Statistical Evaluation of Traffic Accident Severity

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This paper is an attempt to create a scale of numerical values to be applied to traffic accidents, assigning a number to each accident consistent with the severity of the property damage or human injury involved.

A scale is set up which is based upon monetary damage values and American Standard injury classifications currently used in industrial injury study.

The scale was applied to 1,253 accidents at the Lincoln Tunnel during 1953, 1954, and 1955. Accident severity is compared on a monthly, daily, and hourly basis with accident frequency, accident rate and vehicular volume to determine the relationship of severity to other variables. Severity is compared with accident rate on the basis of weather, road, and light conditions.

The results are the following:

1. Severity as a monthly, daily, or hourly pattern does not in general follow the movements of accident frequency or accident rate.
2. Severity of accidents increases with a decrease of natural light.
3. Severity increases with poor road conditions and also with bad weather.

THE EXTENT to which severity is considered in studying traffic accident statistics at present is to classify accidents as property damage, personal injury, or fatal. No one will argue that locations, or times of day, week or year, in which fatalities have been prevalent should not be the first to receive consideration as to remedial and preventive measures. It also seems logical to turn the attention to areas with high frequencies of injury accidents. But the location with a great proportion of extremely disabling injuries is put, by this system, on a completely equal footing with the area commonly producing many minor bumps and bruises.

Fatality rates are, of course, useful as a measure of severity. However, at locations with few or no fatal accidents each year they are meaningless, in which case the number or rate of personal injury accidents becomes the yardstick of severity. The range in this classification, as in the classification of property damage, makes them rather crude.

In this paper an attempt is made to develop a numerical rating system, to be applied to individual traffic accidents, with the purpose of obtaining a more realistic picture of severity and, thereby, hazard or risk. It is felt that the true measure of risk at a location involves more than simply chance or risk of occurrence; it should give an indication of the hazard of degree of damage or injury. However, the concept of a severity-frequency "index" or "ratio" is beyond the scope of the present paper.

The basis of this approach is the assumption that the reporting of both injury and property damage is at a reasonably high level of accuracy. Otherwise there is no benefit in using anything other than the commonly accepted three classifications.

It was found, at least for the facility studied here, that a graph of the numbers of personal injury accidents is very similar to that of accident frequency; and that plotting either the proportion of personal injury accidents to the total number, or the rate of personal injury accidents on a volume basis, gives a picture which seems to lie somewhere between the accident frequency graph and the graph of severity values presented here.

SEVERITY SCALE

The first assumption made in creating a numerical scale was that while the relative position of accidents on the scale is all-important, the actual numbers assigned need have no relation to the true cost or effect of the accident, as long as the purpose in mind is merely comparison. The number need only separate the accident from other less or more severe accidents. With this in mind, a numerical range of 0 to 1,000 was set arbitrarily, with the upper limit equated to a fatality.

The next essential was to delimit the damage and injury classifications. In the field of industrial accident study, methods are already in use for evaluating injury. The source for the injury classifications used in this paper is, therefore, the "American Standard Method of Recording and Measuring Work Injury Experience," (American Standard Z 16. 1-1954, American Standards Association), now used in industrial accident study. With some modifications and additions, the classifications and their relative positions used in the scale are as follows:

Death is any fatality resulting from a traffic accident injury regardless of the time intervening between injury and death.

Permanent Total Disability is any injury other than death which permanently and totally incapacitates a person from following any gainful occupation, or which results in the loss of or complete loss of use of any of the following in one accident:

1. Both eyes;
2. One eye and one hand, or arm, or leg, or foot; and
3. Any two of the following not on the same limb: hand, arm, foot, or leg.

Permanent Partial Disability is any injury other than death or permanent total disability which results in the complete loss of use of any member or part of a member of the body, or any impairment of the functions of the body or part thereof, regardless of any pre-existing disability of the injured member or impaired body function.

The following injuries are not classified as permanent partial disability:

1. Loss of fingernails or toenails;
2. Loss of tip of finger without bone involvement;
3. Loss of teeth;
4. Disfigurement;
5. Strains or sprains which do not cause permanent limitation of motion; and
6. Simple fractures to the fingers and toes; also such other fractures as do not result in permanent impairment or the restriction of normal function of the injured member.

Temporary Total Disability is any injury which does not result in death or permanent impairment, but which renders the injured person unable to perform his regular employment activity on any one or more days subsequent to the date of injury.

Medical Treatment Injury is an injury which does not result in death, permanent impairment, or temporary total disability, but which requires medical treatment (including first aid).

Negligible Injury is an injury which raises no doubt in the mind of either the person injured or a witnessing officer as to its lacking the severity to require medical treatment, and includes the following:

1. Bruises, bumps and slight blows;
2. Contusions;
3. Slight sprains and strains; and
4. "Shaking up" (minor shock).

In order to break down injury classifications from the general to the more specific injuries sustained, recourse was had to a schedule of payment allowances of a medical-surgical payment plan. The costs and periods of hospital care assigned to different injury treatments were taken as indicative of the relative severity of each condition.

As to property damage accidents, the amount of damage in terms of estimated monetary cost of repairs provides a convenient scale. At the point at which the property damage grouping merges with that of injury, it was decided that the upper limit of property damage should coincide with a lower level of personal injury. While it is difficult to accept any level of property damage severity as equivalent to even the slightest personal injury, at the level of damage where a vehicle is totally or almost totally demolished it seems reasonable to assume that the lack of injury in such a case is due almost entirely to chance.

The complete scale evolved is given below:

CLASSIFICATION		VALUE
Death		1000
Permanent Total Disability		800 - 975
Loss both eyes		975
Loss one eye and one hand, arm, leg, or foot		900 - 975
Loss two hands, arms, feet, legs		800 - 900
Permanent Partial Disability		600 - 800
Loss one eye		775
Loss one arm above elbow		750
Loss one leg above knee		750
Loss one arm below elbow		700
Loss one leg below knee		650
Loss one foot, hand		625
Strains, sprains, fractures with permanent impairment		600 - 625
Temporary Total Disability		400 - 600
Fractures: compound		550 - 600
simple		500 - 550
Rank:	Thigh	
	Lower leg	
	Forearm and upper arm	
	Vertebra	
	Neck	
	Lower jaw	
	Pelvis	
	Collarbone	
	Finger, toe	
	Nose	
Dislocations		450 - 500
Rank:	Hip	
	Shoulder	
	Ankle	
	Jaw	
Cuts, shock, etc., within this classification		400 - 450
Medical Treatment Injury		300 - 400
Cuts, bruises, shock, blows examined and diagnosed by doctor		
Negligible Injury		200 - 300
Slight bumps, bruises ignored by injured		
Property Damage $2,000 to $3,000		200 - 300
Property Damage $10 to $2,000		1 - 200

BASIC DATA AND METHOD

The records used in this report were accident records of the Port of New York Authority for the Lincoln Tunnel, covering the three years 1953, 1954 and 1955.

Each record was reviewed individually, a numerical value assigned to it consistent with the severity scale previously described, and the following additional data were taken: hour of day, day of week, month, light condition (daylight, semidark, dark—street lights on, artificial—in tunnel), weather (clear, overcast, fog, rain, snow or sleet), and road condition (dry, wet, snowy, icy).

It is believed that inaccuracy in the original data used is as close to a minimum as is possible in accident reporting. The nature of a facility such as the Lincoln Tunnel does not permit parties to an accident to escape notice by a police officer. Any incident, however minor, which causes a driver to stop his vehicle will bring an officer to investigate.

The accuracy of estimating damage incurred can be questioned, and is potentially the most inaccurate part of the reporting procedure. Comparison, however, of original estimated damage to Port Authority vehicles involved in accidents, with the actual cost of repair, has shown a reasonable level of accuracy.

The reporting of personal injury may also be questioned. However, the arrangements at Port Authority facilities are such that only those injured persons who specifically refuse to be examined by a physician do not have their injuries diagnosed professionally.

It was decided that the severity of an accident is a function of the speed of impact, angle of collision, and type of accident. The number of persons in a vehicle, or the number of vehicles involved, serve only to distort the true level of severity of that specific type of accident. For this reason the severity value assigned to an accident is that of the greatest damage done to a single vehicle or the highest degree of injury to a single person.

The final decision made was in selecting a representative severity value. Because of the equal weight given each severity value for accidents occurring in an hour, day or month, it was considered reasonable to use the arithmetic mean of all values. The mean severity is the index used in this study.

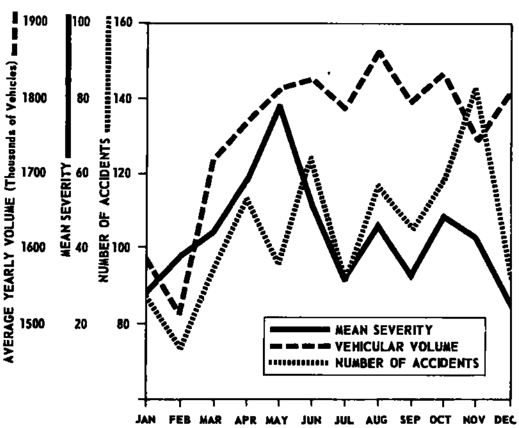

Figure 1. Severity, volume and accident frequency by month.

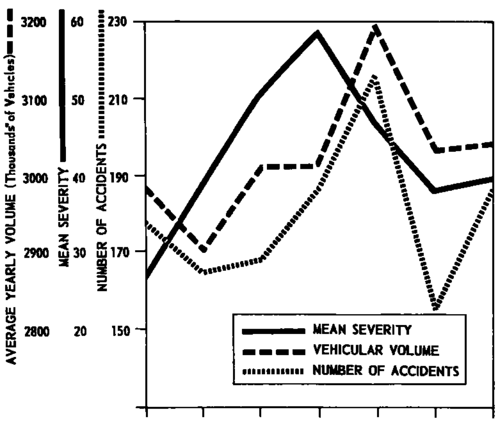

Figure 2. Severity, volume and accident frequency by day of week.

APPLICATIONS

The applications of the scale which were chosen as illustrations are comparisons of mean severity with vehicular volume, accident frequency, and accident rate by month, day, and hour. The hazard rating of accident severity is then compared with that of accident rate for different light, road and weather conditions.

Monthly Variation

In order to arrive at as accurate a monthly, or seasonal, pattern of accident severity as possible, severity values for the three years studied were combined. These values are plotted in Figure 1 together with number of accidents and vehicular volume. Since it was found that accident rate parallels the movements of number of accidents for this particular sample, it is not plotted here.

Figure 1 shows severity to have its peak in the spring, while the greatest number of accidents occurs in the winter

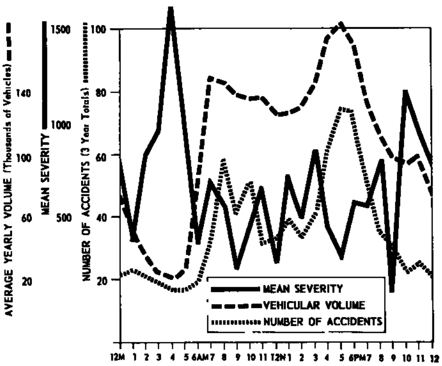

Figure 3. Severity, volume and accident frequency by hour of day.

months. In this case severity follows the rise in volume from February to April, while accident frequency falls off from March to April. The rise in frequency in October and November during the falling off in volume is not reflected by severity.

Daily Variation

Again, values for the three years were combined, and are shown in Figure 2 compared to volume and accident frequency. Accident frequency follows volume, rising to a peak on Friday, while severity has its peak on Thursday, falling with the additional volume occurring on Friday.

Hourly Variation

Figure 3 compares hourly severity values with volume and accident rate. Severity has its peak during the early morning hours, reflecting the rise in accident rate. Number of accidents is low during this period, following the pattern of volume.

Between 5 a. m. and 3 p. m. , severity fluctuates in a manner similar to accident frequency. During the 3 p. m. to 7 p. m. peak volume period, however, accident frequency and accident rate follow this rise while severity falls to a low point.

Variation of Severity with Light Condition

Figure 4 shows the rise in the severity level from daylight through artificial (in tunnel) light conditions. Accident rate, however, indicates semidark, dark and artificial as less hazardous than daylight.

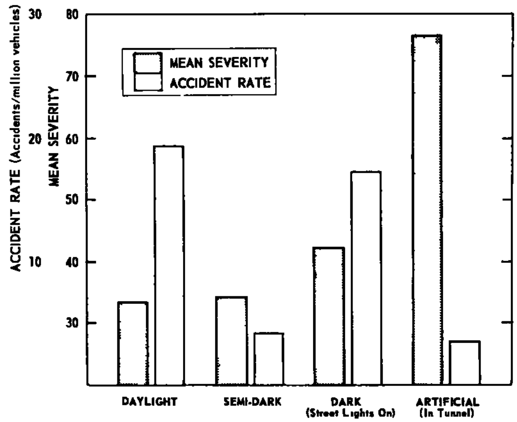

Figure 4. Severity and accident rate by light condition.

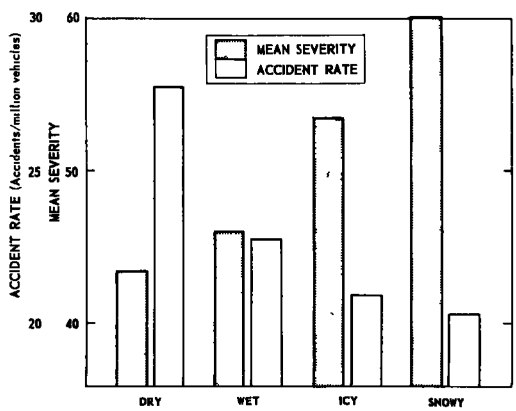

Figure 5. Severity and accident rate by road condition.

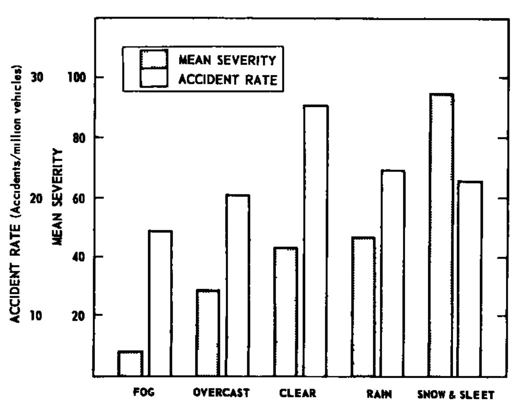

Figure 6. Severity and accident rate by weather condition.

in fact, it gives the in-tunnel condition the best rating, while on the basis of severity it has the worst.

Variations with Road Conditions

Figure 5 gives the rise in severity from dry to wet to icy to snowy. Accident rate gives a completely opposite hazard rating, rising from snowy to icy to wet to dry.

Variation with Weather Condition

Figure 6 has severity rising from fog to overcast to clear to rain to snow or sleet. Accident rate gives clear as most hazardous, followed by rain, snow or sleet, overcast, and fog, in that order.

CONCLUSIONS

For the period and facility considered in this paper, the following conclusions may be drawn:

1. The monthly pattern of severity does not reflect that of accident frequency. The peak in severity occurs in the spring months; that of frequency in the winter months.
2. Severity rises to a peak on Thursdays, falling toward Sunday. The accident rate peak occurs on Fridays.
3. The hourly pattern of severity indicates a peak in the early morning hours 2 a.m. to 6 a.m. Severity follows the movement of volume and accident rate thereafter, until the evening volume and number of accidents peak period, 3 p.m. to 8 p.m. During this time severity shows a depression, falling from 3 p.m. until 5 p.m. and rising until 8 p.m.
4. Severity of accidents increases with decrease of natural light until its maximum, within the tunnel. Accident rate for these same conditions ascribes greater hazard to daylight.
5. Severity increases with poor road conditions, snowy being rated most hazardous. Accident rate gives its lowest hazard rating to snowy, increasing to a maximum for dry.
6. Severity increases with bad weather. As to possibility of occurrence, however, accident rate shows clear weather to be most hazardous.

RECOMMENDATIONS

No doubt there is a great deal of room for improvement in the details of the method outlined here, but a perfected index combining severity and frequency should be of use in directing engineering and enforcement activities to those times and locations which merit priority of attention.

The combining of these two variables seems a logical next step, with possible application of statistical quality-control methods.