Public Bus Accident Characteristics in Ohio

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Characteristics of public bus accidents in Ohio from 1989 to 1991 are identified. Analyses were conducted for determining accident characteristics of the six Ohio major transit systems; this included comparing the average bus accident rates and comparing the average bus accident rates under various conditions for each major transit system. The comprehensive results indicate that Southwest Ohio RTA (Cincinnati) had the highest bus accident rate and that Greater Cleveland Regional Transit Authority (RTA) (Cleveland) and Miami Valley RTA (Dayton) had the lowest bus accident rates. Central Ohio Transit Authority (Columbus), Toledo Area RTA (Toledo), and Akron Metro RTA (Akron) had similar bus accident rates. Rain is found to be a contributing factor to bus accident occurrence, especially for those transit systems in the northern part of Ohio. Snow and clear conditions for weather or roadway conditions were not different in terms of accident occurrence for the systems.

Safety is an important attribute of public transportation for both the operators and the passengers. For the operator, accidents will cause additional costs, lost time, and out-of-service time. A safe public transit system may be a factor to encourage public use.

OHIO PUBLIC TRANSIT SYSTEMS

Fifty-eight public transit systems that offer fixed-route and demand-responsive service are operated or sponsored by local public agencies in Ohio. The Ohio transit systems can be classified into metropolitan systems with regional transit authorities (RTAs) in the larger areas, small urban systems, and rural systems based on annual ridership and service area population (*1*).

Metropolitan Systems

Eight major transit authorities serve the metropolitan areas with over 1 million annual public transportation riders. Greater Cleveland RTA, Southwest Ohio RTA, Central Ohio Transit Authority (COTA), Miami Valley RTA, and Toledo Area RTA are the five largest transit systems in Ohio. Annual ridership of each system exceeds 10 million and ranges to more than 70 million. Large bus fleet ranging from 250 to 740 vehicles are a particular characteristic of the major transit systems. The five large and three medium systems serve three-fourths of the state's population and contain 89 percent of Ohio's transit bus fleet as well as 95 percent of public transit ridership.

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Small Urban and Rural Systems

More than half of the public transit systems in Ohio serve small cities or villages or rural areas. Small buses make up about a half the vehicle fleet, and the remainder is composed of vans and other vehicles.

LITERATURE REVIEW

Only a few studies have been reported on public bus accidents. The analysis methods and related findings of these studies are summarized as follows.

One of the most comprehensive of the transit bus accident studies was done by Jovanis et al. in 1989 (*2*). They analyzed about 1,800 mass transit bus accidents that occurred in the Chicago metropolitan area and developed two regression models for measuring transit accidents. The accident data were provided by PACE, the suburban bus agency. The important findings are summarized as follows:

- Eighty-nine percent of the accidents involved collision with another object or person, and the remaining 11 percent involved passenger injuries while boarding, alighting, or moving.
- Severity was generally low; most accidents involved property damage only.
- Drivers of the other vehicle involved in the accident were much more likely to be injured than the bus drivers.
- Gender does not contribute to accident occurrence, but age appears to have an effect on accident involvement.
- Seventy percent of the collision accidents occurred at intersections, whereas 30 percent occurred at some other locations.
- Bus accidents do not appear to be more frequent during darkness.

A study by Jovanis and Delleur in 1983 looked at exposure to accident risk, including characteristics of the amount of travel, conditions of travel, and characteristics of the driver and vehicle undertaking the travel (*3*). A series of paired comparisons of accident rates between trucks and automobiles on the Indiana Tollway under different weather conditions of travel and regression analyses were conducted to study the relationship between variables, particularly the influence of one mode's vehicle miles of travel (VMT) on the other's accident rate (i.e., interference between modes) and effect of the amount of snow, rain, and nighttime travel on accident experience. The results from the regression analyses indicated that the occurrence of snow was the single most significant exposure variable and that automobile accident rates were found to increase significantly with truck VMT.

TABLE 1 Six Ohio Major Transit Systems (*1*)

Name	Service area	No. of vehicles	Route	Annual Ridership (1,000)	Employees
Toledo Area RTA	Toledo	227 buses	36 bus	10,567.8	346
Greater Cleveland RTA	Cleveland	788 buses 94 hvy rail 67 lt rail	98 bus 1 hvy rail 2 lt rail	75,206.8	2,582
Akron Metro RTA	Akron	113 buses	28 bus	5,133.5	263
COTA	Columbus	336 buses	53 bus	20,456.5	672
Miami Valley RTA	Dayton	227 buses	28 bus	15,244.8	466
Southwest Ohio RTA	Cincinnati	380 buses	44 bus	27,566.7	888

Herd et al. studied accidents during daylight and darkness on the urban and rural roads in 1980 using accident data from Louisville, Kentucky (*4*). The results showed that accident rates on all types of rural roads were higher during darkness than during daylight.

However, no study has been undertaken on the subject of exposure analysis of bus accidents. This study, based on Ohio accident data, focuses on a thorough examination of aggregate bus accident data and the development of a set of hypotheses concerning accident causality. Then statistical procedures are used to identify the factors contributing to bus accidents.

The objectives of this study are to

1. Identify specific problems and characteristics of bus accidents in terms of safety-related variables, such as weather condition, light condition, and pavement condition;
2. Evaluate the safety performance of six major transit systems in Ohio; and
3. Identify whether or not weather has an impact on bus accidents in Ohio.

Toledo Area RTA, Greater Cleveland RTA, Akron Metro RTA, COTA, Miami Valley RTA, and Southwest Ohio RTA are the six largest transit systems in Ohio. All of these systems have annual riderships of more than 5 million; Greater Cleveland has up to 75 million riders each year. In order to have a large enough pool of accident data and still have a manageable set of data to isolate variables and factors, it was decided to concentrate on the accident records of these largest six transit systems instead of using statewide bus accident data to compare the bus accident rates. Doing this gave a wider geographical spread and similar operating characteristics.

The other reason to choose these six systems is the vehicle fleet operated by Ohio transit systems. Most transit systems (except these six systems) operate both buses and vans. Therefore, choosing the six major transit systems enables one to focus on the bus accidents only. Table 1 presents the basic operating characteristics of these six systems, and Figure 1 shows their locations.

All analyses carried out are based on statistical analysis and significant results. The methodology to be used in this study is as follows:

1. Use a single-factor analysis of variance (ANOVA) to test whether there is any significant difference among the mean accident rates of the six major transit systems. If this test concludes that at least two of these means are different, then the Bonferroni multiple comparisons procedure is followed to compare the significant differences between each paired mean accident rate.
2. Use a single-factor ANOVA to test whether there is any significant difference among the mean accident rates in various weather conditions for the six major transit systems. If this test concludes that at least two of these rates are different, then the Bonferroni procedure is followed to determine in what weather condition the transit bus system has a higher accident rate.

DATA COLLECTION AND CODING

To carry out this study, two types of data are needed: transit bus accident data, and exposure data (i.e., VMT). Climatological data were also required for creating exposure measures for bus accident occurrences in different weather conditions.

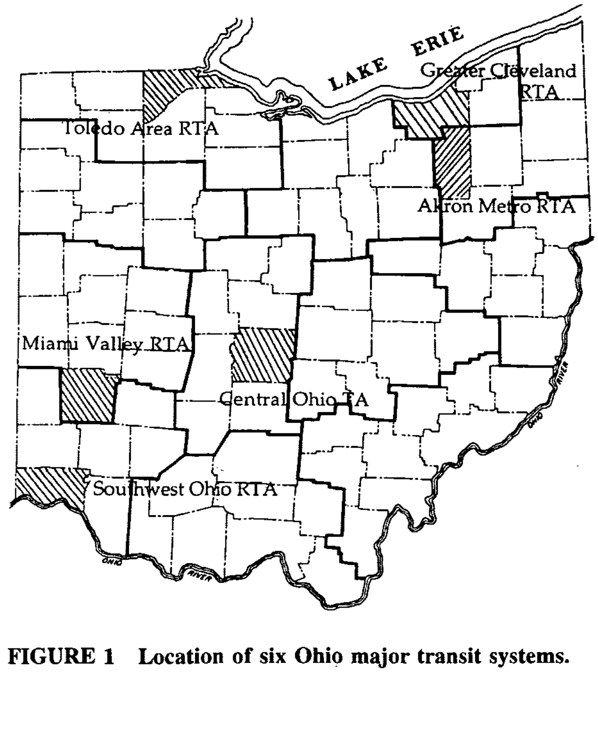

FIGURE 1 Location of six Ohio major transit systems.

TABLE 2 Number of Accidents Involving Buses, Systems and State

Year	Toledo	Cleveland	Akron	Columbus	Dayton	Cincinnati	State
1989	154	315	74	187	86	265	1270
1990	146	341	70	195	84	301	1326
1991	127	286	73	201	88	304	1279

Transit Accident Data Collection

The transit bus accident data came from the Traffic Accident Record System and were supplied by the Ohio Department of Public Safety (ODPS) for 1989 to 1991. The coded information for each accident contains 141 variables, including jurisdiction of roadway, county, and route number. Some variables analyzed in this study are month of accident, day of accident, year of accident, day of week, hour of day, light condition, vehicle type of Vehicle 1, vehicle type of Vehicle 2, vehicle type of Vehicle 3, weather condition, roadway condition, location of accident, type of accident (first harmful event), and accident severity. Transit-bus-related accidents are easily identified by vehicle type entry coded as 18.

The total number of bus accidents that were reported during these 3 years was 3,875. Table 2 gives the number of these accidents by year for the six RTAs and the total state. The total number of public bus accidents does not appear to vary much by year.

Exposure Data Collection

VMT, which is considered to be the most common exposure measure, is used in this study. The VMT data used in this study were obtained from the Public Transit Division, Ohio Department of Transportation (ODOT).

Part of this research focuses on the accident experience of transit bus under three weather conditions of travel: no adverse weather, rain, and snow. *Climatological Data* is a monthly official publication of the National Oceanic and Atmospheric Administration that provides detailed climatic data for each state (*5*).

The authors want to compare the mean bus accident rates of the six major transit systems under different weather conditions. To derive this exposure measure easily, simply define a day with precipitation of more than 0.5 in. to be a rainy day and a day with snowfall of more 0.5 in. to be a snowy day. There might be both precipitation and snowfall over 0.5 in. in the same day; then simply define that day as a rainy day if there was more rain than snow or as a snowy day if there was more snow than rain. Table 3 gives a summary of the number of precipitation days with rainfall and snowfall over 0.5 in. for the six major transit system areas.

TABLE 3 Number of Days with Precipitation over 0.5 in., 1989–1991

Year	Rain/Snow Toledo	Cleveland	Akron	Columbus	Dayton	Cincinnati
1989	21/15	28/33	27/29	30/12	31/12	29/3
1990	30/14	41/19	48/16	41/9	42/8	38/2
1991	17/11	18/25	12/19	21/9	23/9	27/2

DATA ANALYSIS

Overall Accident Data Analysis

All of the bus and bus-related accident data, which were collected and provided by ODPS, are used to conduct a thorough analysis to explore the effects and distribution of various factors. After screening out incomplete and questionable accident reports, the authors developed a data base of approximately 3,860 accidents.

The yearly variation of accident occurrence for the 3 years does not show any distinct trend of accident frequency during this period. It only shows to have a little increase of occurrence in 1990 (Table 2).

Figure 2 illustrates the distribution of accident occurrence by month for the 3 years. Weather conditions that change by season may be hypothesized to have influence on accident occurrence, but they do not appear to be significantly correlated with each other. The greatest frequency of accidents occurred during May and October. The lowest frequency of accidents occurred during September.

The daily occurrence of accidents showed that there is no significant variation during the weekdays, but the accident occurrence dropped significantly on Saturday and Sunday, which may be due to the less intensive service frequency on these 2 days. Monday and Friday were slightly higher than the other days. On the basis of the concept of exposure, this result was expected.

Figure 3 shows the proportion of accident occurrence by RTA. Six major transit authorities contain more than 85 percent of the

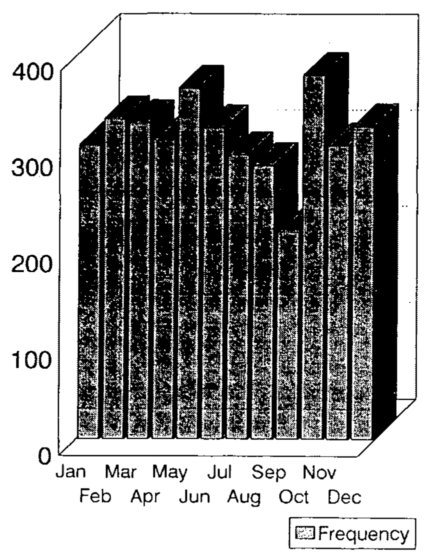

FIGURE 2 Distribution of accident occurrence by month.

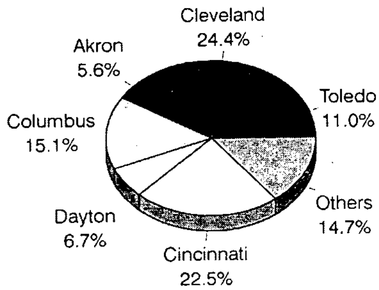

FIGURE 3 Distribution of accident occurrence by transit authority.

bus accidents that occurred in Ohio during the 3 study years. This phenomenon may be because the small urban and rural transit systems operate more vans instead of buses. Greater Cleveland RTA, which has the largest vehicle fleet (788 buses) and is the largest transit system in Ohio, had about one-fourth of the bus accidents that occurred in Ohio. The Cincinnati system had about one-fifth of the accidents. The Columbus and Toledo systems had similar proportions of the accidents, and the Akron and Dayton systems had lower proportions of the accidents.

Figure 4 shows the accident variation under different weather conditions. Almost 80 percent of the accidents occurred in clear weather, with 15 percent of the accidents in rain and 5 percent in snow. Although some studies indicated that rain and snow have influence on motor vehicle accidents, especially on passenger cars, it cannot be told from this figure about how weather conditions affect bus accidents.

Figure 5 is the distribution of accident occurrence on different pavement surface conditions. It shows that more than 70 percent of the accidents occurred on dry pavement, with 20 percent of the accidents occurring on wet and 5 percent occurring on ice- or snow-covered pavement.

The proportion of accident occurrence under different light conditions was examined. More than 80 percent of the accidents occurred in the daylight, and about 4 percent occurred during dawn and dusk. Only a small proportion (12.6 percent) of the accidents occurred in darkness with or without lights. This probably reflects that a few major transit systems provide full service during nighttime and that they also offer less intensive service frequency. Limitations in data preclude any further analysis of the accident rates under daylight and darkness, but it would be of interest to see if the accident rate increases significantly in darkness.

Figure 6 shows the proportion of accident occurrence by different types of collision. The three most common collision types are sideswipe (29.4 percent), angle (26.3 percent), and rear end

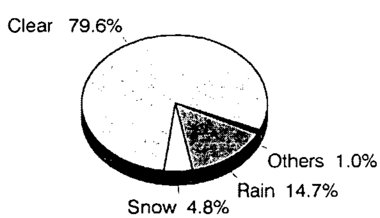

FIGURE 4 Distribution of accident occurrence by weather condition.

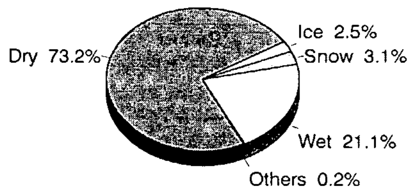

FIGURE 5 Distribution of accident occurrence by roadway condition.

(22.6 percent). These are followed by crashed with parked vehicle (9 percent) and crashed with fixed object (3.2 percent). These indicate that vehicle maneuvering or handling is a major factor in public bus accident occurrence.

The breakdown of proportion of the accidents by severity was carried out. Most accidents were property damage only. Only a very small proportion of the accidents (0.3 percent) resulted in a fatality. The data confirm that buses are one of the safest modes of transportation. Injury accidents, however, are a factor to consider.

In looking at the locations of the accidents, about half occurred at an intersection or intersection-related area, and the other half occurred at a nonintersection or other area (e.g., area of railway crossing and bridge). The proportion of accidents occurring at an intersection area appeared to be small when compared with the study done in the Chicago metropolitan area (2), where more than 70 percent of the bus accidents occurred at intersections. This may be because the Chicago metropolitan area is more urbanized than any of the cities in Ohio.

Analysis of Accident Rates Among Six Major Systems

A single-factor ANOVA problem involves a comparison of k population or treatment means, $u_1, u_2, \ldots, u_k$. The objective is to test H_o: $u_1 = u_2 = \ldots = u_k$ against H_a: at least two of the means are different. This analysis is based on k independently selected random samples, one from each population or for each treatment.

Although a single-factor ANOVA can be carried out to compare more than two population means, it has its own limitations and may need further analysis of data to identify the significant difference among the population means. Consider the case of $k = 3$ populations or treatments and null hypothesis H_o: $u_1 = u_2 = u_3$. If H_o is not true, there are four possible groups of the u's:

1. $u_1 = u_2$ and u_3 differs from these two,
2. $u_1 = u_3$ and u_2 differs from these two,

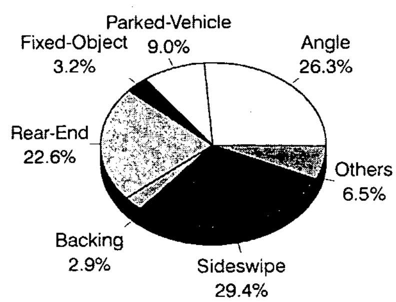

FIGURE 6 Distribution of accident occurrence by accident type.

3. $u_2 = u_3$ and u_1 differs from these two, and
4. All three u's are different from one another.

After H_o is rejected, an investigator would typically want to know which of these four groupings is most plausible. Therefore, following rejection of H_o, a further analysis may be necessary to identify differences among the u's. This is called a multiple comparisons procedure.

The Bonferroni multiple comparisons procedure is easy to understand and apply. The general idea behind this procedure is first to compute a confidence interval for the difference between each pair of u's. For example, in the case $k = 3$, an interval would be computed for u_1-u_2, another for u_1-u_3, and a third for $u_2 - u_3$. After all such confidence intervals have been obtained, each one is examined to see whether it includes 0 or not. If the confidence interval does not include 0, then two corresponding u's are said to differ significantly from one another.

The Bonferroni multiple comparisons procedure is as follows: when there are K treatments or populations to be compared, first compute the following $K(K - 1)/2$ confidence intervals using the appropriate critical value based on error degree of freedom (MSE = mean square error).

For u_1–u_2: $\bar{X}_1 - \bar{X}_2 \pm$ (Bonferroni critical value)$(MSE/n_1 + MSE/n_2)^{1/2}$

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For u_{k-1}–u_k: $\bar{X}_{k-1} - \bar{X}_k \pm$ (Bonferroni critical value)$(MSE/N_{k-1} + MSE/n_k)^{1/2}$

Then two u's are judged to differ significantly if the corresponding interval does not include 0. This procedure guarantees that for (at least) 95 percent of all data sets, no means will be incorrectly judged significantly different.

The bus accident rates of the six major transit systems in Ohio will be compared to see if there is any difference of operation safety problem of the systems. The bus accident rates within each major system under different weather conditions will also be compared to see whether the weather conditions have a negative influence on transit bus operations. As discussed, a single-factor ANOVA, involving a comparison of more than two population or treatment means, is carried out to compare the bus accident rates of six Ohio major transit systems and the bus accident rates under different weather conditions. When H_o: all u's (bus accident rates) are equal is rejected in favor of H_a: at least two of the u's are different, then the Bonferroni multiple comparisons procedure is conducted for in-depth analysis of these bus accident rates to see if there is any significant difference of accident rates among these systems as well as to see if there is any significant difference of accident rates in various weather conditions.

Comparison of Accident Rates

In this study the bus accident rate can be simply defined as

Bus accident rate

$$= \frac{\text{Number of accidents involving at least one bus}}{\text{VMT generated by bus}} \quad (1)$$

The other way to evaluate the system safety performance sometimes used by transit operators is by using VMT generated by bus (Table 4) divided by number of accidents involving at least one bus. This measure indicates the distance between two bus accidents. Table 5 gives the average bus accident rates of the six Ohio major RTAs using these two measures based on the 1989–1991 bus accident data.

The VMT/accident rate illustrates the overall relative safety of bus use in Ohio. Cleveland and Dayton have a low accident/million vehicle miles (MVM) rate, Columbus and Akron are in the middle range, and Toledo and Cincinnati have higher rates.

Statistical Comparison of Accident Rates of Six Major Transit Systems

The authors want to compare the mean accident rates of the six major transit systems in Ohio, which are Toledo Area, Greater Cleveland, Akron, COTA (Columbus), Miami Valley (Dayton), and Southwest Ohio (Cincinnati). Tables 2, 4, and 5 give the basic bus accident data, VMT information and accident/MVM rates for the six major Ohio transit systems, respectively. These tables show that although there is some variability in accident frequency, VMT, and accident rate by year for each of the six systems, there is no major change or trend for any of them.

ANOVA is used to test the significance of differences among these mean rates. The null hypothesis tested is that there is no significant difference among the rates. Let u_{Tol}, u_{Cle}, u_{Akr}, u_{Col}, u_{Day}, and u_{Cin} denote the average bus accident. The results of an ANOVA table show that the computed F-value, 70.15, does exceed the critical value 3.11. So H_o is rejected at a 0.05 level of significance. The data suggest that there are differences in average accident rates among these six transit systems.

The statistical test result concludes that the average bus accident rates for these six systems are different. The Bonferroni multiple comparisons procedure is conducted. For the population $K = 6$, the Bonferroni multiple comparisons procedure requires that $K(K - 1)/2 = 15$ intervals be computed. From the computed Bonferroni t-

TABLE 4 VMT Information, 1989–1991 (100,000 mi)

Year	Toledo	Cleveland	Akron	Columbus	Dayton	Cincinnati
1989	6.391	25.085	4.050	9.768	6.999	11.376
1990	6.380	26.949	4.044	9.881	7.742	11.461
1991	5.976	25.534	4.597	10.368	8.942	11.959

TABLE 5 Bus Average Accident of the Six Ohio Major Transit Systems Using Measures of Accident per MVM and Miles per Accident

Rate	Toledo	Cleveland	Akron	Columbus	Dayton	Cincinnati
Year						
1989	24.10	12.56	18.27	19.14	12.29	23.29
1990	22.88	12.65	17.31	19.73	10.85	26.26
1991	21.25	11.20	15.88	19.39	9.84	25.42
Average						
Accident/MVM	22.74	12.14	17.15	19.42	10.99	24.99
VM/Accident	44,085	82,048	58,491	51,496	91,388	40,114

critical value table, the Bonferroni t-critical value for 15 intervals at a level of 0.05 is 3.65. The intervals are as follows:

For $u_{Day}-u_{Clc}$:

$$\bar{X}_{Day} - \bar{X}_{Clc} = (10.993 - 12.137) \pm 3.65(1.35/3 + 1.35/3)$$
$$= -1.144 \pm 3.65(0.949) = (-4.787,\ 2.499)^{1/2}$$

For $u_{Day}-u_{Akr}$: $(-9.804,\ -2.518)$

For $u_{Day}-u_{Col}$: $(-12.072,\ -4.786)$

For $u_{Day}-u_{Tol}$: $(-15.394,\ -8.108)$

For $u_{Day}-u_{Cin}$: $(-17.643,\ -10.357)$

For $u_{Clc}-u_{Akr}$: $(-8.66,\ -1.374)$

For $u_{Clc}-u_{Col}$: $(-10.928,\ -3.642)$

For $u_{Clc}-u_{Tol}$: $(-14.25,\ -6.964)$

For $u_{Clc}-u_{Cin}$: $(-16.499,\ -9.213)$

For $u_{Akr}-u_{Col}$: $(-5.911,\ 1.375)$

For $u_{Akr}-u_{Tol}$: $(-9.233,\ -1.947)$

For $u_{Akr}-u_{Cin}$: $(-11.482,\ -4.196)$

For $u_{Col}-u_{Tol}$: $(-6.965,\ 0.321)$

For $u_{Col}-u_{Cin}$: $(-9.214,\ -1.928)$

For $u_{Tol}-u_{Cin}$: $(-5.892,\ 1.394)$

Four intervals ($u_{Day}-u_{Clc}$, $u_{Akr}-u_{Col}$, $u_{Col}-u_{Tol}$, and $u_{Tol}-u_{Cin}$) include 0. So the bus accident rates of Miami Valley RTA and Greater Cleveland RTA, of Akron Metro RTA, COTA, and Toledo Area RTA, and of Toledo Area RTA and Southwest Ohio RTA are judged not significantly different, but all other pairs of u's are judged significantly different. This can be summarized by underscoring:

Transit System	*Average Accident Rate*
Dayton	10.993
Cleveland	12.137
Akron	17.154
Columbus	19.422
Toledo	22.744
Cincinnati	24.993

From the Bonferroni multiple comparisons procedure, one can tell that Miami Valley RTA and Greater Cleveland RTA are the two transit systems with the lowest bus accident rates in Ohio. For other systems, there is not enough evidence to distinguish the accident rates either among Akron Metro RTA, COTA, and Toledo Area RTA or between Toledo Area RTA and Southwest Ohio RTA, but one still can tell that Southwest Ohio RTA has a higher bus accident rate than Akron Metro RTA and COTA.

Statistical Comparison of Accident Rates of Six Major Transit Systems Under Different Weather Conditions

Weather condition is considered to have an influence on the occurrence of vehicle accidents, especially on passenger cars. From the previous results, it is hard to tell if weather conditions have an influence on the occurrence of bus accidents or not. To explore how weather influences bus accidents, these six major transit systems can be treated as a whole system.

There are three weather conditions: no adverse weather (clear), rain, and snow. These conditions are analyzed because few bus accidents occurred in fog or heavy wind conditions and because weather data were limited. To compare the mean bus accident rates of these six major transit systems under various weather conditions, separate the VMT data. According to the information given in Table 3, VMT data for six major transit systems under rain, snow, and clear days can be separated easily by their proportions. Then an ANOVA is used to test whether there are significant differences among these means or not. The null hypothesis tested is that there is no significant difference among means. Then the Bonferroni multiple comparisons procedure for the further analysis is conducted, if H_o is rejected at a level of 0.05 alpha test. Let u_{Clear}, u_{Rain}, and u_{Snow} denote the average bus accident rates for three weather conditions.

The results of the ANOVA table gave a computed F-value, 26.81, that exceeds the critical value 5.14. Obviously, H_o is rejected at level of significance 0.05. The data suggest that there are significant differences among the average accident rates in various weather conditions.

The statistical test concluded that the average bus accident rates in different weather conditions for these six transit systems are different. From this outcome, the authors are interested to know in what weather condition the bus drivers experience higher risk of accident. The Bonferroni procedure is conducted for this purpose.

For the population $K = 3$, the Bonferroni multiple comparisons procedure requires that $K(K - 1)/2 = 3$ intervals be computed. The Bonferroni t-critical value for three intervals at a level of 0.05 is 3.29. The intervals are as follows:

For $u_{Clear}-u_{Snow}$:

$$\bar{X}_{Clear} - \bar{X}_{Snow} = (15.182 - 17.804)$$
$$\pm 3.29[(8.91/3) + (8.91/3)]$$
$$= -2.622 \pm 3.29(2.437) = (-10.64,\ 5.396)^{1/2}$$

For $u_{Clear}-u_{Rain}$: $(-24.614,\ -8.578)$

For $u_{Snow}-u_{Rain}$: $(-21.992,\ -5.956)$

Only the interval for $u_{Clear}-u_{Snow}$ includes 0. The bus accident rates in snow and clear weather are judged not significantly different, but all other pairs of u's are judged significantly different. The corresponding underscoring is shown here:

Weather Condition	*Average Accident Rate*
Clear	15.182
Snow	17.804
Rain	31.778

The Bonferroni procedure shows that there is no significant difference between average bus accident rates in clear days and snow, but both accident rates in snow and clear weather differ significantly from the rate in rain. This means that the bus drivers in these six Ohio major transit systems could experience a higher risk of accidents in rain than in snow and clear weather. This also shows that rain could be an important factor for the occurrence of a bus accident.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Approximately 3,860 bus accidents that occurred during 1989–1991 were analyzed to identify factors contributing to bus accident occurrence. For the entire data set, examination of yearly and monthly accident totals could not identify any trend in accident occurrence. From the examination of daily variation, the bus accidents dropped dramatically on Saturday and Sunday, reflecting the less intensive service frequency during these 2 days. From the hourly variation, the accidents appeared to have two peaks occurring at the morning and evening rush hours (7:00–8:00 a.m. and 3:00–5:00 p.m.).

From the analysis of the contribution of environmental factors to the accident occurrence, weather and pavement conditions could be contributing factors, as 79.6 percent of the accidents occurred during clear weather and 73.2 percent of the accidents occurred on dry pavement. These findings are similar to the study done in Chicago metropolitan area (*2*). Bus accidents dropped significantly during night hours, this also reflects the less intensive service frequency in the night hours.

The analysis of types of bus accidents indicated that sideswipe, angle, and rear end were dominant; they contained almost 80 percent of the bus accident totals. The severity level was generally low—there were only 13 bus accidents (0.3 percent) with a fatality. Most of the accidents were property damage only (67.6 percent).

From the analysis of accident locations, about half of the accidents occurred at an intersection or intersection-related area and the other half occurred at a nonintersection or other areas (e.g., area of railway crossing or bridge passing over or under). The proportion of accidents that occurred at an intersection area was smaller in comparison to the study done in the Chicago metropolitan area (more than 70 percent of the bus accidents occurred at intersections in Chicago).

The comparisons of mean accident rates of six major transit systems indicated that Miami Valley RTA and Greater Cleveland RTA are the two transit systems with the lowest bus accident rates in Ohio. For other systems, there is not enough evidence to distinguish the accident rates either among Akron Metro RTA, COTA, and Toledo Area RTA or between Toledo Area RTA and Southwest Ohio RTA. Southwest Ohio RTA still can be judged to have a higher bus accident rate than Akron Metro RTA and COTA.

This analysis does not show that the Greater Cleveland RTA, Southwest Ohio RTA, and COTA, the three largest transit systems in Ohio, have significantly higher accident rates. Therefore, the level of urbanized area can be concluded to have no significant contribution to bus accidents in Ohio for these large urban systems. From the comparison of mean accident rates under different weather conditions, rain is found to be a contributing factor to bus accidents.

Recommendations

A follow-up study should take a longer-term accident period and look at original accident reports to determine more specific results and accident trends. The bus accident rates of Southwest Ohio RTA and Toledo Area RTA are found to be higher than those of all other major transit systems in Ohio. The reasons that these two systems have the high accident rates should be investigated further.

Accident type sometimes is considered to have direct relationship to accident severity. Although a bus is one of the safest transportation modes, it might be interesting to look at their relationship in the future.

Finally, it must be remembered that although there are different accident frequencies and characteristics among the six largest public transit authorities in Ohio, the authors are looking at relative differences. Overall, in Ohio, public bus use is a safe mode, especially considering the level of severity.

ACKNOWLEDGMENTS

The ODPS provided a computer tape containing public bus accidents in Ohio for the 3-year period. ODOT, Public Transit Division, provided a summary of VMT for the transit systems in Ohio for the 3 years. This paper is a summary of a portion of Chang's master's thesis at the Ohio State University.

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