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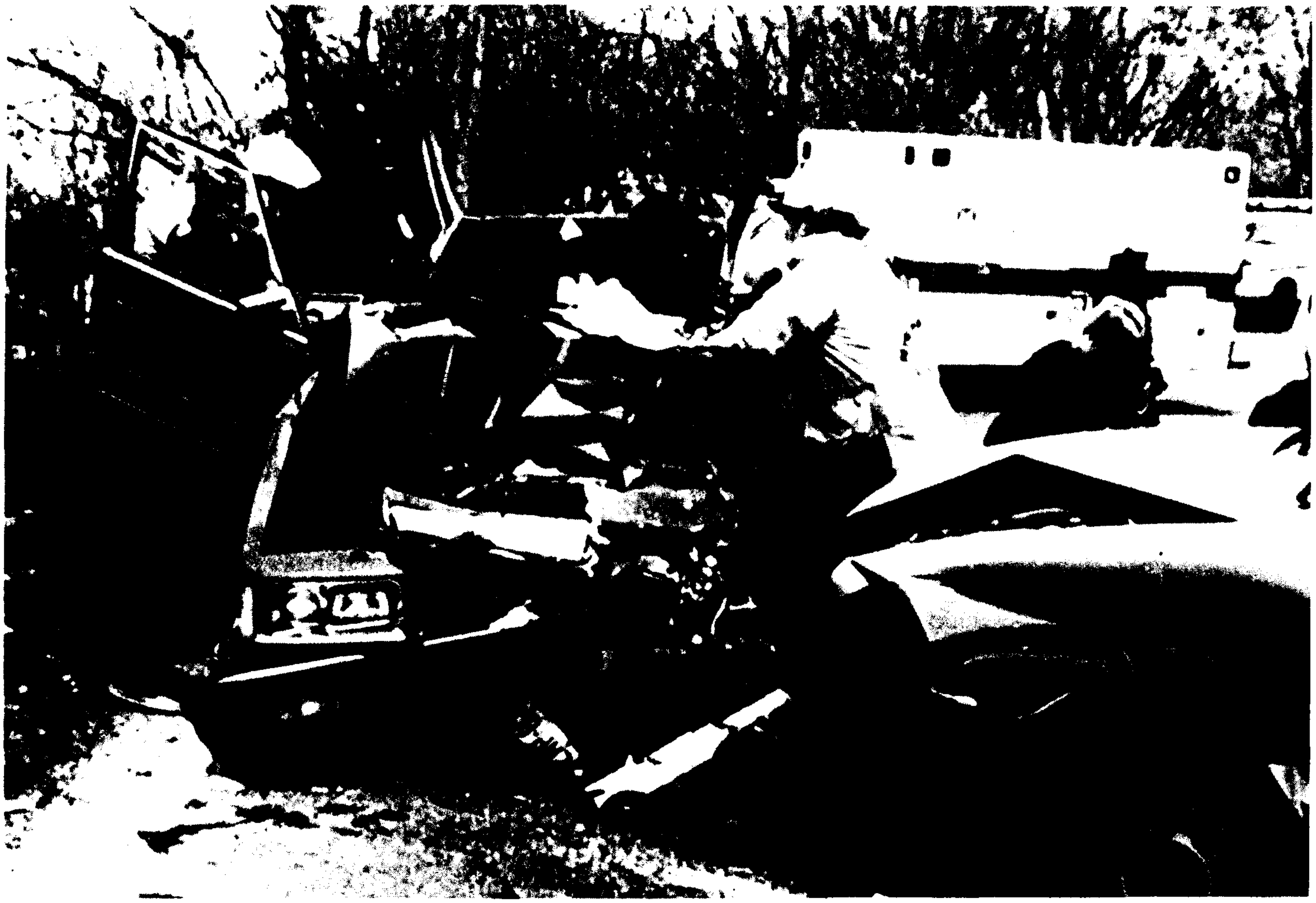

The Highway Safety Information System: Applications and Future Directions

Jeffrey F. Paniati and Forrest M. Council

This is the second in a two-part series of articles describing the development and use of a new highway safety data base. The first article, published in the December 1990 issue of Public Roads, described the need for such a data base, its design, and its content. This article provides an overview of this newly operating data base, illustrates its potential applications, and outlines future development plans.

Introduction

The Highway Safety Information System (HSIS) is a new highway safety data base developed by the Federal Highway Administration (FHWA) and the University of North Carolina Highway Safety Research Center (HSRC). Safety analysts and highway engineers are using the HSIS to access accident, traffic, and roadway data for a variety of applications, ranging from basic problem identification to modeling efforts that attempt to predict future accidents. Note that the goal of the HSIS is not to provide national accident statistics; rather, the HSIS is designed to provide a detailed system linking accident, roadway, and traffic data for problem analysis.

This article describes the capabilities and characteristics of the HSIS and provides five problem analysis examples that illustrate how the HSIS can be used as a problem solving tool. The article also discusses future enhancements to the system that might significantly improve the range of analyses for which the HSIS can be used.

Background

A location-based accident system, the HSIS combines high-quality accident, roadway, and traffic data in a computer-linkable format. The system uses raw data already collected by a select group of States.

Currently, the HSIS includes 5 years of data (1985-89) from five States: Illinois, Maine, Michigan, Minnesota, Utah. These States were selected based on three primary criteria: the quantity of data collected, the quality of the data, and the demonstrated ability to merge data from different files.

The FHWA acquires these data annually, conducts quality control checks, prepares the data in a standard format (SAS), and downloads the data to a microcomputer. These data can then be merged for use in traffic safety analyses. Given the quality and quantity of HSIS data and the ability of the files to be merged with each other, the HSIS is a powerful, flexible tool for analyzing numerous safety issues. For example, if an analyst is studying driver or roadway factors, the HSIS can be used to determine basic problem identification issues. If the analyst needs to predict the nature and location of future accidents using accident, roadway, traffic variables, the HSIS can be used to construct multivariate models.

Initially designed as a mainframe system in which all activities were conducted on the HSRC and the FHWA mainframe facilities, the HSIS was recently converted to a microcomputer-based system. Thus, it is now more accessible for use in measuring highway safety in terms of accident frequency or rates, and relating those measures to factors such as highway geometric design, traffic control devices, roadside hardware and operating policies.

The following problem analysis examples illustrate the range of analyses that the HSIS can perform. While the issues and scope in each case differ, the first step for conducting the analysis is the same: the analyst must define the critical variables and determine the feasibility of using the data available to address the problem.

1: Sight Distance

A feasibility study using HSIS data for quantifying the accident effects of crest vertical curves was recently completed.

Problem

On rural highways, stopping sight distance—the required distance needed by a vehicle to stop before reaching a stationary object—is often factor-related to safety. Moreover, this distance is used to determine the minimum length of a crest vertical curve. Although, the American Association of State Highway and Transportation Officials' *Policy on Geometric Design of Highways and Streets* provides guidelines on the design of such curves, in recent years, the adequacy of these guidelines has been questioned.

HSIS analysis steps

The critical variables, as defined in this feasibility study, were vertical grade and related stopping sight distance information. A review of the State files found that two of the five HSIS States had grade location data; however, one could not be used because it contained data only for substandard vertical curves. The remaining State had appropriate information for all grades, and from these data, nearly 2,400 crest vertical curves were identified.(*1*)[1]

As expected, the State files did not contain specific roadway data on the stopping sight distance associated with each vertical curve. State inventory files cannot capture all the desired variables related to the roadway.

To compensate for the missing data, the analyst merged the accident data with each vertical curve and determined the distance from each accident to the crest of the curve. A plot of accidents versus these distances was made to gain insight into how accidents cluster with respect to vertical crests.

Figure 1 illustrates the results which are plotted both for curves with a grade differential (upgrade plus downgrade) of less than 6 percent and for those with more than 6 percent. The graph shows that a greater proportion of the accidents are found within .02 mi (32.19 m) of the crest and that increased grade differentials show an even greater proportion of accidents. Because grade differential and length of vertical curve determine the available stopping sight distance, these data indicate a potential problem.

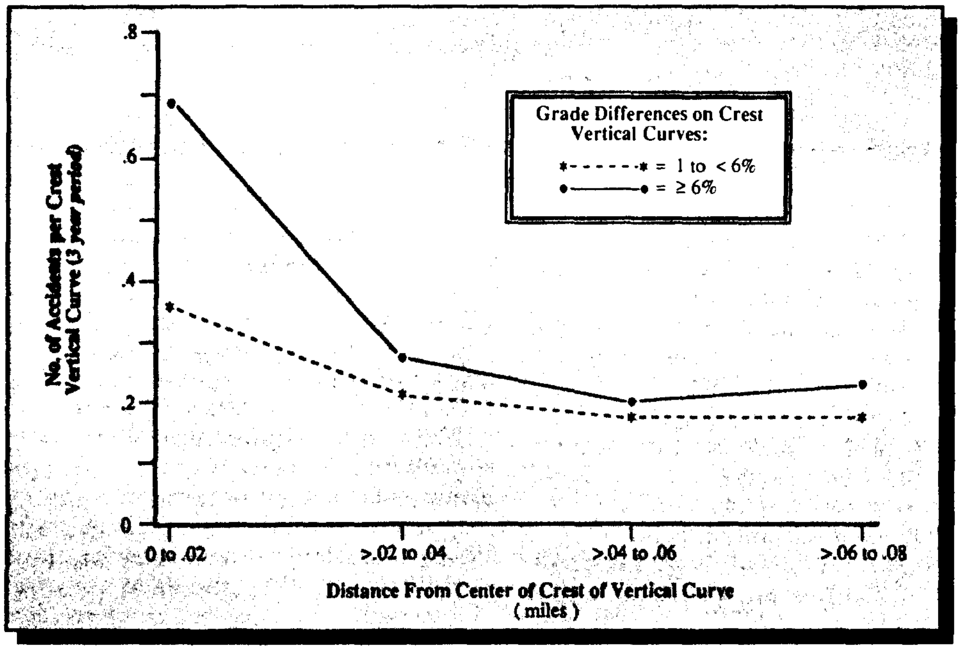

Figure 1.—Accident frequency relative to distance from crest vertical curves.

[1]Italic numbers in parentheses identify references on page 278.

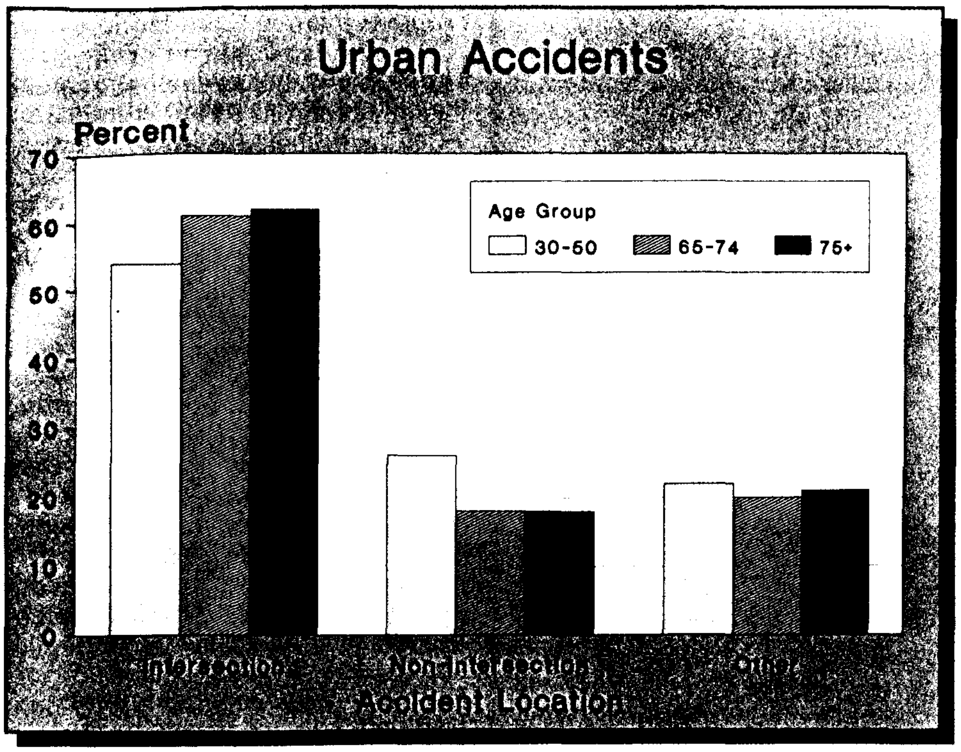

Figure 2.—Location of urban accidents (by age group).

This quick examination of the available data was only part of the feasibility study. The study also recommended other roadway and traffic variables to be examined in more detail and suggested other non-HSIS States that may have useful vertical grade data. Any full analysis will require additional field measures of actual sight distance and vertical curve geometrics to determine the relationship between grade differential and stopping sight distance.

2: The Older Driver

Problem identification represents another type of typical HSIS analysis. Here driver, vehicle, roadway, or traffic characteristics that are thought to contribute to an accident problem are investigated. The findings are then used to direct future research and select appropriate countermeasures.

Problem

Recent research has shown that older drivers, as a group, have significantly higher accident rates than average. This research has major ramifications considering the rapid aging of the U.S. population and projections that older drivers in the next generation will rely even more heavily on automobile mobility than today's older drivers.

The FHWA has developed a research program whose goal is to identify, develop, and evaluate engineering enhancements to the highway system to meet the needs of older drivers. Information on the accident patterns of the older driver is needed to identify the extent of the problem, isolate problem areas, and develop solutions.

HSIS analysis steps

By combining the accident, roadway, and traffic files in the HSIS, analysts can use the data to identify the situations where older drivers are overrepresented. These analyses can be conducted on a State-by-State basis to see if the trends are consistent.

This HSIS study of older drivers is still continuing; however, one State's data has been analyzed. For this State, the accident patterns for both the "young elderly" (ages 65 to 74) and the "old elderly" (ages 75 and older) were compared to those for younger drivers (ages 30 to 50). A wide range of variables was examined and the frequency and proportion of accidents were compared among the three age groups.

Figure 2 illustrates the findings from a comparison of intersection and nonintersection accidents for the three groups. The graph shows that both the elderly groups are involved in a higher proportion of intersection accidents than younger drivers. This was true both for urban and rural locations. Examining the type of intersection accidents where older drivers are overrepresented (figure 3) shows, older drivers are involved in a greater

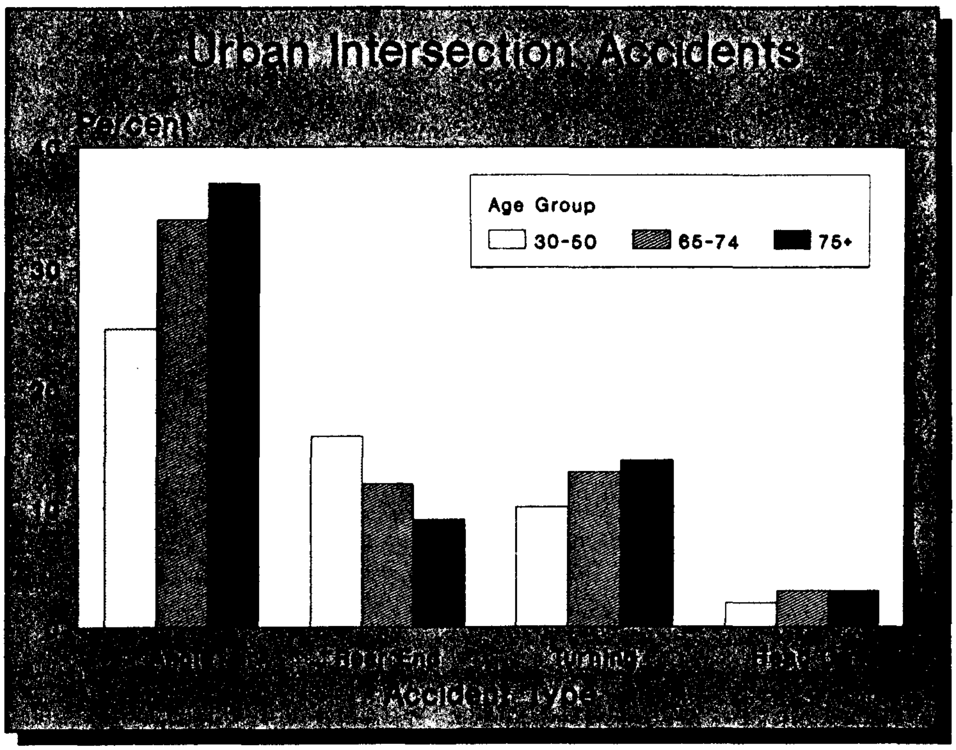

Figure 3.—Urban intersection accident types (by age group).

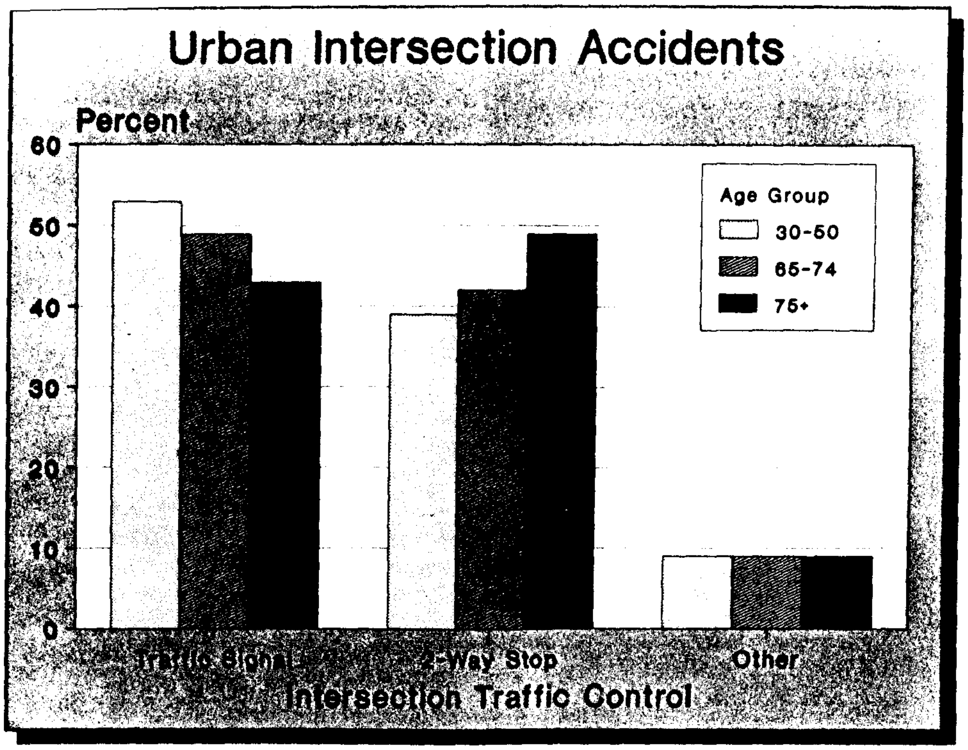

Figure 4.—Effect of traffic control on urban intersection accidents (by age group).

percentage of angle and turning accidents. Further study revealed that the major source of this accident problem was at two-way stop controlled intersections rather than at signalized intersections (See figure 4.)

Clearly, problem identification analysis cannot define the specific risk levels of older drivers, because the HSIS does not classify exposure information by age of driver. Also, overrepresentation at stop-controlled intersections may be partially a result of the fact that more older drivers travel in areas where more stop-controlled intersections are found. However, highway engineers can use this information to gain insight both into locations where accidents involving the elderly occur and into the type of accidents they are involved in.

Given the above data, the engineer, when designing roadway improvements, can focus on those situations where the driver must judge the available gap and the speed of approaching vehicles.

Possible countermeasures may involve treatments such as increasing sight distance or improving intersection control.

3: Median Crossover Accident Rates

The previous analyses focused on problem identification involving accident and roadway information and used accident frequencies (and proportions) to measure highway "unsafety." The following analysis is an example in which accident and roadway information must be merged with traffic data to produce accident rates (accidents per million vehicle miles). Instead of attaching certain roadway variables to each accident, a sample of roadway sections is defined by certain characteristics, and the appropriate accidents and traffic information are extracted for each section. In this way, the HSIS can be used to study a problem by examining how changes in roadway and traffic features affect accident rates.(*2*)

Problem

The increase in travel demand in the United States has resulted in high levels of congestion in many urban and suburban areas. In response to the growing congestion, highway agencies are seeking opportunities to increase the capacity of existing freeways by adding lanes. Because the amount of right-of-way available for this expansion is limited, additional lanes are often constructed by using portions of the existing highway right-of-way, including the median. Reducing the median width, however, has led highway engineers to question the safety of the remaining median width and has forced them to make decisions regarding the use of median barriers.

Specifically, the engineer must trade off the need to minimize the number of median crossover accidents (accidents in which a vehicle from one side of the highway crosses the median and strikes a vehicle in the opposite direction) with a decision to install a median barrier that could result in less recovery area, more fixed object impacts, and more redirected accidents (accidents where a vehicle strikes a barrier and is redirected into the traffic stream). To examine the possible implications of either decision, the engineer must look at information on existing roadways covering a range of median conditions.

HSIS analysis steps

An effort to develop median crossover accident rates was undertaken. This task required the linking of information about the accident type with roadway data (median width and type), with traffic data.

In reviewing the HSIS data files, three of the five HSIS States had the roadway information necessary to conduct this analysis. However, none of these States recorded median crossover accidents as such: instead they grouped these accidents under more general categories—head-on and sideswipe accidents. To estimate the number of median crossover accidents, the analyst looked at the number of head-on and sideswipe opposite direction accidents that occurred on divided roadways. However, analysis of the resulting crashes (involving both computer runs and limited hard-copy accident report analysis) indicated that some were intersection/interchange related, some were "wrong-way" crashes, and some involved vehicles that had spun on icy roads and struck vehicles head-on in their own lanes—none of which were true "cross-median" crashes. To reduce possible biases in the rates, the data file was then screened to eliminate (as best possible) intersection accidents, accidents involving "wrong-way" vehicles, and accidents occurring during the six months when ice and snow were most probable.

Accident rates were then developed for nonbarrier situations on divided urban and rural interstates and freeways, and other roads, categorized by median width (0 to 10 ft [0 to 3.04 m], 11 to 30 ft [3.35 to 9.14 m] , 31 to 60 ft [9.45 to 18.29 m], 61 ft [18. 59 m] and over). Table 1 provides the results for one State during the 6-month analysis period, including the number of accidents, the amount of roadway mileage, and the accident rate.

Since all "biases" could not be eliminated from the rates, they are considered "best estimates" at this time. They are felt to be "liberal" (i.e., higher than true "cross-median" rates) since all biasing crashes (e.g. some head-on crashes due to spinning in the same lane) could not be screened out. They are perhaps "conservative" since they do not include single-vehicle crashes in which a vehicle crosses the median and strikes some roadside object or overturns rather than striking an oncoming vehicle.

Similar tables were developed in the other two States for divided highways without median barriers. An analysis and comparison of these results, further examination of hard-copy accident reports, and development of accident rates for divided highways with median barriers are underway. A full report documenting the results will be available later in 1991.

4: Head-On Accidents

The analysis examples cited previously have all required significant effort to design the required data runs, compile the necessary data, and analyze the results. The following problem analysis, however, illustrates how the analyst can use the HSIS to quickly access information about a particular type of accident to grasp the scope of a problem or to check trends.

Problem

Although head-on accidents occur infrequently, they often result in severe injuries to vehicle occupants. Moreover, highway safety professionals recognize that their efforts are best devoted to planning programs or policies in those areas where the potential reduction in severe injury is the greatest. Therefore, a problem identification analysis of head-on accidents was conducted. Its purpose was to provide better information regarding the extent of the head-on accident problem and the conditions under which these accidents occur.

HSIS analysis steps

To conduct a quick examination of the head-on accident problem in the HSIS States, analysts reviewed recent data for four of the HSIS States.

Table 1.—Median crossover accident rates (2)

	Urban Interstate/Freeway			Urban Other		
Median Width	Rate[a]	Miles	Accidents	Rate	Miles	Accidents
1-10	—[b]	—	—	3.95	105	50
11-30	0.93	17	4	2.17	137	34
31-60	0.13	135	3	0.55	85	4
61+	0.35	143	5	0.00	7	0

	Rural Interstate			Rural Other		
Median Width	Rate[a]	Miles	Accidents	Rate	Miles	Accidents
1-10	—	—	—	—	—	—
11-30	—	—	—	0.61	61	1
31-60	0.00	221	0	1.40	76	6
61+	0.13	1,265	9	0.00	19	0

[a]Rates are in accidents per one hundred million vehicle miles.
[b]Insufficient raodway mileage available.

The first step was to examine the extent and severity of the problem by comparing the head-on accident data to that for all accidents.

As shown in table 2, while head-on accidents are a small part of the total accident problem, they comprise a significant percentage of all fatal accidents.

The second step was to isolate conditions under which head-on accidents occur; here, the proportion of total accidents was compared to the proportion of head-on accidents occurring under key environmental and roadway conditions.

Since the results were consistent across the States, the data were combined to produce the following figures. Figure 5 indicates that ice and snow road surface conditions are overrepresented in head-on accidents. Figure 6 shows that the dark and dark-with-street-light conditions are overrepresented in head-on accidents. Finally, Figure 7 illustrates that head-on accidents are more likely to occur on curves.

A full investigation of the head-on accident problem would require additional analysis of the interaction of these variables—light, road surface conditions and roadway alignment—and a comparison with data from non-snow States. However, this example illustrates how the HSIS can quickly provide information on the extent of a problem and potential contributing factors.

Table 2.—Comparison of head-on accidents with all accidents

State (1)	Head-On accidents (2)	Head-On fatals (3)	All accidents (4)	All fatals (5)	Head-On percent (2)/(4)	Fatal percent (3)/(5)
1	5,319	432	492,812	2,442	1.1	17.7
2	8,951	394	429,959	1,762	2.1	22.4
3	5,257	225	218,158	1,503	2.4	15.0
4	1,986	68	141,802	819	1.4	8.3

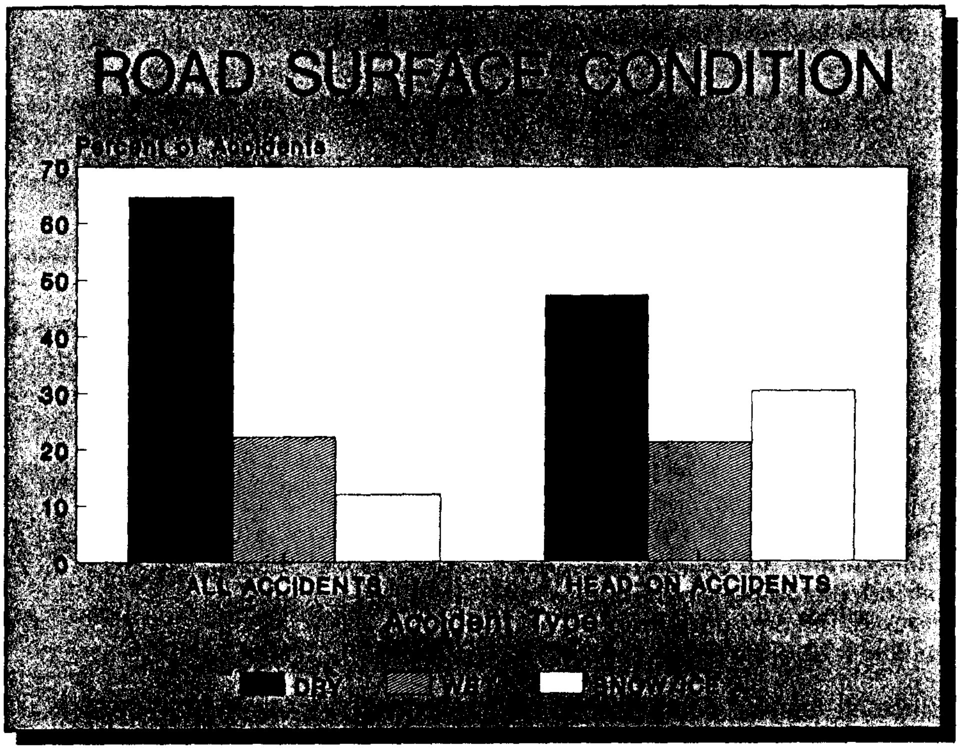

Figure 5.—Effect of road surface condition on accidents.

5: Urban Freeway Lighting

This problem analysis example illustrates a situation where the HSIS contains the necessary accident data and some of the required roadway information, but where additional non-HSIS data are also needed.

Problem

Nationwide accident statistics show that more than 50 percent of fatal accidents occur during the hours of darkness. Because travel statistics show that only 25 percent of travel occurs during the same period, the fatality rate is actually nearly three times higher at night than during the day.

The installation of overhead lighting is a potential countermeasure to this nighttime accident problem. However, this is expensive, and because research to date offers conflicting results about its cost effectiveness, an HSIS study is being conducted to examine the potential benefit of using lighting in high-volume situations such as urban freeways.

HSIS analysis steps

Although the investigation of the cost effectiveness of urban freeway lighting is still in its early stages, a significant effort has been devoted to assembling the necessary information. An examination of the HSIS data files revealed that the desired accident and roadway variables were present, but none of the States had complete lighting information. Moreover, the traffic data in the HSIS provides an indication only of the average daily traffic, not the 24-hour distribution needed to develop day versus night accident rates.

The next step was to determine whether the HSIS States had additional noncomputerized files that could provide lighting information and traffic data. Because the missing data were lighting and traffic

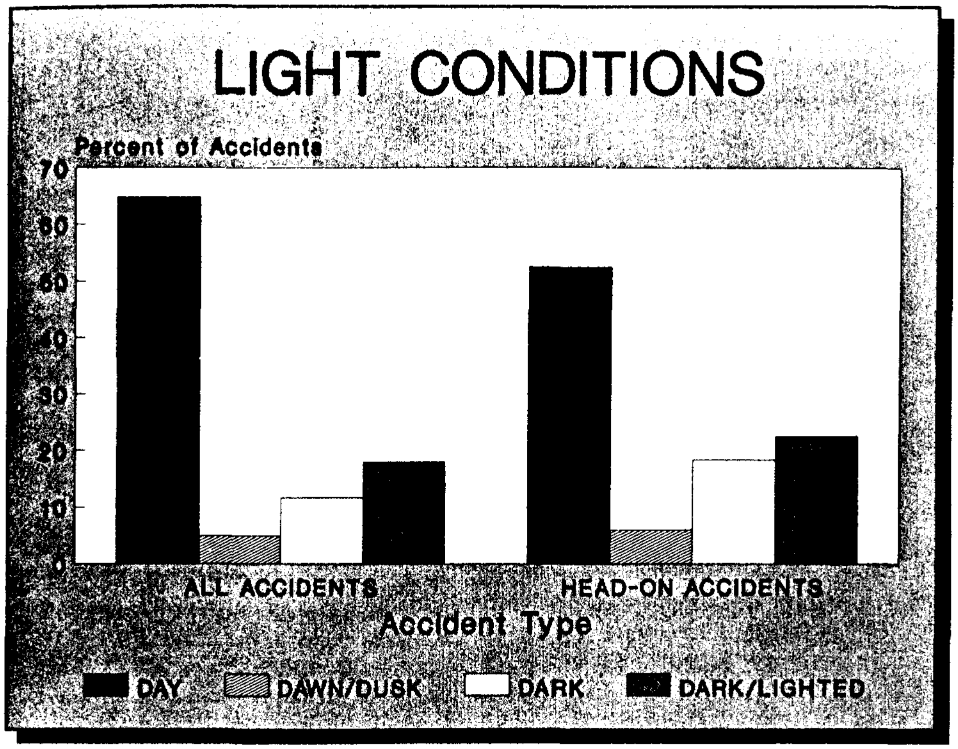

Figure 6.—Effect of light conditions on accidents.

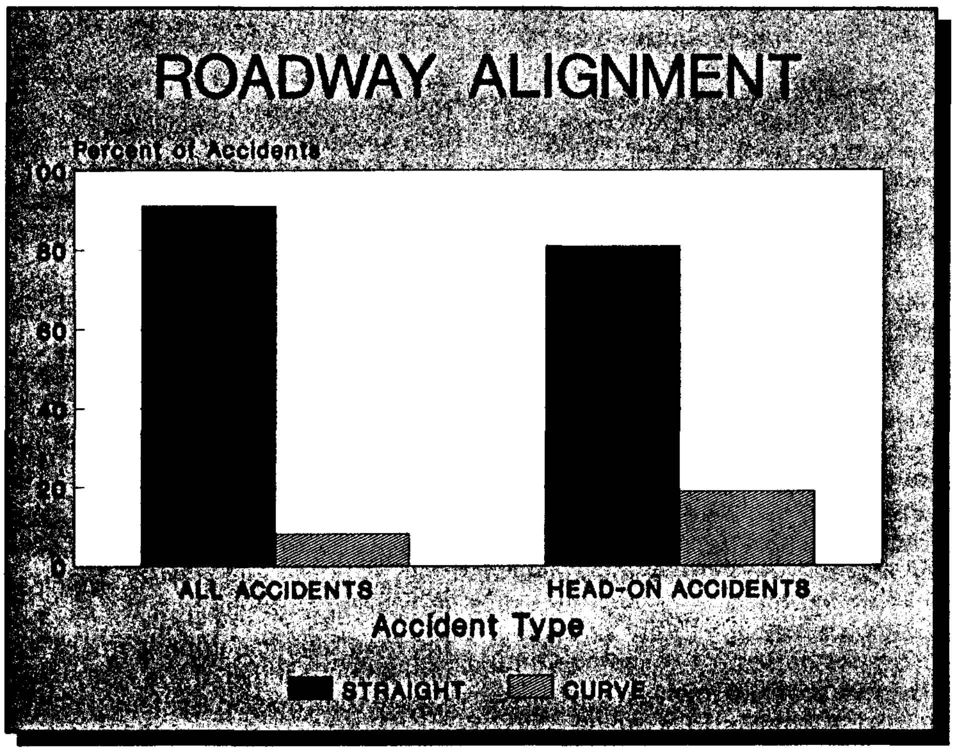

Figure 7.—Effect of roadway alignment on accidents.

information for urban freeways, the three HSIS States with large urban areas were contacted first. Two of the three States provided information about the locations, type, and installation dates of lighting along urban freeways, as well as 24-hour traffic distributions from automatic traffic recorders.

This information provided by the States is now being matched with the existing HSIS accident, roadway, and traffic files, and sunrise/sunset information provided by the U.S. Naval Observatory for a more precise assessment of accident occurrences.

This problem analysis example demonstrates how both HSIS and non-HSIS data can be combined to address a safety question. While, the HSIS accident, roadway inventory, and traffic files will often provide the "core" variables, they frequently must be supplemented by field data collection or acquisition of noncomputerized data files.

The Future of the HSIS

Although the HSIS is now fully operational, it is intended to be a dynamic data base that will adjust to meet the changing needs for safety data. To do this will require a periodic assessment of how well the system is functioning and an identification of potential modifications. The HSRC under contract from the FHWA is conducting such an evaluation. Having converted the HSIS to a microcomputer-based system, the HSRC is charged with two other broad provisions to:

- Use the system for wide range of analysis activities.
- Evaluate the system to determine if modifications or enhancements are required.

Analysis activities

To date, more than 15 HSIS analysis projects have been identified; they include completed or ongoing efforts by HSIS contract staff, FHWA researchers, FHWA graduate research fellowship students, and outside contractors. To fully evaluate the system's effectiveness, the HSIS must be used for a wide range of analysis activities. While it is expected that many of these analysis activities will be short term responding to current issues, several long-range studies have been planned. These include studies of:

- Truck accidents that will examine the relationship between truck accidents and highway characteristics—horizontal curvature, vertical grades, lane width, etc. The study will develop predictive equations for use in identifying deficient highway sections.

- Roadside hazards that will develop a severity index to quantify the effects of roadside hazards on accident severity. This index could be used to evaluate the cost effectiveness of roadside improvements—relocating utility poles, breakaway sign supports, crash cushions, etc. Both HSIS and non-HSIS data sources will be used.
- Intersection accidents that will isolate the intersection characteristics that are overrepresented in accidents such as number and type of lanes, intersection geometry, traffic volume, traffic distribution, etc.

System enhancements

In planning for the future of the HSIS, a number of system enhancements are being examined, including those for improving the user-friendliness of the system and for adding new States or additional data files to the system.

In the near term, enhancement efforts will concentrate on improving the data available for the existing HSIS States. Data enhancements include:

Using vehicle identification numbers (VIN). A VIN is a unique number assigned to each manufactured vehicle. Processing the VIN through an available decoding program will generate information on the size and weight of the vehicle. These data are useful for studying the performance of roadside hardware and the handling of vehicles on certain roadside geometrics.

Merging of a cross-section data base. A detailed cross-section data base was developed for 4,950 mi (7 966 km) of roadway in seven States—two of which are HSIS States—as part of an earlier FHWA effort. Merging this cross-section data base with the current HSIS data files would provide access to information not available in any roadway inventory file in the U.S. New information generated would include: roadside recovery distance, a subjective roadside hazard rating, the number of and distance to roadside obstacles (utility poles, trees), and sideslope data.

Linking with the Highway Performance Monitoring System. Currently, each State reports to the FHWA highway features and traffic data for a sample of their highway sections. The data are used to compile national statistics. They could also be used to supplement the existing HSIS data files. Potential variables include: pavement roughness, passing sight distance, design speed, and roadway capacity.

Using bridge/railroad crossing files. These files were recently acquired for each State. Due to time limitations, however, the raw files have not yet been converted to SAS format. The bridge files contain information on bridge width, railing type, guardrail transitions, etc. The railroad files contain data on the crossing geometry, type of protection, train volumes, etc.

Using videodisc photologs. A least one HSIS State has photologs (pictures taken each 0.01 mi [16.09 m]) available on videodisc for the entire State-maintained highway system. Videodiscs, which are similar to the compact discs used for storing audio information, allow the photolog pictures to be efficiently stored (500 or more mi [804.7 km] per disc) and rapidly accessed. Videodiscs would provide the capability to collect "new" roadway inventory data from an office setting. This data could include the locations of fixed lighting, speed limits, or roadside hardware.

Conclusion

The five problem analysis examples illustrate that the HSIS can be used for a range of tasks, from performing basic problem identification using only one file to developing accident rate models, to performing analyses of complex problems using HSIS data in combination with supplemental data. By incorporating accident, roadway inventory, and traffic data files from five different States, the system can be used to study numerous issues and provides the ability to check the consistency of findings across States. Planned enhancements will increase the flexibility of the system and its range of applications. As with any data system, the long-term success of the HSIS will depend on the expertise, inquisitiveness, and innovation of its users.

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