USES OF TRAFFIC ACCIDENT RECORDS

A MANUAL

Prepared by

Committee on Uses of Developed Information

National Conference on Uniform Traffic Accident Statistics

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PREFACE

It was not until the early twenties that public officials throughout the United States recognized the importance of standardizing and improving report forms and procedures for collecting and analyzing information on motor vehicle accidents. The National Conference on Uniform Traffic Accident Statistics was an outgrowth of this realization. It was formed as the common meeting place of twenty-five organizations and agencies interested in the improvement of highway transportation.* With the reorganization of the Conference in 1941, the principal activities were assigned to three committees: (1) Committee on Forms and Statistical Practices; (2) Committee on Definitions; and (3) Committee on Uses of Developed Information.

This Manual is the work of the Committee on Uses of Developed Information of the National Conference on Uniform Traffic Accident Statistics. When the Committee was created in March 1941, it was recognized that accident information was becoming increasingly available in greater completeness and detail in most cities and states, but that too few uses were being made of this reported information. Accordingly, the Committee undertook the preparation of a Manual which would encourage more extensive and uniform uses of accident records, and which would bridge the gap between the statistical systems employed in the collection and basic analysis of accident data and the uses of accident information. Needs of engineers, educators, enforcement officials, and other groups were taken into account.

Work on the Manual was greatly curtailed because of the war. However, the Committee was kept active and some progress was made by several members.

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*The following agencies constitute the National Conference on Uniform Traffic Accident Statistics:—American Automobile Association; American Association of Motor Vehicle Administrators; American Association of State Highway Officials; American Mutual Alliance; American Public Health Association; American Transit Association; American Trucking Association; Association of Casualty and Surety Companies; Automotive Safety Foundation; Conference of State and Provincial Health Authorities of North America; Federal Interdepartmental Safety Council; Institute of Traffic Engineers; International Association of Chiefs of Police; National Association of Coroners; National Association of Motor Bus Operators; National Association of Railroad and Utilities Commissioners; National Conservation Bureau; National Safety Council; Society of Automotive Engineers; U. S. Bureau of Labor Statistics; U. S. Division of Statistical Standards; U. S. Interstate Commerce Commission; U. S. Public Health Service; U. S. Public Roads Administration; Yale University Bureau of Highway Traffic.

Publication of the Manual at present is especially timely, in view of the new magnitude and complexity of highway transportation. It is the studied conviction of the Committee that there is an urgent need for the best possible uses of accident records and facts, in order that all forces and resources can be properly focused on traffic problems and activities aimed at their correction.

It is realized that this Manual does not cover all aspects of accident record activities and that there are many more uses to which accident data can be put. It is further realized that many additional methods, bibliographical references, and illustrations could be included. On the other hand, it is felt that a significant start has been made towards the compilation of the more important uses of accident information, and it is hoped that the Manual will serve as an important instrument in not only encouraging more extended and serious applications of available data, but also in the stimulation of development of new uses and in the expansion of existing record systems. Should this result, a more complete and comprehensive Manual may be issued through the National Conference in the future.

The personnel of the Committee represents a wide group of agencies interested in highway transportation and traffic safety. Each member has had valuable experiences in the use of accident information and is an expert in his field. In the development of the Manual, work was arranged so that each chapter was the specific responsibility of a few qualified committee members working together as sub-committees. These members, in turn, called upon official agencies of state and local governments as well as on other traffic and transportation authorities for assistance. In this way, the Manual represents the experiences and opinions, not only of members of the Committee, but of agencies and individuals engaged in the day-to-day analysis, collection, and use of accident data.

All members of the Committee had an active part in the preparation of the Manual, and contributed substantially from their experiences and current activities. Much credit is due the many others who contributed valuable suggestions and illustrations and who reviewed the manuscript. Special appreciation for the preparation of the basic manuscript is due Messrs. David M. Baldwin, William G. Eliot, Burton W. Marsh, Daniel G. Reynolds, and George R. Wellington. The Committee is deeply indebted to Mr. Taylor D. Lewis for the great amount of time which he devoted to the preparation of the manuscript and to the general direction of the Committee.

The Committee is grateful to the Eno Foundation for Highway Traffic Control, Inc., for funds for printing the Manual. The widespread free distribution which this support makes possible will insure the maximum utilization of the Manual's contents.

WILBUR S. SMITH, *Chairman*,
Committee on Uses of Developed Information.

Yale University.
August, 1947.

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CHAPTER I

INTRODUCTION

This Manual is intended to encourage greater use of accident records and the development of additional uses for accident prevention purposes.

The use of records of past accidents to guide future accident prevention work is based upon the generally accepted premise that accidents are caused by specific conditions and acts and that, unless altered by safety activities, those same conditions and acts will continue to cause traffic accidents. If accident prevention efforts are spread over all highways, those which are safe as well as those which are hazardous, and are extended to all persons, those who are safe as well as those who commit unsafe acts, the effectiveness of the accident prevention work will be diluted and much effort lost. With limited facilities for accident prevention, it is vital that the strongest efforts be directed at the conditions and persons most in need of correction.

The Committee on Accident Records of the President's Highway Safety Conference selected the following key statement as the highlight of its report:

> "Every administrator—from governors and mayors down—must recognize that records are not merely a by-product of the traffic safety program, and must at every opportunity employ records as an effective aid to the determination of policies and to the economical expenditure of public funds to produce maximum results preventing accidents."

Past Uses of Accident Records

The automobile, almost since its beginning, has been involved in accidents—collisions with other vehicles, pedestrians, or objects, as well as other mishaps. Early collisions were noted on police blotters or in court records. In most areas, only fragmentary information on a small portion of the early collisions was recorded. Accident records were not used as an aid to accident reduction until the automobile became a recognized accident instrument.

Knowledge necessary for the use of accident records as an aid in accident prevention has been available for years. Forms have been developed, tested by use, and continually improved. Procedures are well known by which good reports may be secured, and successful methods have been developed whereby good coverage of accident occurrence can be obtained. Useful statistical analysis procedures have been evolved and used by many accident-prevention organizations. It is regretted that with this knowledge available, so few cities and states are utilizing it fully in accident prevention. It is hoped that this Manual will serve as an impetus to greater use of existing accident data—especially for that group of cities and states which is making little current use of these data.

Some cities and states which now are using accident records extensively for accident prevention purposes may obtain from this Manual ideas for improvements or changes in their programs. Cities and states which make only limited use of accident records should find suggestions for expansion of their programs. Those cities and states which make little or no use of accident records should see in this Manual methods for developing the use of accident facts for effective accident reduction and for the improvement of traffic flow.

Standardization of Uses Important

Some standardizaton of the uses of accident data is important. With no agreement on standardization, comparisons of activities between various public jurisdictions, interchange of information on corrective measures, and rational expansion and improvement of methods cannot be properly achieved. On the other hand, the forms and procedures used to develop practical information should not be frozen into patterns which prohibit local adaptation and free experimentation.

How to Encourange the Use of Accident Records

Just as the process of reasoning can be arranged in orderly fashion by a logician, so can a patterned plan of getting accident record use be outlined. Other plans and approaches, varied as human nature, will be apparent, but the following simple pattern may be thought-provoking for those who now assume that practical application of statistics will automatically follow their tabulation and publication:

1. State clearly the administrative or technical traffic problem to be solved and list possible solutions.
2. Consider what accident information will most likely help to define the problem and to select the best solution.
3. Consider ways and means of getting the needed information.
   a. Is the information readily available from an existing regular summary or special study?
   b. If a special study must be made, exactly what information will be needed and how should it be tabulated, analyzed and presented? Fifteen minutes of planning and thought at this stage may save ten hours of tabulation.
4. Present the information in the most concise, understandable, and usable form possible.

A growing number of industrial and other organizations have brought the statistician into policy-making groups, at least as the fact provider, if not as a voting member. If the statistician is familiar with the problems facing an organization, he can develop the facts which will be helpful in working out the best solutions. This pattern is equally applicable to accident prevention agencies.

Accident Statistics Involve Reasoning

Since accident information is largely statistical information, it is well to consider what are "statistics." One text book definition is: "Statistics are classified numerical information on a large number of cases." But, this is not a definition which will help point the way to increased use of accident information. Two other definitions have been frequently quoted which, while not in Webster's best form, emphasize important points about statistics:

1. Statistics are 90 per cent common sense and 10 per cent mathematics.
2. Statistics are *useful* numerical facts—if the numbers are not useful, they are not statistics.

All too often in traffic accident work the importance of good judgment, common sense, and honesty are overlooked as foundations of good, useful statistics. The interpretation of statistics must take account of non-numerical facts, as well as opinions and observations. Accuracy is fundamental to the use of accident information—errors in published information will soon destroy confidence and when confidence in the figures is lost, substantial use of the information is unlikely.

Most uses of accident information are based upon simple mathematical operations. While some of the relatively advanced statistical techniques have an application in the field of traffic accident prevention, and it is, therefore, always well for the accident statistician to be familiar with all techniques in the field of statistics, the frequent use of advanced statistical techniques has not been found necessary for most practical work with accident facts.

Limitations on Accident Record Use

Maximum use of accident records is more likely if the limitations on accident records are recognized. The application of accident records to prevention problems is not a "cure-all." Sometimes there may be too few accidents of a particular character or at a specific location to warrant conclusions. At other times it will be found that the need for certain accident information was not foreseen and that it was not collected, or not tabulated. Sometimes the type of information on accidents which is really needed cannot be collected from drivers or investigators because it involves events which cannot be readily measured or classified. Then too, accidents may not be the entire story of a particular transportation problem; congestion and other factors must be considered. But, accidents are an evidence of a transportation problem, and accident records can be an effective tool for the development of policy and action.

Even when accident statistics are adequate, technical ability is required to convert the results of the analysis into definite recommendations for most effective and economical remedies. Trained traffic technicians must study accident problems and relate them to all transportation factors. Accidents, unfortunately, are only a part of the required investigations.

Remedial treatments must not only reduce or eliminate accidents, but they must also permit an acceptable movement of traffic. The technician who has an appreciation of traffic requirements and knowledge of safe principles is indispensable in the treatment of accident problems. Guided by accident records, he learns where to look for accident causing factors and where to expend his efforts most effectively. He knows that remedial treatment based on accident facts is less subject to personal bias, and that measurement of results through "before" and "after" accident studies establishes specific yardsticks for safety principles and standards.

Relation of Accident Information to Other Statistics

To get a complete picture of accident causes and circumstances, it is often desirable to relate the accident information to other data, particularly the frequency of exposure to accidents of certain individuals, or of the population generally. For example, the number of miles vehicles are driven is a basic measure of exposure to accidents. Consequently, the tabulation of accidents by the age of drivers involved is more valuable if information on the number of miles driven by drivers in each age group can be set down in an adjacent column and rates by age groups calculated. Frequently, accident record bureaus fail to relate their accident tabulations to other existing tabulations. For example, the accident record bureau publishes a tabulation of accidents by hour of day and by county; arrests by hour of the day and by county are tabulated and published by another unit; and, the two tabulations are never brought together in a single study. The accident statistician should be alert to add comparative and supplemental information wherever possible.

While accident rates are highly desirable as a means of determining whether there is more hazard per unit of exposure in one circumstance than in another, neither accident rates nor the absolute numbers of accidents are in themselves complete pictures. For example, important information is available if it is known that the accident rate for drivers under 20 years of age is three times as high per unit of travel as the rate for drivers 25 to 44 years of age. On the other hand, if only 4 per cent of the accidents involved drivers under 20 years of age and if 55 per cent of the accidents involved drivers 25 to 44 years of age, it is obvious that the total number of accidents can be materially reduced only by proper attention to the 25 to 44 year age group. Similarly, if a given location has 15 accidents during a six-month period, it is important that the engineer analyze conditions and causes to see whether a remedy can be effected, and this would hold even though the traffic volume through the intersection were such as to make it a reasonably safe intersection per vehicle using the intersection. Another intersection with a single accident might have a terrifically high rate in terms of exposure, but an equal amount of attention to that location would not pay as great a dividend as at the location with a large number of accidents and a large traffic volume.

In accident prevention work, absolute values are often more important than accident rates.

Analysis Techniques Must Be Broad

A brief classification of analysis procedures is helpful in considering whether an accident record program is employing all available procedures with proper balance, or whether it has devoted itself exclusively to just a few types of analyses. The enumeration of types of analyses is also helpful in understanding the suggested analytical methods in the various fields of accident prevention.

The following list will serve to classify roughly accident facts, although there can be no sharp lines of demarcation between the various groups:

1. Mass tabulations, such as the overall monthly summary for a city or state.
2. Selective mass tabulations, such as a mass summary of all accidents, involving truck drivers.
3. Highly selective tabulations such as a worst corner list, or a tabulation of accidents by hour of day along a particular stretch of road.
4. Individual cases, such as an analysis of each of four accidents which have occurred at a particular corner, or a detailed study of three serious school bus accidents.

This classification of analysis techniques will be seen to bear a general relationship to the purpose for which accident information is collected—for background or for specific problems. If an accident record bureau is using highly selective tabulations only, it may very well be bringing accident information to bear on specific problems, but is probably not developing proper background information for all members of the department and for other official agencies. Similarly, if a department is preparing only mass tabulations, its product may be valuable as general background information, but is not particularly useful for guidance on specific problems.

A brief description of some of the most frequently used analytical tools will be found in Chapter IX. Some of them, such as collision diagrams, spot maps, accident rates, and worst location lists, are so common in accident records work, that descriptions are hardly necessary. On the other hand, work with accident expectancies, statistical correlation, and other mathematical techniques are not used generally, and are only mentioned briefly in this Manual.

Arrangement of Manual

To discuss specific uses to which accident data can be put, the established accident prevention functions have been selected as the logical chapter headings, i.e. Administrative and Policy Uses of Accident Records, Enforcement Uses of Accident Records, Engineering Uses of Accident Records, Educational Uses of Accident Records, Motor Vehicle Administrators' Uses of Accident Records, Motor Carriers' Uses of Accident Records. An alternate method of discussing uses according to the components of highway traffic, i.e., roadway, driver, and vehicle, was considered and discarded because of the tremendous overlapping which would be developed.

Numerous exhibits and illustrations are included to make the material as practical and current as possible. It will be noted that many materials dated before 1942 are used. These are the best available examples, since the war period did not produce good illustrations of other than emergency conditions. It is not possible to illustrate all the uses of accident data, but it is hoped that the uses listed will suffice to suggest the more important approaches and fields of action in traffic planning, construction, and regulation. The selected illustrations should suggest many others.

A selected list of references has been included at the end of each Chapter. Those desiring more detailed information should review these materials.

CHAPTER II

BASIC REQUIREMENTS FOR ACCIDENT RECORD USES

Care must be taken that the reporting and analysis system is complete and accurate if it is to contribute to a maximum reduction in accidents. Incorrect procedure, together with errors in interpretation due to carelessness or ignorance may give data which, if used, will destroy public and official support of the community or governmental agency in further use of accident records in accident prevention. This, naturally, hinders the entire program. Some of the basic requirements for successful accident record use are discussed in this chapter.

Good record systems, once established, have always proved their worth even though the expense of the system is justified only to the extent to which the information is used. Except for future utilization, a wealth of accident information cannot help in the battle against accidents if it is "pigeon-holed" in the accident bureau.

Adequate Accident Reporting Required

A high standard of accident reporting is the principal prerequisite for the use of accident records. If the original accident reports themselves are poor, the analysis and results from their use must also be poor. Good reporting alone, however, does not guarantee good records; the analysis and use of even good accident records is no small task—inaccurate, incomplete, and too few records make the job of analysis insurmountable and the resultant data are vague, misleading, and often useless.

Studies made from the reports of fatalities alone will represent a very small per cent of the accident total. Since the number of fatalities is small at the city and state level, little confidence can be placed in the results obtained merely from fatality reports. Unfortunately, however, fatal accidents are the only accidents on which nearly complete and accurate reports are now available on a nation-wide basis and in some states.

The ideal reporting system would embrace information on all traffic accidents. This level has not been, and probably never will be attained, but as it is approached, better and better results are achieved through the use of accident data in accident prevention and traffic facilitation.

Table I shows the number of accidents of various types reported in a state with good collection procedures; urban and rural areas have been separated.

TABLE I[1]

TRAFFIC ACCIDENT TOTALS IN STATE WITH GOOD REPORTING

LOCATION	TOTAL ACCIDENTS	FATAL ACCIDENTS	PERSONAL INJURY ACCIDENTS	PROPERTY DAMAGE ACCIDENTS
Urban	47,496	320	9,616	37,560
Rural	21,150	569	6,118	14,463
Statewide	68,646	889	15,734	52,023

[1]Data furnished by Indiana State Police—1946.

REPORTING LAWS DIFFER BETWEEN LOCALITIES

Uniform reporting laws are desirable if sound comparisons are to be made involving areas under different jurisdictions. Some common inconsistencies allowed within existing reporting requirements which affect the validity of statistical comparisons are:

(a) Some reports may be verbal, some written, some brief, some detailed.

(b) They may come from drivers, investigating officers, garages, coroners, or hospitals.

(c) They may come immediately after the accident, "as soon as possible" after the accident, 24 hours after, 48 hours after, or any time within 10 days or more.

(d) They may be rendered to the State Police, Motor Vehicle Department, State Highway Department, Secretary of State, City Police. (Frequently the emphasis on various items of the report varies to favor the department collecting the data).

(e) They may be made for fatal accidents only, for fatal and injury accidents, for fatal, injury and property damage accidents. Minimum property damage requirements may range from "any damage" to as much as $100.00.

The Uniform Motor Vehicle Code[2] recommends reporting standards for states; the Model Traffic Ordinance[3] recommends similar standards for municipalities. These provide that written reports be rendered, within 24 hours, on accidents resulting in death, injury, or total property damage of $25.00 or more. If these standards were adopted everywhere, there would be increased possibilities for accident record comparisons.

It is recognized that certain accident collecting agencies have different collection problems and that requirements must be altered to fit conditions. For example, the Bureau of Motor Carriers, Interstate Commerce Commission, cannot hope to obtain adequately prepared reports within 24 hours, but states and municipalities can and should receive these reports within a relatively short time limit.

Analysis Aided By Standard Report Form

In any well-managed accident records system, complete and accurate reports must be sought. The Committee on Forms and Statistical Practices of the National Conference on Uniform

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[2]National Conference on Street and Highway Safety, *Act V: Uniform Act Regulating Traffic on Highways.* Washington, D. C., U. S. Government Printing Office, 1945.

[3]National Conference on Street and Highway Safety, *Model Traffic Ordinance.* Washington, D. C., U. S. Government Printing Office, 1946.

Traffic Accident Statistics has prepared an accident report form which has been recognized as a national standard for many years. The form is now being revised in an effort to delete all extraneous and unnecessary schedules and data, but the basic items are sure to be retained. The present form, Figure 1, when properly filled out, contains information needed by not one, but by all public agencies—police, educators, engineers, highway and traffic administrators, motor vehicle departments, and others. Some cities and states continue to use forms which are too brief; some ask for too much information; some do not request the right type of information; some confuse the drivers; and some forms are so dissimilar as to hinder comparisons of data between areas. This confusion is eliminated by use of standard forms.

A further advantage of standard forms lies in the fact that they lend themselves readily to punch card analyses through use of common statistical codes.

Precautions Must Be Taken To Insure Complete Reports

An agency which has just started using accident reports, or is planning to start a new program of accident report use, often finds the basic reports incomplete or too general, making it difficult or impossible to conduct desired studies. Not only should the collecting agency make sure that reports are complete and correct, but an educational program may have to be established to inform the public as to the importance of, and the proper method for, completing accident reports, Figure 2. Upon discovery of an error or omission upon receipt of an accident report, a marked blank should be sent to the originator showing the omission or error, with a request for completion. Further follow-ups may be necessary in a small per cent of cases.

One of the most difficult problems in accident reporting is to describe adequately specific locations of accidents. This is

READ CAREFULLY	**MOTOR VEHICLE ACCIDENT REPORT** FOR USE BY DRIVERS STATE OF DEPARTMENT OF Room , State House (City)	FILL OUT COMPLETELY

INSTRUCTIONS

Every operator of a motor vehicle involved in an accident which results in injury or death or property damage of $25 or more must make a report on this form within 24 hours. The failure or refusal of any person to report an accident as required is a cause for the suspension or revocation of the operator's or chauffeur's license of such person. Such failure is also a misdemeanor, punishable by a fine not in excess of $100.

If the driver is physically incapable of making a report, any occupant is required to do so. A witness may also be required to make a report. A supplementary report may be required whenever an original report is insufficient.

ALL REPORTS ARE CONFIDENTIAL AND CANNOT BE USED AS EVIDENCE IN ANY TRIAL.

The principal purpose of this report is to develop information useful in accident prevention. Complete and clear answers to all questions are necessary. An accurate original report will avoid the necessity for supplementary reports. If you have difficulty in filling out the report, consult your nearest police authority.

Observe the following rules:

1. Print all names and addresses.
2. Answer all questions to the best of your knowledge. If unable to answer any question, mark "not known."
3. Under "Location" and on diagram show sufficient information to locate exact scene of the accident.
4. Although other parts of the accident report may be typewritten, the boxes should be filled in by hand. It is simpler and clearer to fill in box items in this manner:

Veh. 1	Veh. 2	
■	□	1. Going straight ahead
□	■	2. Making right turn

5. Use a second report form or a sheet of paper of the same size to report additional vehicles, injured persons, or witnesses, or any other information for which there is insufficient space.

MAIL REPORT TO BUREAU OF , DEPARTMENT OF , ROOM , STATE HOUSE, (CITY)

LOCATION

ACCIDENT OCCURRED IN: County .... City, town or township ....

If accident occurred in rural area, indicate distance from nearest city or town. Use two directions and distances if necessary. .... miles North .... miles South .... miles East .... miles West OF □ limits of □ center of .... City or town

ACCIDENT OCCURRED ON: .... Give name of street or highway number (U.S., State, County). If no highway number, identify by name.

(Check and complete one) □ At intersection with .... Give name of street or highway number

OR

□ Not at intersection .... feet North .... feet South .... feet East .... feet West OF .... Show nearest intersecting street or highway, house number, curve, bridge, railroad crossing, alley, driveway, culvert, mile post, underpass, telephone pole (give number), or other identifying landmark. Show exact distance, using two directions and distances if necessary.

TIME OF ACCIDENT

Day of week ....
Date .... 19....
Hour .... A.M. .... P.M. □ Standard □ Daylight saving

ACCIDENT INVOLVED: □ Pedestrian □ Other motor vehicle □ R.R. train □ Street car □ Animal-drawn vehicle □ Bicycle □ Fixed object........ □ Animal (ridden, herded, unattended) □ Overturned in roadway □ Ran off roadway □ Other non-collision (fell from veh., fire, etc.) □ Other (explain in Remarks)

VEHICLES

YOUR VEHICLE—No. 1

.... Year Make Type (sedan, cab, truck, bus, trailer, etc.) Vehicle registration .... Year Number State I.C.C. Plate No. .... State P.U.C. No. ....

Going .... (North, E., parked, etc.) On .... Street name, highway no., alley, etc. Parts of vehicle damaged .... Amount $........

DRIVER .... Name Street, (or RFD), city and state address Age........ Sex........ Race........

Driving experience........ Years Driver's license........ State Number □ Chauffeur's □ Operator's .... Describe type (regular, beginner's, etc.) Occupation........

Vehicle owned by .... Name Address

VEHICLE No. 2

.... Year Make Type (sedan, cab, truck, bus, trailer, etc.) Vehicle registration .... Year Number State I.C.C. Plate No. .... State P.U.C. No. ....

Going .... (North, E., parked, etc.) On .... Street name, highway no., alley, etc. Parts of vehicle damaged .... Amount $........

DRIVER .... Name Street, (or RFD), city and state address Age........ Sex........ Race........

Driver's license........ State Number □ Chauffeur's □ Operator's .... Describe type Vehicle owned by........ Name Address

Total vehicles involved? ....

Damage to property other than vehicles: .... Name object, show ownership, and state nature and amount of damage.

INJURED

1. Name........ Address........
Age........ Sex........ Nature of injuries........ Was person killed?........ □ Driver □ Passenger Occupant in veh. no........ □ Pedestrian □ Other Race........

2. Name........ Address........
Age........ Sex........ Nature of injuries........ Was person killed?........ □ Driver □ Passenger Occupant in veh. no........ □ Pedestrian □ Other Race........

Total injured? ....

PEDESTRIAN: Was going........ Direction (North, E., etc.) □ On □ Across........ Street name, highway no. From........ To........ (S.E. corner to N.E. corner, or west side to east side, etc.)

(Check one)
□ 1. Crossing at intersection—with signal
□ 2. Same—against signal
□ 3. Same—no signal
□ 4. Same—diagonally
□ 5. Crossing not at intersection
□ 6. Coming from behind parked cars

7. Walking in roadway: (check two)
□ a. With traffic □ c. Sidewalks available
□ b. Against traffic □ d. Not available
□ 8. Standing in safety zone
□ 9. Getting on or off street car
□ 10. Getting on or off other vehicle

□ 11. Pushing or working on vehicle
□ 12. Other working in roadway
□ 13. Playing in roadway
□ 14. Hitching on vehicle
□ 15. Lying in roadway
□ 16. Not in roadway (explain)

Were crosswalks marked? □ Yes □ No
Was pedestrian inside markings or extensions of sidewalk lines? □ Yes □ No
Occupation ....

WHAT DRIVERS WERE DOING

Vehicle 1 2 (Check one for each driver)
□□ 1. Going straight ahead
□□ 2. Making right turn
□□ 3. Making left turn
□□ 4. Making U turn
□□ 5. Slowing or stopping
□□ 6. Starting in traffic lane
□□ 7. Starting from parked position
□□ 8. Stopped in traffic lane
□□ 9. Parked
□□ 10. Backing

(Check applicable items)
□□ 1. Passing
□□ 2. Avoiding veh., object, or pedest.
□□ 3. Skidded—before applying brakes
□□ 4. Skidded—after applying brakes
□□ 5. Hit and run
□□ 6. Driverless moving vehicle

DRIVER VIOLATIONS INDICATED (Check one or more for each vehicle)

Vehicle 1 2
□□ 1. Exceeding lawful speed
□□ 2. Did not have right of way
□□ 3. Following too closely
□□ 4. Drove thru safety zone
□□ 5. Passing standing street car
□□ 6. Passing on hill
□□ 7. Passing on curve
□□ 8. Cutting in
□□ 9. Other improper passing
□□ 10. On wrong side of road
□□ 11. Failure to signal, improper signal
□□ 12. Improper turn—wide right turn
□□ 13. Same—cut corner on left turn
□□ 14. Same—turned from wrong lane
□□ 15. Other improper turning
□□ 16. Disregarded police officer
□□ 17. Disregarded Stop-and-Go light
□□ 18. Disregarded Stop sign or signal
□□ 19. Disregarded Warning sign or signal
□□ 20. Improper starting from parked position
□□ 21. Improper parking location
□□ 22. Other improper action (explain)
□□ 23. No improper driving indicated

Explain other violations: ....

SPEED

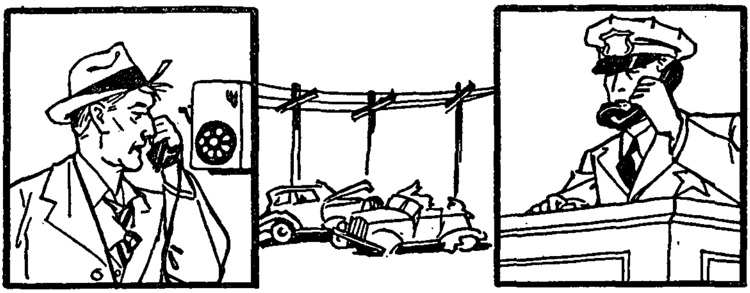
(Fill in six items for each vehicle)

	Veh. 1	Veh. 2
1. Distance danger of accident first noticed (feet)		
2. Estimated speed at that time		
3. Estimated speed at moment of accident		
4. Distance vehicle traveled after impact (feet)		
5. Stated speed limit		
6. Maximum safe speed under conditions prevailing		

National Safety Council—Form Traffic 1 (Driver)—1942 2M- 10-44

FIGURE 1—Standard Accident Report Form for Operators (Front only).

particularly true in rural areas where intersections and identifying landmarks are often far apart. In some states, roadway station numbers are used in place of lengthy geographic location descriptions. While it is desirable to have 100 ft. station markers, there are few localities where they are available, so the existing landmarks have to serve.



PROTECT YOURSELF
NOTIFY POLICE IMMEDIATELY AFTER ACCIDENT
THEN SUBMIT WRITTEN REPORT

Courtesy National Safety Council.

FIGURE 2—Prompt Report of Accidents Essential.

A simpler method which has been successfully used by highway patrolmen in several states is the "Road Log." The log is made from field studies and a duplicate copy is furnished the accident records bureau. Locations of accidents and enforcement actions are referred to the log. The log is simply a strip map of a road section with identifying roadside features, indicated in distances from the starting point.

In city work, it is practical to use house numbers to locate mid-block accidents and intersectional locations are readily established by intersecting street names.

Supplementary Records of Accidents Should Be Utilized

Accident records and summaries from outside agencies should be utilized either separately or in combination with local records. The following is a partial list of supplementary sources and suggested uses:

(a) National accident facts such as those furnished in "The Annual Summary of Motor Vehicle Accident Fatalities," published by the National office of Vital Statistics, and in "Accident Facts," published by the National Safety Council, can be used as standards with which to compare local experiences. This comparison may reveal unfavorable rates or trends in general accident experience; age and sex groups having large numbers of fatalities; correlation of types of accidents with time and place of accident; and other significant facts.

(b) State records can be used by cities to compare local trends, or in some cases to take the place of local records if there is no local collection agency.

(c) School authorities may furnish data involving school-child accidents.

(d) Commercial fleet operators may provide accident facts relating to commercial vehicles.

(e) Transit companies may provide accident data in detail as concerns mass transportation.

(f) Insurance companies may provide general accident information.

(g) Newspapers may report specific accidents and hazards, or provide leads to individual accidents.

Volume of Reports Necessary to Show Accident Pattern

Accidents occur under a great multiplicity and complexity of conditions. Therefore, relatively large quantities of accident reports must be analyzed, before a definite pattern of factors can be established on a statistical base. Reports on a few sensational accidents may be of value in traffic safety education, but volume, regardless of severity, is necessary to indicate hazards and the need for specific preventive measures to reduce the chance for recurrence of accidents. However, detailed investigation of a relatively small number of accident cases will serve to suggest hypotheses which may be tested later by more detailed statistical study.

Central Accident Records Agency Desirable

To prevent duplication of efforts and waste of public funds, only one public agency within a given governmental jurisdiction should be charged with the collection and analysis of accident data. This requires a central accident records bureau, both in states and in cities. The bureau should prepare routine reports and should make special studies for engineering, enforcement, education, and all other official agencies responsible for the reduction of traffic accidents. The accident record files should be made available to those official agencies desiring to study individual reports for accident prevention purposes.

When all accident information is retained in the central bureau and when all accident analyses are made by the bureau, regardless of their uses, the quality and quantity of useful processed data for use in accident prevention can be easily controlled.

A plan which involves the placement of representatives of accident fact-using agencies in the central bureau has met with considerable success in some departments. Representatives of the interested agencies work on the analyses, intended for their departments, under the supervision of the central bureau. This system provides clerks for the usual routine, yet insures more than casual interest in the problems, studies, and research peculiar to the parent agency. The bureau should have competent leaders capable of maintaining a high quality of work and statistical technicians to assist. It must also maintain close cooperation with other organizations and departments interested in accident prevention if it is to function effectively.

Traffic enforcement, engineering, and education agencies have diverse uses for accident information. Analyses should be made only after collaboration with the interested agencies so that the summary will include all relevant information. Interpretation of the analyses should be undertaken by all agencies engaged in traffic accident prevention. Each agency should coordinate its activities with the overall safety program according to a policy jointly conceived and executed.

Qualified Accident Records Personnel

The person in charge of accident analysis should be either a trained statistician or a person with considerable experience in traffic accident prevention, who is willing and able to master the simple mathematics usually involved in accident record work, and who is willing to acquire additional information on the more or less advanced statistical techniques which can be used from time to time and which should always be available to check against statistical misrepresentations. Even though the person in charge of accident record work is a trained statistician, he needs to understand the basic techniques of accident prevention as well as the specialist in the field. On the other hand, if the person in charge of the record work is experienced in traffic accident prevention, expert advice and consultation on statistical techniques should be made available to him for proper exploitation of the available records.

Adequate Accident Analysis System Required

Accident records provide a much greater amount of information than it is practical to place on routine summaries. New methods for the application of this information in the determination of basic accident causes are continually being developed through special analyses. Accident bureaus should never cease in their efforts to glean every possible bit of useful information, regardless of the agency it will benefit most.

Accident reports from drivers and investigators must supply the necessary raw data for analysis. The facts obtained are adequate for practically all studies if the report forms are at least as detailed as the standard form,[4] and if the state or city has achieved relatively complete and accurate reporting. Therefore, with adequate qualified personnel, useful and accurate accident analyses may be prepared when the following requirements are met:

(a) An adequate central accident record agency exists;
(b) Methods of tabulation are rapid and detailed;
(c) Routine summaries are issued on significant factors;
(d) Special summaries are readily obtainable; and
(e) Mechanics of analysis are comprehensive and standard.

Comparison Requires Standard Definition of Terms

In order that accident statistics and situations may be compared, it is necessary that they be prepared with uniform interpretations of terms. To assist in obtaining desired standardization, the Committee on Definitions of the National Conference on Uniform Traffic Accident Statistics has prepared a Manual of Definitions.[5] This manual not only defines types, but also establishes classifications for motor vehicle accidents.

Receipt and Handling of Reports

The source of most city accident reports is the police. Reports may either be filled-out as the result of a police investigation, or they may be prepared at police headquarters, based on drivers' and witnesses' statements. The practice of preparing final accident reports from newspaper clippings, telephone calls and other unofficial sources of information is not recommended as the data are never complete and are often inaccurate, but partial reports should be prepared from this information and a

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[4]Committee on Forms and Statistical Practices of the National Conference on Uniform Traffic Accident Statistics, *Motor Vehicle Accident Report Form.* Washington, D. C., 1943.

[5]U. S. Department of Commerce, *Uniform Definitions of Motor Vehicle Accidents.* Washington, D. C. U. S. Government Printing Office, 1942 (in process of revision).

"follow-up" started so as to obtain the complete report through normal channels.

In many states a large percentage (75 per cent or more) of the accident reports come directly from drivers to the central records bureau. In these cases, where there is no intermediate collection agency, the function of insuring satisfactory reporting coverage, as well as completeness of individual reports, is of increased importance. This is particularly true in sparsely populated states and areas that are largely rural.

Accident reports received in the central accident bureau should first be reviewed for completeness. When inconsistency or gaps in a report appear, the errors should be referred for correction to the person making the report. Two or more reports on one accident must be checked against each other and any differences, other than personal opinion, adjusted. After the reports are edited, the information on each report is transferred in code to a punch card, if the mechanical tabulation method is used, or to a tally sheet. A typical state code sheet is shown in Figure 3.

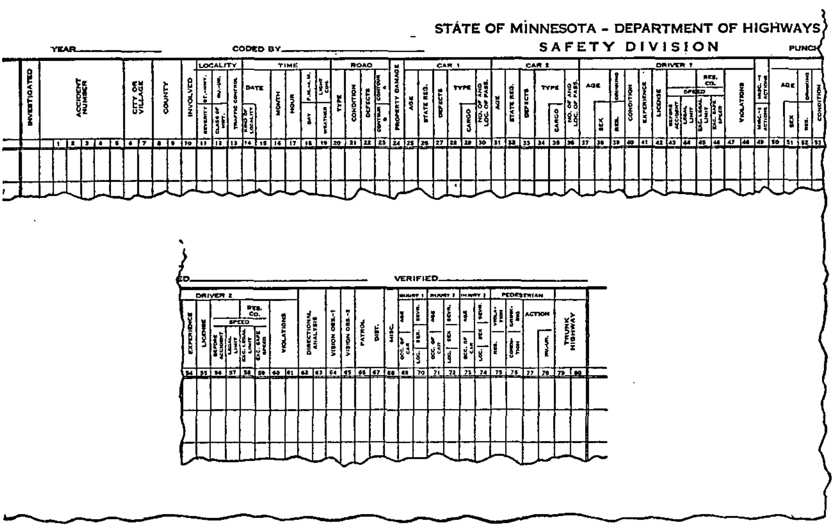
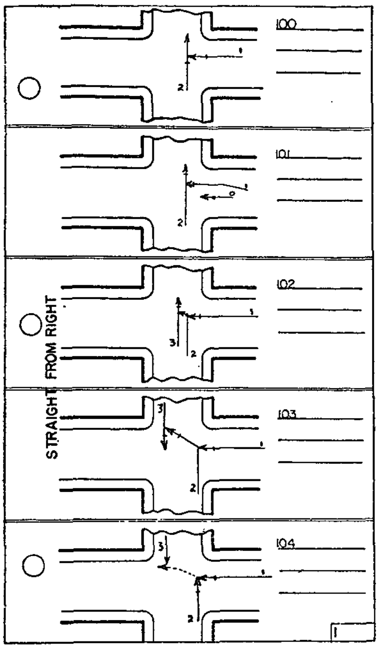


FIGURE 3—*Typical Accident Code Sheet*



Courtesy Oregon State Highway Dept.

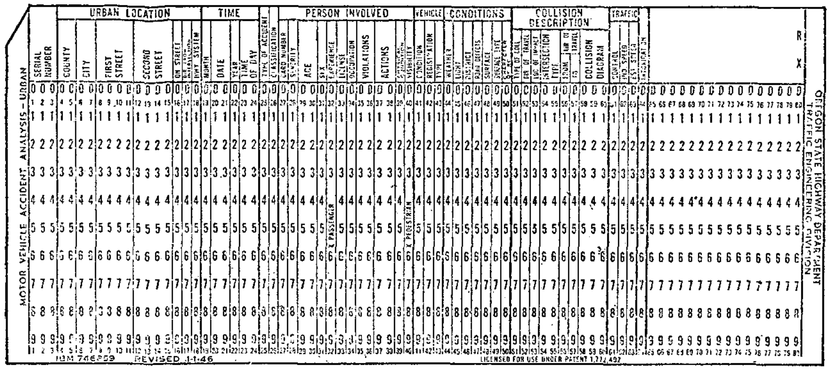
FIGURE 4—Page from Collision Diagram Manual. Coding and De-Coding of Collision Diagrams is Facilitated.

Some agencies have very detailed codes which permit the recording of directional analyses, and other information not usually coded. The Oregon Highway Department, for example, codes data which permit the construction of accident collision diagrams directly from tabulating cards, see Figure 4.

The accident reports are usually filed by "location," under a system of main streets, or routes, divided by intersecting streets and house numbers. Reports of rural accidents are similarly filed, except that the filing system may be based on main routes and distances from reference points along the routes, or on arbitrarily selected highway sections. The punched cards, Figure 5, when filed, are generally grouped by areas or districts without regard to exact location. Both reports and cards are usually separated chronologically. Complete details of accident record bureau procedure are to be found in National Safety Council publications.[6]

Coding, filing, and preparation of regular summaries should be carried out on schedule to prevent the accumulation of unprocessed reports. Enough additional personnel should be provided to allow for special summaries as required; many states

[6]National Safety Council, *Manual on State Traffic Accident Records*. Chicago, The Council, 1946.



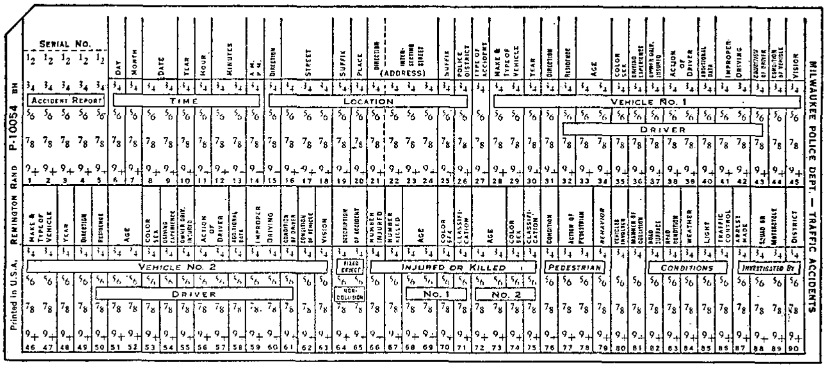


FIGURE 5—Typical Punch Cards Used to Tabulate Accident Data.

and cities develop special analyses and summaries regularly such as the location analyses indicated by the form shown in Figure 6.

Reconciliation of fatal accident reports with the State Bureau of Vital Statistics records should guarantee complete coverage of all traffic deaths. Use of inter-departmental transcripts for motor vehicle accident deaths makes such reconciliations easy in a state. The special four-part transcript of the National Office of Vital Statistics is strongly recommended for use by states.

STATE OF OHIO DEPARTMENT OF HIGHWAYS

DIVISION OF TRAFFIC AND SAFETY

ACCIDENT ANALYSIS

Division............................ Report No..................

Location—SR .... County.............................. S.H.................. Sec...............

DATE / TIME	LOCATION OF ACCIDENT	Type of Accident	SEVERITY			WEA. / Rd. Cond.	TYPE OF LOCATION	DRIVERS				REMARKS
			K	I	P.D.-$			Dir.	Speed	Condition	Violations	

LEGEND

TYPE OF ACCIDENT

A—Sideswipe
B—Head-On
C—Rear-End
D—Pedestrian
E—Angle
F—Turning Movement
G—Turned Over in Roadway
H—Ran Off Roadway
I—Other Non-collision
J—Miscellaneous

SEVERITY

K—Killed
I—Injured
P.D.—Property Damage

FIGURE 6—Form for Special Location Analysis of Accidents.

A detailed, step-by-step procedure for handling and processing accident reports is shown in Figure 7.[7]

The completeness of coverage of accident reporting may be roughly checked with ratios of fatal, injury and property damage accidents established on a national basis by the National Safety Council. However, it must be recognized that these ratios vary for different locations, traffic and physical conditions.

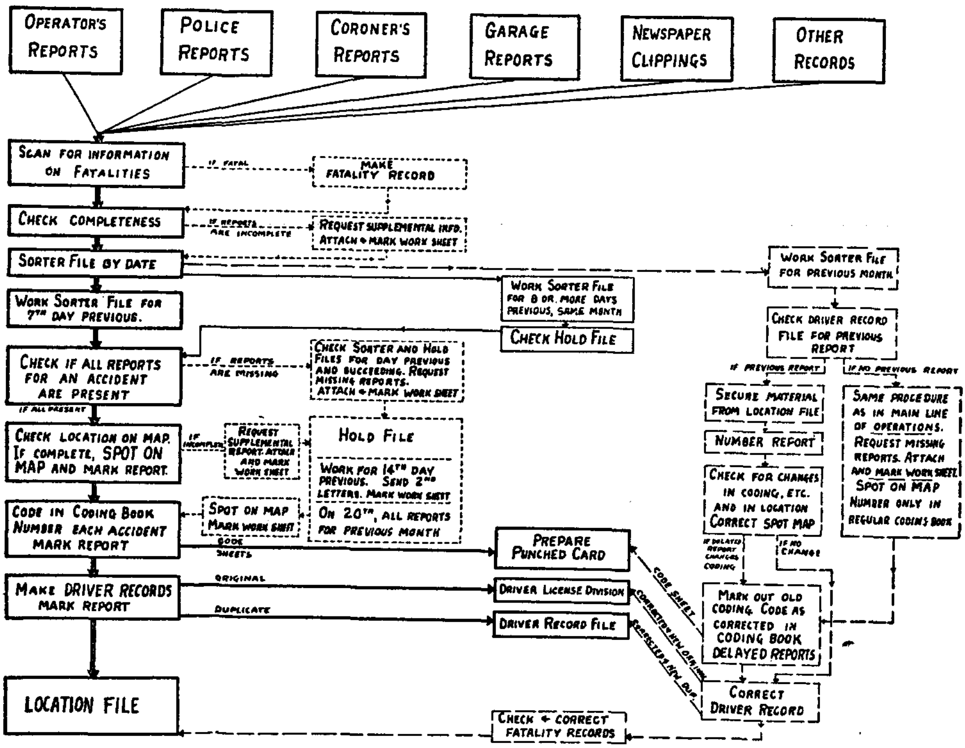
Basic Factors Derived in Using Accident Reports

As previously indicated, two of the undesirable by-products of vehicular traffic are accidents and congestion. While accident records deal directly with the former, they do not always give

[7]National Safety Council, *Public Safety Memo No. 78*, Part XV, Chicago, 1942. Condensed Flow Sheets are available from the various state accident records bureaus.

a true measure of congestion. In fact the most serious accidents often occur when traffic volumes are light. Although an increase in the number of cars on a route increases the possibilities of conflicts, congestion frequently causes an increase in caution and a decrease in speed. Mishaps under congested circumstances are often restricted to minor collisions.

ACCIDENT RECORD BUREAU FLOW SHEET



From: National Saftey Council, Public Safety Memo 78.

FIGURE 7—Recommended Steps in Collection and Analysis of Accident Records.

The effective use of accident information must take into account the following:

Failures in Traffic Operation Shown by Accident Records. While accident reports do not accurately reflect traffic congestion, they do manifest failures in traffic operations which result in mishaps. They indicate operational failures on the part of the driver, the vehicle, and the roadway. These failures are the ones which cause loss of life, injury, and damage to property. For this reason, the mishaps are of greater concern to public traffic agencies and to the public than are the factors responsible for congestion.

Accident Reports Indicate Apparent Causes and Suggest Cures. Accident reports indicate causes of accidents. They reveal how these causes may best be eliminated through traffic safety education, enforcement and engineering. Summaries of accident circumstances will show the over-all importance of various causes within an area. Comparisons of accident rates for different areas indicate the results of accident prevention activities. Accident trends point out the need for special preventive work. Accident location studies are aimed particularly at the correction of high accident locations.

Accident records should be used as the basis for planning all accident reduction programs. When the program is based on accident facts, funds and manpower can be expended most effectively in accident prevention work.

Accident Reports Indicate Size of Accident Problem. The size of an accident problem in terms of location, time, or type is indicated by the volume of accident reports. However, reporting coverage must be checked before the size of the problem can be taken as authentic. Also, care should always be taken to relate accidents to exposures.

Support by Traffic Administrators

The backing of traffic administrators is essential for the effective operation of an accident records bureau. Without the support of administrators, the bureau cannot function effectively, and without the studies and summaries of the bureau, the traffic administrators cannot plan, operate, and evaluate the accident prevention program except on a "hit-or-miss" basis.

REFERENCES ON BASIC ACCIDENT REQUIREMENTS

1. National Conference on Street and Highway Safety, *Act V: Uniform Act Regulating Traffic on Highways.* Washington, D. C., U. S. Government Printing Office, 1945. Requirements for reporting of accidents recommended for inclusion in state laws.

2. National Conference on Street and Highway Safety, *Model Traffic Ordinance,* Washington, D. C., U. S. Government Printing Office, 1946. Requirements for reporting of accidents recommended for inclusion in city ordinances.

3. National Safety Council, *Manual on State Traffic Accident Records.* Chicago, The Council, 1946. Standard traffic accident reporting system for states; organization of accident record work in states; accident report forms; instructions in use of report forms; coroner's report of motor vehicle deaths; garage reports of accidents; motor vehicle fatality records; filing procedures; spot maps; summaries for states; punch card codes; mechanical tabulation methods; special statistical studies; development of complete reporting; office procedures; definitions.

4. National Safety Council, *Standard City Traffic Accident Reporting System.* Chicago, The Council. 1947. Instructions for the organization and operation of an accident records bureau in a city.

5. Committee on Definitions of National Conference on Uniform Traffic Accident Statistics, *Uniform Definitions of Motor Vehicle Accidents.* Washington, D. C., U. S. Government Printing Office, 1943. Definitions of accidents, designed for statistical classifications.

6. President's Highway Safety Conference, *Report of Committee on Accident Records.* Washington, D. C., U. S. Government Printing Office, 1946. Discussion of present practices and recommended procedures for the collection and use of accident statistics.

7. National Safety Council, *Public Safety Memo No. 70—Newspaper and Radio Publicity Material to Encourage the Reporting of Traffic Accidents.* Chicago, The Council, 1945. Suggested newspaper releases and radio spot announcements to develop better reporting by the public.

8. Smith, Wilbur S. *Style Changes in Accident Records.* Public Safety, Vol. 15, No. 2. p. 20-21, 38, February 1939. Chicago, National Safety

Council. Description of forms for accident reports recommended by the National Safety Council's Committee on Traffic Accident Records.

9. Reeder, Earl J. *National Studies of Survey Data on Law Observance*. Institute of Traffic Engineers, Proceedings, No. 5, p. 83-85, 1934. New York, New York, The Institute. Observations on characteristics of high accident locations.

CHAPTER III

ADMINISTRATIVE AND POLICY USES OF ACCIDENT RECORDS

The traffic administrator has three principal ways in which he can use accident records; first, in the inauguration and operation of an accident prevention program; second, in the measurement of the effect of the plan by comparing current performance with previous records and with records of similar jurisdictions, or with national averages; and third, in the development of support for the program and justification for the expenses involved.

Measurement of the Importance of Traffic Safety Programs

Vital statistics for the nation show that traffic accidents were the greatest cause of accidental deaths during 1941, the last year in which traffic was unaffected by the war. For the years 1943, 1944, 1945, and 1946 traffic deaths were exceeded only by accidental deaths in the home, as shown in Table II.

TABLE II

Principal Causes of Accidental Deaths[8]

YEAR	HOME[9]	MOTOR VEHICLE	PUBLIC EXCEPT MOTOR VEHICLE[9]	OCCUPATIONAL[9]
1941	30,000	39,969	15,500	18,000
1943	33,500	23,823	16,500	17,500
1944	32,500	24,282	15,000	16,000
1945	33,500	28,076	16,000	16,500
1946	34,000	33,500	17,000	16,500

[8]National Safety Council, *Accident Facts.* Chicago, Illinois, The Council, 1942, 1944, 1945, 1946, and 1947 (condensed edition.)

[9]Excluding military personnel.

Figures for a state or city are just as revealing and suggest local comparisons, similar to national comparisons, to show relative importance of local accident causing factors.

Measurement of Caliber of Job

A valuable use to which a traffic administrator may put accident records is in the measurement of the caliber of the job performed. The measurement may be obtained by a comparison of past and present accident rates. Comparison of accident figures for similar areas are revealing. Such comparisons must be made with care so that comparable figures will be developed. Many types of forms and summaries have been developed for cumulative and other comparisons; one is shown in Figure 8 and another in Table III.

Sometimes it may be possible to compare the relative effectiveness of various parts of the program. Thus, the night acci-

OREGON STATE HIGHWAY DEPT. - TRAFFIC ENGINEERING DIVISION

CUMULATIVE MONTHLY MOTOR VEHICLE ACCIDENT TOTALS

	YEAR 19____	2-25	3-25	4-25	5-25	6-25	7-25	8-25	9-25	10-25	11-25	12-25	1-25	2-25	3-25	4-25	5-25	6-25	7-25	FINAL
ACCIDENTS	JANUARY																REMARKS:			
	FEBRUARY																			
	MARCH																			
	APRIL																			
	MAY																			
	JUNE																			
	JULY																			
	AUGUST																			
	SEPTEMBER																			
	OCTOBER																			
	NOVEMBER																			
	DECEMBER																			
	TOTAL																			
INJURIES	JANUARY																			
	FEBRUARY																			
	MARCH																			
	APRIL																			
	MAY																			
	JUNE																			
	JULY																			
	AUGUST																			
	SEPTEMBER																			
	OCTOBER																			
	NOVEMBER																			
	DECEMBER																			
	TOTAL																			
FATALITIES	JANUARY																			
	FEBRUARY																			
	MARCH																			
	APRIL																			
	MAY																			
	JUNE																			
	JULY																			
	AUGUST																			
	SEPTEMBER																			
	OCTOBER																			
	NOVEMBER																			
	DECEMBER																			
	TOTAL																			

FIGURE 8—Form for Showing Latest Available Accident Figures. May Be Used for Counties, Cities, or Other Designated Areas.

TABLE III

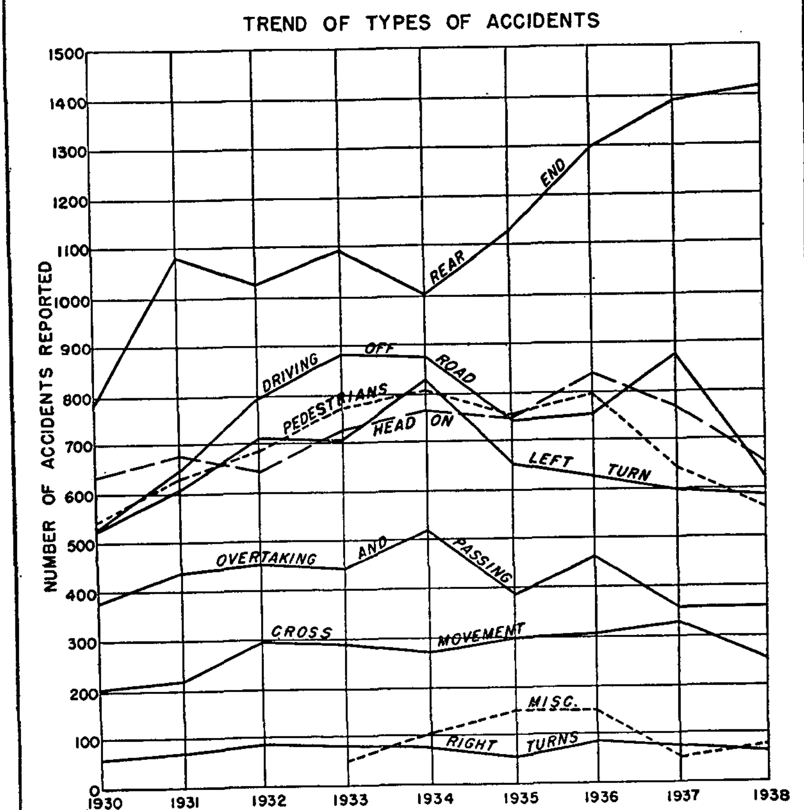
Example of Cumulative Summary Used By
CHICAGO PARK DISTRICT
TRAFFIC SECTION ENGINEERING DIVISION
COMPARISON OF MONTHLY AND ANNUAL TOTALS FOR
1943 1944

MONTH	FATAL Month 1943 Fatal Ped	1943 Fatal Tot	1944 Fatal Ped	1944 Fatal Tot	FATAL Year 1943 Cum. Tot.	1944 Cum. Tot.	NON-FATAL Month 1943 N.F.	1944 N.F.	NON-FATAL Year 1943 Cum. Tot.	1944 Cum. Tot.	PROPERTY DAMAGE Month 1943 Prop Dam.	1944 Prop Dam.	PROPERTY DAMAGE Year 1943 Cum. Tot.	1944 Cum. Tot.	TOTAL Month 1943 Grand Total	1944 Grand Total	TOTAL Year 1943 Cum. Gr. Tot.	1944 Cum. Gr. Tot.	DAILY AVERAGE per MONTH 1943	1944
Jan.	7	8			8		161		161		360		360		529		529		17.0	
Feb.	2	3			11		122		283		229		589		354		883		12.6	
Mar.	4	4			15		109		392		275		864		388		1271		12.5	
Apr.	2	2			17		117		509		257		1121		376		1647		12.5	
May	4	6			23		136		645		328		1449		470		2117		15.2	
June	1	1			24		145		790		250		1699		396		2513		13.2	
July	2	4			28		143		933		270		1969		417		2930		13.5	
Aug.	4	6			34		142		1075		265		2234		413		3343		13.2	
Sept.	5	6			40		127		1202		268		2502		401		3744		13.4	
Oct.	10	11			51		192		1394		316		2818		519		4263		16.8	
Nov.	4	4			55		153		1547		296		3114		453		4716		15.1	
Dec.	5	5			60		180		1727		338		3452		523		5239		16.9	

Corrected Annual Summary

Year	Fatal	Non-Fatal	Property Damage	Total
1935	58	1920	4179	6157
1936	86	2135	5259	7480
1937	120	2770	6781	9671
1938	93	2558	5920	8571
1939	95	2998	7288	10381
1940	90	3240	8000	11330
1941	96	3247	8724	12247
1942	61	2740	5842	8373
1943	60	1727	3452	5239
1944				

dent problem may have been greatly influenced by improved street lighting, a function of the engineering branch. Certain types of accidents might have been reduced more than others, such as by increased enforcement, Figure 9. It is generally difficult, if not impossible, however, to distinguish the contributions made by a single agency to a change in accident experience. It is not feasible in most cases, therefore, to attempt



	1930	1931	1932	1933	1934	1935	1936	1937	1938
TOTAL NO. ACCIDENTS REPORTED	3639	4357	4707	5064	5272	4963	5349	5123	4615
% INCREASE EACH YEAR		19.7	8.0	7.6	4.1	-5.8	7.8	-4.2	-9.9
% INCREASE OVER 1930		19.7	29.4	39.2	44.9	36.4	47.0	40.8	26.8

Courtesy Massachusetts Department of Public Works.

FIGURE 9—Yearly Trend of Accidents by Common Types.

to measure the performance of a single department, section, or individual. The work of all is interrelated.

Measurement of Safety Program Progress

In order to evaluate the progress of accident prevention activities, it is desirable to compare accident experience in different areas for the same period of time, or in the same area for comparable current and previous periods of time. Accident toll fluctuation, however, is not an accurate barometer of the effectiveness of accident prevention work unless account is taken of accident exposure. Exposure may include volumes of vehicular and pedestrian traffic, density of the traffic on the road, general characteristics of the road system, and other factors over which traffic officials do not have control. For example, national records show that motor vehicle fatalities in 1943 dropped 40 per cent below the total for 1941. But traffic mileage decreased 33 per cent during the same period, so the records for the two years were about the same after adjustment for exposure.[10]

Measurement of the progress of the safety program for a city may likewise be made. For example, in 1944 the City of Milwaukee[11] experienced 31 traffic deaths, an improvement over 49 traffic deaths in 1943. In this case traffic mileage changed but little, therefore, the improvement reflects a real gain.

Accident or Death Rate Formulae

Means of comparison are found in rates based on either deaths or accidents and are commonly calculated for population, vehicle registration, or mileage. Care must be taken not to confuse death rate and accident rate figures as they are not com-

[10]National Safety Council, *Accident Facts.* Chicago, Illinois, The Council, 1944. p. 24.

[11]National Safety Council, *Accident Facts.* Chicago, Illinois. The Council, 1945. p. 82.

parable. Some of the more common accident rates are:

1. Population Rates—

$$\text{Death Rate (per 100,000 population)} = \frac{\text{Deaths} \times 100{,}000}{\text{Population}}$$

For example, a city of 300,000 people experienced 50 traffic deaths in one year, therefore,

$$\text{Death Rate (per 100,000 population)} = \frac{50 \times 100{,}000}{300{,}000} = 16.7$$

Only official population data should be used. Such practices as using unreliable annual estimates for a community, just to favor the case, are condemned. Also, population figures should fit exactly the area for which accidents, or deaths are reported; population figures for an entire metropolitan area should not be used with accident figures for the corporate limits of a city.

2. Vehicle Registration Rates—

$$\text{Death Rate (per 10,000 registered vehicles)} = \frac{\text{Number of Deaths} \times 10{,}000}{\text{Motor Vehicle Registration}}$$

For example, a city with 80,000 registered vehicles experienced 74 traffic deaths within one year, therefore,

$$\text{Death Rate (per 10,000 registered vehicles)} = \frac{74 \times 10{,}000}{80{,}000} = 9.3$$

3. Mileage Rates

(a) $$\text{Accident Rate (per million vehicle miles)} = \frac{\text{Number of accidents} \times 1{,}000{,}000}{13.6^* \times \text{gallons of gasoline consumed for highway purposes}}$$

For example, a state experienced 40,000 traffic accidents and used 800,000,000 gallons of gasoline in one year, therefore,

$$\text{Accident Rate (per million vehicle miles)} = \frac{40{,}000 \times 1{,}000{,}000}{13.6 \times 800{,}000{,}000} = 3.7$$

*The National Safety Council recommends a statewide factor of 13.6 miles to a gallon of gasoline; a 1946 figure which may change in other years.

(b) Death Rate (per 100,000,000 vehicle miles) =

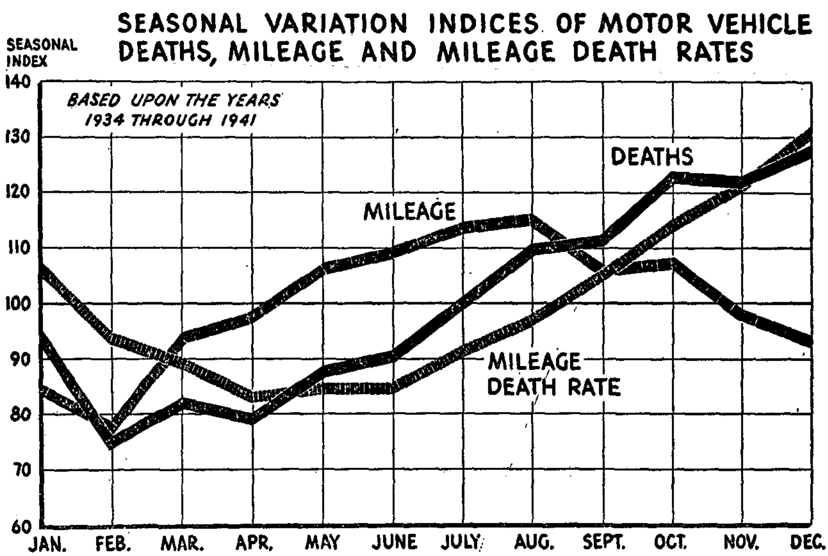
$$\frac{\text{Number of Deaths} \times 100{,}000{,}000}{13.6 \times \text{gallons of gasoline consumed for highway purposes}}$$

For example, a state experienced 200 traffic deaths and used 150,000,000 gallons of gasoline in one year, therefore,

Death Rate (per 100,000,000 vehicle miles) =

$$\frac{200 \times 100{,}000{,}000}{13.6 \times 150{,}000{,}000} = 9.8$$

The relation between mileage death rates, mileage, and deaths, is illustrated by months in Figure 10.



From: Report of President's Highway Safety Confernece

FIGURE 10—Average Monthly Trend in Vehicle Miles, Traffic Fatalities, and Mileage Death Rates.

(c) Accident Rate for a Route (per million vehicle miles) =

$$\frac{\text{Number of accidents} \times 1{,}000{,}000}{\text{Volume of traffic} \times \text{route length}}$$

For example, a route 10 miles long experienced 18 accidents in a year, and the daily average volume of traffic was 2300 vehicles, therefore,

$$\text{Accident Rate (per million vehicle miles)} = \frac{18 \times 1{,}000{,}000}{2300 \times 365 \times 10} = 2.2$$

Because fatalities are faithfully reported in practically all localities, death rates are commonly used, but where reporting is uniform and where the degree of reporting is consistent accident rates are preferable. City figures are usually computed both by population and by vehicle registration. Computations based on mileage are best for comparisons, but, unfortunately, reliable mileage figures usually cannot be obtained for areas smaller than states. Mileage data for routes can, of course, be obtained.

Comparisons for cities based on population were found to be inaccurate during the war years as large war industries forced shifts in population which were not recorded by census counts. Annual counts of automobile registrations were more accurate and were therefore introduced in many areas as a basis for accident rates.

Accident Rates Depend on Assumptions

The previously described population, vehicle registration, and mileage rates are most generally used by traffic accident bureaus. Inasmuch as these rates provide a means of taking into account some traffic exposures, comparisons of accident experience are possible, but the accuracy of the comparisons, as well as of the rates themselves, depend upon the following assumptions:

(a) Traffic accident exposure varies directly with the population.

(b) Traffic accident exposure varies directly with the number of registered vehicles.

(c) Traffic accident exposure varies directly with vehicle miles of travel.

These assumptions are obviously not entirely correct as they do not take traffic concentrations into consideration. It is reasonable to assume that more accidents would occur in one jurisdiction than in another jurisdiction which had the same number of people, but where less use was made of motor vehicles, or which had twice the road mileage of the first but with the same motor vehicle mileage. Furthermore, these assumptions cannot be entirely correct because a portion of all accidents, namely the two-car collisions, theoretically vary as the square of the traffic volume. Likewise, the activity and concentration of the pedestrian must be considered as a separate factor.

Although these accident rates are dependent on assumptions which are known to be in slight error, they are the best rates now developed. In practice they work out well because many of the effects of the variables encountered are compensating.

New Methods of Evaluating Accident Exposures—Development of Accident Expectancies

Accident expectancy may be calculated by the evaluation of important elements in accident causation in reported accidents and in relating them to future conditions. Accident expectancy may also be revealed by forecasting the accident experience of the future, based on the experience of the past by an extension of trends. It is reasonable to expect that if accidents have occurred under certain conditions in the past, nearly the same number of accidents will occur in the future under similar conditions.

Two promising methods of evaluating accident exposures have been developed recently. These lead to the calculation of accident expectancies for given conditions .

Exposure to Two-Vehicle Collisions Varies as Square of Volumes. On a given highway system, the opportunity for single-vehicle collisions is directly proportional to the traffic volume on the highway. This is not true, however, for two-vehicle collisions. The opportunity for such accidents is assumed to vary as the square of the traffic volume. Thus two vehicles passing two other vehicles create four chances of collision, while four vehicles passing four other vehicles offer 16 chances for collision.

It becomes possible, therefore, to calculate from one year to another, the accident experience that might be expected in the second year on the basis of traffic volume changes. The principle obviously does not apply if there were accompanying changes in the highway system which concentrated or dispersed the traffic. The method worked well, however, during the years from 1941 to 1945, when highway building in the nation was at a low point and when traffic volume changes were sharp.[12]

Since street mileage within a city does not change materially from year to year or even over a period of years, this method is particularly applicable to cities. The difficulty in applying the method to cities is that accurate traffic volume figures are seldom available for the city as a whole. An example of the application of the principle to cities is found in a study made in Detroit, in 1944. Here traffic volumes were secured and certain indices assumed for pedestrian traffic. A calculated accident experience was compared with the actual accident experience, and the difference was recognized as progress, or lack of progress, in the accident prevention program.[13]

Other Factors Than Exposure Effect Traffic Deaths. It is quite reasonable to assume that other things being equal, the number of persons killed will vary directly as the exposure. Even if the exposure could be accurately computed for each state there would, however, still be substantial differences in the accident rates. Factors such as education, enforcement, con-

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[12]The use of such calculations is illustrated on page 79 of *Accident Facts* (1945 edition) published by the National Safety Council.

[13]Zechiel, A. N. and Baldwin, D. M.–*Exposing Accident Exposures*. Public Safety, June 1944, Chicago, Illinois. National Safety Council.

dition of the highway, etc., have their effect on the accident rate. By the process of multiple correlation, it is possible to determine the effect of each of these various factors. Knowing the effect of these factors it is possible to calculate for a given state the expected death rate.

In giving credit to enforcement and educational agencies, it is not fair to penalize them for a bad death rate because of physical factors over which they have no control, such as the condition of the highways or the amount of driving.

In order to determine the effect of various fixed factors, an analysis was made correlating each of several factors with the population traffic death rate for the various states. These correlations are given in Table IV.[14] A correlation of 0.00 indicates no correlation while a correlation of 1.00 indicates a perfect

TABLE IV

RELATIONSHIP OF 1941 TRAFFIC DEATH RATE TO VARIOUS FACTORS

FACTORS STUDIED	CORRELATION WITH TRAFFIC DEATH RATE
Gas consumption per capita for 1941	0.62
Percentage of population increase from 1930-1940	0.56
Surfaced highway mileage per capita—1940	0.56
Percentage of increase in gas consumption—1940-1941	0.36
Vehicles per capita—1941	0.35
Percentage of highway mileage surfaced 1940	—0.34
Income per capita—1939	0.28
Highway mileage per capita—1940	0.23
Population per square mile—1940	—0.19
Percentage of population that is white—1940	—0.11
Percentage of population that is urban—1940	—0.02
Percentage of population over 25 years of age with 4 years or less of education—1940	—0.07
Percentage of persons 5—25 in school—1940	—0.04
Percentage of population that is native born—1940	0.03

[14]Allgaier, Earl and Wood, Kenneth.—*Predicting Traffic Death Rates.* Highway Research Board Proceedings, 1943, Washington, D. C. The Board.

correlation or relationship. A minus sign (—) indicates an inverse relationship; that is, an increase in this factor is accompanied by a decrease in the death rate.

By taking out the most important factors from the above table it is possible to construct a formula which will give the expected death rate of each state, assuming other factors to be equal. This formula for 1941 is as follows:

$$T = 0.16827(G) + 0.1933(P) + 1.3278(I) + 0.236(MS) + 1.9720(V) + 4.217$$

Where:

T = Traffic death rate—persons per hundred thousand.
G = Gas consumption per capita in gallons per year.
P = Population increase 1930-1940 in persons per 100 persons.
I = Increase in gas consumption 1940-41 in gallons per 100 gallons.
MS = Percentage of mileage surfaced in miles per 100 miles.
V = Vehicles per capita.

The figure 4.217 is a constant and applies only for the year 1941. To make this formula apply to any other year substitute the average value for all states for all of the factors in the formula and from this determine the constant necessary to make the formula true.

This formula may then be used to estimate what the expected traffic death rate would be for each state. If a state has a higher rate than expected, it may be assumed that this is due to other factors not included in the formula such as enforcement and education. If, on the other hand, the actual rate is less than the expected rate, the enforcement and educational officials deserve more than average credit. By using a procedure of this kind, the traffic safety officials in states, where there are adverse factors affecting the death rate, are not penalized for the factors over which these officials have little or no control.

A similar procedure can be used for estimating the expected pedestrian death rate.

Costs of Accidents

Frequently the administrator will find that the conversion of accident totals into cash values can be very effective. Justification for budgets and expense of construction aimed at accident prevention becomes more easily understood when the accident records are totaled in dollars. There are several methods of conversion in use today. Some states have developed their own conversion factors to fit conditions found in their particular areas. The three most widely used conversion methods are two developed by the National Safety Council[15] and one prepared by the National Conservation Bureau.

The National Safety Council methods are:

(1) A cost of $45,000 per death. This assumes that each death is accompanied by 35 non-fatal injuries and 150 property damage accidents (minimum $25.00 each). This method can be used only when there were more than 10 deaths per city and the year's experience was normal (not more than the national average 1.1 or 1.2 deaths per accident).

(2) With good reporting and over 10 deaths a year, assume costs at:

$11,500 per death.
$ 425 per personal injury.
$ 125 per property damage accident.

Method developed by the National Conservation Bureau:

(3) The Traffic Engineering Division of the National Conservation Bureau uses the values: $10,000 per fatality; $320 per urban injury and $390 per rural injury; (medical bills and salary losses not included); $130 per urban property damage accident and $190 per rural property damage accident, both in the reportable class over $25.00.

Adjustments may be in order in some localities if the costs, particularly for injuries, are too high or low, or, if an increase

[15] National Safety Council, *Unit Costs in Motor Vehicle Accidents.* Chicago, Illinois. The Council, 1940.

in average wages, associated with the increase in living costs, makes a difference in the anticipated future earnings.

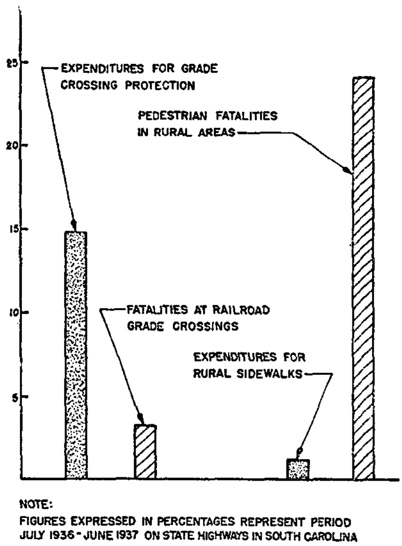
Development and Guidance of Program

Through accident analysis, the traffic administrator obtains facts upon which the safety program should be based. These facts determine the necessity of the program and supply a definite "yardstick" by which need for public support and the expenditure of public funds can be measured.

Continuous analysis of accident facts should help the administrator guide the program into engineering, enforcement, and educational channels wherever greatest need is evidenced by accident trends.

Conversion of accident facts into an index of economic loss should help the city officials make convincing arguments for enlarging traffic departments, constructing new roadways, and making other needed improvements vital to the safety program.

A comparison of the funds spent to reduce various accident factors with the accident record will show often an unbalanced condition such as the one illustrated in Figure 11.[16] Allocation of funds must be made in accordance with the need for correction.



From: Proceedings, American Road Builders Assoc., 1940.

FIGURE 11—Relationship of Grade Crossing and Sidewalk Expenditures to Motor Vehicle Accidents.

[16]Committee on Analysis of Accident Data, American Road Builders' Association, 1940 Proceedings, Chicago, Illinois.

Place of Accident vs. Place of Death

Many accident records bureaus find it important to study the relationship between the places at which accidents occur and places of deaths. This gives the administrator a measure of the hospital, first aid, and medical facilities that should be available in various communities. New York State, for example, develops regularly information showing, (a) place of death, (b) place of occurrence of accident, and (c) residence of the victim.

These comparisons also are of use in checking records of vital statistics bureaus against those of accident records bureaus.

Legislation Requirements

The accident record may often demonstrate to the administrator the need for new, changes in, or repeal of, old legislation. Suggestions and recommendations by the administrator, are often easier to "sell" if the relation to the accident record is indicated. For example, recommendations for legislation on speed control obviously should contain a reference to speed and severity of accidents.

REFERENCES ON ADMINISTRATIVE USES

1. National Safety Council. *Accident Facts.* Chicago, Illinois. The Council, 1946 and previous years–Annual accident statistics classified and analyzed.

2. Vernon, H. M., *Accidents and Their Prevention,* Macmillan Co. Discussion of accident-proneness and its personal and environmental causes; types and conditions of accidents in traffic and otherwise; principally educational.

3. Allgaier, Earl, *A Case History Study of Fatal Accidents,* Highway Research Board Proceedings, 1939, Washington, D. C., The Board. A condensed report of a cooperative project of the Public Roads Administration, Highway Research Board, and American Automobile Assn.

4. Zechiel, A. N. and Baldwin, D. M., *Exposing Accident Exposures,* Public Safety, June 1944, Chicago, National Safety Council. Method of evaluating a safety program by measuring the ratio of actual accidents to potential accidents thru data obtained over a period of years in a city.

5. Allgaier, Earl and Wood, Kenneth, *Predicting Traffic Death Rates,* Highway Research Board Proceedings, 1943, Washington, D. C., The Board, An analysis of factors in traffic death rates over which officials have little control; derivation of formula for predicting death rates in states, with assumption that safety and educational programs are identical and so as to evaluate the actual safety programs.

6. Williams, S. J., *Progress in Promoting Highway Safety,* Highway Research Board Proceedings, 1935, Washington, D. C., The Board. A study of accident causes, including factors in the vehicle, the highway, drivers, and pedestrians.

7. National Safety Council, *Public Safety Memo No. 96–Motor Vehicle Traffic Deaths, Non-Fatal Injuries and Property Damage Accidents, Cities and States.* Chicago, The Council, 1947.

8. The Lansing Safety Council and the National Conservation Bureau, *Direct Costs of Traffic Accidents,* City of Lansing, Michigan, 1946, New York. National Conservation Bureau, 1946. Study of direct costs of traffic accidents, of accident costs per person, of man-hour losses from jobs, and of the causes of the accidents reported and examined.

9. Smith, Wilbur S., *Influence of Parking on Accidents,* Traffic Quarterly, Eno Foundation for Highway Traffic Control, Inc., April 1947. A case study of factors in accidents related to the parking and unparking of vehicles at the curb.

10. Marsh, Burton W., *The Use of Accident Records.* University of Michigan. Eighteenth Annual Conference on Highway Engineering, 34, No. 3. p. 189-225, July 9, 1932. Reprinted by the American Automobile Association. How to collect and analyze accident statistics and how to make them useful in safety work.

11. Williams, Sidney, J., *Accidents on the Road; Bases of Statistics and Their Unification; Determination of Causes of Accidents and Means for Diminishing Them.* Public Roads, 19, No. 5. p. 77-82, July, 1938, Washington, D. C., Superintendent of Documents, U. S. Government Printing Office. General discussion of the need for careful collecting and compilation of accident statistics as a basis for educational safety programs.

12. National Safety Council, *Traffic Accident Records.* Chicago, The Council, 1946. This publication is a collection of articles on traffic accident records which have appeared in Public Safety Magazine in recent months.

13. Forbes, T. W., *The Normal Automobile Driver as a Traffic Problem,* The Journal of General Psychology, No. 20. p. 471-474, 1939. Explanation of some accident statistics showing that the so-called "accident-prone" drivers caused a very small proportion of the accidents occurring during the years reported and indicating that more emphasis should be placed on engineering for the capabilities of the normal driver than upon weeding out the accident-prone.

14. Halsey, Maxwell, *Traffic Accidents and Congestion,* New York, New York, John Wiley and Sons, Inc. 1941. Well-rounded picture of leading elements in the problem of accidents and congestion.

CHAPTER IV

ENFORCEMENT USES OF ACCIDENT RECORDS

The use of accident records in police departments is not new, but greater and more widespread use is warranted and desirable. Departments in which their use is accepted give a large share of credit for their success and efficiency to accident records systems. Intelligent use of records in planning traffic activities of police will assure more effective enforcement and maximum utilization of personnel and equipment.

Responsibilities of Police

The position of the law enforcement agency in traffic accident reduction is paramount. This agency not only puts into use accident statistics and associated data, but is directly responsible for gathering what is probably the most reliable information available on accidents. Where drivers do not report, police investigations may furnish the only information. This information goes to make up the basic report, which is so vital to the planning of other phases of the traffic control program, such as engineering and education. In many jurisdictions this agency is forced to perform these other duties in addition to traffic law enforcement, because other agencies cannot or will not assume responsibility. Thus, the police have many and varied needs for accident records.

As the collection of accident records is not actually a use of accident data, accident investigation by the police is treated only briefly in this Manual. It is included, however, because of its importance in the collection of accident reports which are the foundation on which all accident reduction and other traffic plans are based. In the consideration of various uses of accident information by enforcement officers, the reader is asked to assume that good and sufficient reports are available.

Relative Importance of Traffic

Modern police administrators recognize traffic control and accident prevention as major police problems and assign available manpower on the basis of need.

Comparison of accident and other departmental records will show that losses to the public in traffic accidents are far greater than losses due to crime. The accident record provides adequate justification for the expense involved in traffic work. Far too often, a single spectacular homicide will create a demand that all or part of the manpower devoted to traffic be re-assigned to crime duty. Those who foster such demands apparently disregard the fact that traffic accidents cause far more fatalities, and in addition that there are many traffic injuries for every traffic death.

Good records make possible significant comparisons between accident losses and losses from other major ills of cities, such as the case shown in Table V.

TABLE V[17]

Traffic, Crime, Fire Losses in a Michigan City for One Year

	TRAFFIC	CRIME	FIRE
Economic Loss	$450,000.00	$ 11,109.20	$ 53,710.00
Total Budget	$ 76,830.00	$174,656.33	$338,408.65
Fatalities	11	0	1
Injuries	445	8	16

[17]From a survey by the International Association of Chiefs of Police.

Accident Records Provide Background for Planning

The police department is generally considered the public's first line of defense against traffic accidents. Its chief tool of accident prevention is the enforcement of laws and regulations designed primarily to produce safe and orderly traffic. Before an effective enforcement program can be developed by the police, the complete accident record must be examined and applied. Each officer, from the chief down, should know the accident situation in the area under his protection and whether this experience is worse or better than other areas. Accident totals, trends, and rates will provide the officer with the knowledge of the *size* and *severity* of the accident problem in a given area. Spot maps and hazard lists will point out *where* the problem is most serious. Accident summaries will tell *what* factors contributed most frequently to accidents, *when* they occurred, and *who* was responsible. If police officers have this information, the department is in a position to develop an intelligent program to prevent accidents.

Every police official must anticipate accident problems. "Locking the stable door . . ." is not accident prevention. These plans should be based on all the facts available. In the preparation of a traffic plan or program, the police official must know what the problem is at present, how successful previous plans have been, and what can reasonably be expected from future plans. He also would like to know what problems other police officials have, what they have done, or are doing, to solve them, and what success or failure they have experienced. The reduction of accidents is the problem, and the accident record will furnish the answers to such questions as "when," "where," "why," "how," and "who." A measure of the effectiveness of plans can be obtained by comparison of accident rates of different periods of time for the same area. Also, comparisons can be made of accident rates of different areas, with similar exposure characteristics. In these comparisons, one period or one area might have had a traffic plan and the other lacked a plan.

The Enforcement Program and the Accident Pattern

Examination of individual accident reports generally yields little of value to the enforcement officials except insofar as the individual accident is concerned. But as reports begin to accumulate, analysis may reveal certain common characteristics—certain patterns to which prevention measures may be applied. A common or "repeater" factor may involve specific locations, periods of time, types of violation, or any of numerous other factors.

The police obligation to the public calls for plans to be made and executed for the prevention of traffic accidents *before* the accidents occur. In order to have the plans efficient and the execution successful, certain specific facts, based on the present accident pattern, must be known. The traffic accident experience is determined by analyzing the reports in the accident file. This experience or pattern should be checked to discover changes and the trend of the changes from time to time. Annual, seasonal and monthly comparisons should be made with the same periods for previous years. If changes are detected, investigations should be made at shorter intervals than the periodic check. The enforcement program should cover the accident pattern and anticipate, in so far as possible, any changes. As the program is able to suppress part of the pattern, a new grouping of available forces can attack other aspects of the problem.

Planned Personnel Assignment

Accident trends should be watched closely and the forces at command should be placed where they will be most effective. Planned enforcement recognizes the fact that no police department, city or state, has enough policemen to patrol adequately all of the streets or highways. Since this is true, it is necessary to concentrate the police, particularly the motorized officers, at the places where most accidents are occurring. Assignment of personnel, on a time basis as well as location basis, should be made only after a thorough study of the accident experience. Hence, if 35 per cent of the accidents are occurring between the hours of 5:00 and 9:00 P. M., it may be assumed that about 35 per cent of the department's traffic personnel should be on the streets during this period. An intelligent deployment, based on analyses of past accident records, can be defended successfully. "Hit-and-miss" deployment based on sensational or incomplete data cannot be defended.

Placement of covering forces, allowing for new trends, can be worked out from accident spot maps, accident time distribution analyses, and studies of violations in relation to accidents, Figure 12. Police departments in some areas concentrate on one aspect of the problem for a period and then forget it almost entirely. This pendulum-like action can and should be damped, using the analysis of accident reports as a guide. Comparison of accident causes with those items stressed by the enforcement

PERCENT DISTRIBUTION OF MOTOR VEHICLE TRAFFIC ACCIDENT FATALITIES INVOLVING PEDESTRIANS, OTHER MOTOR VEHICLES, OR BICYCLES BY 4-HOUR PERIODS OF ACCIDENTS IN URBAN PLACES, 1943.
(THE REPORTING AREA INCLUDES 42 STATES, DISTRICT OF COLUMBIA, AND NEW YORK CITY, NEW YORK)
(SOURCE - BUREAU OF CENSUS DATA)

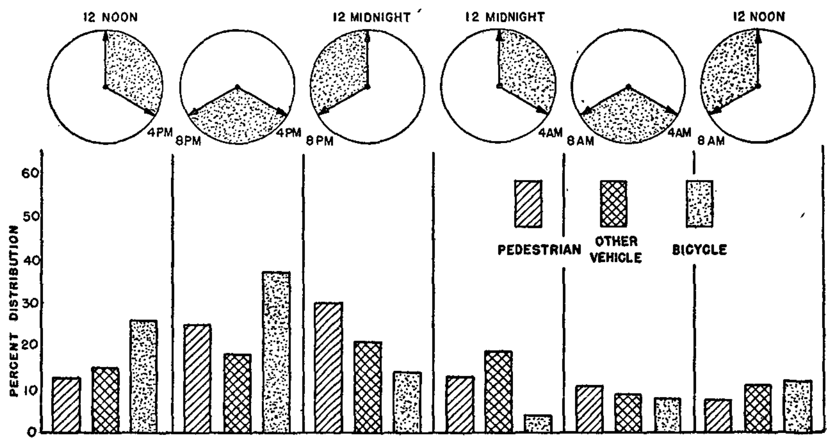


FIGURE 12—Time Distribution of Accidents by Common Types.

program will direct the enforcement activities into the most profitable channels, Figure 13. If records show a number of accidents involving a certain violation in a certain area, it is evident that more active patrolling in that area, with appropriate enforcement measures, is needed.

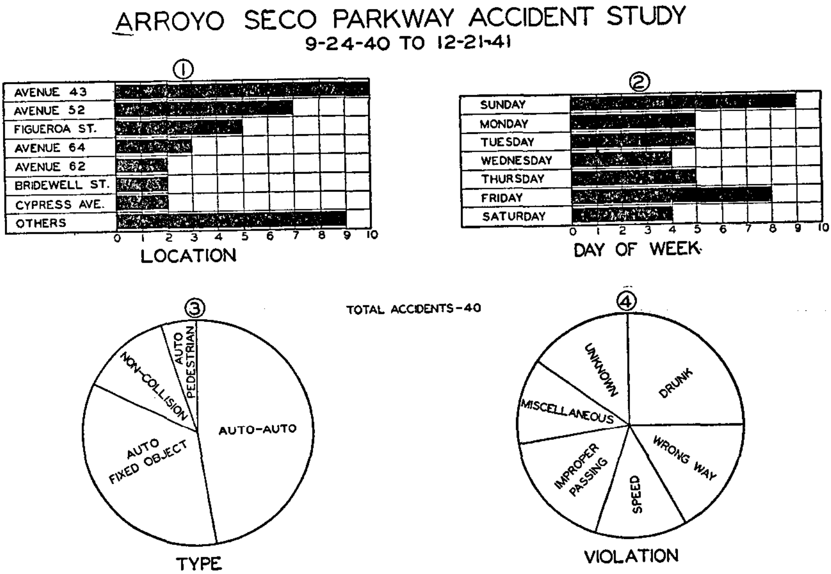


FIGURE 13—Illustration of Special Analysis of Accidents by Type, Location, Time, and Violations.

The enforcement program developed through comparisons of enforcement activity with the accident record, and the resulting effect of such a program in one area, may well be the guide for similar action in another area with a similar accident background. Such comparisons of areas furnish the departmental planner with a keen tool for assigning manpower and equipment and give him a measure of effectiveness of programs and organizations.

Specific Activities in Personnel Assignment

Thus far in this Manual the use of accident records in the determination of the proper and most effective assignment of manpower and equipment to combat motor vehicle accidents has been discussed generally, yet briefly. The specific problem usually involves several factors, such as—

1. Police departments have a limited supply of manpower and equipment.
2. Manpower and equipment must be deployed for the greatest effect.
3. Justification, strong enough to withstand political and other pressure, must be found for deployment.
4. In the interests of efficient enforcement and conservation of manpower, priority must be given in terms of area, time and violation emphasis as dictated by the accident experience.

The problem must be probed continuously, for only continual measurement and complete understanding will lead to intelligent planning in personnel assignment and the direction of the activities of such personnel.

Although most of this discussion is presented in terms of city police departments, the procedures are equally applicable to state police,[18] sheriffs and other law enforcement officers. Only a few state police organizations have sufficient manpower to follow completely such a plan of personnel assignment, but, with the proper adjustments an approximation can be reached by using patrol areas, counties and important highways as the city would use precincts, beats, and intersections. Because of their limited manpower, planned personnel assignment is probably more important in the state police field than for city police. In any case, rural police organizations should follow the principles of assignment based on records and analysis insofar as their requirements for state-wide coverage will permit.

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[18] Miller, George and Baldwin, D. M., *State Traffic Law Enforcement*, Chapter VIII, Enforcement Planning, National Safety Council, Chicago, Illinois. 1944.

Time of Accident Important for Assignment of Manpower

More accidents occur during certain hours of the day or night than during other hours. The relationship of time of day to number of accidents can be determined from accident records. Figure 14 shows such information for a city. It is possible then to balance the available manpower against the time distribution as demonstrated in Figures 15 and 16.

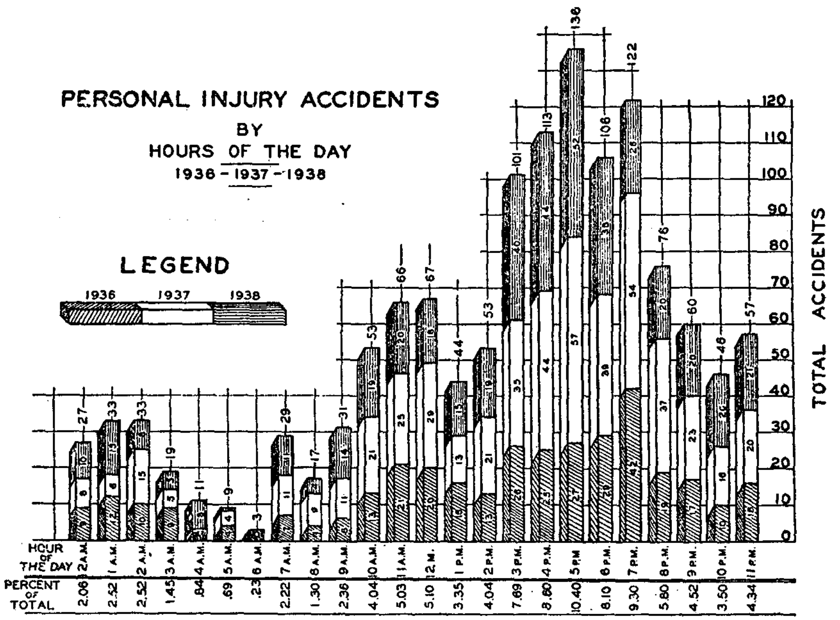
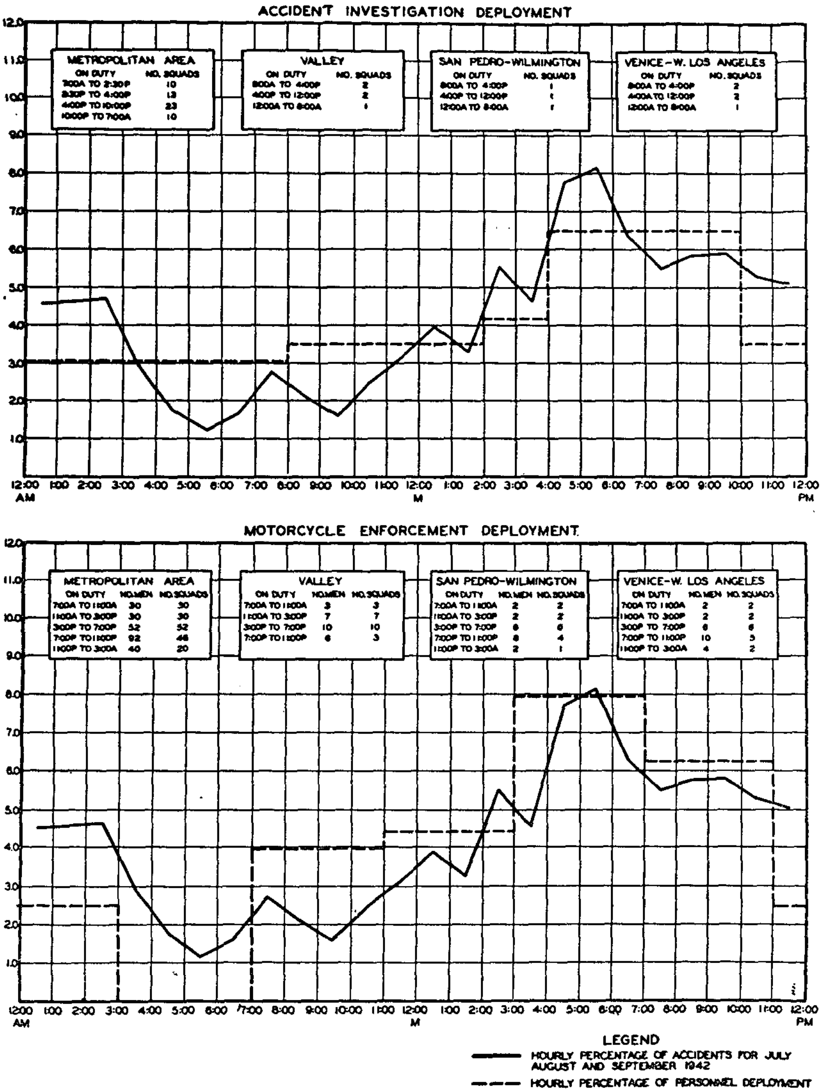


FIGURE 14—Example of Analysis of Personal Injury Accidents by Hours of the Day and Annual Variations.

It is not always possible to make the manpower distribution match exactly the time distribution, for split shifts are not practicable in all cases. There are also marked variations between days of the week and between seasons of the year, and the hourly pattern must be adjusted accordingly.

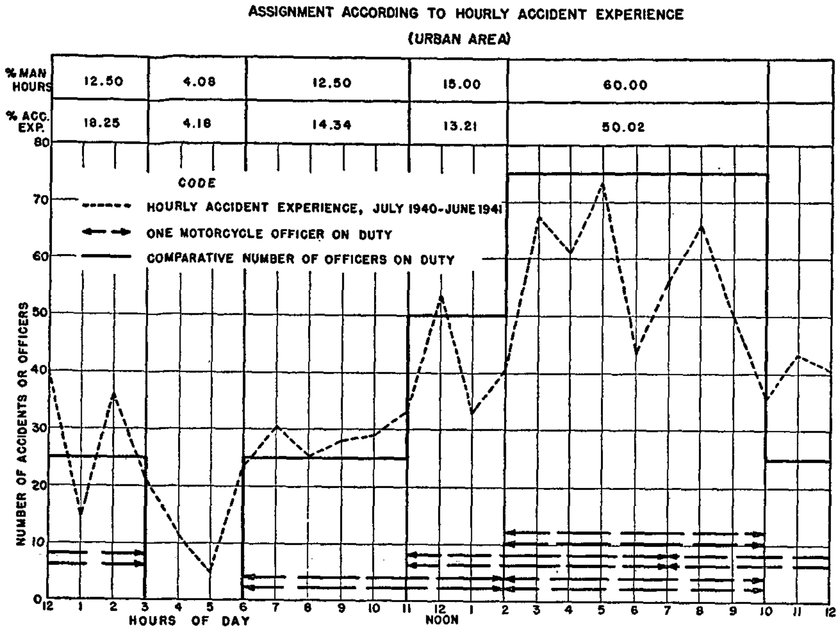
With assignment areas changing according to the accident time distribution, it would not be at all unusual for an area on

HOURLY COMPARISON OF ACCIDENTS WITH PERSONNEL DEPLOYMENT



Courtesy Los Angeles, Cal., Police Department.

FIGURE 15—Comparison Between Accidents, Time of Day, and Deployment of Police Personnel.



Furnished By Northwestern University Traffic Institute.

FIGURE 16—Graph Showing Relationship of Hourly Assignments of Officers and Equipment to Accidents.

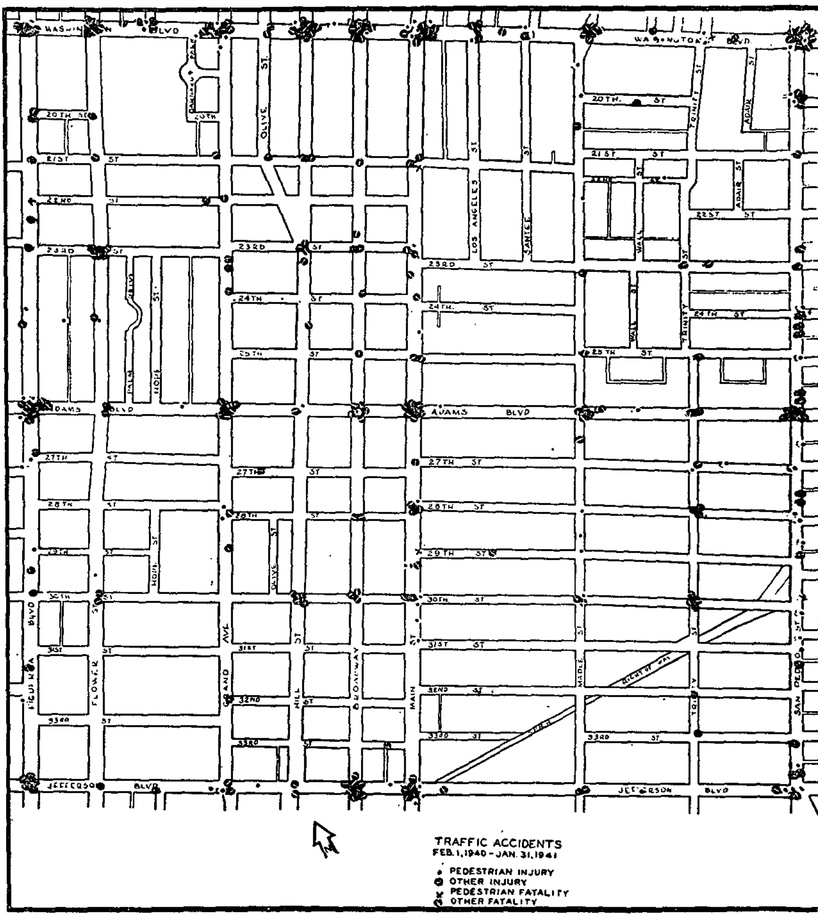
one shift to be divided into two areas on another shift, and vice versa. Areas may vary in similar fashion from weekdays to Saturdays and Sundays and from winter to summer.

A combination of the two factors "where" and "when" will decide the ultimate distribution of manpower and equipment. Areas are not always uniform, homogeneous sections, as there are special locations and routes which may differ markedly from the rest of the area under consideration. These special locations and routes, because of their unusual accident experience, must be given special attention, with enforcement pressure at the time when accidents may be expected.

Locations of Accidents Important for Assignment of Manpower

Accident location information may be indicated on spot maps, with separate maps for various areas and shifts. This procedure is practical, however, only when the volume of accidents is sufficient to indicate a pattern during a single shift. Such conditions seldom occur in rural areas. A section of a city area spot map, showing types of accidents, is reproduced in Figure 17.

Tabulations or lists of accident locations prepared from the accident records give a good picture of locations of accidents,



Courtesy Uran Re-Development Commission, Los Angeles, Cal.

FIGURE 17—Section of City Spot Map Showing Locations of Common Types of Accidents.

and can be used to replace or supplement spot maps. Sub-division of the total area to be policed into workable units (precincts, beats, routes and posts) should be based on accident location facts. Within limits, area divisions should be selected so that the total number of accidents in comparable areas will be equalized. Some divisions which are larger in area than others may have fewer total accidents because there is a desirable limit to the area a patrol unit can cover efficiently. Natural geographic boundaries may often determine boundaries of patrol areas.

Once basic patrol coverage has been provided, further assignment of manpower should be based upon knowledge of accident locations. High accident frequency streets, or intersections, should receive special enforcement attention if police efforts are to be expended efficiently in accident prevention. Only by so concentrating patrol effort at points which accident reports point out as potential locations of further accidents, will accident reduction be effected with conservation of manpower. A sketch of intersection accidents in a given area, together with traffic controls and sight restrictions, such as the one shown in Figure 18, can provide useful information for police.

Violations Involved in Accidents Important in Directing Enforcement Effort

The next step in planning deals with enforcement pressure placed upon traffic violations that are direct or contributory causes of accidents. While it might be argued that all traffic violations would be equally potential causes of accidents, research into the accident report file will show that some violations appear more often than others. A greater effect on accidents can be obtained if the bulk of the enforcement pressure is brought to bear on the more numerous and more serious violations *at the times and places where they have been causing accidents.*

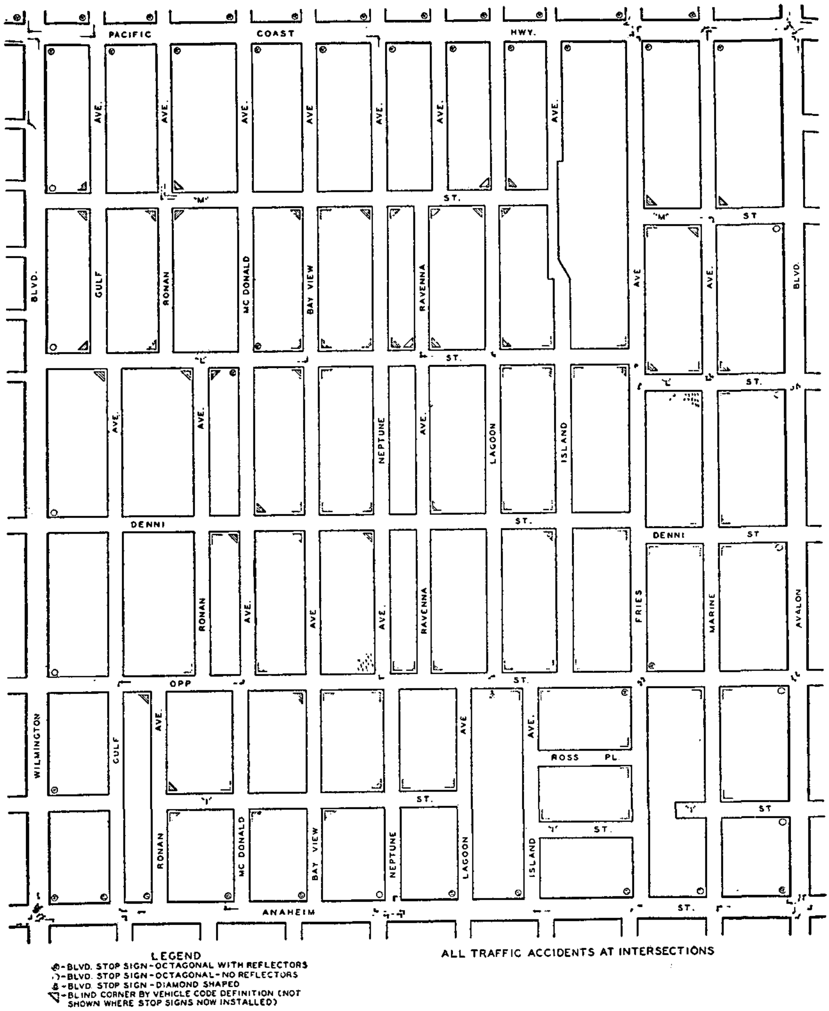


FIGURE 18—A Study of Intersection Accidents in Relation to Traffic Controls and Physical Conditions.

A continuous enforcement program can be built up and a definite measure of success can be obtained if the program is based on accident analysis so that: (1) Enforcement action is principally on the violations shown to rate high as factors in accidents; (2) enforcement action is taken at the locations or in areas shown to be particularly affected; and (3) enforcement action is taken during the times when most accidents are occurring. The accident analysis, such as might be made on a form shown in Figure 19, may show, for example, an increase in accidents with a specific violation indicated as either the direct cause or a contributing cause; the general area, or perhaps a specific intersection or route, is defined by further analyses or studies of spot maps; the officers in the field are instructed to suppress this volation with appropriate enforcement measures. Studies may be made of more serious violations in accidents by time of day, as in Figure 20.

TRAFFIC SURVEY
TRAFFIC LAW ENFORCEMENT ANALYSIS
ACCIDENTS AND DRIVING VIOLATIONS—SUMMARY SHEET

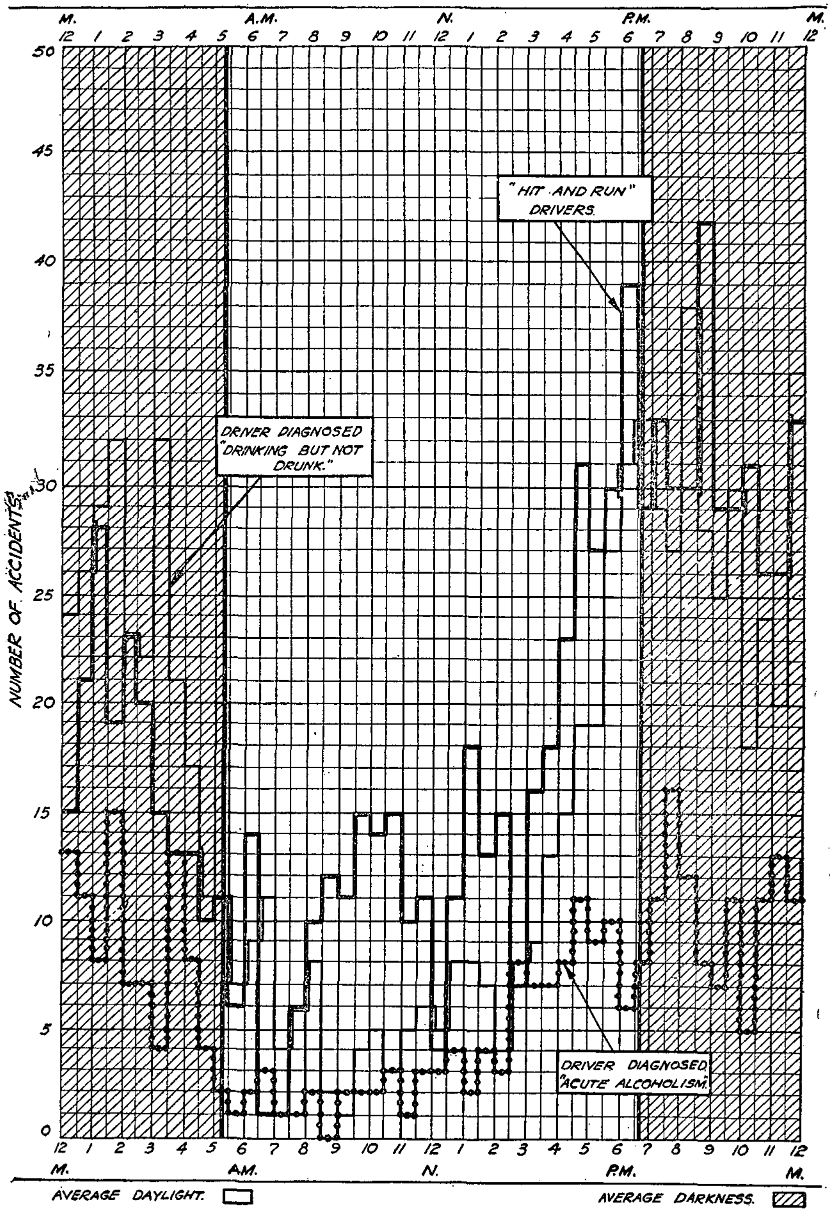
COMPILED BY________ DATE________ CITY________ STATE________

COMPUTED BY________ FOR PERIOD FROM________ TO AND INCLUDING________

DISPOSITION	HIT & RUN (1) No.	%	INTOXICATED (2) No.	%	RECKLESS DRIVING (3) No.	%	EXCESSIVE SPEED (4) No.	%	FAILED TO OBEY STOP SIGN OR TRAFFIC SIGNAL (5) No.	%	DEFECTIVE EQUIPMENT (6) No.	%	PASSING STANDING STREET CAR (7) No.	%	LICENSE & REGISTRATION VIOLATIONS (8) No.	%	ALL OTHERS (9) No.	%	NO CHARGE MADE (10) No.	%	ALL DRIVING CASES (11) No.	%
FATAL AND PERSONAL INJURY ACCIDENT CASES																						
1 DISMISSED																						
2 PENALIZED																						
3 WARNED																						
4 UNKNOWN																						
5 NOT ARRESTED																						
6 VIOLATION SUB-TOTAL																						CLASS TOTAL
7 % OF VIOLATION TOTAL																						
PROPERTY DAMAGE (ONLY) ACCIDENT CASES																						
1 DISMISSED																						
2 PENALIZED																						
3 WARNED																						
4 UNKNOWN																						
5 NOT ARRESTED																						
6 VIOLATION SUB-TOTAL																						CLASS TOTAL
7 % OF VIOLATION TOTAL																						
NOT INVOLVING PERSONAL INJURY OR PROPERTY DAMAGE ACCIDENTS																						
1 DISMISSED																						
2 PENALIZED																						
3 WARNED																						
4 UNKNOWN																						
5 NOT ARRESTED																						
6 VIOLATION SUB-TOTAL																						CLASS TOTAL
7 % OF VIOLATION TOTAL																						
A VIOLATION TOTAL																						GRAND TOTAL
B % OF GRAND TOTAL																						

FIGURE 19—Example of Form Used for Studying the Distribution of Driving Violations and Accident Cases.

A number of questions now must be answered in order that the effectiveness of the force used may be determined and meas-



Courtesy Department of Streets and Sewers, St. Louis, Missouri.

FIGURE 20—A Study of Serious Driving Violations in Relation to Accidents and Time of Day.

ured. Was the enforcement action taken within the indicated "danger" area and time? Were the arrests followed by convictions? Were accidents reduced over a sufficiently long time?

Enforcement Index

A recognized measure of police efficiency in accident cases is the enforcement index. This index is the ratio of the number of convictions for moving and hazardous violations to the number of personal injury accidents. In urban areas, an index of 10 is generally considered as the minimum for efficiency and effectiveness of enforcement. Mere volume of arrests, in other words, is not sufficient.

Unless accident reporting is reasonably complete, the index calculated is valueless, since the denominator (number of personal injury accidents) will be low; the index, consequently, will be too high. An increase in reporting will naturally lower the index.

Many departments principally use the index to compare departmental activities from year to year, and to relate the work of one area division to that of others.

Accident Data as Aid to Supervisors

A most important duty of a police executive is the general supervisory aid given to each of the various departments. Policy making and policy changes are inter-related with this aid. A clear understanding of the problems and general conditions confronting the subordinate is necessary if administration is to be effective. Periodic summaries of the accident experience and special analyses and current studies should be routed to the administrator. In this way the administrative heads will be informed, and coordination within the department and with outside agencies is possible. Coordination of all interested agencies must be effected at all administrative levels in order that a combined assault against accidents can be made. This use of accident records cannot be over-emphasized.

Accident Data Exchange Must Be Encouraged

A comparison of the traffic and safety activities of all departments within any governmental structure may disclose overlapping of effort in some fields and incomplete coverage in others. Through the use of accident facts, studies, summaries, charts, maps and research prepared and used in one department, other interested departments can be helped in the development of effective, coordinated programs in the area of their responsibility and authority. It is not at all unusual to find one department expending a great amount of labor and time on a problem only to find that another department either has already prepared the answer to the identical problem or could solve the problem with little or no effort. Police departments, because of their close contact with traffic accidents and with the public, are especially fine sources of information for all departments having related responsibilities. Encouragement should be given individual investigating officers so that the information they have is included in their reports and directed to other agencies.[19] The finest traffic accident information in the world is useless if filed away and never used.

Budget Planning and Justification

Budget planning and justification must be predicated on a sound basis of facts. Rare indeed is the department that has ever had or ever expects to have such manpower or equipment as to reach a point of diminishing returns. A police budget which takes into account for traffic work the accident experience of the past, and that expected for the future, will come closest to providing the necessary manpower and equipment to do a

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[19]Some governments, Detroit for example, have profitably employed the technique of joint analysis of accident records by enforcement, engineering and public education personnel, thus developing a fully coordinated joint program in these closely related fields. An epecially worthwhile cooperative plan has been developed in Virginia. The highway department maintains a full-time engineer in the accident records division of the State police to assist in analyses that are of particular interest and value to the highway groups.

reasonably complete job. Citizens, tax groups and legislative committees can and should be shown: (1) The present accident situation and what it is costing the community; (2) the accident prospects for the future; (3) the success of the present enforcement program as measured against the accident rate, and (4) future plans for reducing accidents. If a manpower shortage exists, showing how the present force is deployed to obtain maximum coverage will help to prove the need for more men. Comparisons of the accident experience and the authorized manpower of other cities or states with similar characteristics may assist in convincing the finance committee of the need to enlarge present facilities.

Answering Traffic Complaints With Accident Records

Police departments receive many complaints from the public on traffic matters. All complaints require some action, whether they are justified or not. Accident records either alone or in combination with other types of studies can be used to answer many of the critics. For example, the man who sits on his porch and observes the "worst" speeding situation in the city may be right. If he isn't, he should be told that there has been no unusual frequency of accidents on that street due to excessive speed and that a speed study has shown the speeds to be normal and reasonable. Demands for traffic signals and signs are often unwarranted. If a sign or signal is warranted, the person or group making the complaint should be informed that the location has a priority on the "worst" location list and should be told the date, based on funds available, when the improvement is expected to be completed. If the demand is not a just one, the person or group making the complaint should be shown that the accident situation or traffic volume does not warrant the requested control, and that even if it were installed it would not prevent or reduce the type of accident about which the complainant is concerned.

Perhaps one of the most difficult decisions to make in traffic enforcement work is the one involving detailing a man to traffic control at an intersection. Pressure groups frequently demand expenditure of manpower at "favorite" corners. There are as yet no good warrants against which to measure the need for such assignments.[20] In many cases the action has been based on personal opinion and does not involve accident experience. Investigation of the accident record is an important means of justifying refusal to assign manpower in such instances.

Pedestrian Control and Regulation

The seriousness of the pedestrian accident problem can be readily realized by consulting the record. In a thickly populated state such as Connecticut,[21] pedestrian accidents account for only 10 per cent of the total, but pedestrian fatalities number about 55 per cent of the total traffic accident deaths. National figures for 1946 show that pedestrians represent two out of five traffic deaths and suffer one out of four non-fatal injuries.[22]

The local accident record will quickly point out the relative severity of the pedestrian problem in the community. The police will be able to decide whether or not special enforcement attention should be given to the problem—from the standpoint of both drivers and walkers.

Pedestrian accidents respond generally to the same type of analytical treatment as other types of accidents, though the corrective action indicated will usually be peculiar to that group of accidents. Thus the educator uses the accident record to supply information to the walking public on the dangers in incorrect walking and to try to replace the old habits with safe habits (see Chapter VI on Educational Uses of Accident Rec-

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[20]This matter is now being studied by a joint committee of the Institute of Traffic Engineers and International Association of Chiefs of Police.

[21]Connecticut Department of Motor Vehicles, *Traffic Topics*, The Department, September, 1942.

[22]National Safety Council, *Accident Facts*, Chicago, Illinois. The Council, 1946.

ords). The engineer uses the pedestrian accident record to discover the locations where he can make physical changes in order to reduce accidents and as an indication of what type of change to make (see Chapter V on Engineering Uses of Accident Records). The police administrator uses the data to determine where, when, and how much enforcement should be applied.

Driver Education

Some police deparments have entered the field of traffic safety education either with traffic schools for violators or schools for new drivers. Where such schools have been conducted, the greatest success has come by explaining the relation of local accidents to the safe operation of a vehicle in the local area. The past accident experience points out the basic necessity for rules and regulations; it shows where to expect hazards; it reveals the limitations of both car and driver and helps to develop proper driving attitudes. The application of accident records in driver training is discussed further in Chapter VI.

Traffic Control Devices

The police often have responsibility for such traffic control functions as the installation, operation, and maintenance of signs, signals and markings. The accident record is one guide for installation of traffic control devices and will provide protection for the department from complaints and pressures from the public.[23] If there is a traffic engineer, installation, maintenance and supervision of traffic control devices should be under his jurisdiction. It is always desirable, however, for the traffic engineer to work closely with the police in the installation of control devices so that complete cooperation in enforcement will be assured.

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[23]Public Roads Administration, *Manual on Uniform Traffic Control Devices for Streets and Highways.* Washington, D. C., The Administration, 1947.

Curb Parking Enforcement

The accident record frequently shows parking to be a factor in traffic accidents. Proposals to change the type of parking at the curb, anticipated parking prohibitions, and the control of loading and unloading facilities are often supported by accident data. Enforcement of parking regulations by the police can be guided by a study of the contribution of violations in parking accidents to the total accident problem. Records of accidents that show parked vehicles as being involved, can be used to indicate necessary parking regulations.

Studies can be made of accidents to determine the hazards of different types of parking, and of the effectiveness of various parking regulations. While most parking regulations are primarily intended to improve traffic flow, accident data are often effective in getting needed changes adopted.

Vehicle Inspection

Analysis of accident records frequently shows the need for improving the mechanical condition of vehicles. Compulsory, periodic vehicle inspection is the best means to secure this improvement. The items needing inspection are revealed by the reports of accidents involving mechanical failure, which also show the time and place of need for intensified activity in this field. Accident records show that tires, lights, brakes, steering, windshield wipers and glass often influence the frequency and severity of accidents.

Bicycle Inspection

The accident record often may show that bicycle riding is a dangerous pastime, particularly for children. Various police departments have taken advantage of bicycle licensing legislation to do a safety education job, even though licensing may be aimed principally at the recovery of stolen bicycles and at discouraging thefts. But, with the inspection for licensing, the safety devices on the bicycle can be checked and education on safe operation practices can be given. In addition, reckless bicycle riding can be curbed by appropriate enforcement measures. Points needing attention in these programs are best determined from a study of past accident experience.

Safety Contests Within Police Departments

Traffic safety contests between the various command units such as precincts in a city, have resulted in effective reduction of accidents in some jurisdictions. As examples, Detroit and New York both have been successful in this field and although their contests differ in detail, they are based primarily on the accident record, the effectiveness of accident reporting, the extent of enforcement, and the program of public education.

Some police organizations use accident records effectively as the basis for merits, recognition and awards for officers and troops.

Uses of records on departmental vehicles should not be overlooked in departmental vehicular safety programs.

Accident Investigation

"On the spot" accident investigation and reporting by trained policemen is a most satisfactory method of securing complete accident data. Other methods of reporting often result in records which are fragmentary, biased, or a complete failure, insofar as the reporting of a large segment of the accident experience is concerned.

Completion of Report Essential

It usually is agreed that an accident report is of little value if it does not contain complete factual information on a standard form so designed that the information can be compared, grouped and analyzed with other reports. Complete information includes investigation into the reasons for the accident which is best accomplished by the investigator based on his "on the spot" knowledge of the accident and the location.

Training of Investigators

The training of accident investigators can make frequent use of accident data. This training is valuable not only because of the resulting better reports, but because of the time saved by introducing a method (step by step procedure) in making the reports. Such training for the investigation of common types of accidents is not beyond the capabilities of the average law enforcement officer. All police officers, traffic men and others alike, should receive sufficient training to enable them to make a complete accident investigation, and turn in a workmanlike report, when necessary. Aside from the value of the completed report, the officer making the report and the investigation of the accident increases his own knowledge of how to enforce the accident prevention program better in the future.

Assignment of Accident Investigators

In departments where special accident investigators are utilized, personnel assignment planning should provide coverage of all accidents. During those hours when more accidents are reported, additional accident investigators should be on duty. The first officer at the scene should investigate the accident and complete the report, to the best of his ability with the equipment available.

Additional Benefits from Accident Investigation

In addition to the resulting better reports and increased public service, there are two other benefits from accident investigations, such as—(1) violations of the law are uncovered by good accident investigation which otherwise would escape undetected; (2) good accident investigation tends to increase both the volume and quality of accident reports which in turn makes for better analysis and leads to greater and more widespread use of accident records; and, (3) this, in turn, results in more efficient use of personnel and equipment.

Accident Information Uses in Prosecutions

It is assumed that an arrested violator of the traffic regulations will eventually arrive in a court. Also, it is recognized that the court is the last link in the enforcement process. Here the accident records may be a valuable guide to the court and may increase the effectiveness of court actions.

Familiarization of the Court with the Problem. The use of up-to-date local, regional, and national accident figures will provide for the court a background and understanding of the accident problem. For example, the courts should be familiar with the number of fatalities, personal injuries and property damage accidents of the locality. This information will give the court the proper perspective of the traffic situation as a major community problem. The successes or failures of the total enforcement program (which includes the court) may be shown by studying trends in accidents and rates. Further, accident records can be used in support of the court's policy in cases requiring punishment. Factual studies, such as the one reported in Figure 21, serve to show the dispositions of court cases growing out of traffic accidents.

Relation Between Violations and Accidents. Since one of the reasons for prosecuting violators is to bring about a reduction in accidents, the court should be interested in the accident records which show the violations causing the greatest number and the most serious accidents. The court also should be familiar with the recurring patterns of accidents—times and places where accidents occur—particularly those traceable to violations which the court will be called upon to adjudicate.

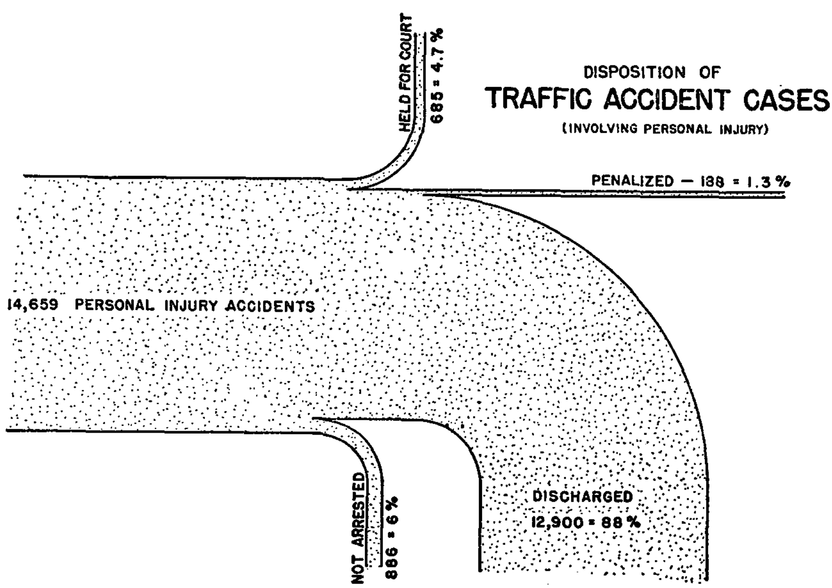


FIGURE 21—**Flow Chart Showing the Distribution of Traffic Accident Cases for a Large City.**

Preparation of Cases. The prosecution in an accident case must be able to present to the court the picture of events before, leading up to, during and after the accident. Good accident investigation and reporting provides this necessary information.

Accident and Violation Repeaters. The judgment of a case is limited to consideration of the facts involved in that one case. But, after a person has been found guilty, consideration can be given to the driving history of that person in fixing the penalty. The court should have at hand the traffic history of previous warnings, convictions of moving violations, involvement in accidents, and driver license penalties. The court should realize that traffic violations are indications of unsafe driving practices which, if uncorrected, are apt to result in accidents.

Table VI shows interesting relationships between the frequency of citations, involvement in accidents, and ratios of citations to accidents for a typical city.

TABLE VI

RELATION OF NUMBER OF CITATIONS TO PER CENT DRIVERS CITED IN ACCIDENTS AND PER CENT ACCIDENTS PER DRIVERS CITED
DATA FROM A CALIFORNIA CITY

CITATION	DRIVERS RECEIVING CITATIONS	DRIVERS IN ACCIDENTS	% CITED DRIVERS IN ACCIDENTS	NUMBER OF ACCIDENTS	% OF ACCIDENTS PER DRIVERS CITED
1st	12,175	879	7.2%	930	7.6%
2nd	4,011	675	16.8%	787	19.6%
3rd	2,197	555	25.2%	662	30.1%
4th	1,367	500	38.0%	609	44.5%
5th	949	343	36.1%	483	50.9%
6th—more	2,101	1,049	49.9%	1,682	80%
Totals	22,800	4,001	----	5,153	----

Uses of Accident Data in Education by the Court. Some judges have found that the accident information in visual forms, such as spot maps, charts, graphs, and tables is effective in court and makes excellent material for pointing up the seriousness of the violation for which penalty is being imposed.

Ready Access of Accident Facts. The court should be encouraged to request the accident records agency for special studies and research data which will assist the court in its work. Such studies of interest to a progressive court would include the connection of alcohol with accidents, pedestrian walking habits in conflict with motor vehicle operation, and histories of persons convicted of moving violations or involved in accidents.

Measure of Efficiency. A job cannot be considered complete unless the overall efficiency is measured. One of the most important measures of the effectiveness of the enforcement program is the conviction rate for cases involving accidents. There is something radically wrong with an enforcement program if most of the cases that are brought to court are dismissed for lack of sufficient evidence, or for other reasons. The desired deterrent effect that an enforcement program should achieve on accidents cannot be reached unless traffic violators are convicted. All of the good work that has gone before will be nullified if there is a breakdown in court.

REFERENCES ON ENFORCEMENT USES

1. Northwestern University Traffic Institute with cooperation of Safety Division of International Association of Chiefs of Police, *Accident Investigation Manual*. Evanston, Illinois: The Institute. 1946. Manual on traffic accident investigation, report writing, case preparation and court presentation, with explanations of provisions of law which police officers should know.

2. Billings, Curtis. *Accident Prevention Bureaus in Municipal Police Departments: What They Do and How They Are Set Up*. Northwestern University Traffic Institute, Evanston, Illinois, 1937. Discussion of functions of an accident prevention bureau; work of investigating accidents; activities aimed at prevention of accidents.

3. Miller, Geo. and Baldwin, D. M. *State Traffic Law Enforcement*, National Safety Council, Chicago, Illinois, 1944. Contains recommendations as to effective utilization of accident records in enforcement planning.

4. Federal Bureau of Investigation, *Traffic Control and Accident Investigation*. Institute of Government, University of North Carolina, Chapel Hill, N. C., 1947. Contains chapters on accident records, accident investigation procedures and methods of traffic measurements and general traffic enforcement techniques.

5. U. S. Public Roads Administration. *Motor Vehicle Traffic Conditions in the United States, Part 2: Skilled Investigation at the Scene of the Accident Needed to Develop Causes*. U. S. 75th Congress, 3rd Session, House Document 462, Part 2, Washington, D. C., U. S. Government Printing Office. 1938. A technical study of accident cases, including investigation techniques; accident analyses, and law-violation records.

6. National Safety Council. *Public Safety Memo No. 107. A Method of Using Accident Records to Direct Selective Traffic Enforcement in Cities*. Chicago, Illinois, 1943, The Council. Explanation of records required, filing and analysis procedures, incident to effective use of accident data in urban enforcement programs.

7. National Safety Council. *Public Safety Memo No. 106. A Method of Using Accident Records to Direct Selective Enforcement in Rural Areas. 1944.*

8. National Safety Council. *Enforcement for Traffic Safety. 1942.* General.

9. Tripp, H. Alker, *Road Traffic and Its Control*, Edward Arnold and Co. London, England, 1938. A text on traffic law enforcement, accident investigations, and related activities.

10. California Highway Patrol, Department of Motor Vehicles. *Reference Manual of Traffic Accident Investigation and Selective Enforcement*, California, Department of Motor Vehicles.

11. Taylor, Clarence P. *Traffic Officers' Training Manual*, National Safety Council, Chicago. 1930.

12. National Conservation Bureau. *Traffic Engineering and the Police*. Published jointly by the National Conservation Bureau and the Safety Division of the International Association of Chiefs of Police. New York, New York, National Conservation Bureau, 1946. Enlarged and revised manual containing approved traffic engineering methods to be applied by police officials responsible for traffic control.

CHAPTER V

ENGINEERING USES OF ACCIDENT RECORDS

For the purposes of this Manual, engineering may be considered to include the design, construction, and maintenance of streets and highways, together with the control of vehicle operations on those highways. It thus embraces highway engineering in its original sense, and traffic engineering as a more recent branch of the profession. The two fields necessarily overlap, since traffic engineering is usually understood to include the designing or redesigning of highways for the purpose of expediting traffic movement or making that movement safer, while highway design and construction must assume a knowledge of traffic characteristics and behavior.

Engineering Responsibilities

The engineer is responsible for providing the public with streets and highways which can be traveled upon with speed, safety, and comfort. These three essentials of travel are closely interrelated, and, fortunately, effort expended towards satisfying one essential will generally completely or partially satisfy the demands of the other two essentials. Engineering to reduce accidents through planning, design, construction, maintenance, and traffic operations, usually brings with it additional rewards in increased comfort and speed.

From the public standpoint, the engineer's primary objective is a reduction in the total number or severity of actual or potential accidents. He must think in terms of *all* accidents in the city or state. This usually means giving attention first to the principal traffic ways where large volumes of traffic are accompanied by numerous accidents even though the accident rate per million vehicle-miles may be lower than elsewhere on the highway system, and even though correctives might be more expensive than at other locations. Ten accidents at an intersection of two boulevards are far more costly to the public than two accidents of the same type and severity at a secondary street intersection, though the boulevard traffic volumes may be ten times those of the secondary streets and the relative hazard per unit of traffic, therefore, only half as great as that at the minor intersection.

The engineer must also consider the cost of accident prevention at any particular location in comparsion with the cost of achieving the same reduction of accidents elsewhere. If some simple low cost expedient like the erection of warning signs or stop signs at a number of points can be expected to prevent even one or two accidents each year, the public funds may thus be more efficiently spent, than, for example, by a $10,000 reconstruction of a major intersection to prevent a dozen accidents. It must be recognized, however, that the highway engineer must consider other elements as well as safety, and that a major expenditure may amply pay for itself through reduced traffic delays, apart from safety. Accidents represent an economic cost, although that cost cannot always be measured. Similarly, traffic delays are an economic cost, and are almost as intangible. Weighing one cost against another is one of the most delicate responsibilities of the highway engineer.

Engineers must accept their responsibilities in accident prevention; however, the engineer must concede that "engineering" as here treated is not the only means of reducing or preventing accidents. He should be able to recognize situations where, perhaps, the key to safety lies in police enforcement activity, or in the better training of the pedestrian of elementary school age. It must be realized, however, that engineering solutions in accident prevention, although costly and difficult to accomplish, are usually more effective and lasting than the purely regulatory measures. Physical corrections achieved through technical traffic engineering approaches, provide long-term cures.

Engineering Applications of Accident Data

Accident analysis is a major tool of the engineer in his constant effort to reduce hazards and prevent future accidents through the correction of deficiencies[24] in existing highways and through the sound design of new highways. Accident data must be depended upon to reveal deficiencies in engineering at existing locations. They must also aid in the development of engineering principles generally applicable to future design, construction, maintenance, or operation, in advance of, or independent of, the accumulation of an accident record at any particular location.

These two uses of accident data are inseparable and closely related. The engineering remedy, determined upon for a given location that has experienced more than its share of accidents, must reflect general conclusions as to what constitutes safe practice, even while it deals with the immediate difficulties revealed by a study of accidents at that point. On the other hand, the experience and statistics gained in the practical treatment of bad locations should contribute to the improvement of general engineering standards. If, for example, a certain traffic circle proves to be hazardous to traffic entering it from one of its approaches, a study of the accidents may reveal that the approach curvature is too sharp. In reconstructing this circle according to a better plan, past experience in highway design should be called upon to guide the preparation of specifications for approach curvature and other details such as pavement sur-

[24]"Deficiency" is here used in the broad sense that if accidents can be prevented by engineering improvements, the existing condition is deficient.

face, superelevation, and roadway width. In the same manner, the lesson learned from the accident record of this circle will be applied profitably in plans for future circles. These future designs should include improved curvature for greater safety. Accident records thus are used to correct existing deficiencies and to prevent repetition of similar deficiencies elsewhere.

Engineering Deficiencies Contributory to Accidents

Because almost every accident is the result of a complexity of causes, it is not easy to appraise the contribution of any single factor or group of factors. Roadway "deficiencies" are taken for granted because they have been a part of our highway plant for many years. Usually some act of careless or incompetent driving also is involved in any given accident, or some violation of the traffic code, either of which directs attention away from possible shortcomings of the highway. Accident analysis too often classifies accidents according to major causes, and ignores factors which may seem to the statistician in charge to be less obvious, less remediable, or simply less important from his point of view. For this reason we have widely varying estimates of the relative importance of roadway deficiencies in accident causations, ranging from as low as 2 per cent to as high as 20 per cent.[25] Whatever the actual percentage may be, it is high enough to demand the attention of engineers.

Development of Accident Information

As with all other uses of accident information, the analysis of the data is basic to engineering applications. When, by analysis, the facts have been properly developed, it remains only for those in authority to choose (usually on an economic basis) between, (1) engineering measures and possible alternative expedients of a non-engineering nature, and (2) the benefits

[25]American Road Builders' Association. *Report of Problem Committee on Analysis of Accident Data.* Washington, D. C. The Association, 1940.

of the proposed solution as compared with the benefits that might be derived from an equivalent expenditure elsewhere.

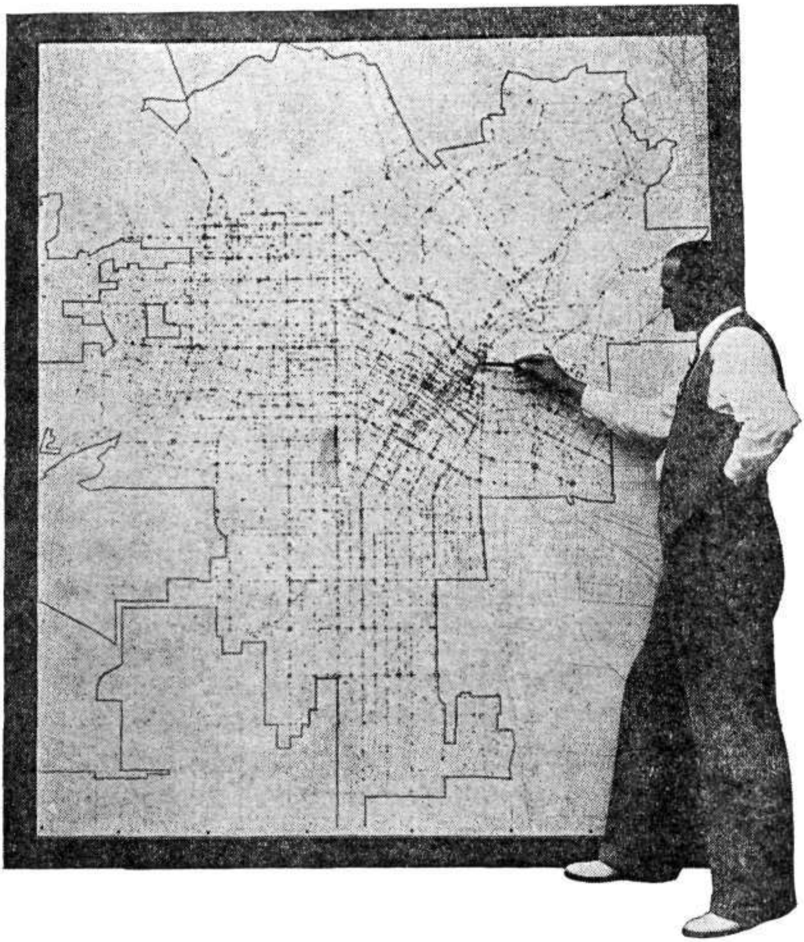
It is assumed that the quality of accident reporting and the quantity of reports on hand are sufficient to conduct the types of analysis which are needed by the engineer. The primary collection of accident data can be made but once, and the data collected must anticipate all expected uses. Standard procedures and forms as developed by the National Conference on Uniform Traffic Accident Statistics are accepted as the minimum standard for this groundwork for the analysis. Certain other basic steps in analysis also have a common usefulness for other purposes as well as for engineering. An example of this is the study of high-accident frequency locations, where all possible elements of accident causation should be considered and evaluated. Engineering is only one of several possible remedial treatments that may be indicated.

Despite these common elements of accident causation, however, the engineering approach to possible remedial treatments through accident analysis involves numerous special problems which are to be discussed here.

High-Accident Frequency Locations

The simplest use of accident information is in the discovery and treatment of locations at which accidents have occurred with undue frequency. The proper development of the information into usable form is accomplished in several steps of procedures, as follows:

The identification of the high-accident-frequency locations by means of "spot maps" or "location files." The details of such devices are explained in many existing publications. It is here necessary only to note that a "spot map" consists of a reasonably large scale map on which a pin or other marker is placed to indicate the exact point of occurrence of each accident,



Courtesy City of Los Angeles, Cal.

FIGURE 22—City Accident Spot Map.

Figure 22. The pins are allowed to accumulate and concentration of pins at one location or in a defined area is an indication that something should be done. A "location file" accomplishes the same thing by so filing the accident reports that

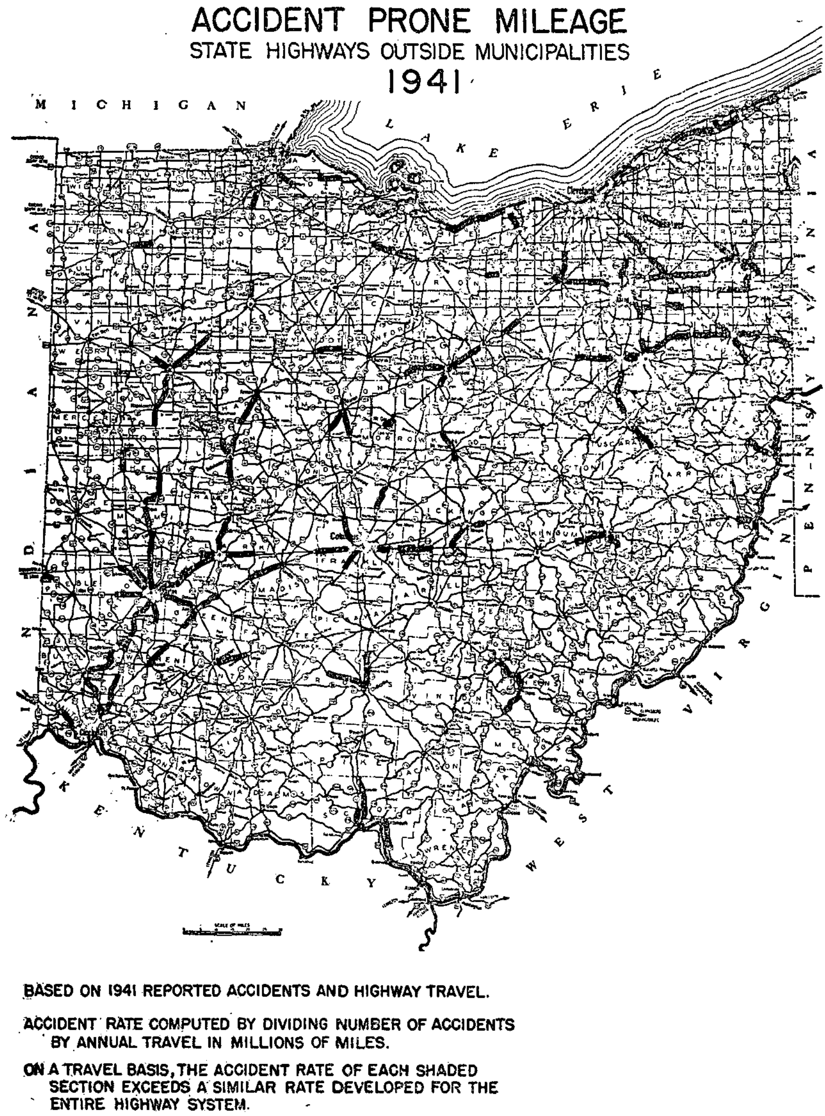
those at any given location will be grouped. The "spot map," is thus a graphic display of the location file, and has publicity value as well as engineering utility.

The definition of "high accident frequency" is, of course, altogether arbitrary. If resources permit, the study of every site where even a single accident has occurred may be justified although common practice requires routine investigation of a location, usually only when the accumulation reaches three to five of the less severe accidents or two to three of the more severe type. A "location" is also broadly defined. For purposes of study and treatment a long tangent, for example, may be considered as a unit location.

The Ohio Department of Highways has developed a listing of accident prone road mileage, Figure 23. They found, for example, that one-third of all accidents reported in 1941 were concentrated on 5 per cent of the state highway mileage, and that this mileage accounted for only 19 per cent of the motor vehicle travel.[26]

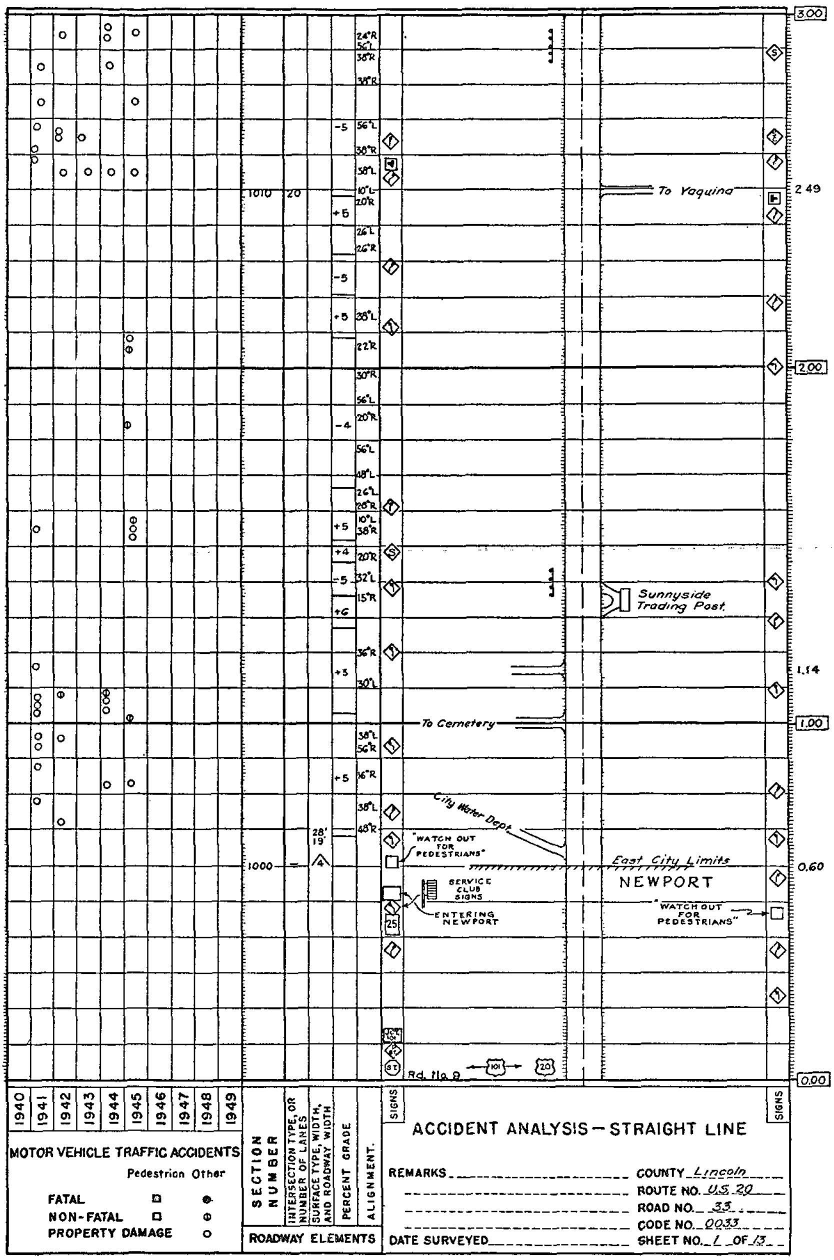
The analysis of the circumstances under which accidents have occurred at each location obviously comes next. Such an analysis employs a variety of techniques. First, all the accidents at a given location should be tabulated, with respect to the known facts, to discover, if possible, a consistent pattern of circumstances which may, in turn, point to a remedy. Then a detailed map, or plan, may be needed showing all the physical characteristics of the location, such as roadway widths and grades, sidewalks and curbs, obstructions to vision, and traffic control devices. Such a straight line accident analysis diagram used by a state is shown in Figure 24. This may reveal some hazardous condition that causes or is a contributory cause to frequent accidents. A further step is an "accident or collision diagram"

[26]Ohio Department of Highways, Division of Traffic and Safety, *Accident Prone Mileage–State Highways Outside Municipalities.* The Department, 1942.



Courtesy Ohio Department of Highways.

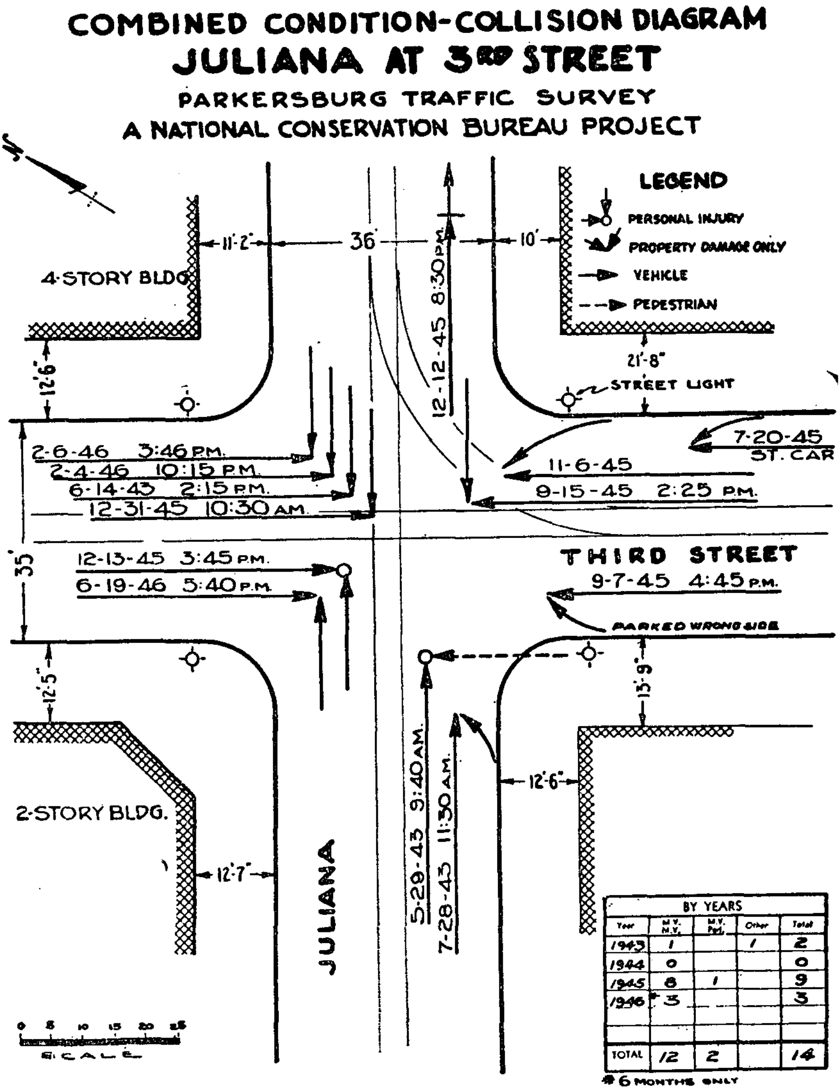
FIGURE 23—Studies of Accidents in Relation to Locations and Travel Indicate Most Accident-Prone Sections of Highway.



Courtesy Oregon State Highway Dept., Traffice Engineering Division.

FIGURE 24—Straight Line Diagram Used in Accident Analysis. Roadway Surface Widths, Types, Alinement, Percent Grade, Intersection Types, Number of Lanes, Section Numbers, and Accidents Are Indicated Along With Traffic Control Devices.

(Figure 25) showing by suitable symbols the type of each individual accident and the directions in which the vehicles involved were traveling. This also may reveal a pattern of cir-



BY YEARS				
Year	M.V. M.V.	M.V. Ped.	Other	Total
1943	1		1	2
1944	0			0
1945	8	1		9
1946*	3			3
TOTAL	12	2		14

*6 MONTHS ONLY

Courtesy National Conservation Bureau.

FIGURE 25—Typical Combined Condition and Collision Diagram.

cumstances and thus give a clue to the treatment needed. The employment of still other devices may be useful, such as traffic flow diagrams showing vehicular traffic volumes, turning movements, and pedestrian traffic, all with special reference to the hours when accidents are most frequent. Concentrations of school children or industrial workers during certain hours may be highly significant if pedestrian accidents are numerous. Speed studies may throw additional light on the situation. All of these tools have been described and explained more fully in publications listed at the end of the chapter and which are generally available.

A trained and experienced investigator should make a personal study of the site, with the above described data at hand, to complete the procedure. This study may require several visits so as to cover all the periods of hazardous conditions. An able investigator can frequently spot deficiencies that have not become apparent from the limited accident data available for a single location. Comments and observations of persons who frequent the location in question may be of value to the investigator.

Treatment of High-Accident-Frequency Locations

Before treatment of any dangerous location is begun it is a good policy to make up a "worst location" list, and thus to establish priorities for attention. Since current funds are rarely, if ever, sufficient to do everything desirable, a decision must be made as to which work can best be delayed. A priority list based on engineering studies is a very useful defense for the highway administrator against the clamor of well-intentioned citizens who see only the serious conditions prevailing in front of their own houses, and who find it difficult to understand that there may be worse troubles in other neighborhoods.

To establish priorities for railroad grade crossing protection, for example, accident records must be combined with highway and train traffic data, as well as with physical data. A form used for such a special study is shown in Figure 26.

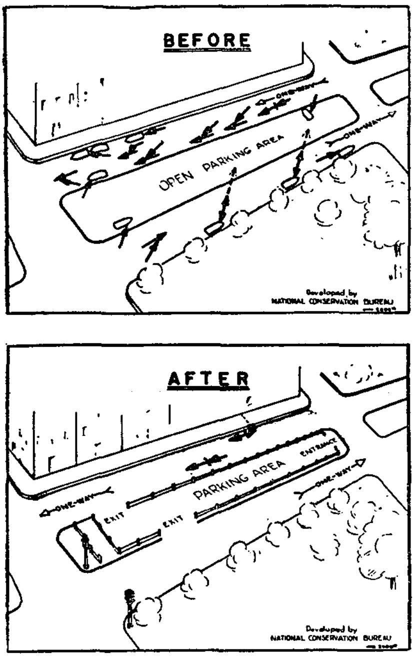
FORM E-216 500 12-42 OREGON STATE HIGHWAY COMMISSION TRAFFIC ENGINEERING DEPARTMENT RAILROAD GRADE CROSSING SURVEY	Crossing number ....
Railroad company	Road number .... Mile post ....
Number of tracks: Main line .... Other	County .... City ....
Traffic: Vehicles .... Trains	Street ....
Protection	Inherent hazard ....
Remarks	State-wide priority .... Railroad company priority .... State highway priority .... Date ....

FIGURE 26—Special Form Used for a Study of Railroad Grade Crossing Accidents. A Complete Record is Obtained of Train Movements, Protection, and Accidents for Each Highway-Railroad Grade Crossing. (Only one side of form shown).

On the basis of all the information developed from the study of a local accident situation, together with any other pertinent data regarding safe engineering principles derived from experience elsewhere, suitable recommendations can be made for the elimination of dangerous physical conditions, if these are present, and the substitution of features that have been found to be safer. In any recommendations, consideration must be given to possible remedies of a non-engineering character. Also, a decision must usually be made as to whether labor and materials might more profitably be expended elsewhere.

Measuring Effectiveness of Improvements

Following any treatment of high-accident-frequency locations, subsequent accident records at the spot should be carefully checked to determine the effect of the measures used. Exposure conditions must be related to accident facts to get a true measure of "before" and "after" conditions. This Manual contains several illustrations of such studies, one of which is Figure 27.



Courtesy National Conservation Bureau

FIGURE 27—Study of Accidents Before and After Improvement in Traffic Signs.

Development of Highway Design Standards

The highway engineer or traffic engineer should not be satisfied with the correcting of existing highway deficiencies. Through the analysis of highway accidents he should attempt to develop standards for the safe design of future highways. It is another case of "an ounce of prevention being worth a pound of cure!"

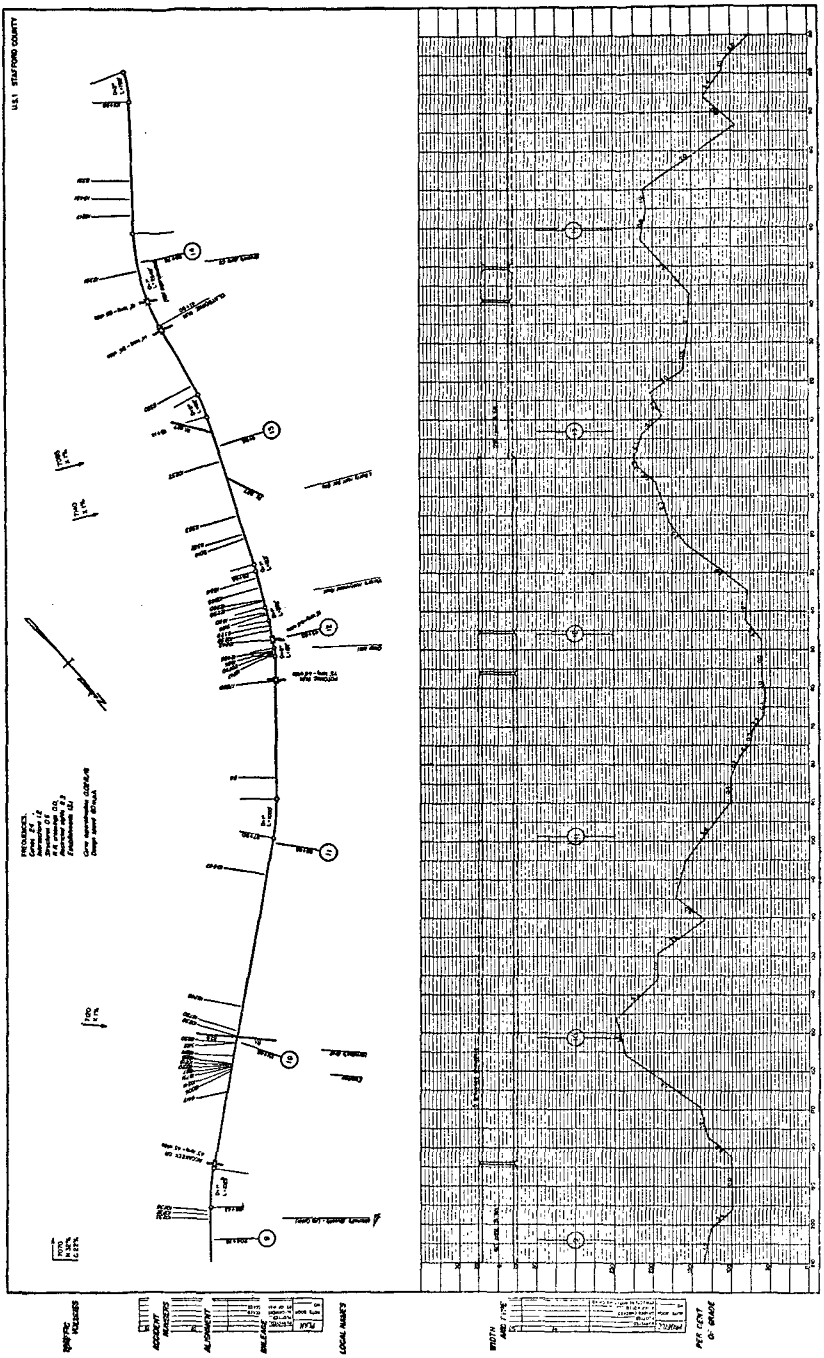
The usual approach to this problem is to analyze accidents as to causes and circumstances, and thus develop the relative frequency with which certain elements of highway engineering are classed as direct causes, contributory causes, or in other ways involved in the accident analyzed. This procedure results in rates of involvement of certain engineering elements, or combinations of elements, in relation to the total number of accidents studied. At best, it suggests what elements or combinations thereof to avoid in highway design. A more useful goal of accident analysis is the establishing of accident rates for various elements of design, of such validity as to permit a calculated choice, in a given case, of the elements that will give the greatest degree of safety per dollar spent. The actual attainment of this goal may be remote, but it is significant that at least 15 state highway departments, with the cooperation of the National Safety Council and the U. S. Public Roads Administration, have set up active projects for analyzing accident expectancy in relation to particular features of highway design. Figure 28 is taken from the pilot study of the Virginia Department of Highways, and shows the accidents reported on a section of roadway, together with grades, alinement, pavement data and volumes. Table VII[27] gives, for example, preliminary information as to the relationship between curvature and accidents for different traffic volumes on two-lane roadways.

TABLE VII
TWO-LANE CURVES BY DEGREES OF CURVATURE BY VOLUME—(8 STATES)*

DEGREE OF CURVATURE	ACCIDENTS (ADJUSTED TOTAL) UNDER 5000 VEHICLES PER DAY	ACCIDENTS (ADJUSTED TOTAL) 5000 TO 10000 VEHICLES PER DAY	ACCIDENT RATE (PER 1,000,000 VEHICLE-MILES) UNDER 5000 VEHICLES PER DAY	ACCIDENT RATE (PER 1,000,000 VEHICLE-MILES) 5000 TO 10000 VEHICLES PER DAY
Less than 2	250	37	2.4	1.9
2 to 2.9	221	47	3.3	2.5
3 to 3.9	152	65	3.5	3.5
4 to 4.9	158	64	3.7	3.7
5 to 5.9	139	35	4.3	3.3
6 to 6.9	119	34	3.9	2.8
7 to 9.9	115	25	3.1	2.5
10 to 13.9	132	24	3.7	2.6
14 to 19.9	108	12	6.3	*
20 and over	129	13	7.6	*

*Sample considered too small for reliability.

[27]Baldwin, D. M. *The Relation of Highway Design to Traffic Accident Experience.* Paper presented at Annual Meeting of American Association of State Highway Officials, Los Angeles, California, December 1946.



From: "A Plan For Relating Traffic Accidents to Highway Elements," by C. F. McCormack, Presented at Meeting of The American Association of State Highway Officials, Cincinnati, Ohio, 1944.

FIGURE 28—Straight Line Diagram for Study of Accidents on Inter-Regional Highway System. Physical Factors of the Roadway Are Combined With Accidents for a Long Period.

In favor of the more usual analysis of accidents, according to contributing factors, is the fact that the analysis is relatively simple, requiring only a statistical breakdown of frequencies. It is evident, however, that this technique will not yield accident expectancy rates for any particular situation, nor will it indicate the relative hazard of engineering design elements, since the statistics tabulated will cover only those locations where accidents have actually occurred, and will take no account of "exposure." Statistics show, for example, that a great majority of highway accidents occur on straight highways. It may be assumed that this is because dangerous curves are few on our modern highway systems, not because sharp curves are safer than tangents.

Nevertheless this technique will clearly indicate what elements, or combinations of elements, are more frequently contributory to accidents. It will also point out the causes which can be attacked most profitably, and in addition which will be most likely to justify further study. At any time special conditions may be investigated that have hitherto been unrecognized and even unsuspected, or that have come as a result of technological changes. If an engineer suspects a new factor, he can re-analyze a group of accidents to discover whether or not that factor has any significance or whether there is a possible means for the prevention of future accidents attributable to it.

Accident Expectancy Rates

The derivation of accident expectancy rates for specific features of highway design is the newest and potentially the most useful application of accident data. There are many complexities in such a study, and a great volume of data will have to be analyzed and correlated if the results are to be valid and significant. Accident records in many states and cities, however, are now becoming sufficiently complete and detailed to warrant analyses of the type needed. If the engineer can have before him figures to suggest the relative degree of safety that may be expected from each of the many possible elements that go into the designing of a highway, he is in a position to plan his design wisely.

At any given location an accident is the result of a web of circumstances in which there is a large element of chance. To separate and evaluate the contribution of a single engineering detail in the case of an individual accident is ordinarily impossible. If, for example, the whole responsibility for any given accident is laid upon some one deficiency of the highway, it follows logically that every passing vehicle should experience the same accident—a plain *reductio ad absurdum*. It is necessary to analyze a rather large number of accidents in respect to a single element to cancel out, even partially, the extraneous variables.

An average accident rate calculated from the accident frequency at all locations in which a given engineering element is present, is not the true measure of the contribution of that element, since it reflects in part the contribution of all other elements. For practical purposes, however, it is a useful index of hazard.

More significant would be rates derived separately for each possible combination of circumstances. These, however, would involve an enormous number of combinations, for most of which accident frequencies, over any reasonable period of time, would be insufficient for statistically valid conclusions. Useful rates for typical situations might, however, be developed through an analysis of selected locations of uncomplicated types.

Multiple correlation technique is often used to segregate and evaluate the contributions of a series of variables in a complex situation. A multiple correlation, however, becomes difficult to interpret and requires large volumes of data if any considerable number of variables are to be dealt with. In the case of engineering data, a more serious difficulty is that only those design elements (variables) that can be expressed in numerical values can enter the correlation. Intersections, traffic signs, and many other features could not be considered except, possibly, by calculating separate multiple correlation coefficients for locations where such qualitative, non-numerical elements were present. This might approach in complexity the calculation of separate rates for all different combinations of circumstances.

Finally, it is difficult, if not impossible, to place all engineering elements on a comparable rate basis. Curves and tangents, grades, and pavement types have measurable lengths, and the traffic using them, i.e., exposed to their hazards, must be measured in units of vehicle-miles. Bridge abutments or traffic signs, on the other hand, are points having no dimension of length. For these the unit of passing traffic must be the vehicle itself. Intersections have length, but their zone of influence, as to accident causation, extends to an indefinite distance in either direction.

It is clear that even if we can arrive at statistically valid accident rates for various elements of highway design, the best we could do, using them singly or in combination, would be to calculate an expected accident frequency. At any given site the accident record might vary greatly from the calculated probability due either to pure chance or to the presence of some element (not necessarily related to engineering) that was not considered in the expectancy computation. The expectancy rate, however, would be a scientifically sound guide to design, and would make it possible for the engineer to choose the safest practicable standards in any particular application.

Accident Records Useful In Road Construction

Construction engineers can frequently gain valuable information from a study of accident records. It is not enough to derive safe design standards—they must be correctly built into the roads, with the safest techniques. Traffic must be handled safely during construction, standards and methods of construction must be well developed, and safety features of designs must be checked "on the ground." An understanding of accidents, especially as discussed in this Chapter, should enable construction engineers to recognize and correct many dangerous practices and hazards during the building of the roadway.

Road Maintenance Practices Aided By Accident Records

Since a principal function of a roadway is to provide safe travel, maintenance practices must include the prevention of accidents. Studies of accidents of specific types or at high-accident frequency locations will aid in determining the needs for better or changed maintenance practices. Priority for maintenance, planning seasonal maintenance, and the need for better cooperation between various roadway agencies, are among the items which should be considered in the use of accident records.

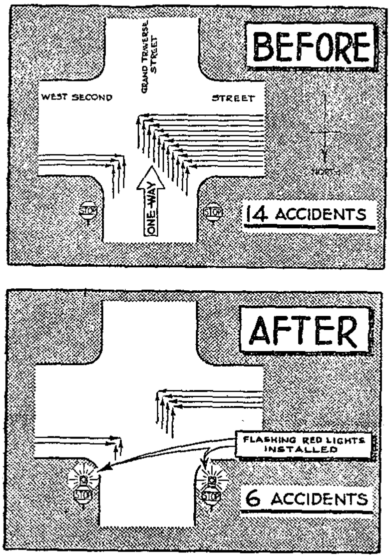
The Value of Training and Experience In Accident Investigation

After such a serious discussion of the value of refined statistical analysis in a long-time program of accident prevention, it is perhaps something of an anti-climax to suggest that a trained engineer, who has studied many accidents in the field and has followed up on the effects of remedial treatments, can probably, in most cases, make as sound recommendations for safe engineering practice at any given location as if he were in possession of rates calculated to several decimal places, based on similar but different locations elsewhere. This is because most situations have in them special elements, often of an intangible nature, which cannot be recognized by any general statistical treatment, but which can often be detected by a trained observer. The basic principles of safe design are already fairly well-known, from trial and error experience. Special studies of particular locations are continually correcting or confirming this experience. On the other hand, the methods of statistical analysis, though slower in securing results, are more inclusive and may develop elements which even the trained and experienced engineer would never grasp because of the complexity of the whole situation. Furthermore, the engineer, being human, is liable to personal bias. As a result of his own special experiences, he may give undue weight to certain factors when appraising hazards.

Accident Data Applied to Special Engineering Problems

Engineering uses of accident data include, but are by no means limited to such specific problems as those which follow:

Use of Traffic Control Devices. The proper design and application of traffic control devices, despite the existence of widely accepted standards, is still subject to much uncertainty and even to open disagreement. There is, for example, much need for more definite "warrants" for the use of particular devices. When, for example, should a Stop sign be used at an intersection? When is an intersection warning sign adequate? When should traffic signals replace a Stop sign? Is the "Four-way Stop" ever warranted, and, if so, when? What is the minimum suitable size of any given sign under any given conditions? How does color affect the visibility of pavement markings? When is the marking of a "no-passing zone" warranted? How can safety be built into a street-car loading zone? How should "delineators" be installed, and under what circumstances are they useful or warranted? These and many other questions might be asked. Much of the information needed to answer them can be gained from controlled tests and from observation of traffic behavior. An important contribution, however, can come from the analysis of data covering accidents at points where traffic control devices are present. Particularly useful, in the traffic engineering field, are, "before-and-after" studies, in which the accident record at a given point is studied before and after some form of traffic control is installed. Figure 29 shows such a study of accidents at an intersection. Other things remaining the same, the "before-and-after" accident trend over a reasonable period of time is a fair indication of the justification for the traffic control device. Care must be taken to allow for changes in traffic volume or other independent factors in appraising possible gains.



Courtesy National Conservation Bureau.

FIGURE 29—Collision Diagrams Showing Accidents at an Intersection Before and After Treatment With Special Stop Control.

Warrants for traffic control devices are usually based on vehicular traffic volumes, pedestrian volumes, speeds, physical conditions, or accident frequency, or a combination of these. An unwarranted device may cause more trouble than it prevents, because of the introduction of needless delay and annoyance, because unwarranted devices are difficult to enforce, or because under some circumstances they may be a direct cause of accidents. Accident records are valuable guides in the development of warrants where a control device can be expected to bring greater safety. Established warrants incidentally can often be used to advantage in discouraging requests for controls at locations where they cannot be justified, thus effecting economies in the face of public pressure for an inefficient use of funds.

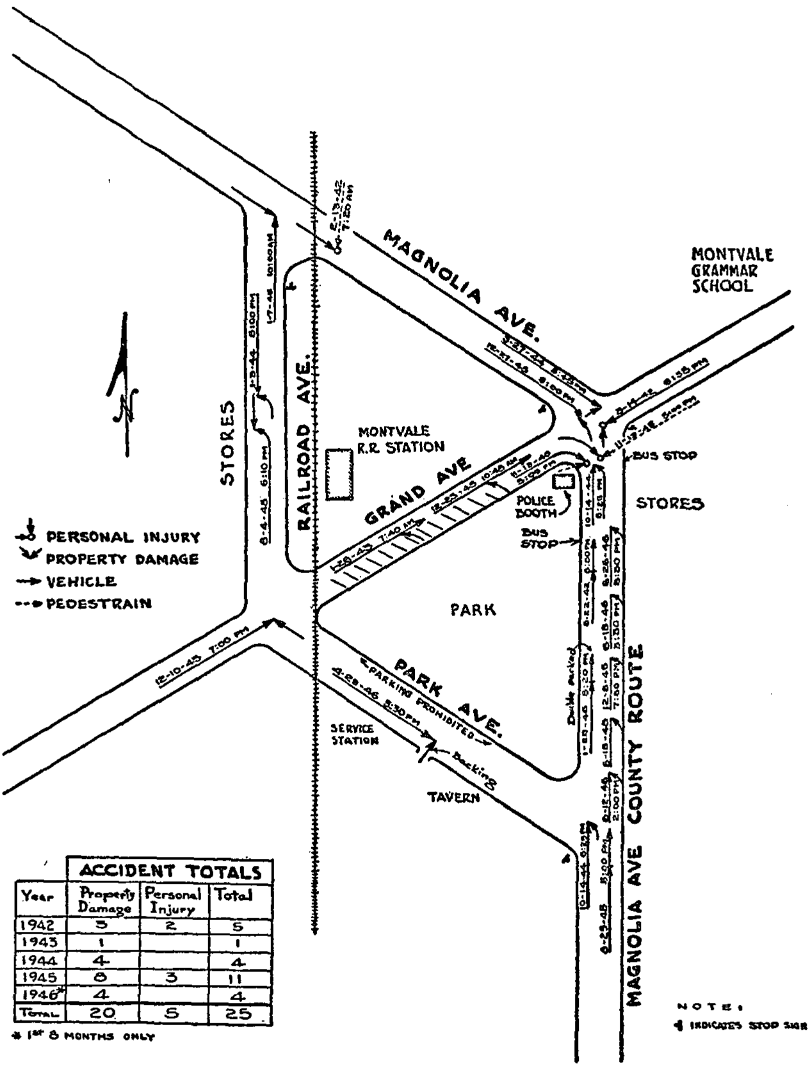
Pedestrian Safety. The pedestrian accident opens up a large field for the engineering study of accidents, as there are many elements of highway design that directly affect pedestrian safety. Research may be set up to determine the effects of such features as pedestrian underpasses and overpasses, pedestrian barriers, safety islands, sidewalks, pedestrian signals, and highway lighting.

Speed Zoning and Speed Control. A restrictive measure, aimed at the reduction of accidents, which has proved successful in the interval necessary before construction or reconstruction of a highway is possible, is speed zoning. Determination of safe and reasonable speeds depending on sight distance, horizontal and vertical curvature and other conditions found on a highway are definitely measurable. Relating speed to safety generally, and at specific locations, still falls in the category of needed research with accident records.

Changes in Traffic Regulations. Traffic engineers can frequently use accident data in determining the need for changes or revisions in traffic regulations. The support for such changes, and the measure of effectiveness of the changes, once effected, can be aided by accident facts.

The involvement of parked vehicles in accidents can point the way to changes in types of curb parking, to the prohibition of curb parking, and to other parking regulations, Figure 30. Accident hazards created by illegal parking practices are graphically illustrated in Figure 31.

Before and after accident facts can help prove or disprove the need for one-way traffic. A typical study is shown in Figure 32.

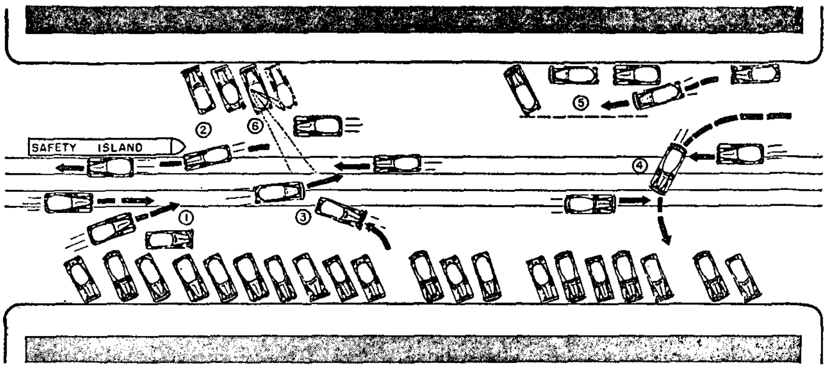


ACCIDENT TOTALS			
Year	Property Damage	Personal Injury	Total
1942	3	2	5
1943	1		1
1944	4		4
1945	8	3	11
1946*	4		4
Total	20	5	25

* 1st 8 MONTHS ONLY

Courtesy National Conservation Bureau.

FIGURE 30—Illustration of the Use of Accident Facts in Developing Curb Parking Regulations.



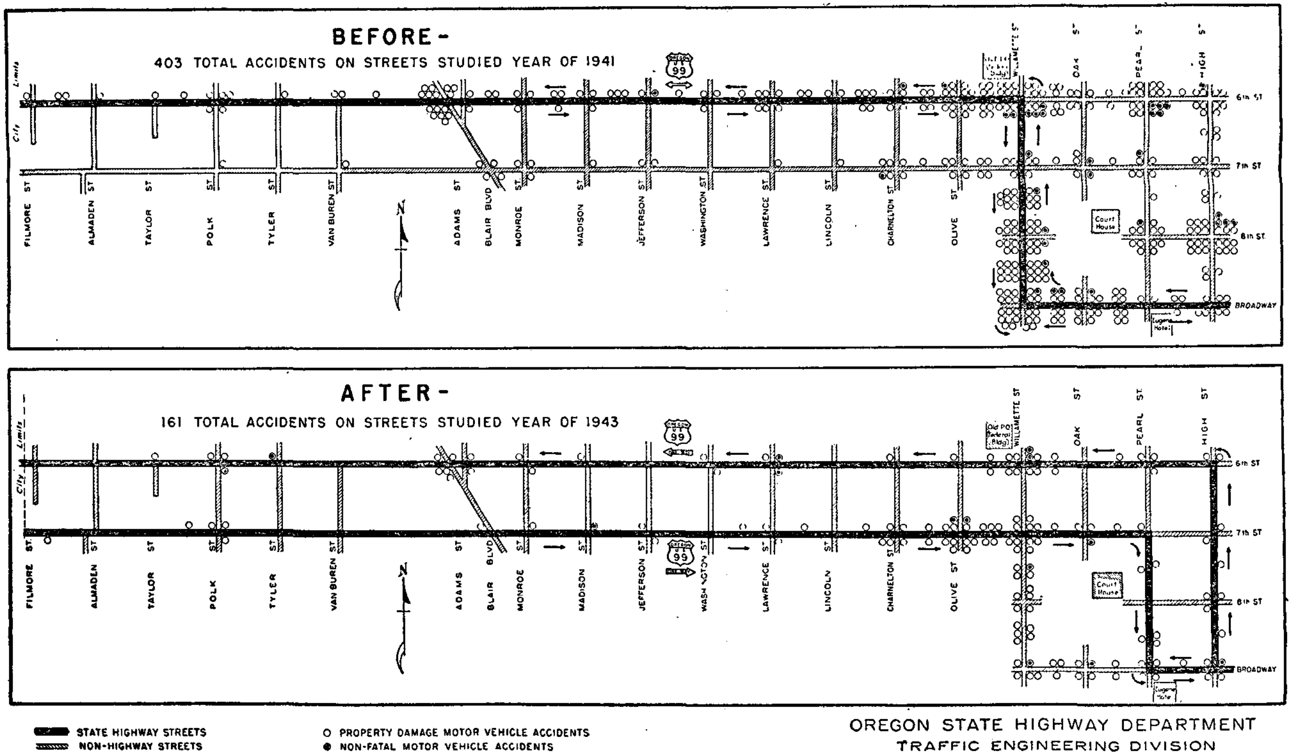
1. A double parked vehicle blocks the street so that only one lane is open to moving traffic on that half of the street.
2. Vehicles parked in a No Parking zone opposite a safety island cause most traffic to drive to the left of the island on the street car tracks.
3. A vehicle backing from an angle parking space blocks one-half of the street and frequently forces traffic to enter the wrong side of the roadway.
4. Angle parking encourages drivers to "U" turn and cross lanes of traffic while entering curb space.
5. A vehicle pulling out from a parallel parking space uses less street space than is required to park a vehicle at an angle with the curb.
6. A driver backing from an angle parking position does so with his view blocked by other parked vehicles. His range of vision through the rear window is not adequate for safe entry into a moving lane of traffic.

From the Report: "Effect of Roosevelt Road Parking Practices on Public Convenience and Safety." Published by the Chicago Surface Lines, Sept. 1939.

FIGURE 31—Illustration of Common Accident Hazards Created by Illegal Parking Practices.

Through streets, turning prohibitions, and other regulations necessitate complete and continuing studies of accidents to insure the best treatments for given traffic and physical conditions.

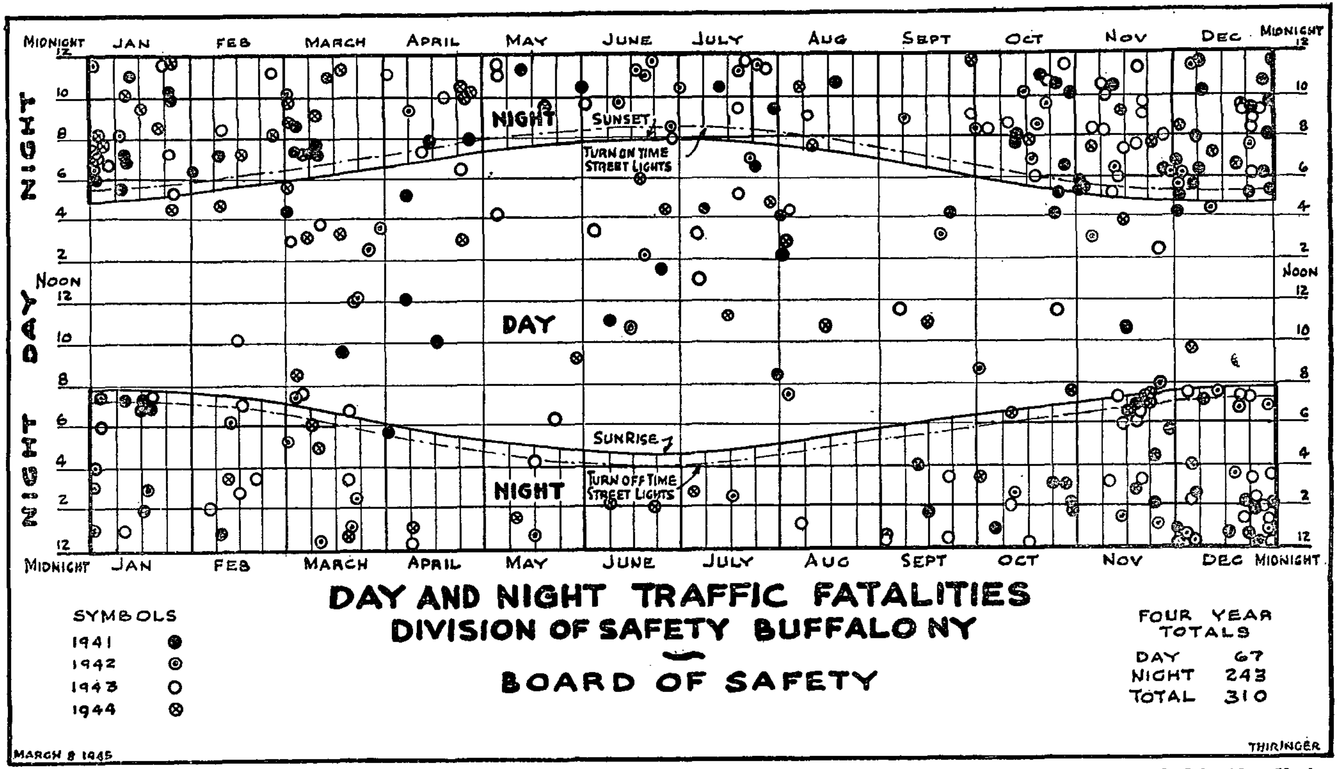
Application of Street and Highway Lighting. Street and highway lighting is usually promoted primarily as a safety measure, hence accident studies are most appropriate to test its justification. Various types of summaries can be used to show the relation between accidents, time of day, seasons of year, and use of street lights, such as the chart prepared by the city of Buffalo, New York, and shown as Figure 33. Possible research would cover: (1) Accident experience in relation to different types, intensities, and distributions of lighting, and, (2) the establishing of "warrants" under which highway lighting can be justified as an aid to traffic.



OREGON STATE HIGHWAY DEPARTMENT
TRAFFIC ENGINEERING DIVISION

Courtesy Oregon State Highway Department, Traffic Engineering Division.

FIGURE 32—A Study of Accidents Before and After Installation of One-Way Street Plan for Through Highway in Small City.



Courtesy Board of Safety, Buffalo, New York.

FIGURE 33—Comparison of Day and Night Traffic Fatalities by Months.

Designing or Redesigning Intersections. Here is an almost limitless field for exploration in which accident records should contribute a great deal. Accident frequency under given volumes of traffic will itself be some indication of relative hazards of different types of intersections. A more scientific study might undertake to discover points of conflict where collisions occur within the intersection area and to determine necessary sight distances, critical intersection angles, appropriate curb radii, and the effects of varying pavement widths, grades, lighting, traffic control devices, and channelization.

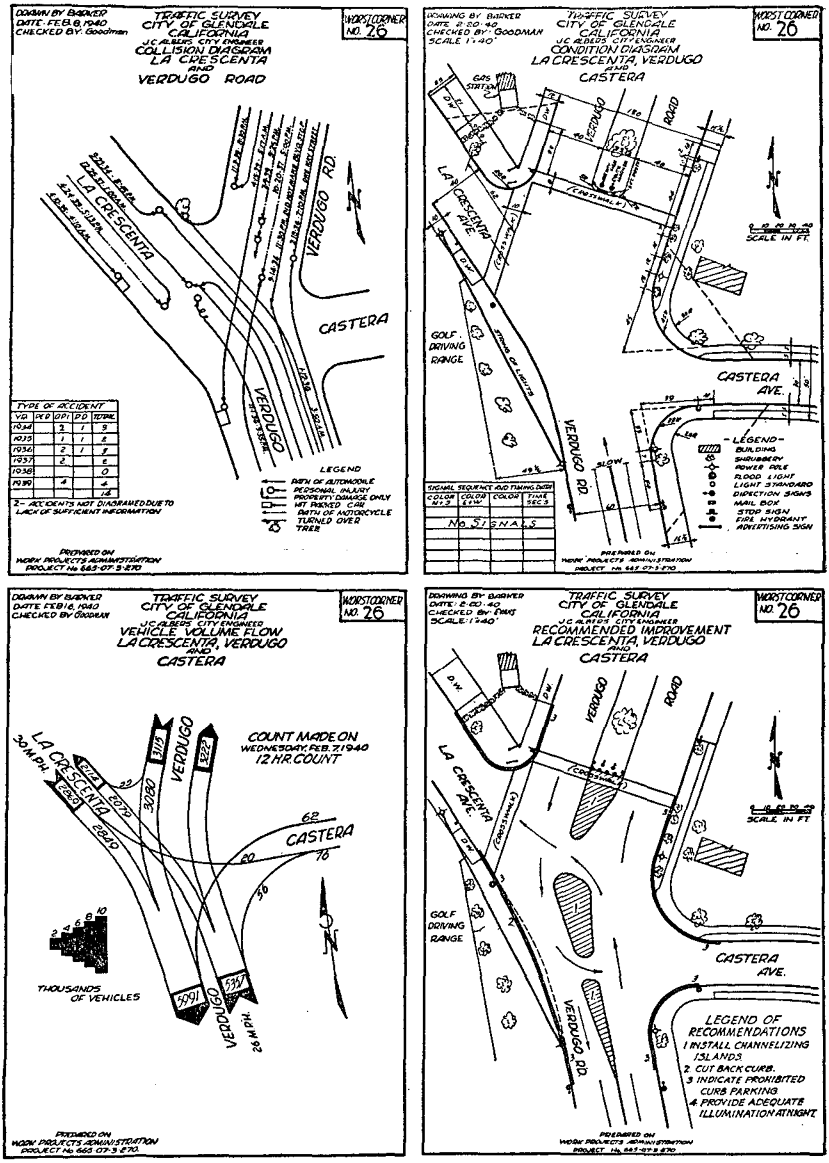
Designing and Providing Channelizing Islands and Dividing Strips. Much is yet to be learned about the channelizing of traffic and the use of one-way roadways. Geometrical design must recognize the physical characteristics of vehicles, especially as to turning radii and rates of acceleration and deceleration. After such tangible elements are provided for, however, there is still the problem of driver behavior to reckon with, and this will appear in part at least, in the accident record. Accidents may indicate that an intersectional area is too large, and that the points of junction of traffic streams should be controlled through channelization. The angle of intersection may also be conducive to collision. An undue number of accidents involving left turns may indicate a need for channelizing protection of one sort or another. The principal function of a medial divider is to prevent head-on accidents, and the actual or potential number of such accidents is an important factor to be considered in the use of such dividers. Specific suggestions for study include: (1) Analysis of accident records at channelized intersections to reveal faulty location, shape, or size of islands; (2) comparison of accident rates at channelized and non-channelized intersections; (3) comparison of accident rates on divided and undivided roadways for various types of dividers; or, (4) a study of accidents with a view to improving safety in the design of the approach ends of islands and medial strips.

A complete study of accidents, physical conditions, and traffic volumes may lead to the recommendation of channelization as indicated in Figure 34.

Provision for Traffic During Construction. In order to expedite traffic movement with safety, considerable thought should be devoted to arrangements for detours and one-way operations. A road to be considered for a construction expenditure must necessarily be important enough to warrant sufficient effort expended to insure safe and orderly traffic movement during the construction. Accident records of proposed detours and on the job accidents should provide a starting point for plans to make the detour safe to carry the increased traffic volume and plans for the provision of on the job traffic where the road cannot be closed. Further research is also needed in the field of lighting and signing of barriers and can be started with the accident record.

Specific Maintenance Procedures in Relation to Safety. Accident records may point out hazardous procedures by maintenance personnel. Such things as leaving road materials in the center of the road or along the road, and lose gravel on turns or intersections may be discovered to be dangerous from an analysis of accident records. Deficiencies in roadway shoulders, drainage, snow and ice removal, tree trimming, resurfacing, signs and markings, and other maintenance neglect are reflected in accidents.

Planning or Correcting Vertical and Horizontal Alinement. Accident studies on existing highways may reveal locations where accidents are occurring with undue frequency because of some defect in alinement or grade. Degree of curvature or superelevation may not be commensurate with speed for



From: Report on City-Wide Traffic Survey and Proposed Improvements, Glendale, California, 1939-40.

FIGURE 34—Complete Intersection Study Resulting in Recommended Channelization and Other Improvements.

which the highway has been otherwise designed. Sight distances may be inadequate because of curvature, or grades may be such as to induce skids under unfavorable weather conditions. These conditions are usually remediable, either by reconstruction or by the application of suitable traffic control devices. The experience gained from individual locations can be used in avoiding similar deficiencies in the future.

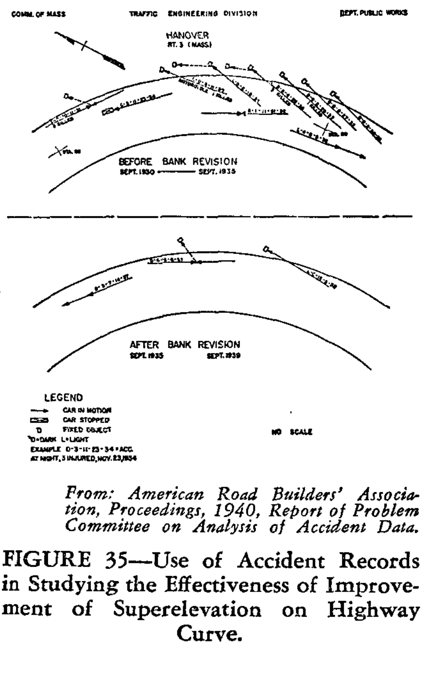
Specific objectives might include: (1) The establishing of accident expectancy ratings for different curves and grades and combinations thereof; (2) determination of the safe distance between reverse curves by comparison of accident records on such curves variously spaced; (3) determination of the accident potentialities of curves at the ends of long tangents; or, (4) the investigating of accident rates on sustained grades due to motor truck traffic.

Provision of Adequate Sight Distances. Accidents on curves, hillcrests, or intersections may indicate locations where sight distance is too restricted for safety. Some obstructions to view are easily corrected, as by removal of trees or billboards. Others are more permanent. The engineer may be assisted by accident records in deciding which locations will yield the greatest accident reduction for the least expense. Suggested studies include: (1) The establishing of hazard ratings for various lengths of vertical and horizontal sight distances for passing vehicles, for stopped vehicles or other roadway obstructions, and for intersecting traffic; (2) determination of the relation between frequent restrictions in sight distances and accidents; or (3) relating night accidents to headlight visibility distance on horizontal and vertical curves.

Determining Suitable Width for Pavement and Bridges. The study of accidents in relation to pavement widths may suggest a minimum desirable width to reduce side-swiping or running off the road. Conceivably it might also indicate a maximum, above which separate roadways would be safer. The volume of traffic must necessarily be considered in these cases. Whether bridge roadways should exceed the width of the approach pavements, and, if so, how much, is another question that may be at least partially answered by accident studies. Studies of transverse placement of vehicles on the roadway, passing maneuvers, and other phases of driver behavior are also important in the design of pavement width. Such studies may indicate desirable factors of safety, whereas accidents show only where the margin of safety is too small. Possible lines of research include: (1) Comparing the accident experience on pavements and bridges of differing lane widths and differing numbers of lanes; (2) measuring the hazard of bridge abutments or headwalls near the edge of the pavement; or, (3) relating pedestrian accidents to roadway width and the presence or absence of suitable shoulders.

Improving Pavement Surfaces. This relates particularly to skidding accidents, as affected by pavement design and maintenance. A study of accidents on different types of surfacing and under different weather conditions should aid in the selection of suitable pavement textures to minimize skidding. Winter maintenance, particularly ice and snow removal, may also be improved if accident experience is taken as a guide. Possibly accident studies may reveal some relation between the color or texture of pavement and the driver's ability to see obstacles or persons in his path at night. Consideration should be given to such studies as: (1) Comparing the number and types of skidding accidents experienced on various road surfaces; (2) appraising through accident investigation the effectiveness of contrasting pavement for channelization or lane marking; or, (3) comparing accidents on various types of pavements to establish possible standards of sunlight or headlight glare reflectivity or of brightness characteristics of pavements under street light illumination. It is apparent that such research should supplement, or be supplementary to, various laboratory and field tests, and observations of driver behavior.

Designing or correcting superelevation and roadway crown. On modern highways, crown is generally kept to a minimum and superelevation is scientifically designed for the expected speeds. There are, however, roads of obsolete design where accident records may reveal a need for reconstruction, as was the case shown in Figure 35.

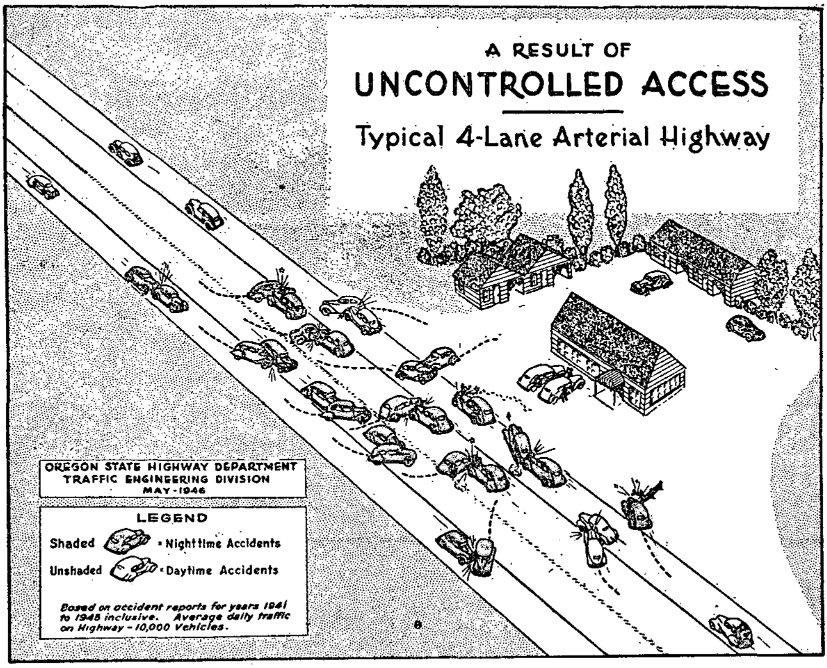


From: American Road Builders' Association, Proceedings, 1940, Report of Problem Committee on Analysis of Accident Data.

FIGURE 35—Use of Accident Records in Studying the Effectiveness of Improvement of Superelevation on Highway Curve.

Improving road shoulders. The circumstances of many accidents suggest that they might have been far less serious, or avoided entirely, had the road shoulder been of better design or better maintained. A study of accident data should indicate where more adequate shoulders might be provided, and should also aid in improving the design of future construction, as to width, slope, surfacing, and the presence of such obstructions as trees, poles, and even traffic signs. Suggested studies include : (1) Relating accident occurrence to unstabilized, improperly drained, or excessively narrow shoulders; (2) investigating the relation between shoulder design and accidents caused by vehicles stopping on the pavement; or, (3) relating pedestrian accidents to the condition of the shoulder.

Installing adequate guard rails where needed. Accident data will reveal many hazardous locations on curves, high fills, or



Courtesy Oregon State Highway Department, Traffic Engineering Department.

FIGURE 36—Graphic Application of Accident Facts to a Highway Access Problem.

mountain roads, where guard rails may be of the greatest importance in deflecting or stopping and holding vehicles that have left the road and would otherwise continue into a worse crash. The design of guard rails should depend principally on controlled tests of strength and performance under impact, but a study of actual performance, as revealed in accident records, may show desirable or undesirable characteristics of a nature not adapted to laboratory measurement. Accident analysis should provide useful data regarding: (1) The relative severity of injuries and vehicle damage caused when different types of guard rails have been hit; (2) accident experience in relation to guard rail visibility; or, (3) the effect of location of the guard rail in respect to the pavement edge.

REFERENCES ON ENGINEERING USES

1. Hammond, Harold, and Sorenson, L. *Traffic Engineering Handbook*. New York, N .Y., 1940. Institute of Traffic Engineers. Contains chapter on engineering techniques and examples related to the analysis and use of accident records.

2. Vey, A. H., *Improvements to Reduce Traffic Accidents,* Transactions of American Society of Civil Engineers, 1939. New York, N. Y. The Society. Analysis of accident experience in 1934 on N. J. State Highway System, description of highway improvements and tables of "before" and "after" data.

3. Halsey, Maxwell, N. *Traffic Accidents and Congestion,* New York, N. Y., John Wiley and Sons, Inc., 1941. Discussion of the leading elements in the problem of traffic accidents and congestion.

4. Hallett, J. T. *Measuring the Hazards on Rural Highways*. Civil Engineering, New York, N. Y., American Society of Civil Engineers. Description of a method used in Indiana for measuring the hazard on sections of rural highways; emphasis on need for more refined units of measurement for engineers in traffic work.

5. American Road Builders Association. *Report of Problem Committee on Analysis of Accident Data*. Washington, D. C., The Association, 1940. Review of accident reports from numerous locations before and after highway improvements with suggestions for further accident reporting and new factors to be watched.

6. Harrold, D. H. *Rural Accident Investigation in the State of Washington*. Traffic Engineering, May, 1942. Institute of Traffic Engineers, New Haven, Conn. Analysis of location and causes of pedestrian accidents, single-car fatal accidents and multiple-car accidents from statistics gathered for a study of rural accidents for three-year period.

7. Dennis, T. H. *Annual Survey Shows Rural Road Accidents Keep Pace with Normal Growth*. California Highways and Public Works, April 1937, Sacramento, Calif. California Dept. of Public Works. A study showing the relation of traffic accidents on rural highways to traffic volumes.

8. Oregon State Highway Department. *A Study of Rural Sidewalks*. Technical Report no. 44-3. Oregon State Highway Commission. 1944. A study of the problem of the rural pedestrian and the development of a method of computing relative indices for establishing warrants

for construction of pedestrian facilities between a group of several projects.

9. National Safety Council. *Engineering for Traffic Safety*. Chicago, The Council. 1944 (revised). General.

10. National Safety Council. Public Safety Memo No. 61. *Studying the Danger Spots in Traffic*. Chicago, The Council, 1946. Application of collision and condition diagrams to studies of high accident locations.

11. National Conservation Bureau, Traffic Division. *Getting Results Through Traffic Engineering*, a Series of Traffic Situations Exemplifying the Use of Traffic Engineering Techniques in Reducing Accidents and Facilitating Traffic Flow. New York: National Conservation Bureau. Before and after studies of traffic problems and remedies.

12. National Conservation Bureau, Traffic and Transportation Division. *Manual of Traffic Engineering Studies*. New York. National Conservation Bureau, 1945. Methods, forms and procedures for various types of traffic studies, taken from successful traffic studies and surveys conducted in numerous cities by experienced traffic engineers.

13. National Safety Council, Traffic Enginering Bureau. *Filing Traffic Accident Reports by Locations*. Public Safety Memo No. 40, Revised May, 1938. Chicago: The council, 1938. Description of the method devised by the National Safety Council of filing traffic accident reports by street location.

14. Halsey, Maxwell. *Traffic Accidents and Congestion*. New York. John Wiley and Sons, Inc., 1941. This volume attempts to set forth the principles which underlie the scientific methods currently being developed to reduce traffic accidents and congestion.

CHAPTER VI

EDUCATIONAL USES OF ACCIDENT RECORDS

Accident records provide material for all phases of the traffic safety education program. Some activities of the program (safe driving contests, published daily accident totals, etc.) may be based entirely on accident records. Other activities may be based on material into which accident information has been woven to show need and to create public interest. Drivers and pedestrians alike take more interest in safe traffic practices when unsafe practices resulting in accidents are known.

Types of Safety Education Programs

There are roughly two distinguishable types of educational programs; specific and general. The first type is highly directional, like a rifle; the general type may be classed with the shot-gun. In the specific type of education, accident records indicate specific groups in need of specific kinds of education. A typical list is shown below:

GROUP	EDUCATION NEEDED
Pre-school	Pedestrian training
Grade-school	Pedestrian training
High school	Driver training
Adult	Driver training
Violators	Driver re-training
Commercial	Driver training as a business
Aged	Pedestrian training for night walking

The general educational program, on the other hand, attempts to take a broad view of the situation and reach all groups with general instruction on how to live with the automobile.

Accident records should be used to guide both types of educational programs into useful channels. Mass analyses disclose the causes of accidents and therefore reveal the nature of needed driver and pedestrian education. They point out the individuals or groups of individuals who require particular types of education. This identification is important because educational material can then be selected which will appeal to each class of individuals through a medium which will reach them effectively.

Administrative Factors In Safety Education

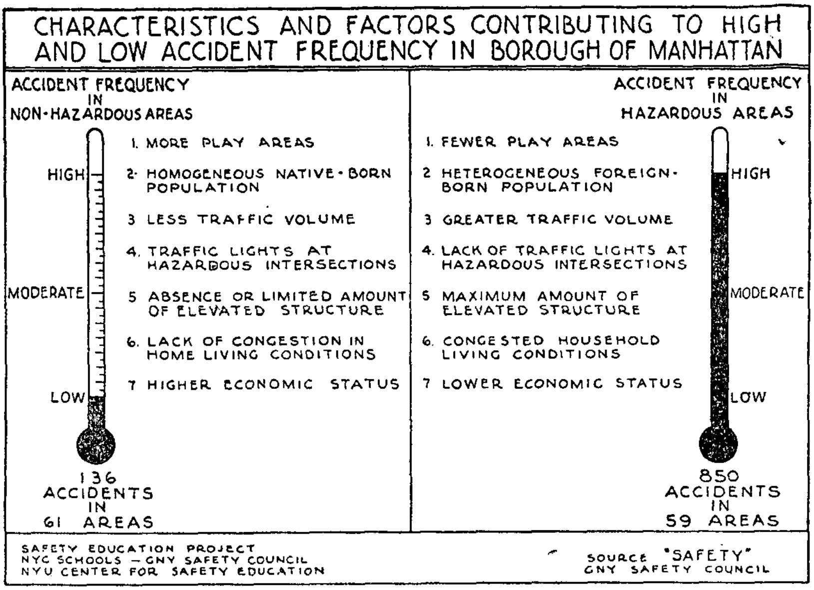
In the administration of the safety program of a city or state, traffic safety education must always be given a prominent position. Effective use of accident figures is one of the simplest methods of arousing the public and of developing public support for traffic safety work.

A good illustration of the use of accident data to show the relation between accident rates in various districts with different levels of safety work is shown in Figure 37.

"Before and after" accident comparisons show the effect and importance of specific traffic law enforcement, education, or safety legislation measures. Through education, advance publicity can be given to engineering or enforcement changes at specific locations, so as to show the need for the changes and thus insure public understanding and cooperation. Forewarning is particularly important when restrictive measures are indicated.

Typical Uses of General Statistical Summaries

Routine general statistical summaries of accident reports on a monthly, quarterly or yearly basis reveal trends and suggest material for the educational program. A comparison of the



From: "Safety Education in The Schools" Board of Education, New York City, 1945.

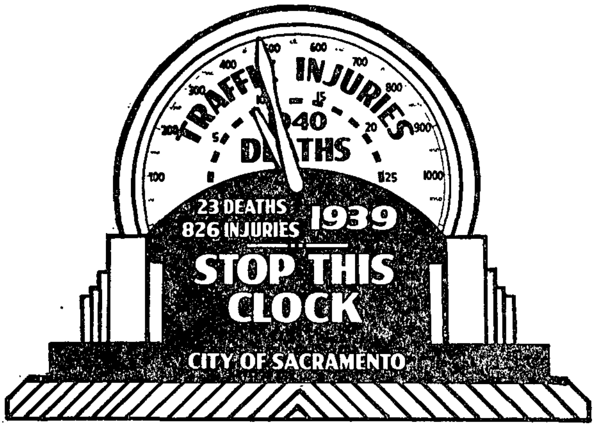
FIGURE 37—A Study of Street Accidents Occurring to Children Sixteen Years or Under Related to Hazardous Areas.

frequency of accidents of different types and of accident severity by type will determine which problems should receive the most attention and will furnish basic data for the attack. For example:

(a) Actual deaths, injuries, and rates can be compared with previous years and with other states and communities to emphasize the size, relative importance, and trends of the problem.

(b) High percentages of particular types of accidents should indicate fertile fields for educational efforts. Similarly, important classifications which show increases from previous years should be considered in the educational program.

(c) A traffic accident scoreboard, "clock", or "barometer" can be used, as a public display in the form of a sign or poster, or in the press, to publicize the actual figures, Figure 38.



Courtesy Sacramento, Cal., Police Dept.

FIGURE 38—Accident Score Board.

(d) Monthly or special holiday data can be used to schedule seasonal programs throughout the year. Suggestions for each of the seasons are indicated below:

SUMMER

Closing of schools
Opening of playgrounds
Fourth of July
Motoring vacations
Fairs, carnivals, & festivals
Circuses
Baseball games
Picnics

FALL

Labor Day
Closing of playgrounds
Opening of schools
Football games
Thanksgiving
Hunting trips
Harvest festivals
Weather–
  falling leaves
  early snow, sleet, fog
  increased hours of darkness
  increased danger from carbon monoxide

WINTER

Shopping trips
Christmas holidays
New Year's holidays
Weather–
  snow and ice
  long hours of darkness
  poor visibility
  increased danger from carbon monoxide

SPRING

Memorial Day
Increased traffic volumes
Late storms

NON-SEASONAL

Conventions
Celebrations
Parades

Specific Application of General Summaries

In addition to the uses developed from the general statistical summaries just discussed, there are a number of ways in which information obtained from these analyses may be applied to specific problems. To avoid confusion, it must be understood that the dividing line between general statistical summaries and selective analyses is not sharp, and statistically there is no difference in technique except variances in size of "population" for analyses. The following suggestions can be based on information obtained from the standard summary:

(a) Age and race.

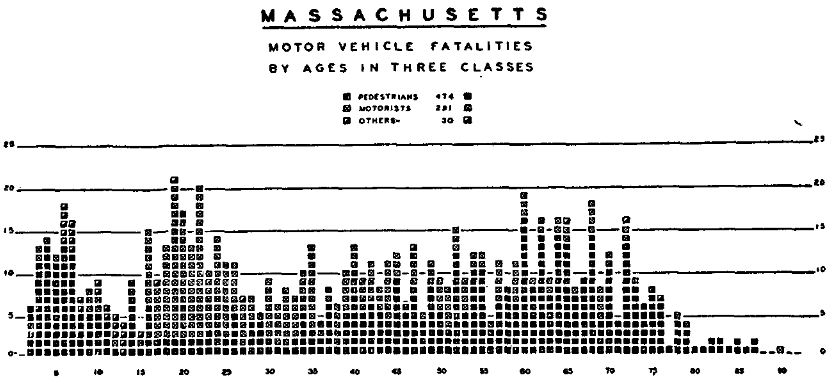
(1) Comparison of age groups in accidents with age groups in the general population will indicate specific groups needing attention, Figure 39.

(2) Child pedestrian accident data (supplemented by spot maps of such accidents) can form the basis for a school safety program.

(3) Elderly pedestrians may need special treatment through church groups, old-age assistance agencies, and others.

(4) Ages of persons killed or injured in bicycle accidents will provide a guide for the bicycle safety program.

(5) Race of persons killed or injured may suggest opportunities for educational efforts through churches, newspapers, civic, business or fraternal associations, clubs, etc.



Courtesy Massachusetts Department of Public Works.

FIGURE 39—Relationship of Motor Vehicle Fatalities to Ages and Classes of Persons Killed.

(b) Driver violations.

(1) General violations totals will indicate the need for enforcement and will present an opportunity for building public interest in, and support for, the work of traffic officers.

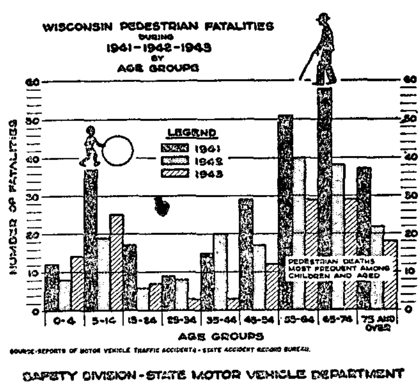
(2) Specific violations may form the basis for a program featuring safe driving hints and an explanation of traffic laws.

(c) Pedestrian accidents.

(1) Totals of accidents resulting from pedestrian actions contrary to law or safe practice can be used to build support for pedestrian regulation.

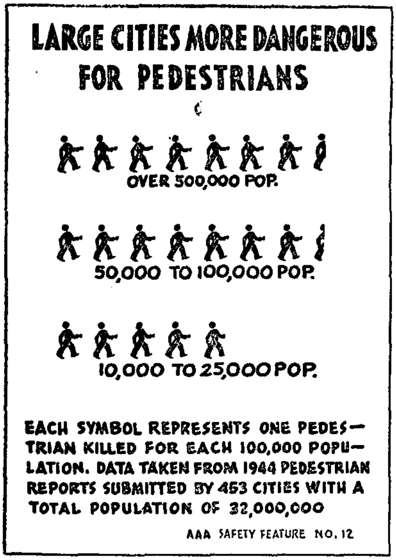
(2) Specific violations may form the basis for a program featuring safe walking hints and an explanation of pedestrian traffic laws.

(3) Age groups, Figure 40, can be used to determine which actions should be emphasized to school groups, elderly groups, and others.



From: "How They Won" Pedestrian Protion Hazards for 1944, American Automobile Association.

FIGURE 40—Distribution of Pedestrian Fatalities by Age Group. For Use in Educational Work.



Courtesy American Automobile Association, Traffic Engineering and Safety Department.

FIGURE 41—Presentation of Pedestrian Fatalities in Terms of Population of Cities.

(4) Locations where pedestrian accidents occur most frequently, Figure 41, are valuable guides to program.

(d) Driver and pedestrian characteristics.

(1) Drivers' ages will serve to point the program toward the age groups responsible for more than their share of accidents.

(2) Race of drivers involved in accidents will suggest special educational efforts through religious, civic, or fraternal groups.

(3) Residence of drivers will suggest areas in which special educational efforts may be put forth effectively.

(4) Occupation of drivers will serve to direct the educational program and suggest media such as business groups, labor groups, etc.

(5) Pedestrian characteristics, (age, race, residence, occupation) can be used in similar fashion to direct the program and furnish material for it.

(e) Vehicle.

(1) The type of vehicle will determine the attention to be devoted to commercial vehicles as compared to other types.

(2) Age and condition of vehicle may be helpful in betterment of maintenance and operation practices.

(f) Light, weather, and roadway conditions.

(1) Information on light conditions will be valuable in talking about hazards of darkness and may even suggest a program on that subject.

(2) Poor visibility and road surfaces with poor traction might be emphasized in a program of reduction of speed for weather hazards.

(g) Directional analysis.

(1) Directional analysis data will be useful in explaning how accidents happen insofar as movement of vehicle and pedestrian are concerned.

(2) Directional factors in accidents, such as rear end and side-swipe collisions, can be used advantageously in development of safe driving and walking programs.

Typical Uses of Selective Analyses

General statistical summaries result from the summarization of accident factors involved in all accidents. Obviously, certain factors are likely to predominate in specific types, or classes, of accidents and are likely to appear in combination with other factors under particular circumstances. Selective statistical analysis is the consideration of a group of accident records, having some common element, to establish relationships of associated factors. This type of analysis will provide specialized and localized information useful for educational purposes. Again, it must be stated that there cannot be sharp lines of demarcation between general statistical summaries and selective statistical analyses. Examples are:

(a) Pedestrian—The preparation of a pedestrian summary will provide data similar to that available from the overall summary, but including only pedestrian accidents.

Selective summaries for pedestrian accidents may include the following:

(1) Rural daytime pedestrian accidents.
(2) Rural night pedestrian accidents.
(3) Rural daytime non-pedestrian accidents.
(4) Rural night non-pedestrian accidents.
(5) Urban daytime pedestrian accidents.

(6) Urban night pedestrian accidents.

(7) Urban daytime non-pedestrian accidents.

(8) Urban night non-pedestrian accidents.

(9) Age of pedestrian—summaries by age groups of pedestrians, including actions of drivers involved. If only one age group can be studied, the most important one should be determined from the general summary—probably the child or the elderly group.

(10) Race of pedestrian—separate summaries for pedestrians of each major race present in the community.

(11) To-and-from-school accidents—a special summary of accidents involving children going to or coming from school.

(12) Pedestrian actions by residence—separate summaries for actions of rural pedestrians in both urban and rural accidents and for actions of urban pedestrians in both urban and rural accidents.

(13) Pedestrian actions and driver violations—a cross classification of pedestrian actions by driver violations.

(b) The Driver—Selective summaries may include the following:

(1) Type of accident—separate summaries by type of non-pedestrian accident.

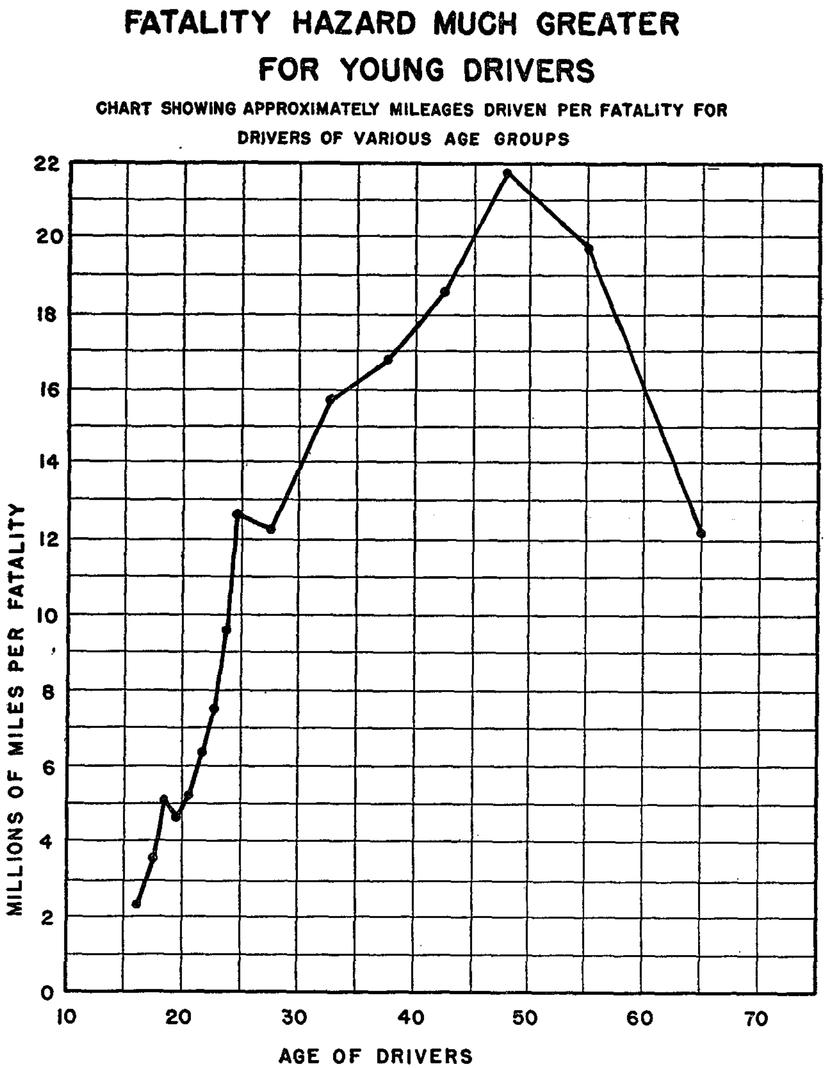
(2) Age of driver—summaries by important age groups of drivers, separating school groups, young adults, Figure 42, a large middle group, and elderly drivers.

(3) Race of driver—separate summaries by each of the major race groups present in the community.

(4) Occupation of driver—summaries for each of the occupational groups listed in the overall summary.

(5) Driving experience—separate summaries for new drivers, those with less than one year of experience, and for those who have driven more than one year.

(6) Residence of driver—(for states) urban and rural summaries of accidents in which urban residents were involved, and similar urban and rural summaries for accidents involving rural residents. (Driver actions should be



Courtesy American Automobile Association,
Safety and Traffic Engineering Department.

FIGURE 42—Relation of Fatalities to Travel May Reveal Accident Hazard to Persons in Early Age Groups.

included on each summary for only those drivers whose residence corresponds to that of the group included on that summary.)

(7) Place of employment of drivers—(alternate for cities) if information is available, schedules by types of accidents and drivers' violations for employees of major business houses and industrial establishments in the city.

(c) Miscellaneous suggestions for selective summaries.

(1) Type of vehicle—separate summaries by type of vehicle, or a separate summary of all accidents involving commercial vehicles.

(2) Week-end accidents—a summary of accidents from Friday night or Saturday noon to early Monday morning.

(3) Rush-hour accidents—a summary of accidents occurring during the morning and evening rush hours.

(4) Winter accidents—summaries of accidents during snow and ice season.

(5) Location of accident—summaries by precinct or ward in cities, by county or towns in states. City summaries prepared by a state may be confined to a single summary covering each urban population group listed on the standard form.

(6) Kind of locality—(urban only)—separate summaries for accidents occurring in business, industrial, residential, or other districts.

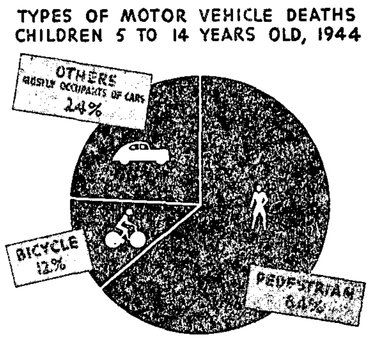
(7) Weather—separate summaries for accidents occurring under various weather conditions listed on the standard summary.

(8) Highway class—(state only)—summaries of accidents, by primary state highways, secondary state highways and county or local roads.

(9) Cross classification of violations and directional analysis—a summary cross-classifying the directional analysis items on the standard summary with the violations listed in that summary.

Accident Records In Development Of School Curricula

Analysis of accidents can be very valuable to the schools for the purpose of re-organizing the school safety curriculum. The records of accidents become an indication of unsafe acts on the part of children. School authorities can use the records for what might be called selective education, whereon studies of accidents show where special stress should be given in the schools. A typical chart showing major types of school accident deaths is shown in Figure 43.



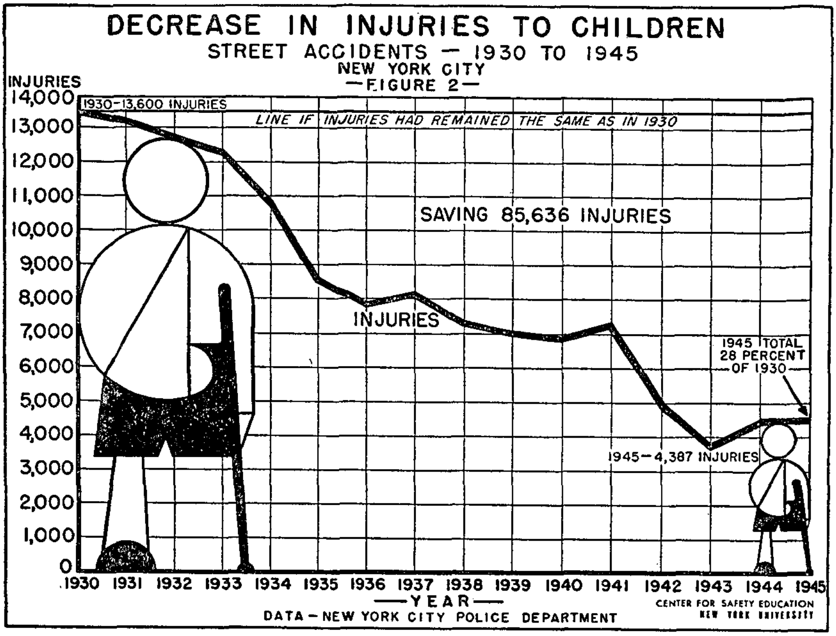
Courtesy National Safety Council.

FIGURE 43—Percentage Distribution of Most Common Types of Motor Vehicle Deaths to School Children.

In many areas, monthly accident summaries are furnished school superintendents. The information is used to re-direct instruction in order to prevent a repetition of similar accidents in the school district. Analyses of various types of accidents are used to study the other factors that make for greater safety of children. For example, several studies have shown that as the numbers of parks and playgrounds increase in a school district, school child accident rates dropped.

Measuring Effectiveness Of Child Safety Programs

Schools can also use accident records to determine the effectiveness of their safety educational programs from year to year. Most cities have found records of child fatalities inadequate for comparisons. Total accidents involving children usually serve as a more satisfactory measure of the effectiveness of child educational programs.



Courtesy Center for Safety Education, New York University.

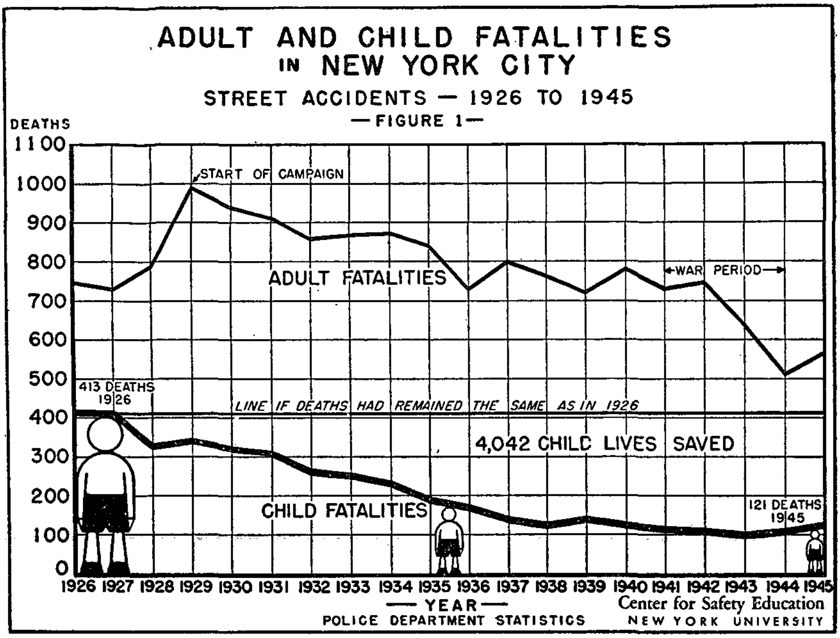
FIGURE 44—A Major Reduction in Injuries to School Children from Traffic Accidents is Revealed from 1930-1945.

The trends in injuries and deaths to children, such as those prepared for New York City and shown in Figures 44 and 45 are useful in proving effectiveness of child safety efforts.

Records of accidents from year to year may also be used to determine the "saving", or cumulative reduction in child accidents over a period of years. Facts of this kind, such as those presented in Figure 46, help justify the child safety activities in the community.

Use of Location Studies In Education

Location accident studies show how drivers and pedestrians are involved in accidents at specific locations. Most location studies are instigated to determine the need for roadway better-



Courtesy Center for Safety Education, New York University.

FIGURE 45—Relating Child Traffic Fatalities to Trends in Adult Fatalities Reveals a Major Saving in Children's Lives in New York City, 1926-1945.

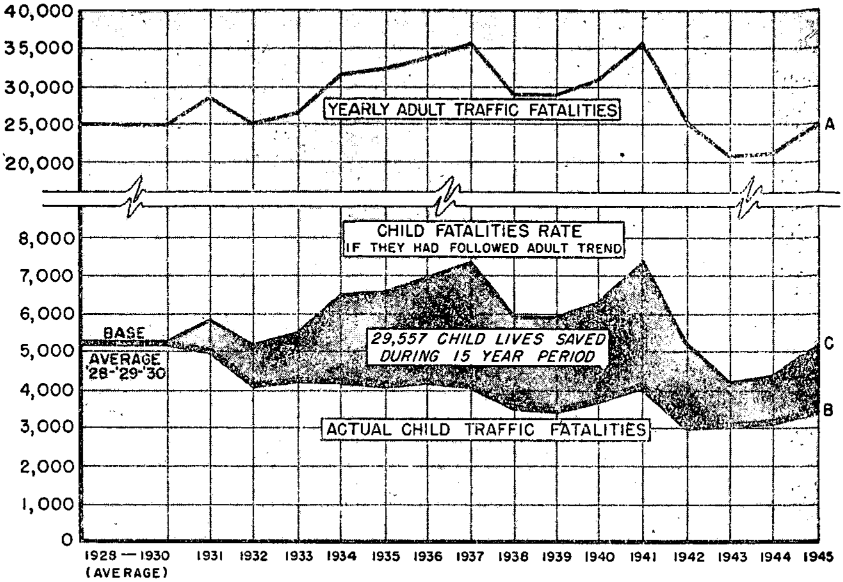
ment or for traffic controls. Accident facts and findings of investigations may also be effectively used in safety education. The following uses are typical:

(a) To call attention to unsafe practices and conditions at specified points.

(b) To determine safest routes to and from school for walkers or for school buses.

(c) To show chain of events, circumstances, and causes of accidents at individual locations.

(d) To determine the need for special stress in the curriculum in the various school districts of the city.



Courtesy Center for Safety Education, New York University.

FIGURE 46—Savings Credited to Traffic Accident Prevention Activities Among School Children 1928-1945.

Use Of Spot Maps In Safety Education

Spot maps maintained on a routine basis can be valuable in the educational program. An accident location map on public display will develop public awareness of the prevalence of traffic accidents and support of a prevention program. For best effect, the map is located where it can be seen by the greatest number of people. (Spot maps are discussed in Chapter IX.)

Special maps indicating the location of accident concentrations of pedestrian accidents, of child pedestrian accidents, or of other special types will indicate that something should be done to aid pedestrians, child or adult. In addition, maps showing drivers' or pedestrians' residences may indicate that something is particularly amiss in certain localities that calls for a special educational effort.

FIGURE 47—Typical Uses of Accident Data in Safety Education Publications.

Outlets For Safety Education Accident Data

Accident facts as used for safety education can be used in any number of methods of presentation and may find outlets through any number of channels. Several interesting uses are demonstrated in Figure 47. Listed below are a number of typical methods of presentation and channels of release.

Outlets For Accident Data In Safety Education-Channel For Release

1. Mailing lists
2. Newspapers
3. Magazines
4. School papers
5. Trade papers & house organs
6. Bulletin boards or billboards
7. Messages to parents conveyed by school children
8. Store window displays
9. School debates
10. Radio
11. Public address systems
12. Mailing inserts with utility bills, pension checks, etc.
13. Playgrounds
14. Churches
15. Transportation systems
16. Theaters
17. Service clubs, associations, and fraternal organizations
18. Home for the aged
19. Garages and filling stations
20. Youth organizations
21. Police
22. Fairs, festivals, conventions, etc.

Methods of Presentation

1. School safety patrols
2. Letters written by school children to parents
3. School debates
4. Mailing inserts
5. Leaflets and cards
6. Talks and lectures
7. Written articles
8. Graphical methods of presentation
9. Forum discussions
10. Police warnings
11. Cartoons
12. Posters
13. Pictures or drawings
14. Spot maps
15. Tabular methods of presentation
16. Films & slides, both silent and sound
17. Indication at fatal accident locations
18. Radio scripts
19. Plays and dramatizations
20. Recordings
21. Postage meter inserts
22. Slogans
23. Commercial advertisements
24. Pavements & sidewalk stencils
25. Contests—essay or poster

REFERENCES ON EDUCATIONAL USES

1. Selling, L. S. *Faulty Attitudes as Factors in Traffic Accidents,* University of Michigan, Annual Highway Conference Proceedings, 1941, Ann Arbor, Michigan, The University. Discussion of the driver from the psychological point of view; passive attitudes; active dangerous attitudes.

2. Marsh, B. W. *Pedestrian Protection.* University of Michigan, Anual Highway Conference, Proceedings, 1940, Ann Arbor, Michigan, The University, 1940. Ratio of pedestrian injuries to fatalities; specific pedestrian aids; education for pedestrian protection.

3. Marsh, B. W. *Pedestrian Research.* Highway Research Board Proceedings, 1939, Washington, D. C., The Board. A detailed study of pedestrian accidents.

4. DeSilva, Harry R. *Why We Have Automobile Accidents.* New York, N. Y., John Wiley and Sons, Inc., 1942. Appraisal of entire accident problem with criticisms of methods, programs, and propoganda used in dealing with problem.

5. Board of Education of City of New York, *Safety Education In The Schools,* New York, N. Y., The Board, 1945. A study of accident facts and suggestions for the development of a safety education program.

6. Eno Foundation for Highway Traffic Control, *Traffic Safety Education,* Saugatuck, Conn., The Foundation, 1947. A guidebook for state and city officials; contains information as to educational uses of accident facts.

7. National Safety Council, *Selective Education,* Chicago, 1941. The Council. Report of the Committee on Public Safety Education, suggesting methods of directing the educational program at specific groups.

8. American Association of Motor Vehicle Administrators and National Conservation Bureau. *A Guidebook for Traffic Safety Education.* National Conservation Bureau, 1940.

9. National Safety Council. *Educating the Public for Traffic Safety.* Chicago. The Council, 1942. A general description of the problem of public education.

10. National Safety Council. Public Safety Memo. No. 5. *Traffic Safety Information* (for states). The Council, 1944. Suggestions for media and procedures for public information programs.

11. Brody, Leon. *Personal Factors in Safe Operation of Motor Vehicles.* Research Contributions to Safety Education. New York, New York. New York University, Center for Safety Education, 1941. Report of an investigation at the Center in which groups of accident free drivers and accident repeaters were compared with respect to psychological and physical traits.

12. Johnson, H. M. *Detection of Accident-Prone Drivers.* Highway Research Board Proceedings, No. 71. p. 444-454, 1937. Washington, D. C. The Board, A study of accident histories of 30,000 drivers.

CHAPTER VII

MOTOR VEHICLE ADMINISTRATORS' USES OF ACCIDENT RECORDS

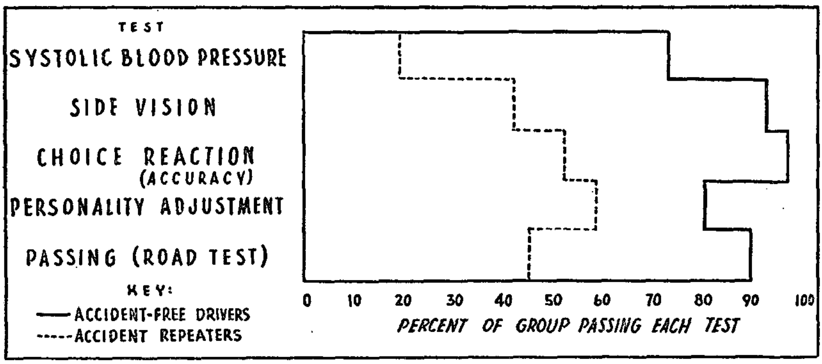
There are many activities of the state motor vehicle department in which accident records can be profitably employed. The control of the operator and the vehicle are perhaps the most important. Control of the operator may be obtained by denying him the right to drive an automobile unless he conforms to certain regulations and is able to meet certain standards. A great many persons and agencies exert some influence on the action of the driver, but the ultimate control lies in the granting and suspension, or revocation of the driver's license. The use of vehicles is controlled through licensing, or registration. It is possible to keep unsafe vehicles off the highway and to compel owners to maintain their vehicles in safe operating condition.

Driver Licensing And Legislation Based On Accident Experience

It is the rule in most states that in order to obtain the privilege of operating a motor vehicle in public, a driver must prove to the satisfaction of the motor vehicle administrator that he has the necessary knowledge and skill to operate a motor vehicle, that he knows and understands the traffic code under which he is to operate, and that he has the proper attitude toward the rights and privileges of others he may encounter while operating a motor vehicle. In some states, he must be financially able to pay for all damages he may inflict upon others through the misuse of a motor vehicle. Unfortunately, many damages and losses are irreparable. In those cases only partial restitution can be made.

Traffic rules and regulations are necessary to foster safe use of the streets and highways. Many of these regulations reflect accident records of the past and aim to correct those practices which drivers have demonstrated to be unsafe.

Accident analysis will indicate improper driver actions and practices which most often contribute to accidents. Further research into the indicated causes of accidents by investigating what the driver was doing, or neglecting to do, will assist in the development of safe driving regulations. As the accident experience varies, the need for changes in driving regulations and rules of operating procedure should be considered and recommended by the motor vehicle administrator. For example, the accident record may be used to develop a measure of the validity of various license examinations. The relation of certain tests to accident and non-accident drivers are shown in Figure 48. In the past, some states have refused to grant drivers' licenses to color-blind persons, but since it is generally proved by accident records that this defect seldom causes accidents, the attitude of licensing agencies has relaxed.



From: "Personal Factors in Safe Operation of Motor Vehicles," by Leon Brody, Center for Safety Education, New York University, 1941.

FIGURE 48—Driver Profiles: Performances on the Most Discriminating Tests. This chart should be read as follows: About 20 per cent of the repeaters passed the test of systolic blood pressure, as compared to about 75 per cent of the accident-free drivers. In the test of side vision, approximately 40 per cent of the repeaters passed, as compared to some 90 per cent of the accident-free drivers, etc.

The rules and regulations controlling motor vehicle drivers, both as to qualification and operation, must be provided by proper legislation. Unless a law is a reasonable law, based on sound reasoning and readily understood by the public, that law will not be enforceable and will be largely disregarded by the public. Therefore, a prime factor in motor vehicle regulations—elimination of accidents—must never be lost from view. The accident picture is the basis upon which to build regulations governing drivers; accident reports and analyses must back up proposed changes. For example, there are at present several states concerned over the lowering of age limits for drivers' licenses for light delivery service. This was made necessary by the war. They are watching closely the accident and violation experience of this age group, so as to be able to make reasonable recommendations to the legislature for a continuance of this policy, or a return to former age level.

Accident Drivers Require Special Attention

The use of accident records to detect faulty drivers is very important. Mr. Randall R. Howard says: "As yet, there is not a practical working program by which drivers who might be expected to have accidents could be culled out in advance. Since psychology has not yet made it practical to detect the accident prone driver, there remains only observation or systematic tabulation of their accident or traffic violation records."[28]

Drivers who have been involved in several reportable accidents, or who have repeatedly been convicted for violating traffic regulations, require special attention from the motor vehicle administrator. Some states cite a driver when his name has come up two or three times, depending on the severity of offenses. In many cases, both drivers involved in an accident

[28]Howard, Randall R., *Psychology Tackles the Accident Prone Driver.* Journal of American Insurance. January 1941.

are held equally responsible until blame can be fixed by the courts, or through investigations. Such drivers in some states are required to show cause why their licenses should not be suspended or revoked. In other states summary suspensions of licenses are effected and subsequent hearings may be requested by the operators involved. This latter procedure is recommended by the Uniform Motor Vehicle Code.

Some states are faced with the problem of large population shifts, which occurred during the war. A number of the new drivers and other drivers may not have met the states' drivers' qualifications. These drivers may neglect to apply for drivers' licenses, and are often detected only through accident records.

Reciprocal Driving Privileges Among States

The interchange of accident information between states can serve a valuable purpose in connection with reciprocal privileges. This interchange helps to encourage states to raise and to keep all licensing standards at the same high level. In this connection, if accident information is exchanged by the states, the more widely dispersed knowledge of the principal causes of accidents can lead to greater uniformity of standards and less reluctance to extend reciprocity.

When drivers from a particular state have consistently had accidents or violations recorded in another state, there may be evidence of inadequate examinations and controls in the former state. Stronger controls and stricter enforcement measures may be appropriate to meet the proper conditions.

Accident Records In Financial Responsibility

In the operation and administration of financial responsibility laws, accident reports are essential. The details of the law differ from state to state, but usually a driver who is found responsible for an accident, or who proves to be a menace to society by repeatedly violating the traffic regulations, is forced to prove financial responsibility, or is restrained from future operation of a motor vehicle. The accident record and drivers' file are two of the documents upon which the official conducting the investigation, or hearing, establishes the background of the case.

Registration of Vehicles

Registration of the vehicle is the permission granted the owner of a vehicle to operate that vehicle on the highway. Under ideal conditions the motor vehicle administrator, in granting that permission, would certify to the public that the design of the vehicle is basically sound and that the vehicle and its accessories are in such repair that, to the best of his knowledge, no accidents will occur as the result of mechanical failure. An approach to that ideal condition is being made in states with vehicle inspection as a condition of registration particularly on initial registrations. The owner in applying for and accepting a motor vehicle registration theoretically would also agree to keep the vehicle in safe condition and to obey the regulations governing the operation of the vehicle on the highway.

From accident records, it may be found that vehicles of certain sizes or weights are contributing to accidents or interfering with the free flow of other traffic. Inasmuch as roads are built with limitations, it is necessary to limit sizes and weights of the vehicles to fit the roads. Some of the restrictive features are underpasses with limited height and width, narrow lanes, pavement thickness and strength, curves, and steep or long grades. All these limit the operation of large and heavy vehicles and make their control necessary.

Accident records are a source of information about the hazard of operating different types of vehicles over different type roadways. Such data are useful in the determination of restrictions and requirements for special permits.

Standard For Registration Based On Accident Experience

In selecting the vehicles that are to be permitted to operate on the highway, the motor vehicle administrators must satisfy themselves that the basic designs of the vehicles so selected are safe. Standards may be set up against which to measure the built-in safety of vehicles. Most standards have been built up over a period of years from trial and error. The error is revealed by accidents. Accident records, because they describe conditions which cannot be simulated in a laboratory, are among the most important criteria of all those applied to the testing of a vehicle. An example of this use of accident records was the development of safety glass, now required in most states by legislation.

Standards For Vehicle Accessories Based On Accident Experience

As with the basic design of the vehicle, the test and proof of accessories can be measured by accident records. The motor vehicle administrator can base his approval or disapproval, at least in part, on accident experiences. The accident records, with supporting evidence, can furnish data as to the relationship of various accessories to accident factors.

Accident Records Indicate Need For Compulsory Vehicle Inspection

The value of mechanical inspections of vehicles has been demonstrated by the wide adoption of compulsory inspections in various states. Here, again, accident records point out the need. The National Safety Council reports that there has been a decided increase in traffic accidents resulting from defective equipment, from 8 per cent to 18 per cent of the national accident fatalities over a six-year period beginning in 1940. Even this sizeable figure does not include all the accidents in which defective equipment may be partially to blame.

Accident records often indicate common and serious mechanical defects of vehicles involved in accidents. Smooth tires in skidding accidents, brakes and steering in speeding accidents, faulty windshields and non-operating windshield wipers in obstructed view accidents and poorly adjusted or non-operating lights in glare-blind or rear-end accidents, are typical items listed in accident reports. However, in certain types of accidents, the condition of the vehicle is likely to be a much more serious cause than the accident reports ever show.

Justification for vehicle inspection can also be found in less dramatic ways than the publicizing of accident causes. Driving a car may be a boon or a bane. Any measure which increases the pleasure of driving and lessens the discomforts, the strain caused by blinding headlights, the annoyance of having to maneuver around decrepit vehicles, the failure of one's own car or the failure of the driver from ignorance or confusion, needs no further justification.

Other Uses of Accident Records By Motor Vehicle Departments

In many motor vehicle departments there are numerous other activities in which accident records are of assistance. Some departments are engaged in educational efforts, some operate their own enforcement agency, some have set up engineering sections and employ traffic engineers. Therefore, if the activities of the department cover a broad area, other Chapters of this Manual will be of interest and the subject material applicable in motor vehicle administration.

REFERENCES ON MOTOR VEHICLE ADMINISTRATION USES

1. Johnson, H. M. *The Detection of Accident-Prone Drivers.* Highway Research Board Proceedings, 1937. Washington, D. C. The Board. A study of accident histories of over 30,000 drivers.

2. U. S. Public Roads Administration. *Motor Vehicle Traffic Conditions in the U. S., Part 1: Non-uniformity of State Motor Vehicle Laws,* U. S. 75th Congress, 3rd Session, House Doc. 462, Part 1. Washington, D. C. U. S. Govt. Print. Off. 1938.

3. U. S. Public Roads Administration. *Motor Vehicle Traffic Conditions in the U. S., Part 6: The Accident-Prone Driver.* U. S. 75th Congress, 3rd Session. House Doc. 462, Part 6. Washington, D. C. U. S. Govt. Print. Off. 1938. Study of accident-prone drivers and methods of control.

4. American Association of Motor Vehicle Administrators and National Conservation Bureau. *Traffic Accident Prevention Through Motor Vehicle Inspection,* New York, New York, The Bureau. 1945. Importance of inspections to traffic accident prevention; promotion, organization and administration of program.

5. DeSilva, Harry R. *Why We Have Automobile Accidents.* New York, John Wiley and Sons, Inc. 1942. Discussion of many aspects of the accident problem with emphasis on the driver and the psychological characteristics which influence his behavior.

6. The Eno Foundation for Highway Traffic Control, Inc. *Traffic Safety Education,* A Guidebook for State and Civic Officials. Saugatuck, Connecticut. The Foundation. n.d. The purpose of this publication is to show the importance of accidents in a community, to determine the educational methods which have proved to be most successful in accident prevention, to evaluate the relationships between the engineering, educational, and enforcement activities and to serve as a guide for community programs.

7. President's Highway Safety Committee–*Report of Committee on Motor Vehicle Administration.* U. S. Govt. Print. Off. Washington, D. C. 1946.

8. President's Highway Safety Committee–*Report of Committee on Laws and Ordinances,* Washington, D. C. U. S. Govt. Print. Off. 1946.

9. The American Legion. *Motor Vehicle Inspection: An Aid to Traffic Accident Prevention.* A joint publication of the American Legion and National Conservation Bureau. Indianapolis, Indiana. The American Legion, 1946. Periodic motor vehicle inspection—an essential factor in any well-planned and administered traffic accident prevention program.

10. Canning, William S. *Motor Vehicle Inspection.* Highway Research Board Proceedings No. 15. p. 287-293, 1935. Washington, D. C. The Board. An analysis of the effect of inspection upon the accident rate.

CHAPTER VIII

USES BY MOTOR CARRIERS OF ACCIDENT INFORMATION

Information obtained from accident reports has many uses in the operation of motor fleets. Motor carriers are especially interested in accident reduction as a means of keeping operating costs down. A reduction in number, severity, and frequency of accidents can cause a substantial reduction in these costs. Furthermore, for solvency the rates charged for hauling must be directly derived from costs of operation, including accident costs. Accidents, then have a bearing on the cost of commerce.

The Cost of Carrier Accidents

Insurance is an important operating cost and accident experience has a direct bearing on the determination of insurance rates. There may be numerous claims as the result of an accident involving a motor carrier; the owner of the cargo is interested in the damage to his goods and the delay in delivery, or the complete destruction and non-delivery; other persons involved in the accident are interested in the damage to their property, and in personal injuries or deaths. In addition, the motor carrier is, of course, interested in the damage to his own equipment, not necessarily an insurance cost, and the deaths or injuries sustained by his employees. It follows that reasonable expenditures for safety work, per vehicle in operation, are justified.

Aside from the effect of the accident picture on insurance rates, an accident causes the motor carrier other expense. Completion of the contracted haul, after an accident, involves the use of other equipment and personnel with added time, labor, and supplies not easily figured in the rates charged. Clearance of the damaged vehicle and cargo from the highway is an added expense. Repair or replacement of the damaged equipment must be considered as double expense; both that of the actual repair or replacement cost and that of the time lost when the equipment could have been earning, but was not available for use. The repair and maintenance department reflects the cost of accidents by overtime, extra personnel required, and interruption of scheduled maintenance. The service of an employee may be lost as the result of an accident, with the expense found in hospital and doctor bills as well as in injury compensation. The effect of accidents on business can be seen by the reluctance of shippers to send their goods by a particular carrier if accidents have tied up loads in the past. Publicity which comes from accidents is bad for business.

Operators of truck fleets have found that accident cost records are of immense value as an aid in planning. Complete and detailed reports, coupled with intelligent analysis, may indicate means by which operating costs can be reduced and services improved. Also, in addition to the motor carrier, others, such as governmental agencies and insurance companies, are vitally interested in the many uses of accident records in the fleet operating cost field.

Use of Records in Accident Prevention Programs

Of all the activities which go to make up the business life of a motor carrier, the operations branch is most directly affected by accidents. Therefore, it follows that there is a direct and mutual dependency between accidents, operational activities, and the use of accident information in a program designed to eliminate those traffic accidents. From the direct relationship there may be worked out an overall basic program of prevention measures. The best programs are usually based on studies of accident causes and accident trends.

During recent years, many operators have experienced increasing property damage severity. That is to say, the property damage per reported accident has increased. This would indicate that more dollars in safety work per vehicle may be justified than before.

The relationship between accidents, operation costs, and efficiency can be found in accident analyses showing the number of accidents, number of fatalities and injuries, amount of property damage (segregated into cargo and vehicle damage and separated between "own" and "other" ownership) and number of miles driven.

The classification of accidents by type, or cause, may show the number of collision, non-collision and fire accidents, also the "overturn on highway" or "running off roadway" accidents. Accident trends may be best discovered by studies showing the number of accidents by month, by year, by season, or by other distinctive time period. Within any time period category, the kinds or types of accidents should be indicated according to the aforementioned classification.

Development of the accident prevention program can come from two types of information which analyses of accident records reveal: (1) Examinations of accident analyses point out and evaluate accident causation factors so that, by successive steps, principal causes may be eliminated; and (2) careful analysis will often open up broader fields, posing factors which previously were not only unanswered, but unknown.

As suggested, the greater the amount of information developed upon any *general* question which has been posed, the further that general question can be broken down into *specific* questions, for which specific answers can be sought. But, at the same time, every change in highways, equipment, etc., and in the requirements of shippers and of travelers, will bring with it new questions to be discovered, and stated, before the search for an *answer* can begin.

In the long run, of course, analysis of accidents narrows down to the first category as more and more things are discovered and as more and more means for accident prevention are applied.

The importance of accident records in the development of an accident prevention program is emphasized in the long background of the Interstate Commerce Commission in accident studies. Complete and detailed reports of accidents involving I.C.C. vehicles are, and have been, required for the entire life of the Commission. From these reports exhaustive studies are made on which changes and revisions in safety regulations are based.

The Vehicle and Accidents

The safety and operating features of commercial vehicles have a direct relation to accident experience. Fitness of the vehicle for the job, particular equipment for particular uses, improvements or changes in equipment and accessories, inspection and maintenance practices, and liaison between operating and maintenance departments, are important in accident reduction programs.

The fitness of any particular vehicle must be linked with the type of work for which it has been used. In addition to considerations of capacity, body type and power, the fitness of a vehicle for a job can be indicated by the number and severity of accidents, either personal casualties or property damage. Various types, kinds, sizes and weights of vehicles must be studied in relation to reported accidents.

Particular types of equipment have inherent qualities which make them especially suitable for particular uses, just as other types, because of their built-in characteristics, are most unsuitable for certain uses. For example, the army had a type of vehicle that was excellent for large bulk loads, but the frame of this same vehicle would break in two under heavy concentrated loads. Much information needed to determine suitability of various types and kinds of vehicles can be found in accident reports and maintenance records.

Vehicle Accessories and Accidents

A number of improvements in, or modifications of equipment specifications, including accessories, vehicle parts, and brakes, come up for consideration from time to time. Depending on the item under consideration, the information required to make the study can be found in accident reports, drivers' reports, maintenance reports and numerous other sources. For example, the type of mechanical arrangement and the power of various brakes for certain types of vehicles may come up for consideration after a series of similar accidents have pointed out defects in an existing system.

The need for development of different kinds of accessories, or equipment, will often be found in accident records. For example, the need for the development of better fuel tanks was plainly indicated by the number of accidents involving fires which started at fuel tanks. It was revealed by accident analyses of fire accidents over a period of years that there was a large difference in severity of casualties between those fire accidents involving spillage of fuel as compared to those fires not involving such spillage (not to mention the non-fire accidents, compared to which the fire accidents are so much more severe), and that spillage of fuel was directly traceable to smashing of fuel tanks in many instances. Cooperative work of the Interstate Commerce Commission and the Society of Automotive Engineers in preparing a specification for improved fuel tanks was undertaken and the promulgation of this specification is now a recommended practice of the Society of Automotive Engineers. All types of vehicle accessories are suggested for consideration by studies of accident records, drivers' reports, and maintenance records.

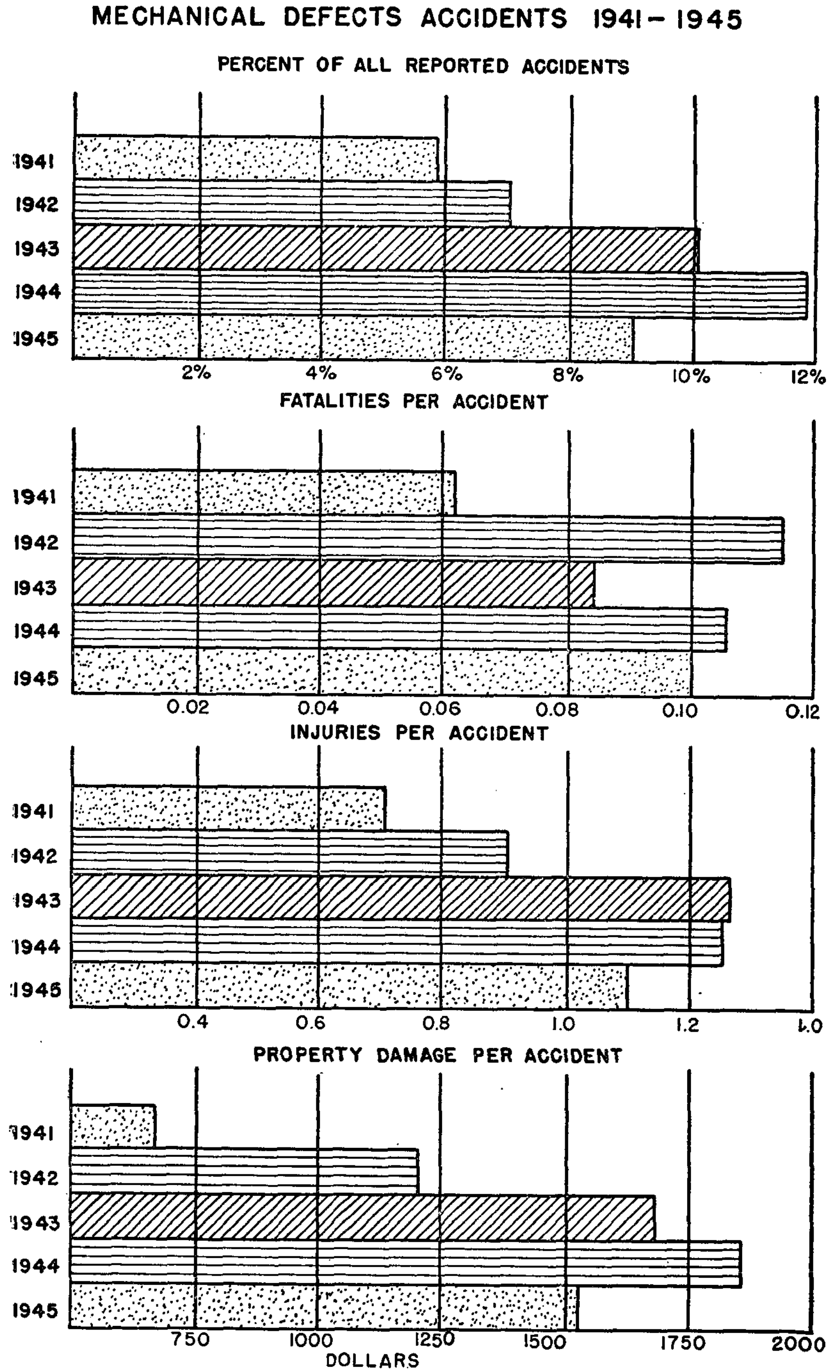
Inspection and Maintenance

Suggestions for improvements in, or additions to, the routine inspection and maintenance practices are found in analysis of the record of the number and severity of accidents or road stoppages involving mechanical defects of brakes, lights, wheels, springs, electrical systems, or other items. The opportunity for testing the various safety devices of a vehicle after an accident is often overlooked.

The magnitude of mechanical defect accidents reported to the Interstate Commerce Commission is shown in Figure 49.

A simple illustration of how the solution of a minor maintenance problem can yield out-of-proportion dividends is the story of a number of fires starting on long grades. These fires were found to be caused by the oil and grease on dirty engines which melted and fell on the exhaust system which was red hot as the result of the long pull up the grade. The dirty engines were cleaned, and the fire problem was eliminated.

A use of accident records as an indicator of lack of liaison between operating and maintenance departments may also prove valuable. Based on the accident record, a system of penalties and rewards can be worked out, so that the drivers will inspect their vehicles and report defects at once, and mechanics will become alert in detecting and correcting otherwise seemingly unimportant defects. This double inspection has saved vehicles from lengthy "dead line" and will positively reduce accidents due to mechanical failure. Preventive maintenance should be carried on as a combined responsibility.



From: "Analysis of Mechanical Defect Accidents of Motor Carriers in 1946," Interstate Commerce Commission, Bureau of Motor Carriers.

FIGURE 49—Graphical Presentation of Mechanical Defect Accidents in Relation to All Accidents, Fatalities, Injuries, and Property Damage.

Control of Personnel

The selection and assignments of personnel are problems involving numerous considerations, only one of which is the accident record. Here, however, that aspect of the problem alone will be considered.

The accident records of a carrier may show a number of mishaps involving a certain group of drivers. Even though it might be obvious that few accidents are of such a nature that the carrier driver cannot be held responsible, such as a "drunk" sideswiping a truck even though the truck driver had pulled over to the right as far as possible and had come to a halt, all records must be scrutinized so as to obtain facts which do reveal driver deficiencies. After elimination of some accidents, the number, kind and frequency can be shown for each of the carrier's drivers. From such studies, certain drivers can be singled out for reprimand, training, or other treatment in an attempt to improve the record and reduce the accidents. For example, when studies are made of the relative frequency and severity of accidents involving drivers in the youngest age categories and comparisons are made with the accident experience of all drivers of vehicles of motor carriers, it may be found that a greater number of accidents and the more severe accidents are traceable to the youngest age category. This strongly indicates that there should be greater supervisory attention paid to the younger drivers and greater care exerted in the selection, training, and subsequent observation of such drivers.

Mechanics and loaders should also be considered in accident analyses. The number and severity of accidents involving mechanical defects of brakes, light, wheels, springs, electrical systems, etc., including road stoppage due to defects in or failure of any of these devices can become the basis for control of mechanics and loaders involved. This may suggest such correctives, or controls, as education, retraining, rewards, discipline, or discharge.

Many fleet operators use accident records to give new personnel a complete introduction to their fleet accident experience. Such an introduction could include familiarization with the number, kind, frequency, and severity of accidents involving personnel of various ages, kinds of training, and physical qualifications. From this picture the new driver should be able to plan intelligently to avoid possible accidents and to form good driving habits.

Old personnel should be kept up-to-date on the accident picture. When old methods of training are abandoned and new methods are built up from accident experience, the old driver should be called in and retrained so that dangerous driving habits or misconceptions can be changed before accidents occur. Just as hazards to navigation are charted and brought to the attention of all nautical persons concerned, so the accident record points out driving hazards and all drivers should be given every assistance possible to avoid the hazard.

Safety contests between shifts, or areas, are extremely effective in keeping accident rates down and interest in safety up. The measure of success between groups is indicated by the accident rates or the safety record of the groups. Accidents, fatalities, injuries, property damage per unit of time worked, miles traveled, or other selected common standards when given numerical values will show which group is achieving most success in preventing accidents.

Similar to the group safety contest, is the system of individual rewards and discipline. From the accident records it can be seen whether a man has avoided accidents where others driving with the same exposure have not avoided accidents. The incentive to avoid accidents may be encouraged by an award. Men like to excell and prove to themselves and others that they are well qualified for particular jobs.

Many suggestions can come from studies of truck accidents by time of occurrence. Data, such as shown in Figure 50, when related to exposures can point the way to improved operating practices.

Studies of accident reports submitted by motor carriers indicate a relatively high proportion of non-collision accidents as compared to collision accidents for certain hours of the day, notably between 2:00 A.M. and 8:00 A. M. Since many non-collision accidents are largely traceable to driver failures and, in a considerable proportion of cases, to driver fatigue and sleepiness, this factual information from accident records corroborates a prevalent opinion that drivers are more prone to drowse just prior to and just following dawn. These data indicate the desirability of devising means for the better control

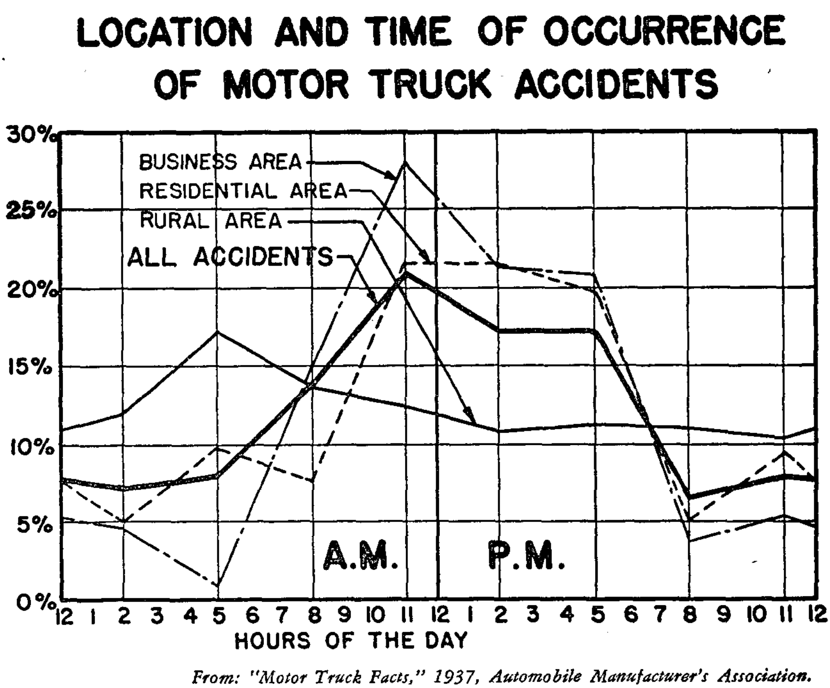


FIGURE 50—Results of Study of Relationship of Truck Accidents to Business, Residential, and Rural Locations.

of drivers and operations during these particular periods to avert or ameliorate indicated hazards. Pertinent items for research are: (1) hours on duty, (Figure 51), (2) hours driving, (3) how the driver spends off-duty time, (4) adequacy of sleeping quarters, and (5) noise, temperature, and other adverse conditions at rest stops. State and interstate laws now provide some control, but the problem will always require continuing study.

Accident reports and statistics, with mechanical reports, special inquiries and research, further reveal that motor carrier operators are exposed to occupational disabilities. The driver's physique, temperament, or attitude may be definitely altered by the effect of working hours, time of day on duty, comfort of cabs, position or dimension of the driver's seat, and operating mechanisms. Strain on the driver, imposed by trying to compensate for a single defect may cause him to be negligent of another. Continued strain will result in a breakdown of safe and efficient operation. Perhaps it will never be classed as a direct cause of an accident, but it may be a contributing cause

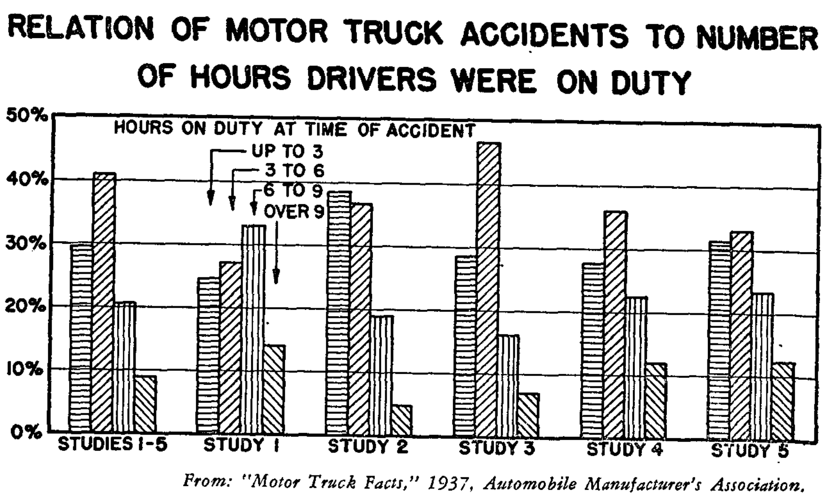


FIGURE 51—Relationship of Truck Accidents to Hours of Driving by Operators.

even though not readily detected. For example, an analysis of accident reports indicates that there was a relatively large category of accidents reported which involved over-turns on the highway, running off the highway, running into culverts and bridge abutments, and similar accidents in which there was no apparent reason for occurrence. As has been pointed out, there was probably a correlation between the occurrence of such accidents and excessive hours of service, extreme fatigue, illness, etc. Still the causes of many of these accidents remained unknown. Conjecture was aroused, after the study of such unexplained accidents as to the behavior of drivers, which, in some accidents was suspiciously like the behavior of persons under the influence of carbon monoxide poisoning. Carbon monoxide detectors were purchased and field work was undertaken to ascertain whether or not there was a correlation between the occurrence of otherwise unexplainable accidents and the presence of carbon monoxide. Many other similar studies may be suggested by accident records.

Operational Practices

Where there is a choice, the selection of new routes and changes in old routes may be settled by the answer to the question "Will the load be delayed or stopped by accident?" A study of the contemplated route, considering frequency and severity of accidents at particular locations, driving time, and speeds will usually indicate the proper decision. The greater operating expense involved in choosing a longer but less hazardous route rather than a shorter route is justified. The experience of one company showed the loss of at least one truck a month on a narrow, twisting route through the mountains during the winter months. A change in route increased the mileage, but eliminated the accident loss, thus producing an overall saving.

Flexibility in time scheduling should be utilized in avoidance of hazards influenced by the time of day or day of the week. For example, Sunday night between eight and midnight on all roads leading into New York City may be found to constitute a high accident expectancy period and should then be avoided when possible.

The loading of a truck directly affects its operating characteristics. The relationship of accidents to payload distribution, shifting of load, or overloading should govern the approved loading practices followed by the carrier. It is not uncommon for the load to get out of control, in spite of the driver's skill. Overturning, sideswipes, skidding, and rear-end collision accidents may occasionally be due to improper loading. The severity of an accident may also be affected by loading practices. Using the vehicle best suited to the load, securely fastening the load, and avoiding top heavy and loose loading will go a long way toward preventing this type of accident. Special investigation may be necessary to develop the best plan for peculiar loadings.

Shippers may actively cooperate with the carrier when the relationship between parking, loading, and containers and accidents becomes known or is suspected. Any changes, or improvements, work to the benefit of the shipper because his goods then arrive at destinations safely and in better condition.

Certain types of lading, such as explosives and other dangerous articles, by their very physical and chemical characteristics, present difficulties and risks in transportation. Correction of practices in handling these types of lading can be found by research involving number, kind, and severity of accidents peculiar to each. For example, analysis of accidents involving the transportation of explosives has led to the improvement of inspection and maintenance practices of motor carriers so engaged. Examination after one fire on a vehicle transporting dynamite, (fortunately not an explosion) revealed that a leak in the exhaust system had been the source of the fire. Forewarning from previous analyses of similar accidents indicated where to look for the source of the trouble *with particular regard to the place at which it originated.*

Once again the measurement of the fitness of vehicles for the type of work for which they are being used arises in the discussion of dispatching. Dispatching usually includes selection of the proper vehicle for the load. This selection can be checked by the consideration of a number of factors, one of which is the relationship of accidents to vehicles ill-adapted to the carrying of particular kinds, sizes, or weights of loads when others better adapted are available.

In the discussion of fitness of vehicles for the job they are expected to perform, the matter of obsolescence must be considered. Comparisons of accident frequency and severity and the cost of repair of various vehicles by age, miles traveled, and also by frequency of driver complaints and number of highway breakdowns will assist in decisions as to when to retire the vehicle or continue it in service.

Changes or Modifications of Legislation or Regulations

Laws, ordinances, and regulations almost without number, have been proposed and often passed to regulate, control, hamper, and sometimes to "strangle" motor carriers. Some actually increase the confusion, while others are necessary and result in the reduction of specific types of accidents. The motor carriers, by the use of accident reports and statistics, can help clarify the situation for the law-makers and thus avoid needless expense and trouble. Laws regulating the number of hours a driver can drive had their beginning in accident reports and now work for the benefit of carriers and drivers alike. Many unsafe practices have their origin in the necessity of meeting competition; perhaps they could be eliminated by the industry as a whole through requested legislation based on accident records and statistics.

Development of Public Relations

A carrier can realize considerable benefit from the publicity of certain results gained through a safety and accident elimination campaign. Courteous and safety-minded drivers are the best advertisement a carrier can possibly develop. Selling safety is selling goodwill. Many aspects of public relations which are related to safety will suggest themselves.

Terminal Facilities

An intelligent survey of the accident picture will show the carrier that accidents are not restricted to the road, but even invade his terminals. Inadequate yards, docks, platforms, exits, gates, and lighting account for a substantial part of the accident expense. Even such a simple thing as continual damage to rear lights when trailers are backed to a dock should be investigated. Often an elementary solution can be supplied. Consideration given to various yard or dock buildings, fixtures or equipment, mentioned repeatedly in accident reports, will pay dividends in the long run.

Use of Accident Data by Groups of Carriers or by Carriers' Associations

It is apparent that in certain cases an individual motor carrier will not have a sufficient number of data on a particular subject to warrant conclusions being drawn from his own accident experience. In such cases, the consolidation of accident statistics of a group, on a company, state, sectional, or nationwide scale may serve to accomplish the purposes which the individual could not accomplish alone. From such cooperative use of statistics may come broad educational policies, development of new or novel methods of awards or discipline, safety contests on a broad scale, statewide or nationwide public relations, needed legislation or regulations. These are illustrative and are but the most obvious. Others will be suggested.

Suggestions for improvements in such basic devices as brakes, headlights, ignition systems, wiring, and fuel tanks, are particularly important, but are difficult to prove for the individual carrier with limited experience. Therefore, the development of these and other basic devices can well be included in the research program of larger groups. Defects and suggestions for improvement may be indicated by the larger possible volume of accident records available to the cooperative group.

From extensive analysis of mechanical defects, may come the development of new mechanisms and devices. The need for such development may be established by the examination of many accidents in which these mechanical devices may appear to be causative factors.

Since the effect of an accident is felt by a motor carrier in all phases of operation, and it might even be said that continuance in business depends to a considerable degree on accident experience, it follows that collection, analysis, and use of accident statistics should be a major consideration. Most carriers, because of governmental and insurance regulations, have at hand detailed and complete accident data. Therefore, continual analysis and use of the data cannot be too emphatically emphasized.

REFERENCES ON MOTOR CARRIER USES

1. Interstate Commerce Commission, Accident reports and bulletins of Motor Carrier Safety Section. Statistical data on the involving of motor carriers in accidents, analyses of causal factors; etc.

2. Kraft, M. A. and Forbes, T. W., *Evaluating the Influences of Personal Characteristics on the Traffic Accident Experience of Transit Operators*, Highway Research Board Proceedings, 1944, Washington, D. C. The Board. Results of a study by the American Transit Association of accident experiences of a large sample of transit operators, to ascertain the degree to which personal characteristics influence accident rates.

3. Farmer, E. and Chambers, E. G. *A Study of Accident Proneness Among Drivers.* Medical Research Council, Industrial Health Research Board. Report No. 84. London. His Majesty's Stationery Office, 1939. 9d. Report of an investigation among omnibus drivers "to see if it were possible to measure inequality in accident liability among certain groups of motor drivers and if so, whether it were also possible partly to detect beforehand by means of psychological tests those most likely to sustain accidents".

4. *Motor Carrier Safety Regulations Revised:* Rules and regulations governing qualifications of employees and safety of operation and equipment of common carriers and contract carriers by motor vehicle. Washington, D. C. U. S. Govt. Print. Off. 1939, 99 pp. Part 1. Qualifications of drivers; 2. Driving of motor vehicles; 3. Parts and accessories necessary; 4. Reporting of accidents; 5. Hours of service of drivers; 6. Inspection and maintenance.

5. U. S. Interstate Commerce Commission. *Motor Carrier Fire Accidents*, 1945. Washington, D. C. The Commission, March 1947. 44 pp. mimeo. Published annually. Results of analysis of accidents reported by motor carriers to the Commission, involving fire.

CHAPTER IX

BASIC ACCIDENT ANALYSIS METHODS

The collection of accident records alone is of little benefit in accident reduction. The inspection of a single accident report will seldom yield valuable information; it will indicate some sort of traffic trouble, but only as it affects an extremely small part of the motoring public. The comparison of that report with another usually will yield only a little more information of value, but a start has been made,—a feeble, vague, and often misleading indication. This indication grows clearer as the number of reports is increased. This sorting of evidence and adding up small items of fact is the analysis of accident records. As a result of such analyses, conclusions may be drawn and plans may be made for the reduction of future accidents.

The material included in this Chapter may be partially classified in terms of the complexity of the mathematics involved. It is assumed that the user of this Manual is adept at simple arithmetic and algebraic calculations. At the other extreme, the relatively advanced statistical techniques, which experience has shown are not normally necessary nor practical in traffic accident analysis work, have also been excluded. Those with adequate mathematical background are urged to familarize themselves with advanced statistical techniques so that upon occasion when application to accident analysis is desirable, they are prepared to make this application. Such individuals are referred to the bibliography of standard statistical texts at the end of this Chapter.

Here will be found the simple statistical techniques which are normally and frequently employed in accident records work. These techniques should be used from day to day by traffic accident statisticians. In many cases, the user may not have realized that he is making use of a particular technique, or he may not recognize it by technical name. In any case, these techniques should be familiar to everyone in accident records work, and their use should be second nature. It is recognized that the contents of this chapter are extremely elementary to persons familiar with statistical techniques, and it is intended. therefore, for users of the Manual who are not so well versed in statistical procedures.

The Organization and Description of Numerical Data

The Array—The simplest method of organizing numerical information is an array, or list, of values from high to low. For example, the number of accidents occurring in each county is tabulated and the counties are then arranged in order from the high number of accidents down to the low number of accidents, or vice-versa. In cities, a frequently used technique is the "worst corner list" which is an array, with intersections arranged in order of the number of accidents occurring at each one. Many such lists are used chiefly to establish priority of treatment and are, therefore, in such cases, termed "priority list" or "worst location lists".

Frequency Distribution—Another commonly used method of organizing numerical data is called frequency distribution. Here data are grouped together into a number of conveniently sized groups, or "class intervals." A common example of a frequency ditsribution is found in the schedule of drivers' ages, common to most traffic accident summaries. A typical schedule is shown below:

AGE OF DRIVER	NUMBER OF DRIVERS
Under 16 years	24
16-17 years	39
18-20 years	52

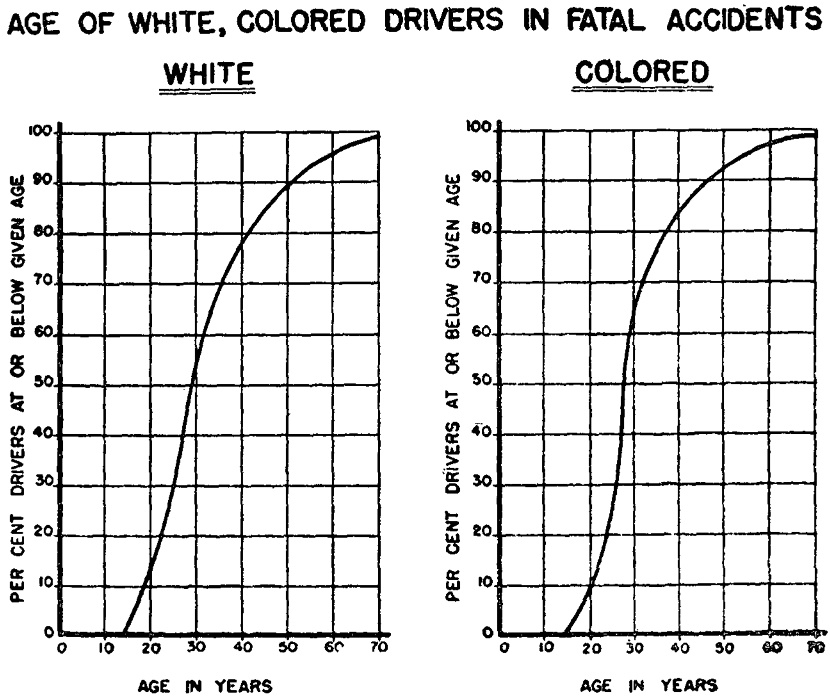
20-14 years	67
25-34 years	214
35-44 years	161
45-54 years	62
55-64 years	49
65-74 years	33
75 years & over	11
Total Drivers	712

As a general rule, class intervals of equal size are preferred over intervals of varying size. In the age distribution just shown, the five principal class intervals each cover an age span of ten years, but for the ages below 25, the class intervals are smaller because it is generally desired to study these groups more closely. Notice also that the intervals beginning and ending the distribution need not be definitely fixed.

Sometimes the frequencies are cumulative, and the graph of such a distribution is known as an "*ogive*". Examples of this occur more frequently in traffic engineering, perhaps, than in accident records. The curve shown in Figure 52 is an example of a cumulative distribution curve in accident analysis.

Averages—In many studies, it is desirable to find a single value which represents a group of data. This single value is loosely termed an "average", although there are actually several different kinds of averages. To avoid misunderstanding, it is preferable to refer to each kind of average by the correct technical term.

(1) *Arithmetic Mean*—This is the most common type of average. It is determined by adding together the individual values of a number of items and dividing by the total number of items. Thus the mean number of accidents on Monday during a given year may be calculated by adding together the accidents occurring on all Mondays during the year and dividing by the total number of Mondays during that year. If, as is frequently the case with accident rates, it is desired that an average reflect



From: "Facts About Traffic Accidents in South Carolina, 1940," South Carolina State Highway Department.

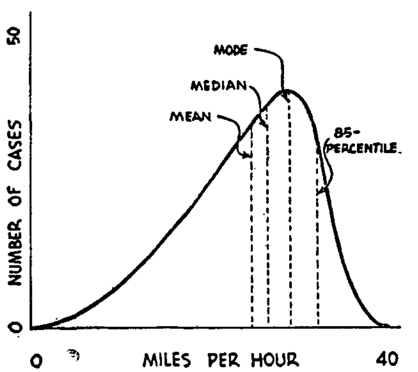
FIGURE 52—Sample Cumulative Distribution Curves Applied to Traffic Accident Data.

the size (and therefore the importance) of the various cases, a weighted average may be employed. Thus, if the average death rate for a number of cities is desired, it is customary to add all the populations and all the deaths, and then to divide the total deaths by the total population to obtain a weighted mean. The mean has the disadvantage of being influenced by any extremely wide variations of one or more of the individual values. Thus, if ten cases totaling 250 are averaged, the mean is 25. If a single additional case of 500 is added, the mean is 750 divided by 11, or 68—a value which does not represent either the original 10 cases nor the one additional extreme case which was added to the group.

(2) *Mode*—The mode is the value which occurs most frequently in a frequency distribution. The class interval in which this value falls is known as the "modal group." Thus in the distribution of drivers' ages shown previously, the age group 25 to 34 years had in it a larger number of drivers than any other age group. The group 25 to 34 years is then the "modal group". The mode is not affected unduly by extremely high or extremely low figures as in the mean.

(3) *Median*—The median is the middle case counting from either end of an array. If the array has an odd number of cases, the median will be the middle value. If the array has an even number of cases, the median will be midway between the two middle cases. The median of the series 1, 4, 5, 9, 9, 10, 11 is 9. The extreme values may be changed so the series is 4, 7, 9, 9, 15, 16, 24 and the median remains 9, although the mean has been increased from 7 to 12. Because the median is a positional value, it is relatively free from the effect of wide variations in an extremely low or extremely high figure.

(4) *Percentile*—In some cases it is not desirable to pick the middle value—the median. If another positional value is fixed, it is called a *percentile* and is preceded by a figure which indicates the position. That is, the 85 percentile value is the positional value 85 per cent of the way from the bottom to the top of the array. The median, which is the middle positional value, is thus the 50-percentile value. The 85-percentile value is commonly used in talking about speeds, for traffic engineers feel that this value, which indicates the speed at or below which 85 per cent of all the vehicles observed were traveling, represents the maximum safe speed better than the mean or the median.



From: Manual of Traffic Engineering Studies, National Conservation Bureau, 1945.

FIGURE 53—Speed Distribution Curve Showing Location of Different Types of Averages and 85 Percentile Value.

The location of this value in relation to the others previously mentioned is indicated in the speed distribution curve shown in Figure 53.

Ratios—To express the size relationship between two quantities, it is common to say that one is a certain number of times as large as the other. This is called a *ratio*. The commonly used traffic "enforcement index" is a ratio—expressing the relationship between convictions for moving traffic violations and personal injury accidents. Another relationship, frequently expressed as a ratio, measures the volume of reporting of traffic accidents. Thus, if a record bureau receives reports of 20 fatal accidents, 840 non-fatal injury accidents and 3,260 property damage accidents, the ratio of personal injury to fatal is 42 to 1 (or 42:1, as commonly written) and the ratio of property damage to fatal accidents is 163 to 1 (or 163:1). That is, there were 42 times as many personal injury accidents reported as fatal accidents, and 163 times as many property damage accidents reported as fatal accidents.

Rates—A special kind of ratio in which one quantity is measured in terms of another is called a *rate*. Motor vehicle speeds are commonly expressed as a rate, i.e., "40 miles per hour". Gasoline consumption is referred to in terms of "miles per gallon". Rates are necessary in accident work to compare the frequency of accidents in different areas, or for different periods, since exposure to accident may vary widely and a uniform basis for comparison must be adopted.

Three types of rates are commonly used: (1) The population rate; (2) the motor vehicle registration rate; and, (3) the mileage rate. The first two are most frequently used for comparing accident experience of cities, while the mileage rate is generally used for state-wide, rural area, county, or specific highway comparisons. The population rate is generally expressed as deaths per 100,000 population or accidents per 1,000 population. Thus, a city with 50,000 people having ten deaths is said to have a population death rate of 20.0 deaths per 100,000 population. If the population were 250,000 and the deaths totaled 40, the population death rate would 16.0 deaths per 100,000 population. The motor vehicle registration rate is commonly expressed as deaths per 10,000 registered vehicles or accidents per 100 registered vehicles. The mileage rate is usually in terms of deaths per 100-million vehicle-miles, or accidents per million vehicle-miles.

The rate bases selected are quite arbitrary, having been chosen to yield a rate which usually has two figures to the left of the decimal for most cities or states. A rate of 12 is easier to remember than a rate of 0.012 or a rate of 1200. The rate bases, although arbitrarily selected in the first place, should be used uniformly by all cities and states.

Comparisons of accident conditions in relation to changes or improvements are commonly referred to as "before" and "after" studies.

Percentages—Another special ratio is called a *percentage*. This is the "rate per 100", and is commonly used in determining the proportion of a whole which a quantity represents, or in calculating the change or difference between two quantities. Thus, if accidents during a year totaled 1240 and 150 of these occurred on Wednesday, the proportion of all accidents which occurred on Wednesday can be expressed as the ratio $\frac{150}{1240}$, or 0.121, that is, 12.1% of them happened on Wednesday.

Rates and percentages are especially useful in comparing distributions when the magnitudes in the distributions vary widely. For instance, in checking the results of enforcement planning it is usual to compare accident experience and arrests by time, violation, and location. In Table VIII, the two are compared by day of the week, and without the percentage columns it would be very difficult to pick out the fact that on one day (Sunday) enforcement was not applied in as high degree in relation to accidents as on other days. The same deficiency is reflected when the ratios of accidents to arrests are compared.

TABLE VIII

COMPARISONS OF ACCIDENTS AND ARRESTS

DAY OF WEEK	ACCIDENTS NO.	ACCIDENTS %	ARRESTS NO.	ARRESTS %
Monday	54	9.7	705	10.5
Tuesday	47	8.4	584	8.7
Wednesday	64	11.5	818	12.2
Thursday	65	11.6	806	12.0
Friday	89	15.9	1110	16.5
Saturday	142	25.4	1766	26.3
Sunday	98	17.5	923	13.8
Total	559	100.0	6712	100.0

Percentages are also useful in calculating changes. If pedestrian accidents totaled 44 during the month of January in a particular city and increased to 62 in February, this change can be expressed as a percentage of the January total. The increase was 18, which is 41 per cent of 44. The statement would then be made that pedestrian accidents had increased 41 per cent from January to February. If, on the other hand, the February total had been 40, the decrease would amount to 4, or a 9.1 per cent decrease for February as compared to January.

Several precautions are necessary in dealing with percentages. When calculating percentage changes, for instance, if the numbers used are very small the calculated per cent change may be misleading. An increase of from 1 to 2, or a decrease from 1 to 0, both indicate a 100 per cent change, which would be startling to say the least if the figures were larger. Actually it signifies little or nothing, since the change in this case is only 1. A 20 per cent increase from 5 to 6 certainly does not stand out in the same fashion as 20 per cent increase from 200 to 240. It is evident that percentage change must be considered in connection with the actual change to determine whether or not it is significant.

Another common source of error in dealing with percentages develops when an attempt is made to combine or average them. The same thing can be said for rates. Assume that a state record bureau determines that 30 per cent of its fatalities in rural areas are pedestrians and 80 per cent of its urban fatalities are pedestrians. What is the state-wide percentage? Is it 55 per cent, the average of 30 per cent and 80 per cent? The answer is probably no, for no account is taken in making that calculation of the relative number of urban and rural deaths. If the total rural deaths were 100 and the total urban deaths were 300, then the urban percentage is 3 times as important in determining state-wide pedestrian percentage as is the rural percentage. Actually, there were 30 rural pedestrian deaths and 240 urban pedestrian deaths, or a total of 270 pedestrian deaths—67.5 per cent of the total of 400 deaths.

Time Series—When data are arranged by time, rather than by magnitude as in a frequency distribution, the tabulation is called a time series. Such series are often called "chronological series". They reflect accident trends for successive periods of time. The hour of day schedule on conventional traffic accident summaries is an example of a time series. Accidents listed by month or by year are other examples.

Four types of fluctuations occur in time series, and they should be recognized so that they will not be wrongly interpreted. These four types are: (1) secular trends; (2) cyclical fluctuations; (3) seasonal fluctuations; (4) other or random variations.

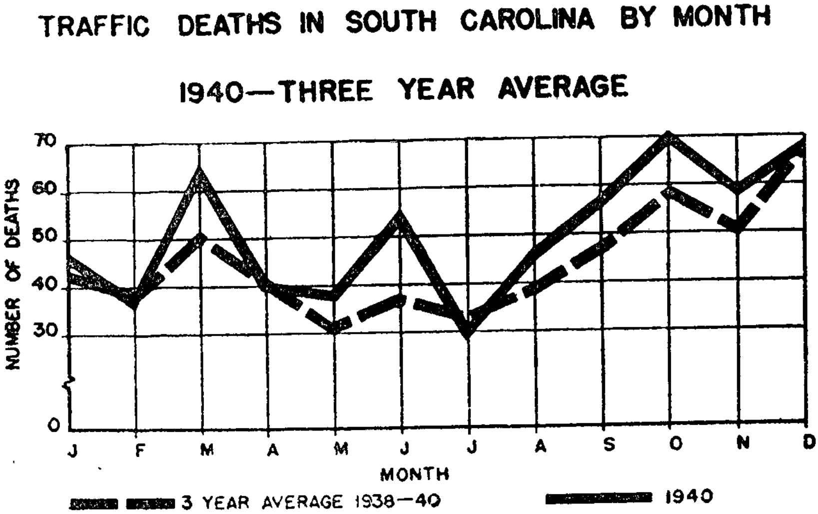
Secular trend is a non-periodic change which is evident over a long period of time. An example is the downward trend in mileage death rates during the past twenty years. This rate has declined steadily from 19.0 in 1925 to 9.7 in 1946.

Cyclic fluctuations are the phenomena probably responsible for the old adage that "history repeats itself". They occur fairly regularly, generally at intervals longer than a year, producing waves first on one side and then on the other side of the secular trend line.

Seasonal variations occur at shorter intervals—a year or less. They occur periodically, at annual, monthly, daily, or hourly intervals. A time series of deaths by months of the year shows pronounced seasonal fluctuations. Year after year, deaths drop sharply in February, are low in March and April, begin to climb in May, and reach a peak in December. The fact that deaths in a particular state were lower in February than in January is not necessarily cause for congratulations, therefore, since it probably reflects only the normal seasonal fluctuation. Seasonal variations are also found in a distribution of accidents by hours of the day and by days of the week. The chart shows secular trend, cyclical fluctuations, and seasonal variation in relation to one another. A typical trend is shown in Figure 54.

Other variations may be random variations, caused in some cases by chance, or they may be variations due to some special cause, such as an intensified enforcement or educational program. These other variations, therefore, become of primary importance to the accident records bureau. If secular trends, cyclical fluctuations and seasonal variations are eliminated, and if the sample is large enough so that random variations are not apparent, the remaining change may be evidence of a trend brought about by accident prevention efforts. Adequate studies of the influence of important factors on accident trends, may permit the calculation of "accident expectancies."

Index Numbers—Frequently when it is desired to indicate change, particularly in a time series, one quantity or several quantities may be expressed in *index numbers*. This means that each quantity at one particular time, referred to as the base



From: "Facts About Traffic Accidents in South Carolina, 1940," South Carolina State Highway Department.

FIGURE 54—Trend in Traffic Deaths by Months.

period, is assigned the value of 100. At any other time, then, the quantity is expressed as a percentage of the quantity during the base period. This percentage is the index of the quantity at that time. In Table IX, are listed accident totals for each of five years, from 1941 through 1945, with index numbers shown for each year, using 1941 as the base period:

TABLE IX

ACCIDENT INDEX NUMBERS

YEAR	NUMBER OF ACCIDENTS	INDEX (1941 = 100)
1941	320	100
1942	300	93
1943	242	76
1944	260	81
1945	384	120

Index numbers are particularly useful when it is desired to relate in a time series two quantities which differ greatly in magnitude. By expressing them both in index numbers, it is much easier to compare trends and relative changes.

Fallacies in Interpretation of Results

There is an old saying that "figures don't lie, but liars figure." The origin of this adage undoubtedly lies partly on the shoulders of statisticans who painstakingly collect and analyze data and then fail to summarize or interpret them correctly. Obviously data are of no value unless their meaning can be indicated clearly and translated into policy and action by administrators.

It has been pointed out that there are two principal defects with traffic accident statistics today.[29] One of these is that published figures often don't mean anything–sometimes they are trivial, sometimes they are obscure or too complex, and sometimes they "prove" something already well-established, or they unnecessarily refine facts already known with accuracy sufficient for all practical purposes.

On the other hand, some figures don't tell the whole truth. Casual factors, which are not obvious to the lay reader, but should be to the competent technician, are not mentioned. Deaths go down and credit is taken for the safety program, when actually the reduction was due to a decrease in the use of vehicles. Accidents of one particular type go down, and this fact is widely publicized as a *general* improvement in the record, with no mention of an increase in another equally important accident type. Or perhaps child accidents go down–daytime accidents also go down, and pedestrian accidents go down. No mention is made of the fact that more children are pedestrians than drivers, and that most child accidents occur during daylight hours. The relationship between these items is so involved as to make

[29] Williams, Sidney J. *The Whole Truth,* Public Safety, Vol. 28, No. 2, pp. 6-7, August, 1945.

it relatively impossible to assign a specific cause for a reduction in any one of these three types.

There are a number of specific fallacies which can be enumerated and with which statisticians are familiar. These are set forth in the following paragraphs.

Generalization of the Basis of an Average—A state traffic accident records bureau may determine that railroad grade crossing accidents represent only a small proportion of the state's total traffic deaths, and the conclusion may, therefore, be reached that the problem is not important. This may be true for the state as a whole, but may be wholly untrue for a particular area in the state in which grade crossing accidents may be relatively quite important. Another example may be cited in the case of a city records bureau which decided that accidents on icy road surfaces accounted for a small proportion of the annual accident total. When the months of December, January and February were considered alone, however, this road condition would be discovered to be much more important than was at first believed true.

Reasoning From a Particular Case to a Statistical Generalization—Moving in the opposite direction may be just as fallacious. It is incorrect to assume that because a particular type of accident or a particular accident circumstance is prevalent at one location or at one time, it is prevalent throughout the whole area or for a long period of time. Special circumstances at the instant or at the specific location may not be repeated in other areas or at other times. A concentration of child accidents in a particular area may mean only that a large elementary school in that area produces such child pedestrian traffic, and the child accident problem in the whole city may not be proportionately large. Drunken driving may be 50 per cent of the accident problem in a night club area, but only 20 per cent of the total accident problem.

Unjustified Assumption of Cause and Effect—This fallacy interprets as cause and effect what may be actually the result of other causes or of pure coincidence. An educational program is instituted on the theme that a "STOP" sign means a full stop, and accidents involving this violation show a decrease. The educational program may be credited with this decrease, when actually reference to arrest records of the police department will indicate that enforcement of this particular phase of the law was greatly stepped up during the same period. Was the increase due to the educational program or to the additional enforcement effort?

Street lighting is improved in another area, and night accidents decrease. Was this the cause, or was the decrease attributable to the fact that night traffic volume fell off sharply with the ending of night shifts at large industrial plants in the immediate vicinity?

If one event *always* follows another—if the grass is always greener after a rain, or if accidents go down every time an educational program is conducted or improved street lighting is installed—then we may properly conclude that the one event caused the other. Obviously there are exceptions due to chance or other factors—a rain in August may not revive a lawn burned by the hot July sun—but the cause and effect relationship still holds.

Spurious Accuracy—One of the marks of a beginner in the field of statistics is over-accurate results. Figures are carried to two, three and four decimal places, property damage losses are carried to the last penny, and totals generally are refined beyond reasonable limits.

Statistical data come under two headings: (1) Counts of real and distinct things, such as persons or accidents; each item making up a total can be accurately counted and tabulated without fractional values; and, (2) Measurements and estimates, such as economic loss from accidents, vehicle-miles operated during a given period of time, or the total number of accidents which probably happen, based upon partial or incomplete figures.

When working with the first group of figures, results may be written with a fine degree of accuracy. If 781 persons were injured in traffic accidents, and we have an actual count of this from reports, then we know that the figure is 781 and not 780.99 and not 781.01.

This is not true when dealing with the second group discussed above. Suppose we are attempting to calculate total property damage as a result of traffic accidents. One report states that the damage amounted to $2,500, while the report on the next accident says that the damage was $16.80. Obviously, the first is a round figure, probably representing the approximate value of a large vehicle, while the second figure is presumably a garage estimate or perhaps the actual repair bill. It would be definitely wrong to add these two and say that the total property damage of these two accidents amounted to exactly $2516.80.

Likewise, the state highway department may furnish a figure representing vehicle-miles traveled on rural state highways during an average 24-hour period during the year. Suppose this figure were 8,265,000 vehicle-miles per day. Multiplying by 365 to get the annual figure would produce a result of 3,016,-725,000—a figure which is too refined for the data going into it. The total should be expressed as 3,017,000,000—or even 3,000,000,000—vehicle-miles. This is based on the principle of *significant figures.*

Significant figures are those which are, or can be, written down to indicate the magnitude of an item or factor. They are a measure of the accuracy of the data used in determining the number. Integers—whole numbers like the 781 deaths mentioned above—are absolutely accurate. This number can be written 781.0000—with as many zeros as desired. There is no limit to the number of significant figures in such a case. The number 2.1, however, has but two significant figures. The number 21 also has two significant figures, as does 210 or 21,000. The number 2.10 has three significant figures, and 21,000.6 has six significant figures. The number 0.002 has only one significant figure, however, since the zeros in front of the "2" do not add to its accuracy. The number 0.00280 has three significant figures, while 0.0028 has but two significant figures.

This discussion of significance should not be confused with significance for size. That is, we say that 0.002 has but one significant figure (see above) but we also say that 0.002 is "significant to the third decimal place," and that 0.00280 is "significant to the fifth decimal place."

To avoid spurious accuracy when adding or subtracting numbers, the results should be stated with no more accuracy than the least accurate figure going into the problem. An example of proper accuracy in addition is as follows:

$$\begin{array}{r} 2087 \\ 69.21 \\ 4.018 \\ 120.9 \\ \hline 2281.128 \end{array} \quad \text{Answer} = 2281$$

Since the least accurate figure, 2087, is not good to any places to the right of the decimal, the answer should be rounded off to 2281. If the 2087 had been an exact figure which could have been written 2087.0000 . . . . , the least accurate figure would have been 120.9, and the answer would have been written 2281.1, or with five significant figures. The individual items could have been rounded off before addition, but this would have produced slight errors in each figure which might have accumulated into a sizeable error in the sum.

When multiplying or dividing, the results should be stated with no more significant figures than the least accurate of the numbers used to form the product or quotient. For instance, 12 multiplied by 12.2 is 146.4, but since 12 has only two significant figures, the product should be written as 150. Had the 12 been a whole number—that is, had it been possible to write it at 12.000...—the 12.2 would have been the limiting factor and the product would have been written 146. Had it been possible to write the second figure in the multiplication problem as 12.20, the answer would have been correctly stated as 146.4 (assuming the 12 to be a whole number).

All of these examples assume that the numbers used in the multiplication are all stated as accurately as possible. It must be recognized that the degree of accuracy may vary. Thus a figure of 21,000 may be used as the population of a city. The total of 21,000 may be the official census figure—as accurate as any census can be—or it may be a round number determined by estimate or guess. As a census figure it would have several more significant figures than if it were in the later classification.

Failure to Recognize Chance and Probability—Another fallacy which frequently appears in statistical work involves the undue importance attached to small figures. Records dealing with such figures fail to take into account the elements of chance. A city, for instance, experiences 10 traffic deaths during one year, and the following year has only 9 deaths. Arithmetically this represents an improvement of 10 per cent—statistically it does not indicate much, since the figures are so small that chance alone could well have accounted for the difference.

Frequently enforcement planning, involving the assignment of police patrols on the basis of accident experience, fails because too small a sample of accidents is used as a base. Hourly assignments are planned on a total of perhaps 30 accidents, which means that during many hours of the day only one or two accidents are indicated and that during some hours of the day no accidents are shown. If this were taken literally, twice as many patrols would be assigned during those hours with two accidents as during the hours with one accident, and patrols would be removed entirely during the hours when no accidents were reported. Actually, if a larger group of accidents were used as a base, these large fluctuations would disappear in all probability, and the need for enforcement attention would be much more even, but with definite peaks during certain periods and definite lows during other periods.

Another aspect of the problem develops when statisticians fail to take into account the normal probability of accidents. Two examples of this are cited.

The first involves a study of accidents by day of the week for a given month during which 100 accidents were reported. These were distributed during the 7 days of the week as follows:

DAY	NUMBER OF ACCIDENTS
Monday	12
Tuesday	10
Wednesday	10
Thursday	12
Friday	13
Saturday	25
Sunday	18
Total	100

Before attempting an assignment on the basis of such a distribution, the factor of probability must be considered. During this particular month, which had 31 days, there were not an equal number of each of the 7 days. There were 5 Mondays, Tuesdays and Wednesdays, and only 4 of the other four days.

Although at first glance it would appear that 12 per cent of the accidents occurred on Monday, actually this percentage should be 10.2 per cent, as indicated in Table X.

TABLE X

COMPARISON OF ACCIDENTS BY DAY OF WEEK

DAY	NUMBER OF ACCIDENTS	NUMBER OF DAYS	ACCIDENTS PER DAY	ADJUSTED PER CENT
Monday	12	5	2.4	10.2%
Tuesday	10	5	2.0	8.5
Wednesday	10	5	2.0	8.5
Thursday	12	4	3.0	12.8
Friday	13	4	3.3	14.1
Saturday	25	4	6.3	26.8
Sunday	18	4	4.5	19.1
Total	100	31	3.2	100.0%

Since each day represents one-seventh of the week, the normal probability of accidents for any particular day would be 14.3 per cent. It is immediately obvious that Friday had nearly its normal share of accidents, but that Tuesday and Wednesday were far below normal and Saturday and Sunday far above normal.

The other example of probability occurs in the so-called "enforcement index" discussed in an earlier chapter. Here it is recognized that an increase in traffic volume on a given highway system will produce an increase in all accidents, but that this increase will be disproportionately large for two-vehicle collisions. In fact, the increase in this particular type of accident will be about equal to the square of the increase in volume. Conversely, a decrease in volume will bring about a decrease in two-vehicle collisions nearly equal to the square of the decrease in volume.

Thus, if traffic volume increases sharply from one year to another without a corresponding increase in highway capacity (road facilities), and if the mileage death rate remains the same, a real gain has been recorded for traffic safety. The increase in mileage would normally produce an even larger increase in two-vehicle collisions—but if the mileage death rate itself did not increase, then this increase in two-vehicle collisions did not occur. Hence, a gain for safety.

Statistical textbooks will provide an explanation of the term "standard deviation," which is too complex for discussion here, but which affords a technique for measuring the probable error of a sample. An average calculated from a number of observations can be determined as accurate within certain limits by this technique. The accuracy increases as the number of cases or observations increase. As a rule of thumb, it is safe to say that reliability should not be attached to a value determined on the basis of less than 30 cases—and many more cases are desirable.

Collecting Data

The problems of collecting traffic accident data in states and cities are well discussed in existing publications. The reader is referred to those listed at the end of Chapter II.

One statistical technique for collecting data economically has not been covered in any of these source materials, and it probably merits some mention here. This is sampling. This procedure assumes that it is possible to determine the pattern taken by a very large number of values by examining a representative portion of the total. Sampling has been widely used in measuring public opinion, and is equally applicable in many fields of traffic. For instance, sampling has frequently been resorted to in the determination of relative proportions of men and women licensed to drive. Instead of examining each of several million licenses issued by a state, the investigator examines every tenth or twentieth license and notes the sex of the license. Speed observations by traffic engineers are generally only samples of the total traffic operating over a given street or highway.

One of the factors affecting the accuracy of the sample is pure chance. The smaller the number of observations, the greater the chances that the values picked will give a false pattern. The magnitude of this chance error goes down as the square root of the number of items in the sample increases. That is, if the sample is 4 times as large, the error is reduced one-half, and if the sample is 9 times as large, the error is reduced two-thirds.

The method of sampling may affect the value of the sample. A public opinion poll, for instance, which questions only people with an income of $10,000 a year or more on their opinion of the proper rate for the federal income tax, would certainly not represent what the general public thought the rate should be. Nor would such a sample made in one particular area of the nation accurately reflect the opinion of people in all 48 states. A question on what people thought of the local police department obviously would not produce a valid answer if names of persons to be questioned were selected from the arrest file of the department. A transportation survey inquiring as to whether or not people drove their cars to work, with part of the questioning being done before gasoline rationing ended and the remainder after gasoline was available, would certainly be distorted.

The requirements for a representative sample can be summarized as follows: (1) The sample must be selected without bias; (2) the components of the sample must be completely independent of one another; (3) the sample must be truly representative of the whole area being studied; and (4) conditions must be the same for all items constituting the sample.

Sampling as a general procedure in the collection of traffic accident records might be satisfactory for collecting information on sex of driver, age of driver, time of accident, weather conditions, type of vehicle, etc. Sampling would not produce proper information, however, even if a truly representative sample could be secured, on specific items such as the locations at which accidents were occurring, or the particular drivers who were involved in accidents. The study of high-accident locations would be seriously handicapped if not rendered impossible, if only samples were available. Driver improvement programs which involve work with drivers who have had several accidents would likewise suffer, since a sampling of accidents might easily fail to bring to light drivers who have had two, three or even four accidents. The use of the sampling technique, therefore, does not appear to be applicable to the collection of general traffic accident statistics by a state or city accident records bureau.

Presentation of Data

The final job of the statistician is to present his findings in usable and understandable form. Statistics that accumulate in file drawers do no one any good. In no field is this more true than accident records, which can play such an important part in accident prevention program planning.

Data are usually presented in any of three ways—text, tables, or graphs.

Text—The problem of presenting statistical information in word form is chiefly one of simplicity. Every attempt should be made to confine a sentence to one idea. Keep the use of figures at a minimum and in round numbers as far as possible. For example: "Vehicle miles increased from 8,996,000,000 in 1945 to 9,012,000,000 in 1946, whereas injuries were reduced from 28,906 to 27,423 and deaths from 847 to 804," would be expressed better by the simple statement, "Deaths and injuries were reduced by more than 5 per cent, despite a slight increase in traffic volume."

The text affords an opportunity to summarize detailed tabular information, to comment upon the significance of certain figures, and to point out the general implications of the statistical work. The reader who then wants the background and the details can go to the tables for further information.

Tables—Detailed information can usually best be presented in tabular form. It is important to recognize, however, that tables scare many readers, and that for full effectiveness they must be as simple and easy to read as possible. A number of specific rules can be laid down which will help make tables attractive and understandable.

1. *Title*—Every table should have a title (and if necessary a sub-title) which clearly and completely identifies the material contained in the table. Titles should be as simple as possible, however, and should avoid being stodgy—avoid, for instance, the term "distribution."
2. *Arrangement*—The table should be arranged in a logical and orderly fashion. Numerical items should usually be in numerical order, and non-numerical items grouped in logical fashion. If the table compares data for more than two periods of time, these periods should be arranged in order from left to right or from top to bottom, with the most recent period last. If figures for the current period and a preceding period (a total of only two periods) are to be compared, however, the usual practice is to show the current period first with the preceding period either to the right or below. Totals should be in a logical place—generally at the beginning or the end of the table—and should be conspicuous, either set off by spacing or type face.
3. *Column Headings*—Column headings must be complete enough to identify accurately the figures appearing in the columns. There must not be any question, for instance, as to whether figures represent personal injury accidents or persons injured—whether they stand for accidents, or for drivers involved in accidents. If a column is headed

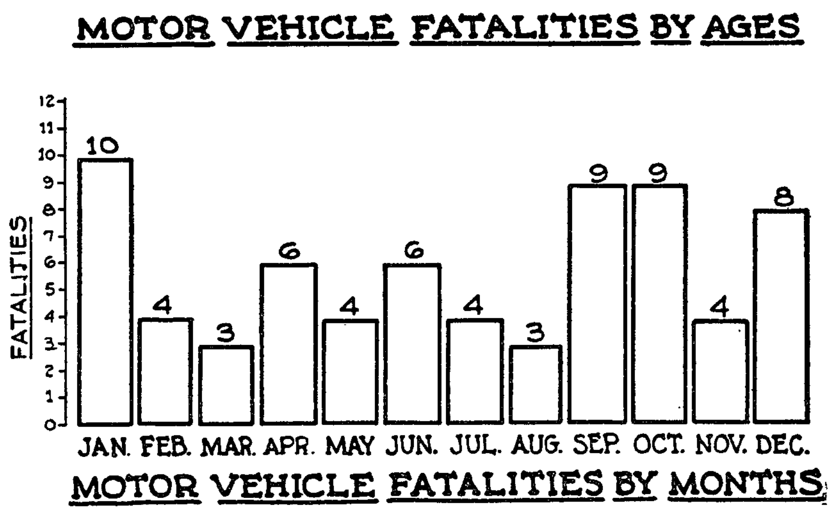
"Distance" the units used should be shown i. e., feet, miles, etc. Horizontal and vertical ruling should be used in the headings to clearly indicate the division and relationship between main headings and sub-headings.

4. *Ruling*—Ruling within the table itself, other than that in the heading, should usually be kept at a minimum, since too much ruling makes the table difficult to read. In general, vertical rules are not necessary between columns if they are properly aligned and spaced. Horizontal rules in the body of the table are also seldom necessary. If the number of horizontal lines in the table is very great, it is desirable to leave space at every fifth horizontal line to break the table into readable groups. This greatly assists the eye in following a horizontal line across the table. Proper vertical alignment of items within a column demands that the decimal points be lined up.
5. *Source Notes*—Every table should contain, either in the heading or in a source note, information as to the source, or sources, of the data used.
6. *Footnotes*—If items in the table need further explanation, a footnote should be used. If only one or two footnotes are required, a single asterisk and a double asterisk can be used satisfactorily. If many footnotes are required, a numerical or alphabetical system is usually best. Footnotes should be numbered in order, beginning at the upper left corner of the table and working from left to right across the first line, then from left to right and across the second line, and so through the table.

Graphical Presentation—Charts and graphs are particularly useful in presenting statistical material since they afford a visual impression easier for most people to understand than either text or tabular material. They are especially useful in illlustrating trends or making comparisons.

In constructing a chart or graph, it is important to define clearly the purpose which it is to serve. Some charts, particularly those used by engineers and scientists, are used primarily for reference and are very detailed, with fine lines, many background lines, and complete scales. Other charts may have some reference value, but also attempt to convey an idea or impression of a trend or of comparative values. Still other charts have little or no reference value and are designed primarily to convey a simple idea. Most charts used in accident records work are of the latter two types, and, therefore, should be less detailed and much simpler than purely reference charts.

1. *Bar Charts*—Bar charts consist of a series of vertical or horizontal bars, the length of each bar being in proportion to the magnitude of the value which it represents. They are particularly useful in comparing totals for several periods of time, or for comparing proportions of which components represent a total. A typical bar chart is shown in Figure 55. A special kind of bar chart uses bars which are divided to indicate the various components which go into the total represented by the overall length of the bar. Thus, a bar chart might be constructed comparing motor vehicle traffic deaths for two years. The total length of each bar

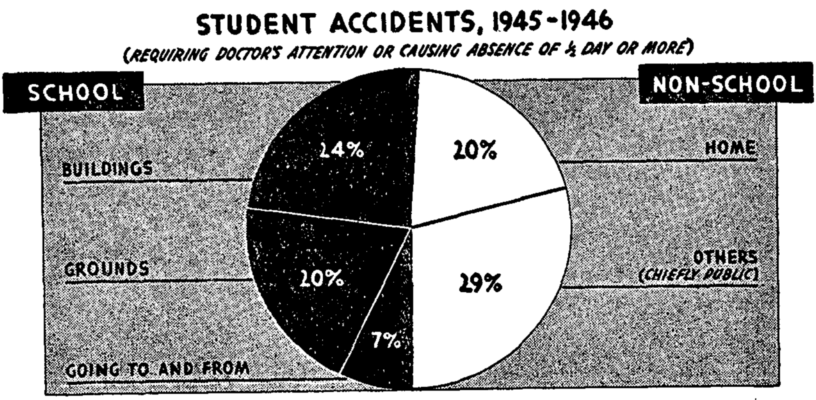


Courtesy of Milwaukee Safety Commission.

FIGURE 55—Example of Use of Bar Chart in Presenting Motor Vehicle Fatalities by Months.

would represent total motor vehicle deaths in each year, but a portion of each bar would be solid to indicate deaths occurring during hours of darkness, and the remainder of each bar would be white to indicate deaths occurring during daylight hours. Each section of the bar would be proportional to the darkness and daylight deaths in the given year. Occasionally it is not possible, due to space limitations, to carry the scale all the way to zero. In this case, bars should be broken near the base to indicate that the scale is not continuous. In any case, each bar chart should contain a complete title, a legend clearly identifying the significance of symbols used, totals indicating the values at the end of the bars, and adequate source notes.

2. *Pie Charts*—More frequently used are circular charts, cut like sections of a pie, with each section proportional to the value which it represents. These are useful in showing the distribution of a total into its component parts (i.e., how total motor vehicle traffic accidents were distributed between the various classifications of two motor vehicle, pedestrian, bicycle, etc.) A typical *pie chart* is illustrated in Figure 56. Title, legend, totals, and source should be complete on any pie chart.



From: "Accident Facts," 1946, National Safety Council.

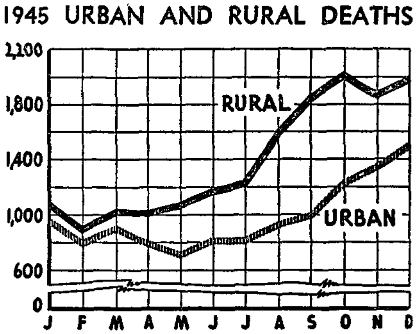
FIGURE 56—Example of Pie Chart in Traffic Accident Recapitulation.

3. *Line Charts*—A third type of chart, perhaps more frequently used than either of the other two, is a *line chart.* This chart is used chiefly in illustrating a time series, although it is also commonly used in illustrating relationship between two variables. It consists of a horizontal axis and a vertical axis, with one scaled for one variable and the other scaled for the second variable. The "independent" variable should ordinarily be plotted on the horizontal axis, with the "dependent" variable (the variable which changes due to a change in the "independent" variable) plotted on the vertical axis. Thus, in a time series, time is always plotted on the horizontal axis, and the other factor, which changes in relation to time, on the vertical axis. Points determining the line are located by scaling on the horizontal axis to the proper value for that variable and then moving vertically a distance determined by the scale on the vertical axis. This determines one point on the "curve" or line. When all points have been located, they are connected and the result is a line chart.

   Line charts should be used only in cases of a "continuous series." In other words, there should be a continuity of the independent variable, such as is present in the case of time, speed, or similar items. It would be improper to attempt to construct a line chart, for instance, which would show deaths by counties. There is no continuity here, and the proper graphical representation would be a bar chart or a map (discussed later).

   For most accident record purposes, line charts should be simple, with few background lines and with adequate but simple scales. As few curves as possible, sometimes called "trend" lines, should be put on one chart. One such line is usually best, although for comparisons under certain circumstances it may be desirable to plot two, three or even four.

   If the lines overlap, however, then two become a practical maximum. As in the case of bar charts, the scales should go to zero, at least for the dependent variable. If it is impossible to carry the scale to zero, then the chart should be broken to indicate this fact. This technique is

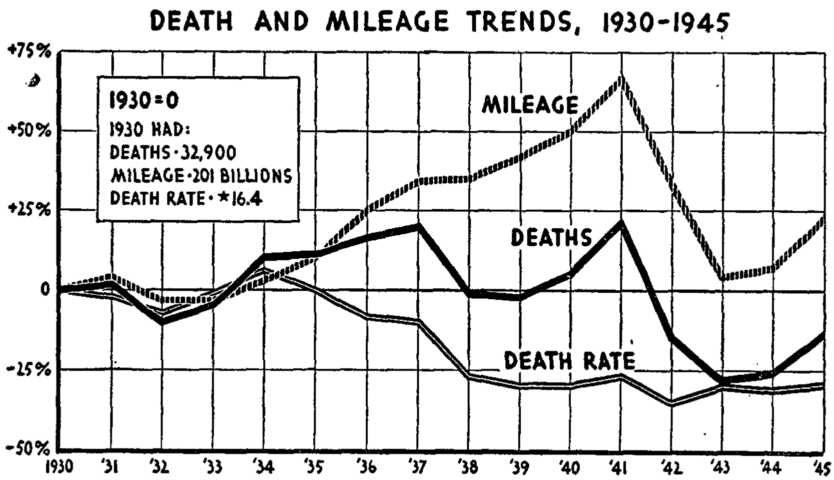


From: "Accident Facts," 1946, National Safety Council.

FIGURE 57—Example of "Broken Scale" in Development of Line Chart.

illustrated in the chart shown as Figure 57.

An exception to this rule about carrying scales to zero occurs when index numbers are being plotted. In this case, it is often desirable to show the "100" line as zero, with index numbers above 100 as percentage increases above the base and index numbers less than 100 as percentage decreases, as demonstrated in Figure 58.

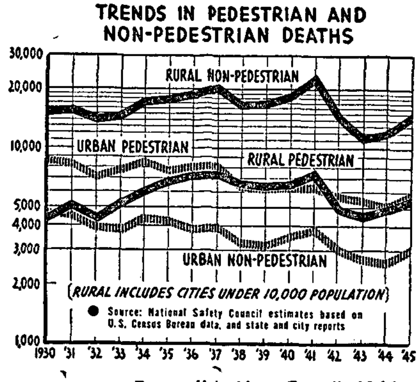


From: "Accident Facts," 1946, National Safety Council.

FIGURE 58—Illustration of Method for Showing Percentage Increases and Decreases With Relation to a Base Year.

Multiple scales on one axis are generally not desirable. Frequently it is desirable to adopt a logarithmic scale for one or both axes. When such a scale is used on one axis only the chart is said to be "semi-logarithmic." The chart shown in Figure 59 illustrates this procedure. When a logarithmic scale is used, it is not possible to carry the scale to zero since the same vertical distance always represents the same percentage change at whatever point in the scale it occurs.

4. *Pictorial Charts* – Effective use can frequently be made of pictorial charts which are easily understood and, therefore, readily accepted by the average reader. These are infinite in variety.

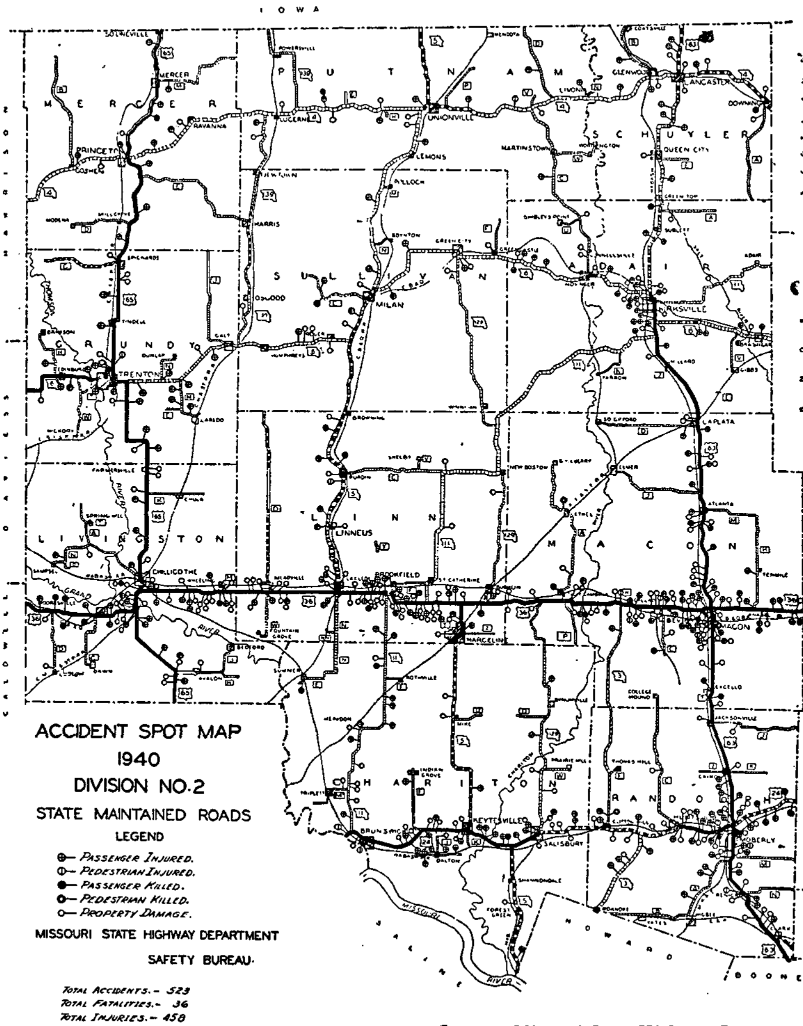


From: "Accident Facts," 1946, National Safety Council.

FIGURE 59—Example of Utilization of Semi-Logarithmic Scale in Line Charts.

Spot Maps—A special method of data organization and presentation is found in the use of spot maps. These are maps of geographic areas with pins, spots or other visual indications of events—motor vehicle traffic accidents, arrests, etc. The colors and/or different shapes of the visual indications denote the types, severity, or frequency of the accidents, or other events, while the spot or pins show the approximate locations of the accidents. Time is shown by keeping different maps for different periods of time. These time periods may be by hours of the day, days of the week, months of the year, seasons of the year or by the year itself. Spot maps are discussed in detail in several references which are listed at the end of this chapter and at the end of Chapter II.

A base map plotted on the scale of "one inch equals one mile" is most popular for state spot maps. Generally, a larger scale for city maps is more convenient and a scale of from 400 to 600 feet to the inch is recommended. Congested areas should be separated and shown in a scale enlarged two or three times so as to allow sufficient space for the accumulation of pins. Smaller or larger scales may better fit special cases and the most convenient scale will be found by experiment. A spot map for a rural area is shown in Figure 60.



Courtesy Missouri State Highway Department.

FIGURE 60—Typical Rural Highway Spot Map Showing Locations of Common Types of Accidents.

Care must be taken to avoid confusion resulting from too many symbols and colors. Reproduction of the map is often desirable.

Permanent records are made of spot maps by photography. These photos are not taken only at the end of the designated period, but at regular intervals as the pins accumulate so as to show the growth of the map by comparing one picture with another.

Spot maps differ as the use for which they are designed differs. Some of the more common items shown on spot maps are listed below; some are of interest to several agencies while others are designed for only one specific use.

1. Accident locations and type—pedestrians, vehicle vs. vehicle, vehicle vs. fixed object, vehicle non-collision, etc.

2. Severity—pedestrian death or injury, vehicle operator death or injury, passenger death or injury, bicycle death or injury, property damage.

3. Residence of principals in accidents—pedestrians, motor vehicle operators.

4. Place of employment or occupation—pedestrian, motor vehicle operator.

5. Age—pedestrian, motor vehicle operator.

6. Race—pedestrian, motor vehicle operator.

7. Violation—place, pedestrian violation, operator violation.

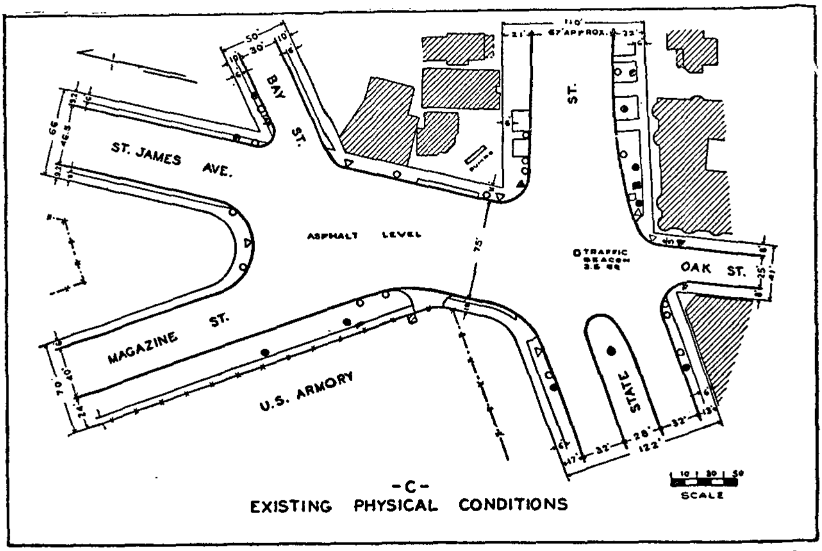
8. Location of accidents investigated.

9. Locations of violations and arrests.

10. Time differences— day, night, day of week, season of year, months.

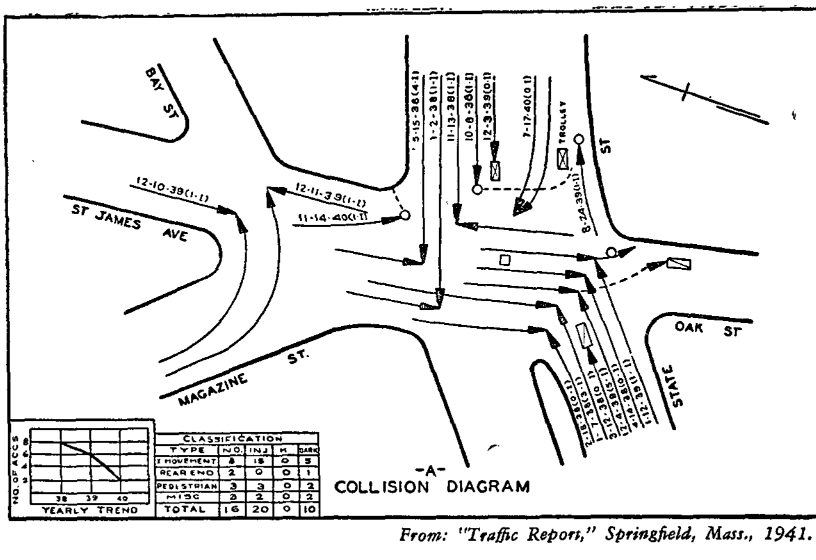
11. Weather—rain, snow, ice, sleet, clear, fog.

Collision Diagrams—Collision diagrams are schematic diagrams of a highway location on which symbols indicate colli-



From: "Traffic Report," Springfield, Mass., 1941.

FIGURE 61—Accident Collision Diagram.



CLASSIFICATION				
TYPE	NO.	INJ	K	DARK
X MOVEMENT	8	15	0	5
REAR END	2	0	0	1
PEDESTRIAN	3	3	0	2
MISC	3	2	0	2
TOTAL	16	20	0	10

From: "Traffic Report," Springfield, Mass., 1941.

FIGURE 62—Condition Diagram for Accident Study.

sions which have occurred and the manner of collision. For example, a collision diagram of an intersection will show all the accidents reported, or only those for a given period, plotted on the plan of the intersection, indicating direction of travel of vehicles and pedestrians, and points of collision as well as time, date, weather, and type of accident. A pattern of recurrent accident factors will sometimes suggest remedies. Collision diagrams (Figure 61) are chiefly an engineering technique, and their construction and use, together with Condition Diagrams (Figure 62), (scale drawings of the location), are adequately covered in existing publications, some of which are listed at the end of this chapter.

REFERENCES ON ACCIDENT ANALYSIS METHODS

1. Any good textbook of high school or college algebra.

2. Annual and Special Accident Summaries of States and Cities.

3. National Conservation Bureau. *Manual of Traffic Engineering Studies*, New York. The Bureau, 1945. The appendices provide a quick survey of statistical methods, including some material on "standard deviation."

4. Arkin, Herbert, and Colton, R. R., *An Outline of Statistical Methods*, 4th ed. New York, Barnes and Noble. One of the "College Outline Series," this volume reviews the field of statistics in handbook form, omitting theory and derivation of formulae. Several typographical errors make careful study necessary.

5. Mills, F. C. *Statistical Methods*, revised, New York, Henry Holt & Company, 1938. One of the standard statistical texts, containing much of the theory of statistics.

6. Fisher, R. A., *Statistical Methods for Research Workers*, 4th ed. London, Oliver and Boyd, 1938. Standard methods of statistical analysis designed for those not trained in advanced statistical techniques.

7. Ezekiel, Mordecai, *Methods of Correlation Analysis*, New York, John Wiley & Sons, 1930. A standard work on correlation.

8. Davies, G. R. and Yoder, Dale, *Business Statistics*, 2nd Ed., New York, John Wiley & Sons, 1941. A general treatment of the statistical method as applied to the business world.

9. Hall, Marguerite, F., *Public Health Statistics*, New York, Paul B. Hoeber, Inc. 1942. The Statistical method as applied to vital statistics work.

10. Modley, Rudolf, *How to Use Pictorial Statistics*, New York, Harper and Bros., 1937. A good discussion of the use of charts and graphs.

11. Brinton, W. C., *Graphic Presentation*, New York, Brinton Associates, 1939. Another valuable work on charts and graphs.

12. National Safety Council. *Accident Facts*, The Council, Chicago, published annually. Illustrative material on presentation and interpretation of statistics.

13. DeSilva, H. R., *Why We Have Automobile Accidents*, New York, John Wiley & Sons, 1942. Illustrative material on presentation and interpretation of statistics.

14. American Transit Association, *Collision Accident Diagrams, A Manual on the Use of Diagrams in Analyzing Collision Accidents.* New York, N. Y., The Association, 1940. Diagrams of collision accidents, lineal symbols and techniques of analysis of transit accidents.

15. Oregon State Highway Department, Traffic Engineering Div., *Motor Vehicle Accident Analysis Coding Manual.* Salem, Oregon. The Department, n.d. Instructions for the preliminary classification and coding of accidents for transfer to punch cards.

16. Neal, Harry E., *Preparing Accident Summaries by Mechanical Tabulation.* Traffic Engineering 11, no. 2:25-28, June, 1940, New Haven, Connecticut. Institute of Traffic Engineers, Strathcona Hall. Description of the method of mechanical tabulation used in Ohio and some other states. The method was originally designed and recommended by the National Safety Council.