the program decreases the number of accidents significantly, while & increases significantly (significant level is 5 percent). The distributions in significant cases of daytime are also shown in Figure 9. These results suggest that the downsizing possibly decreases about 0.4 HV type accidents, while increases 0.17 LT type accidents annually.

Table 4 shows the result of *t*-test for average annual accident reduction by the repositioning of pedestrian crossing in daytime and nighttime. It is remarkable that the repositioning of pedestrian crossing has larger effect on HV type accident reduction than the downsizing itself. The same tendency that this program possibly increases the number of LT type accidents is observed.

### 4.3 Effect of Right-turn Related Improvement of Accident Reduction

Table 5 shows the result of *t*-test for average annual accident reduction by the attachment of guideline for right-turn in daytime and nighttime. It is interesting that this program can reduce LT type accident significantly compared with RT type accident, while the number of HV type accidents increases significantly. However, this phenomenon cannot be adopted because it is natural to consider that HV type accident is reduced mainly by the downsizing simultaneously implemented with this program at many intersections distributed in "Without" at large negative value shown in Figure 10.

Table 6 shows the result of *t*-test for average annual accident reduction by the attachment of lane for right-turn in daytime and nighttime. The same phenomenon as Table 5 is observed in case of HV type accident. It is interesting that this program can reduce RT type accident significantly in nighttime, while guideline cannot reduce it shown in Table 5.

### 4.4 Effect of Left-turn Related Improvement of Accident Reduction

Table 7 shows the result of *t*-test for average annual accident reduction by the attachment of lane for left-turn in daytime and nighttime. It is interesting that this program has less effect on LT type accident reduction, while huge effect on RT type accident reduction in daytime. The number of HV type accidents increased significantly by this program. The huge significance of the increase of RE type accidents should be neglected because of same reason in Section 4.3.

### 4.5 Summary of Result from Statistical Analyses

We summarize the results of relation between safety programs and accident reduction explained in this chapter into Figure 11. The reasons are considered in Chapter 5.

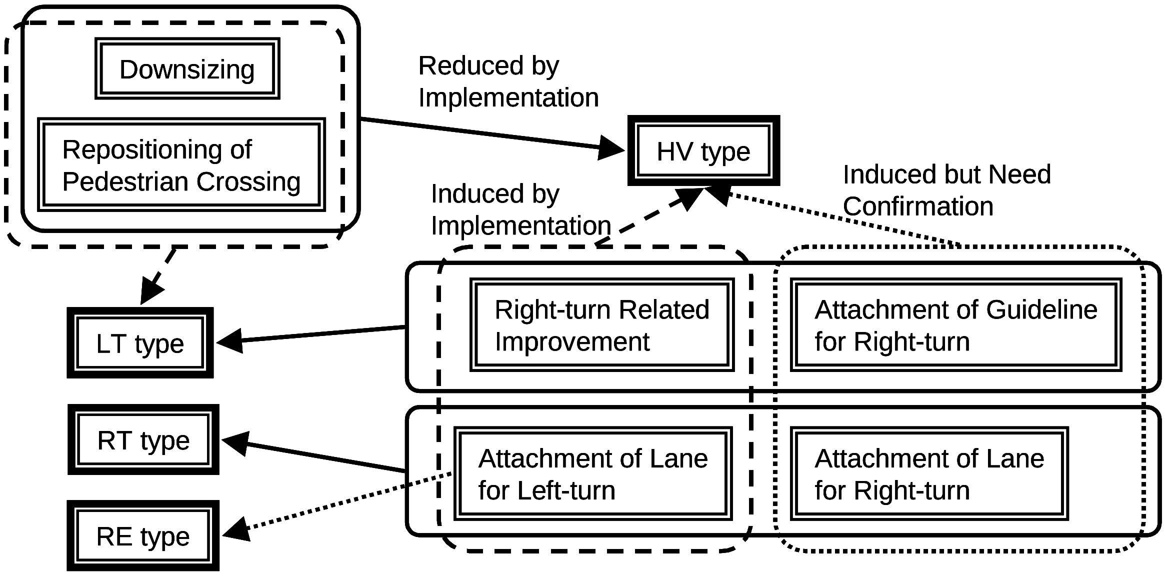


Figure 11. Summary of Results

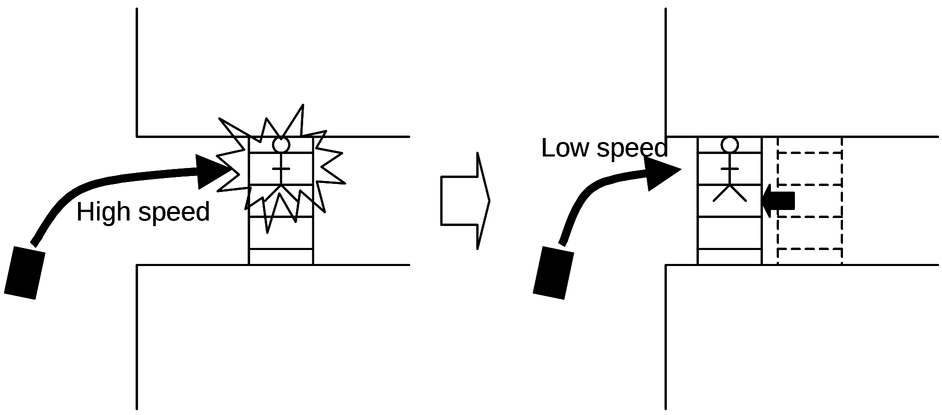


Figure 12. Change of Behavioral Condition by Repositioning of Pedestrian Crossing

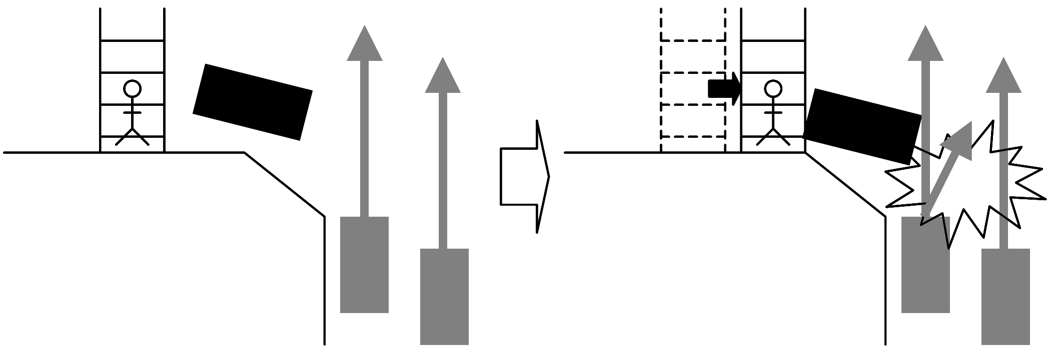

Figure 13. Bad Effect of Repositioning of Pedestrian Crossing

## 5. MECHANISM OF ACCIDENT OCCURRENCE AND AVOIDANCE AFTER IMPLEMENTATION OF SAFETY PROGRAMS

### 5.1 Effect of Downsizing

In this chapter, the mechanism of accident occurrence and avoidance by the implementation of safety programs with viewpoint of microscopic behavioral changes.

It is pointed out that the downsizing-related programs possibly reduce the number of HV type accidents in Chapter 4. Figure 12 shows the behavioral characteristics of vehicle turning right at intersection with pedestrian crossing. Driver accelerates more and cannot find a pedestrian crossing very quickly when the pedestrian crossing is located far from intersection. This is because the repositioning of pedestrian crossing can reduce this type accident.

On the contrary, the downsizing-related programs induce the number of LT type accidents. One reason of this phenomenon is considered that vehicle turning left should wait at very intersection area when pedestrians cross the pedestrian crossing and following vehicle easily collides against this waiting vehicle as shown in Figure 13. Another reason is that the downsizing possibly makes the path of vehicle turning right and the path vehicle turning left close.

### 5.2 Effect of Right/Left-turn Related Improvement

It is pointed out that the attachment of guideline for right-turn possibly reduces LT type accidents. Figure 14 shows the mechanism of this phenomenon. The running path of vehicle turning right becomes stable owning to the guideline and the probability of collision with vehicle turning left with much responsibility (in this case, accident is classified as LT type by the definition of database) can be decreased.

The effect of the attachment of lane for right-turn is explained by the visibility at intersection. A vehicle waiting at intersection without lane for right-turn possibly stops to the direction of cross leg and its driver has difficulty in confirming approaching vehicles from opposite leg. On the contrary, a vehicle waiting on lane for right-turn with lesser angle can confirm approaching vehicle easily as shown in Figure 15. These facts will explain the reason of RT type accident reduction by attaching lane for right-turn.

The effect of the attachment of lane for left-turn can be considered by the application from the case in the downsizing.

## 6. CONCLUSIONS

We aim at the post-evaluation of safety programs on accident reduction at 1,713 intersections with frequent accident occurrence. The accident factors are hypothesized though the basic data analyses. These hypotheses are verified by two statistical analyses, cross tabulation analysis and *t*-test. We understand that the downsizing at intersection possibly reduces the number of human-vehicle type accidents, while right-turn related improvement induces this sort of accident. We also find out very interesting phenomena about the difference of the effect on the accident reduction between right-turn related improvements and left-turn related improvements. Several suggestions about the mechanism of accident occurrence and avoidance by safety programs standing on the statistical analyses are given with viewpoint of the microscopic behavioral change.

For further study, the effect of multiple safety programs on accident reduction should be analyzed to understand the multiple effects. In addition, more detailed data about road circumstances such as traffic volume by directions, road design valuables, and so on should be obtained to conduct deeper study.


## ACKNOWLEGDEMENTS

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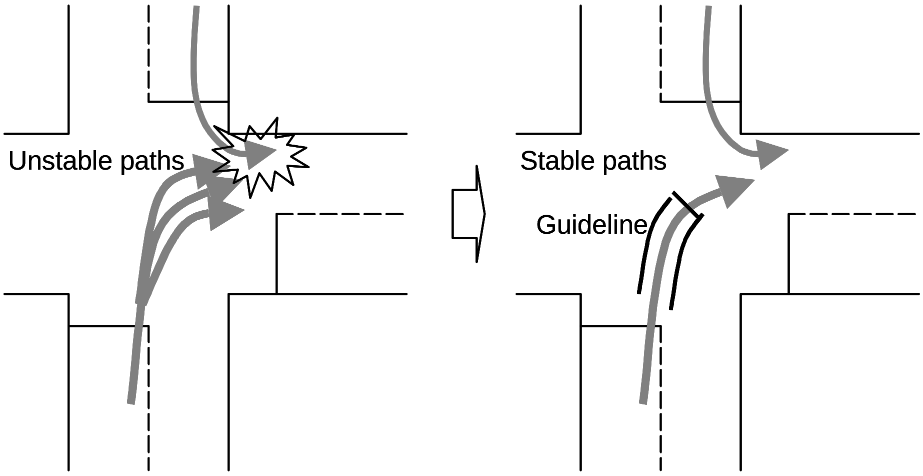


Figure 14. Mechanism of Reduction of LT Type Accident by Guideline for Right-turn

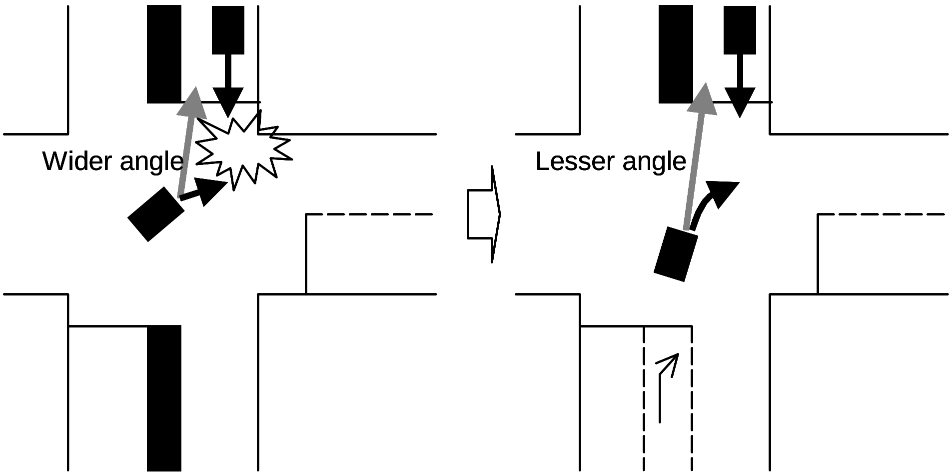


Figure 15. Effect of Attachment of Lane for Right-turn

very useful database. Authors also thank to the ITS Sub-committee, the Infrastructure Planning Committee, Japan Society of Civil Engineers for their assistance.

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