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# POLICE SCIENCE

## SINGLE-VEHICLE ACCIDENTS ON ROUTE 66

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The study here reported was one part of Operation 66 Joint Engineering Enforcement Project conducted in the summer of 1964 by the Office of Highway Safety, U. S. Bureau of Public Roads, and the seven states on the major road between Chicago and Los Angeles. Information about single-vehicle accidents on a major highway was gathered in greater detail than ever before.

For this purpose, the highway patrols of the seven states used a special form to supplement each state's official accident report. The two-page, 8½- x 11-inch form contained 27 schedules. Most of the schedules listed several items. (See tables 1 and 2.) A copy of the official highway patrol report for each accident was also obtained.

Qualifying accidents outside of incorporated places between San Bernardino, California, and Joliet, Illinois, were reported. Most of the route was in sections of Interstate Routes 15, 40, 44, and 55. The remainder was in U. S. Highway 66 (figure 1). Accident data were collected between June 1 and October 31, 1964. At intervals of approximately 150 miles, traffic volumes by hour and type of vehicle were counted on one or more week days.

Except for completing the supplementary

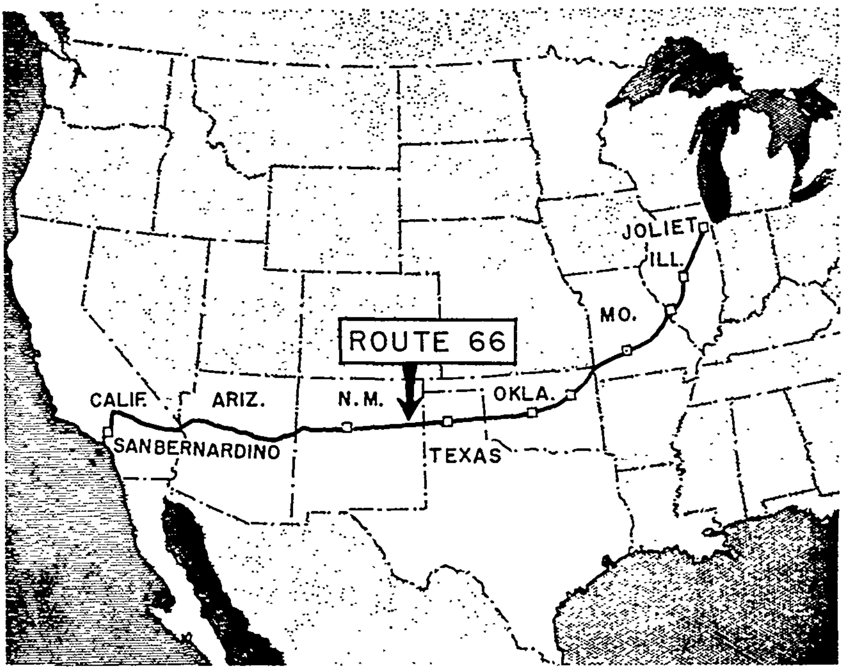



FIGURE 1

TABLE 1

OPERATION 66
JOINT ENGINEERING ENFORCEMENT PROJECT

| | |
|---|---|
| ON | Street or road |
| AT | Junction with a distance from |
| IN | Town or village / County / State |
| HOUR m | DATE / MONTH / 196 |
| ACCIDENT NO. | REPORT BY |
| APPROVED BY | DATE / MONTH |

A. TYPE OF ACCIDENT — Mark which one.

1 ☐ Ran off road (Road includes shoulder.)
2 ☐ Overturned on road without hitting anything.
3 ☐ Collision on road with parked motor vehicle.
4 ☐ Collision on road with fixed object.

B OPERATIONAL FAILURE - Mark which one.

1 ☐ Left pavement area intended for traffic.
2 ☐ Hit stationary obstacle while on pavement.
3 ☐ Overturned while on pavement traffic area.

C. SEQUENCE OF EVENTS — Show event number in appropriate column. Mark boxes in columns to indicate circumstances of events. Circle event causing major damage or injury. See instructions.

Event No.

a. ON PAVEMENT
1 Turned over
2 Hit curb
3 Hit guardrail
4 Hit parked car
5 Hit barricade
6 Hit overhead
9
8
9 Stopped on pavement
10 Left pavement
ALSO
1 Right
2 Left
1 Going straight
2 Skidding straight
3 Sideslip right
4 Sideslip left

Event No.

b. ON SHOULDER
1 Turned over
2 Hit curb
3 Hit guardrail
4 Hit pole
5 Hit tree
6 Hit hole or soft spot
7
8
9 Stopped on shoulder
10 Left shoulder
ALSO
1 Right
2 Left
1 Going straight
2 Skidding straight
3 Sideslip right
4 Sideslipped left

c. ON ROADSIDE
1 Turned over
2 Hit bank
3 Hit wall
4 Hit fence
5 Hit pole
6 Hit tree
7 Hit soft spot
8
9 Stopped on roadside
10
ALSO
1 Right
2 Left
1 Going straight
2 Skidding straight
3 Sideslip right
4 Sideslip left

d. EFFECT OF HIT
1 Marked
2 Scraped
3 Dented
4 Torn
5 Broken
6 Failed to hold

e. SIDESLIP ANGLE TO LINE OF MOTION
0 No rotation
1 45° ↗ or ↖
2 90° → or ←
3 135° ↘ or ↙
4 180° ↓ or ↓
5 225° ↙ or ↘
6 270° ← or →
7 315° ↖ or ↗
8 360° ↑ or ↑
9 More

D. FINAL POSITION (In feet)

| | | 1 | 2 |
|---|---|---|---|
| | What points on vehicle | | |
| 1 | Distance from zero or key point | | |
| 2 | Distance from pavement edge On / Off | | |

E. STOPPED IN CONTACT WITH OBJECT HIT 1 No ☐ 2 ☐ Yes

F. LOCATION OF OBJECTS HIT —

| Kind of object | Damage | Distances in feet Zero | Off |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

G. OCCUPANTS AND SEAT BELTS — Mark at least first 6 columns.

| | | Dr. | F C | F R | R L | R C | R R | Other | |
|---|---|---|---|---|---|---|---|---|---|
| a. No such seat | | | | | | | | | |
| No occupant | | | | | | | | | |
| b. Sex | | | | | | | | | |
| c. Age | | | | | | | | | |
| d Ejected | | | | | | | | | |
| e. Injury code | | | | | | | | | |
| f. Belt? | 0 None | | | | | | | | |
| | 1 Unfast'nd | | | | | | | | |
| | 2 Loose | | | | | | | | |
| | 3 Snug | | | | | | | | |
| g. Broke? | 0 No | | | | | | | | |
| | 1 Webbing | | | | | | | | |
| | 2 Buckle | | | | | | | | |
| | 3 Anchor | | | | | | | | |

H. AFTER-ACCIDENT CONDITION OF INFORMANT

| | Driver | Pas'nger |
|---|---|---|
| 1 Dead before interview possible | | |
| 2 No memory of events of accident | | |
| 3 Injured and confused | | |
| 4 Injured but no confused | | |
| 5 Confused or hysterical but uninjured | | |
| 5 Apparently normal | | |
| 1 Hours unconscious after accident | | |
| 2 Hours before able to talk about accident | | |
| 3 When interviewed — hours after accident | | |

I. SPEED LIMITS AND SIGN DISTANCES

| | M. P. H. | Ft. or Mi. |
|---|---|---|
| 1 General limit applicable to road | | |
| 2 Zoned limit, if any | | |
| 3 Advisory limit, if any | | |
| 4 Conditions requiring reduced speed | | |

J. ESTIMATES OF SPEEDS AND DISTANCES

| | | Max. | B.E. | Min. |
|---|---|---|---|---|
| a. Approach speed | 1 Driver | | | |
| | 2 Passenger | | | |
| | 3 Other | | | |
| | 4 Investigator | | | |
| b. Key-point speed | 1 Driver | | | |
| | 2 Passenger | | | |
| | 3 Other | | | |
| | 4 Investigator | | | |
| c. Distance from discovery to key point | 1 Driver | | | |
| | 2 Passenger | | | |
| | 3 Other | | | |
| | 4 Investigator | | | |
| d. Key to final pos. | Investigator | | | |

OPINION CODE — For marking all hexagons

Y = Yes N = No P = Possibly 0 = Do not know
R = Refuses to say U = Unavailable for response

K. NONCONTACT VEHICLE

| | | Drv. | Pas. | Inv. |
|---|---|---|---|---|
| a. Vehicle entirely alone on the road | | | | |
| b. Other vehicle near by but not involved | | | | |
| c. Other vehicle encroaches | 1 Vehicle approaching and turning | | | |
| | 2 Vehicle crossing or entering | | | |
| | 3 Changing lanes | | | |
| | 4 Slowing in lane | | | |
| | 6 Other | | | |
| d. Subject vehicle affected | 1 Blinded by lights | | | |
| | 2 Misunderstood intentions | | | |
| | 3 Returning to lane, approaching car | | | |
| | 4 Returning to lane, after overtaking | | | |
| | 5 Other | | | |

TABLE 2

L. OPINION OF SPEED AND PERCEPTION — Driv. Pas. Inv.

1 Would accident happen had speed been 1/6 less?
2 Could driver have perceived situation sooner?

M. WHAT WAS DRIVER TRYING TO DO?

| | | Driv. | Pas. | Inv. |
|---|---|---|---|---|
| Before operational failure | 1 Nothing but follow path on pavement | | | |
| | 2 Avoid hitting other veh., ped., etc. | | | |
| | 3 Avoid stationary object in path | | | |
| | 4 Exit on ramp or at angle | | | |
| | 5 Turn at crossroad or driveway | | | |
| | 5 Change lanes | | | |
| | 6 Attend to something in vehicle | | | |
| | 7 Other | | | |
| Evasive tactic | 8 Applied brakes before key event — a. ☐ heavy b. ☐ light | | | |
| | 9 Steered right or left before key event — a. ☐ little b. ☐ much | | | |

N CONTRIBUTING FACTORS

| | | Driv. | Pas. | Inv. |
|---|---|---|---|---|
| a. Road factors | 1 Confused by road situation or signs | | | |
| | 2 Unexpected road surface conditions | | | |
| | 3 Other | | | |
| b. Driver factors | 1 Driver asleep or dozed | | | |
| | 2 Alcohol or drugs | | | |
| | 3 Illness | | | |
| | 4 Distraction | | | |
| | 5 Others | | | |
| c. Vehicle factors | 1 Brake failure | | | |
| | 2 Steering gear failure | | | |
| | 3 Light failure | | | |
| | 4 Tire failure | | | |
| | 5 Other | | | |

O. SUICIDE OR ATTEMPTED SUICIDE?

P. HOW WOULD DRIVER AVOID SIMILAR ACCIDENT?

1 Driver's opinion

2 Investigator's opinion

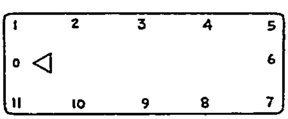
Q. KIND OF VEHICLE — Mark passenger or cargo and trailer.

| a. Passenger veh. | b. Cargo veh. | c. Trailers | |
|---|---|---|---|
| 1 ☐ Standard | 1 ☐ Tractor | 1 ☐ None | 8 ☐ Semi |
| 2 ☐ Compact | 2 ☐ Machinery | 2 ☐ House | 9 ☐ Full |
| 3 ☐ Small | 3 ☐ Freight | 3 ☐ Boat | 10 Axles |
| 4 ☐ Sport | 4 ☐ Empty | 4 ☐ Machy | |
| 5 ☐ Bus | 5 ☐ Loaded | 5 ☐ Cargo | 11 Tires |
| 6 ☐ Motorcycle | 6 No. axles | 6 ☐ Empty | |
| 7 ☐ Other | 7 No. tires | 7 ☐ Loaded | |

R. EXTENT OF DAMAGE TO VEHICLE

| a. Drivable | b. Had to be towed | c. ☐ Fire |
|---|---|---|
| 1 ☐ None | 1 ☐ Briefly dr. | |
| 2 ☐ Inconspic's | 2 ☐ Repairable | |
| 3 ☐ Superficial | 3 ☐ Not repr'bl. | |
| 4 ☐ Unsafe | 4 ☐ Demolished | |

S. LOCATION OF DAMAGE — Show thrust and contact damage areas.




T. ROAD SITUATION (Road - pavement + shoulder)

1a ☐ Oneway 2a ☐ Barrier line 3a ☐ Delineators 4a ☐ Lighted
1b ☐ Twoway 2b ☐ No such line 3b ☐ None 4b ☐ Not
5 Number of lanes in paving ☐ (Not total in divided highway.)

V. ALIGNMENT

| | | Enter | In | Leave |
|---|---|---|---|---|
| 1 Horiz. | a. Right | | | |
| | b. Left | | | |
| 2 Vert. | a. Crest | | | |
| | b. Sag | | | |

W. ROAD SURFACES

| | | Kind | Width |
|---|---|---|---|
| 1 Pavement | | | |
| Shl'dr. | 2 R | | |
| | 3 L | | |

X. PAVEMENT EDGE

| | | L. | R. |
|---|---|---|---|
| 1 Gut'r | a. Width | | |
| | b. Depth | | |
| 2 Curb | a. Height | | |
| | b. Type | | |
| 3 Lip | a. Height | | |
| | b. Length | | |
| 4 Edge stripe | | Yes | No |
| 5 Irregularities | | | |

Y. SHOULDER EDGE

| | | L. | R. |
|---|---|---|---|
| 1 Curb | a. Width | | |
| | b. Type | | |
| 2 Guard rail | a. Height | | |
| | b. Type | | |
| 3 Ditch | a. Grade | | |
| | b. Length | | |
| 4 Bank | a. Grade | | |
| | b. Length | | |
| 5 Other | | | |

Z. SURFACE

| | a. Pavement | b. Shoulder |
|---|---|---|
| 0 Normal | | |
| 1 Wet | | |
| 2 Soft | | |
| 3 Holes, ruts | | |
| 4 Loose m'trl. | | |
| 5 Construction | | |
| 6 Repair | | |
| 7 Other | | |

AA. SPECIAL FEATURES

0 ☐ None present
1 ☐ Narrowing pavement
2 ☐ Dividing pavement
3 ☐ Exit turn
4 ☐ Exit branch
5 ☐ Bridge
6 ☐ Other

AB. TIRE MARKS

1 ☐ On pavement 2 ☐ On shoulder 3 ☐ On roadside

NOTES AND EXPLANATIONS

TABLE 3

SEVERITY OF ACCIDENTS

| Severity | Number | | Percent | |
|---|---|---|---|---|
| Fatal | | 17 | | 2.0 |
| Class A Injury | 164 | | 19.3 | |
| Class B Injury | 141 | | 16.6 | |
| Class C Injury | 66 | | 7.7 | |
| Total Injury | | 371 | | 43.6 |
| No Injury | | 447 | | 52.7 |
| Injuries Not Known | | 15 | | 1.7 |
| Total | | 850 | | 100.0 |

TABLE 4

TYPES OF VEHICLES INVOLVED

| Types of Vehicle | Total Vehicles | | With Trailer | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| Standard Cars | 519 | | 88 | 17.0 |
| Compact Cars | 141 | | 13 | 9.2 |
| Small and Sport Cars | 75 | | 3 | 4.0 |
| Total Cars | 735 | 86.5 | 105 | 14.3 |
| Tractors and Semi-trailers | 47 | | 47 | 100.0 |
| Trucks | 63 | | 20 | 31.8 |
| Total Trucks | 110 | 12.9 | 64 | 59.1 |
| Motorcycles | 5 | 0.6 | 0 | 0.0 |
| Buses | 0 | 0.0 | 0 | 0.0 |
| Total | 850 | 100.0 | 169 | 19.9 |

report, each highway patrol followed its usual reporting procedure for the single-vehicle accidents. These procedures were not exactly the same. It may be, therefore, that some of the states reported a greater proportion of minor accidents than others did.

Data collection was planned to require no more than an additional hour for the investigator to record the supplementary single-vehicle-accident information. Hence, no claim can be made that accidents were investigated "in depth." A 37-page instruction manual was provided for the supplementary form. Each reporting officer was supposed to receive from a supervisor a day's instruction in this special work.

## SINGLE-VEHICLE ACCIDENTS REPORTED

For the purpose of this study, supplementary reports were required for four standard types of motor-vehicle traffic accidents:

1. Collision on road with parked motor vehicle
2. Collision on road with fixed object
3. Overturned on road
4. Ran off road.

The road, for this purpose, was defined as including both pavement and shoulder.

From the four types of accidents reported, some were eliminated: "Those in which there is a supported claim that a non-contact motor vehicle encroached on the path of the vehicle directly involved or otherwise clearly influenced its behavior."

A total of 951 reports were received. Of these, 12 were not used because they were other than the specified four types, and 89 more were eliminated because non-contact vehicle involvement was well supported. This left exactly 850 reports to be tabulated. Table 3 reports the accident severities and table 4 the types of vehicles involved.

The types of vehicles involved were as follows: Of trailers towed by cars, 56 percent were for cargo, 30 percent were house trailers, 11 percent were other vehicles, and 3 percent were boats. Of 20 trailers towed by trucks, 30 percent were for cargo, 35 percent were other vehicles, 30 percent were house trailers, and 5 percent boats.

Three kinds of special data were sought in this study:

1. Factual (objective) information about the circumstances of the accidents.
2. Opinions (subjective) about contributing factors.
3. Comparisons which would help evaluate the reliability of police inferences in accident reporting.

Each of these will be separately discussed.

## FACTUAL INFORMATION ABOUT CIRCUMSTANCES

*Time of accidents.* Because of the character of the route studied, distribution of accidents differs somewhat from usual countrywide figures. Morning and evening peaks are less pronounced.

Friday has most accidents, 18.7 percent; followed closely by Saturday, 18.0 percent. Tuesday has fewest, 10.7 percent. The modal hour of the day, without regard to day of week, is 1 to 2 p.m. with 6.4 percent of the total 24-hour accidents;

minimum hour is midnight to 1 a.m. with 2.5 percent.

These values largely reflect traffic volume. Therefore, risk indexes were computed by dividing the percentage of accidents in each hour by the percentage of traffic counted in that hour. The lowest index, 0.57 was from 9 to 10 p.m. and the highest, 3.43, was from 3 to 4 a.m. Darkness is probably a factor in the risk index because most of the high-risk hours are dark. But if darkness is the only factor, the index should be one value for all hours of darkness and another for all daylight hours. But they are not. Hence there are probably differences in quality of driving at different hours of the day for single-vehicle accidents. The hours with high-risk indexes are those during which one would expect to find more drivers who had been drinking and those in which drivers would probably be most likely to fall asleep.

*Seat-belt usage.* The easiest route from Chicago to Los Angeles obviously carries an unusually high percentage of long-trip vehicles. It is believed that people are more likely to use seat belts on long trips. Therefore, experience on this route should represent maximum use of seat belts for 1964.

Of 2,050 occupants in single-vehicle accidents, only 472 or 23.0 percent were in seats equipped with belts. Of the occupied seats with belts (for which it was known whether the belt was in use), only 48.3 percent of the occupants had their belts fastened.

Among drivers, 31 percent had belts available but only 50.2 percent were reported to be in use. Of right-front-seat passengers with belts, 43.3 percent had them fastened.

Of 189 fastened seat belts, none was reported to have broken in an accident. One driver of a sport car said that his belt was fastened before the accident but unbuckled (without damage) while he turned over twice.

Men used their belts more than women, 51 percent compared to 43 percent. In the 16–19 age group, 54 percent used their belts as contrasted to 43 percent for older people and 38 percent for younger children. The highest percentage, 60, of seat-belt users were male passengers less than 16 years old. The lowest percentage, 28, were male passengers 30 or more years old. Seat belts appear to be catching on with the younger generation.

*Operational failure.* To escape accident, the road-vehicle-driver system must operate so as to avoid three principal hazards:

1. Left roadway ("jumped the track").
2. Struck object while still on roadway.
3. Overturned before leaving roadway.

If one of these hazards is not avoided, the car-driver-road system has failed in some operation required for safety; there has been an operational failure. The operational failure describes the accident. Note that these operational failures differ from the four standard *types* of accidents which were required to be reported in this single-vehicle accident study: leaving the roadway is leaving the pavement, not "running off the road," which includes shoulder; and striking an object is "collision with parked motor vehicle" or "collision with fixed object," but only *before* the vehicle leaves the pavement. A vehicle is considered to have left the roadway when one wheel is off the pavement.

TABLE 5

PERCENTAGE OF OFF-ROADWAY ACCIDENTS BY ROAD ALIGNMENT

| | |
|---|---|
| Straight | 79.4 |
| Moderate curve | 14.8 |
| Sharp curve | 1.9 |
| Ramps, channelization, etc. | 3.9 |
| Total | 100.0 |

*Operational Failure No. 1, left roadway,* accounted for 781 or 91.9 percent of the single-vehicle accidents studied. It includes many accidents in which the vehicle turned over or struck an object on the shoulder or after running off the shoulder. It does not include accidents in which vehicles turned over on the pavement after they had run off and come back on.

Most of these left-roadway accidents were on straight roads (see table 5).

From where the vehicle left the pavement to where it stopped varied from a few feet to more than a thousand. Very few of the vehicles stopped more than 100 feet from the edge of the pavement. A few more cars left the right side of the road than the left side (see table 6). Many of the cars which left the road came back on it before they came to rest (table 7).

In some cases, after returning to the pavement after leaving it, the driver left it again on the same or the opposite side. From these data it would

TABLE 6

SIDE ON WHICH VEHICLE LEFT ROADWAY

| Number of Vehicles | Left | Right |
|---|---|---|
| Curve to left | 21 | 38 |
| Curve to right | 36 | 29 |
| Straight 1-way (divided) | 201 | 233 |
| Straight 2-way (undivided) | 48 | 123 |
| Total | 306 | 423 |

52 vehicles left roadway at intersections, etc.

TABLE 7

NUMBERS AND PERCENTAGES OF CARS RETURNING TO ROADWAY AFTER LEAVING IT

| Road | Off Left | | Off Right | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| Curve left | 4 | 19.0 | 15 | 39.4 |
| Curve right | 11 | 30.5 | 8 | 27.6 |
| Straight 1-way | 50 | 24.8 | 87 | 37.3 |
| Straight 2-way | 13 | 27.1 | 43 | 35.0 |
| Total | 78 | 25.5 | 153 | 36.2 |

TABLE 8

PERCENTAGE OF VEHICLES LEAVING ROADWAY BY ATTITUDE WHEN EACH LEFT

| | Percent |
|---|---|
| Going straight without yaw | 41.2 |
| Sideslipping in a sharp turn | 47.9 |
| Had been weaving side to side before leaving road | 8.9 |
| Unknown | 2.0 |
| Total | 100.0 |

seem that for single-vehicle accidents, when a driver ran off the roadway to the right, he succeeded in getting back on the roadway in a third of the accidents; on the left he was successful in a quarter of the accidents.

The foregoing leads to consideration of the attitude of the vehicle when it left the road (table 8). In nearly half of the left-roadway accidents, the car was sideslipping or yawing. The driver was out of control by some maneuver before he ran off the pavement.

*Operational Failure No. 2, struck object while still on roadway,* accounted for 38 or 4.5 percent of the single-vehicle accidents studied. Because the vehicle must have struck the object while all wheels were on the pavement, it follows that the object struck must have been in or very close to the pavement. But in some cases, the vehicle was crosswise of the road when it struck the guardrail or other roadside object. Hence the object could be as much as five feet from the pavement and be struck by rear-end overhang while wheels were still on pavement (table 9).

Fifteen of the 38 struck-object accidents were in Arizona. This was the most conspicuous difference among states in the data gathered. The kinds of objects hit in Arizona were as varied as among the other states so there seems to be no logical explanation of the larger number of those.

*Operational Failure No. 3, overturned before leaving roadway,* accounted for 31 or 3.6 percent of the single-vehicle accidents studied. It was mainly on straight ordinary roads. Table 10 shows

TABLE 9

NUMBER OF TIMES VARIOUS KINDS OF OBJECTS WERE STRUCK

| | |
|---|---|
| Guard rails | 8 |
| Bridge rails or structures | 7 |
| Traffic control devices | 7 |
| Barricades | 5 |
| Culverts | 2 |
| Information signs | 2 |
| Railroad crossing gates | 2 |
| Rock slides | 2 |
| Guard post | 1 |
| Divider reflector | 1 |
| Parked car | 1 |
| Total | 38 |

TABLE 10

PERCENTAGE OF OVERTURNING BEFORE LEAVING ROADWAY BY ROADWAY ALIGNMENT AND CONDITION

| | |
|---|---|
| Straight, or nearly straight and dry | 64.4 |
| Ramps, channelization, narrowing and driveways | 16.1 |
| Slippery pavement (2 accidents) | 6.5 |
| High wind (2 accidents) | 6.5 |
| Unknown | 3.5 |
| Total | 100.0 |

a breakdown on this data. Vehicles which overturned *after* leaving roadway, and there were many more of them, were classified as left-roadway operational failures.

Of the vehicles in single-vehicle accidents, the percentage which overturn-on-roadway (before leaving pavement) varies greatly with the type of vehicle (table 11).

Of the 629 cars without trailers in single-vehicle accidents, the small percentage which overturned before leaving roadway is due to the predominance of standard vehicles, none of which overturned. Of the seven which overturned 5 were small or sports cars and 2 compacts. Of the five small cars which overturned before leaving the pavement, four were Volkswagens and one was a Renault Dauphine.

*Object struck* is of interest to those considering roadside improvements to reduce severity of single-vehicle accidents. The data apply to *both* struck-objects-before-leaving-roadway and ran-off-the-roadway accidents. These objects in table 12 do not necessarily stop the vehicle or damage it severely. It may roll over after striking.

*Age and sex of driver.* There is nothing unusual about the distribution of single-vehicle accidents according to sex of driver: 71.6 percent were male and 28.4 percent female.

For both male and female drivers, those 20 to 25 years of age were involved in more single-vehicle accidents than any other 5-year age group: 23.6 percent for males and 16.7 percent for females. For both sexes the number of accidents diminished steadily with age. The distribution of those accidents doubtless reflects to a large extent differences in miles driven by the age and sex groups. Unfortunately exposure data were not obtained from which risk indexes could be computed. But

TABLE 11

VEHICLES OVERTURNING BEFORE LEAVING ROADWAY BY TYPE OF VEHICLE

| | Number | Percent |
|---|---|---|
| Motorcycles | 2 | 40.0 |
| Truck and trailer | 3 | 13.1 |
| Car with trailer | 13 | 12.3 |
| Truck without trailer | 3 | 7.0 |
| Tractor with semitrailer | 3 | 6.8 |
| Car without trailer | 7 | 1.1 |
| All | 31 | 3.6 |

TABLE 12

DISTANCE FROM ROADWAY OF OBJECT STRUCK

| Feet from Roadway | Percentage | Principal Objects Hit |
|---|---|---|
| Less than 1 | 20.1 | Curb, guardrail, barricade |
| 1 to 6 | 21.2 | Guardpost, delineator, guardrail |
| 7 to 14 | 26.8 | Bank or ditch, guardrail, information sign |
| 15 to 29 | 18.3 | Bank or ditch, fence, culvert |
| 30 to 49 | 9.9 | Bank or ditch, fence |
| 50 or more | 3.7 | Bank or ditch, fence |
| Total | 100.0 | |

TABLE 13

RISK INDEX BY TYPE OF VEHICLE

| Type of Vehicle | Without Trailer | With Trailer |
|---|---|---|
| Standard car | 1.00 | 4.57 |
| Compact car | 2.23 | 8.48 |
| Small car | 3.49 | 14.47 |
| Truck | .69 | 4.33 |
| Tractor and semitrailer | — | 1.21 |
| Bus | 0.00 | — |
| All Types | 1.17 | 2.67 |

it seems unlikely that as many as one driver in five of all drivers using the route would be between 20 and 25 years old. Hence, it would seem that this age group has an unusually high risk.

*Risk index by type of vehicle.* Types of vehicles involved have been enumerated in the discussion of the accidents reported and in connection with overturning accidents. Counts were made in each state to determine the proportion of each type of vehicle using Route 66. From these data it was possible to compute a risk index by major types of vehicles. The risk of a standard car without trailer was established at 1.00 as the base for this index. Values for the vehicles of other kinds are shown in table 13.

In general, compact cars are 2¼ and small cars 3½ times as risky as standard cars. Adding a trailer multiplies the risk by approximately four. Actually, there were only four small cars with trailers in accidents so that the risk index for this type is not statistically significant but it is compatible with the other indexes. Because no buses had single-vehicle accidents during the study period, their calculated index is zero. Buses probably do have the lowest risk index, but an index based on a sample large enough to show some bus accidents would obviously not be zero.

The considerable differences in risk indexes of the three classes of passenger cars is paralleled by the differences in percentage of those cars that overturn on the road as mentioned earlier; but the total number of overturning accidents is so small that overturning cannot alone explain the differences in risk indexes.

Indeed, nothing in the data collected explains the risk-index differences among the three groups of passenger cars without trailers. Because guesses will inevitably be made to explain this phenomenon, three different, entirely speculative possibilities will be mentioned here.

First, there is a substantial proportion of rear engine cars among the compacts and a large proportion of rear engine cars among the small cars. No standard cars have rear engines. Thus there is a correlation between rear engine construction and the risk index. However, from these data, one cannot justifiably reach the conclusion that this correlation indicates any cause and effect relationship.

A second, equally reasonable, speculative inference may also be made. Many parts of Route 66 are exposed in areas where high winds are common. Wind was suggested as a contributing factor in a number of the accidents reported. In general, the area of a car exposed to wind pressure varies as the square of its linear dimension; doubling car size would quadruple surface area. But weight varies as the cube of linear dimension; doubling the linear dimensions will multiply the weight by eight. Therefore, the ratio of weight to wind pressure area varies as the 3/2 power of car length. In other words, the larger the car is, the greater its road friction resistance will be compared it its wind area. Large cars will therefore be deflected or buffeted less by sudden gusts of wind or air blasts from passing trucks. Hence wind will trigger fewer drivers of large than of small cars into losing control.

A third possible explanation would seem to be the least speculative. The greatly higher accident experience of the young driver is recognized. Indeed, it is suggested by the data in this study. For economic and cultural reasons, young drivers seem to be much more likely than older drivers to be on long, fast trips in small and compact cars. Hence, a difference in driver skills or attitudes may also explain the difference in risk indexes of the three classes of cars.

## Opinions about Contributing Factors

The circumstances which are thought of as contributing factors in traffic accidents are, unfortunately, rarely conditions which can be objectively observed or which leave unmistakable signs after the accident. Hence, "determination" of causative factors is largely a matter of inference. Conclusions concerning such factors are, consequently, opinions of those making the inferences and must be evaluated accordingly.

Information about causative factors solicited by the supplementary report form for this study inevitably reflects stereotypes or common patterns of the investigator's beliefs, lack of time to seek further proof (for example, by disassembling the vehicle), and the limitations of investigators' scientific training. Nevertheless, highway patrol officers attending the accident are in the best position to make inferences relating to contributing factors. Therefore, until better procedures are available, cautious consideration must be given their opinions as expressed in special schedules on the supplementary report form. This part of the study, therefore, has many characteristics of an opinion poll.

*Speed.* The supplementary report called for a "best estimate" of speed and also a possible minimum and maximum value. In two-thirds of the reports, the minimum estimate was given as five miles per hour less and the maximum estimate as five miles per hour more than the best estimate. With such uniformity of range, only the "best estimate" need be used here. The estimates are set forth in table 14.

Almost half of the accidents occurred where the speed limit is 70 miles per hour because most of the route is posted for that speed.

Note that the percentage of accidents at more than the speed limit diminishes steadily as speed limits increase.

Most of the investigators' speed estimates which were more than 75 miles per hour were substantiated by observations of witnesses. Some occurred while the violator was actually being pursued.

*Contributing factors.* In the supplementary report, a schedule was provided on which the investigator could mark an item on a list to indicate his opinion relating to "contributing factors." The list was subdivided into groups for road, driver, and vehicle. Place was provided in each group to write in "other" factors than those specifically listed. More than one factor could be listed and the investigator could indicate his degree of certainty by marking "yes" or "possibly." If an investigator listed more than one factor (which investigators did for only 16.5 percent of the accidents), only that one which seemed to be best substantiated by circumstances described or reasoning expressed was recorded in table 15.

Examples of "other" road factors: pavement narrows suddenly, soft shoulders, drop-off to shoulder; of "other" driver factors: drag racing, "headstrong," blacked out, confused by traffic; of "other" vehicle factors: overloaded, shifting load, wipers quit in heavy rain, axle or spindle broke, accelerator stuck, smooth tires, trailer collapsed.

Driver factors are more frequent than car and road factors combined. But because most of the investigator's information about contributing factors comes from the drivers, it may be surmised that, if anything, driver factors are underreported and vehicle and road factors are overreported. The most commonly reported factors appear in table 16.

Drivers tend to explain accidents by circumstances which have least culpability compatible with credibility. Hence drivers may sometimes tell investigators that they fell asleep when actually

TABLE 14

INVESTIGATORS' BEST ESTIMATE OF APPROACH SPEED

| Speed Limit | Number of Accidents | Approach Speed: Mean | Mode | Lowest | Highest | Percentage Over Limit |
|---|---|---|---|---|---|---|
| 30 | 4 | 46.3 | 40 | 15 | 85 | 75.0 |
| 35 | 6 | 44.2 | 35 | 85 | 55 | 75.0 |
| 40 | 6 | 45.0 | — | 20 | 65 | 50.0 |
| 45 | 13 | 46.2 | 45 | 25 | 65 | 38.0 |
| 50 | 35 | 49.3 | 50 | 10 | 85 | 31.2 |
| 55 | 82 | 56.2 | 50 | 40 | 80 | 30.3 |
| 60 | 131 | 54.7 | 60 | 25 | 75 | 19.1 |
| 65 | 127 | 57.3 | 65 | 10 | 85 | 11.8 |
| 70 | 417 | 61.1 | 65 | 10 | 110 | 8.9 |
| 75 | 1 | 45.0 | 45 | 45 | 45 | 0.0 |
| All | 822 | 57.3 | 65 | 10 | 110 | 15.5 |

TABLE 15

INVESTIGATORS' OPINIONS ABOUT CONTRIBUTING FACTORS

| Factor | | Number | Percent |
|---|---|---|---|
| Road factors, total | | 155 | 18.3 |
| *Confused by road situation or signs* | | 18 | 2.1 |
| *Unexpected road surface condition* | | 111 | 13.1 |
| Wet, slippery | 110 | | |
| Hole, bump | 1 | | |
| *Other* | | 26 | 3.1 |
| Wind | 12 | | |
| Sun glare | 2 | | |
| Object in road | 2 | | |
| Other | 10 | | |
| Driver factors, total | | 378 | 44.5 |
| *Driver asleep or dozed* | | 205 | 24.1 |
| *Alcohol or drugs* | | 69 | 8.1 |
| *Illness* | | 3 | .4 |
| *Distraction* | | 74 | 8.7 |
| In car | 49 | | |
| Outside of car | 25 | | |
| *Other* | | 27 | 3.2 |
| Inattention | 7 | | |
| Lack of skill | 6 | | |
| Other | 14 | | |
| Vehicle factors, total | | 169 | 19.9 |
| *Brake failure* | | 9 | 1.1 |
| *Steering gear failure* | | 12 | 1.4 |
| *Light failure* | | 0 | 0.0 |
| *Tire failure* | | 101 | 11.9 |
| *Other* | | 47 | 5.5 |
| Trailer hitch | 21 | | |
| Other | 26 | | |
| No factor mentioned | | 148 | 17.3 |

TABLE 16

PERCENTAGE OF ACCIDENTS FOR MOST FREQUENTLY MENTIONED FACTORS

| | |
|---|---|
| Driver asleep | 24.4 |
| Slippery road | 13.0 |
| Tire failure | 11.9 |
| Distractions | 8.7 |
| Alcohol | 8.1 |

they were intoxicated. Driving under the influence is illegal and, therefore, more culpable than falling asleep while driving, which is not specifically unlawful. Likewise, when a driver falls asleep, he may be happy to explain the accident by some road or vehicle condition. In this connection it is interesting to note what drivers said when they did not concur with investigators with respect to being asleep or under the influence of alcohol. In 11 (5.4 percent) of the accidents which investigators believed falling asleep was a factor, the drivers had claimed:

- 4 tire failures
- 2 distractions
- 1 confusing road situation
- 1 wind blast
- 1 sun glare
- 1 alcoholic influence
- 1 other drivers condition

and in 10 (14.5 percent) of the accidents listed by investigators with alcoholic influence as a factor, drivers had indicated:

- 3 confusing road situations
- 2 distractions
- 1 tire failure
- 1 steering gear failure
- 1 other road condition
- 1 driver asleep
- 1 illness.

By the same principle, we may hypothesize that some drivers may have suggested tire failure as a factor, when in fact, the driver had been drinking, had fallen asleep, or had otherwise been responsible. Such an explanation might be credible if a tire was, indeed, disabled after the accident. Even had the tire been damaged by collision or furrowing in, the investigator would not have at his disposal facilities for removing and examining the tire to determine the nature and probable cause of its disablement. Because tires would most likely be disabled by the accident if they were in the vehicle's most heavily damaged area, the position of the tire which was supposed to have failed was tabulated so far as data were available:

| | |
|---|---|
| Tire in most heavily damaged area | 72 percent |
| Tire in other positions | 28 percent |

TABLE 17

POSITION OF TIRE THOUGHT TO HAVE FAILED

| Position | Number | Percent |
|---|---|---|
| Rear right | 36 | 36.8 |
| Rear left | 26 | 26.6 |
| Front right | 19 | 19.3 |
| Front left | 17 | 17.3 |

TABLE 18

PERCENTAGE OF ACCIDENTS FOR EACH SEX AND AGE GROUP BELIEVED TO HAVE CERTAIN FACTORS

| Age Group | Tire Failure | Driver Asleep | Driver Under Influence | Distraction |
|---|---|---|---|---|
| Less than 20 | 13.7 | 29.4 | 4.9 | 9.8 |
| 20 to 29 | 11.4 | 30.2 | 8.1 | 7.1 |
| 30 to 39 | 15.7 | 18.6 | 8.1 | 8.1 |
| 40 to 49 | 12.3 | 18.4 | 12.3 | 7.0 |
| 50 to 59 | 16.0 | 20.2 | 9.6 | 4.2 |
| 60 or more | 14.3 | 16.4 | 3.6 | 16.4 |
| Males | 12.9 | 24.5 | 9.9 | 6.4 |
| Females | 14.5 | 20.9 | 3.8 | 11.6 |

If approximately three times as many tires which were claimed to have failed were in the heavily damaged part as in other parts, it is reasonable to assume that some of these were improperly considered to be a factor in the accident.

The positions on vehicles of tires which investigators believed to have contributed to accidents are shown in table 17. With front-tire failure, the vehicle went off the roadway much more often on the side on which the tire failed. With rear tire failure, the reverse seems to be true, but the difference between rear tires is small and probably not significant.

*Age and sex related to contributing factors.* The percentage of drivers in each age group believed by the investigator to have been connected with accidents having certain contributing factors was tabulated in table 18. The differences for tire failure are probably too small to be significant, but the other factors show interesting variations with age and sex.

*Distractions* are generally believed to be important contributing factors to accidents, but they are difficult to detect. Either the driver has forgotten them or he sees no reason to mention them. A tabulation of investigators' opinions relating to distractions reported in this study will give an idea of their great variety (table 19).

*"How would driver avoid similar accident?"* This question was asked investigators. No specific list of possibilities was provided for checking. For 40 accidents the reply to this question was indeterminate. The 10 most common ideas offered by investigators are listed in table 20. These generally correspond with opinions concerning contributing factors. Driver asleep heads the

list in both cases. Speed appears prominently here. Slower for conditions perhaps reflects a tendency of police to explain accidents by "too fast for conditions" when nothing more specific comes to mind. Attention is high on this list but not among the contributing factors, probably because it was not specifically mentioned in the driver-factor check list.

TABLE 19

DISTRACTIONS REPORTED AS CONTRIBUTING FACTORS

| | | | |
|---|---|---|---|
| Talking to passenger | 5 | | |
| "Back-seat driving" | 2 | | |
| Watching passenger | 2 | | |
| Trying to awaken wife | 1 | | |
| Horseplay | 1 | | |
| Total passenger distractions | | 11 | |
| Turned to cover or attend baby—usually in rear seat | 6 | | |
| Looking at child or baby | 2 | | |
| Turned to talk to children | 1 | | |
| Child's balloon blew up in driver's face | 1 | | |
| Child pulled gear shift lever back | 1 | | |
| Child alongside driver | 3 | | |
| Total children | | 14 | |
| Reaching for cigarette | 1 | | |
| Lighting cigarette | 2 | | |
| Dropped lighted cigarette or lighter | 4 | | |
| Reaching for water jar | 1 | | |
| Reaching for pop corn | 1 | | |
| Eating | 1 | | |
| Total smoking or eating | | 10 | |
| Adjusting sun visor | 1 | | |
| Tuning radio | 2 | | |
| Total car adjustments | | 3 | |
| Kleenex blew in driver's face | 1 | | |
| Suitcase fell off seat | 1 | | |
| Wasp in car | 1 | | |
| Particle in driver's eye | 1 | | |
| Reaching in car | 1 | | |
| Emotionally upset | 1 | | |
| Total miscellaneous in car | | 5 | |
| Unspecified in car | | 5 | |
| Total inside car | | | 49 |
| Watching vehicle behind | 2 | | |
| Vehicle alongside or ahead | 4 | | |
| Gesturing at overtaken driver | 1 | | |
| Total watching other cars | | 7 | |
| Total looking at scenery | | 6 | |
| Watching road grader | 1 | | |
| Observing barricades | 1 | | |
| Total construction | | 2 | |
| Luggage on roof came loose | 1 | | |
| Trailer acted up | 1 | | |
| Steering gear seemed wrong | 1 | | |
| Total own vehicle | | 3 | |
| Unspecified (probably speculative) | | 7 | |
| Total Outside | | | 25 |
| Total Distractions | | | 74 |

TABLE 20

MOST COMMON RECOMMENDATION FOR AVOIDING SPECIFIC ACCIDENTS

| | |
|---|---|
| More sleep | 182 |
| Slower for conditions | 134 |
| Drive more slowly | 96 |
| Better attention | 94 |
| Better evasive action | 65 |
| Less drinking | 52 |
| More trailer experience | 47 |
| Inspect tires | 39 |
| More special experience | 31 |
| More general experience | 21 |

## COMPARISONS TO EVALUATE RELIABILITY OF OPINIONS

In this study of single-vehicle accidents, a crude effort was made to gain some idea of how highway patrol officers arrive at conclusions in usual working situations. Some of this evaluation has already been suggested in connection with tabulating their conclusions.

For comparison purposes, in addition to reporting their own conclusions, investigators were also asked to report conclusions of drivers. Admittedly this is no elegant research technique but it does give some tentative insights which might not otherwise be available.

In general, investigators appear to accept drivers' versions of how and why the accident occurred; but they may disagree in a few instances, especially where observable conditions contradict drivers' statements.

*Speed.* Police estimates of speeds are consistently higher than drivers' estimates, especially above the speed limit. Drivers average speed estimate was 54.8 miles per hour, that of police 57.3. The difference seemed to be about the same for all speed limits at which there were enough accidents to give reliable figures. Police believed 128 drivers were exceeding the speed limit as opposed to 50 drivers who admitted to more than the limit. For the most common speed limit, 70 miles per hour, only four drivers admitted going faster. None of these acknowledged more than 75 miles per hour. Police, on the other hand, considered 37 to have been exceeding 70 miles per hour. Only 17 exceeded that limit by as little as five miles per hour. One driver was reported at 95, one at 100, and one at

110. Perhaps drivers would have admitted higher speeds to others than police, but this is doubtful.

*Contributing factors.* In general, investigators and drivers agree remarkably on contributing factors. Of 573 cases for which both driver and investigator offered an opinion, there were 537 in which they agreed and 36 in which they disagreed. In other words, the investigator differed from the driver in only 6.3 percent of the cases. This probably means that in a large number of cases the investigator accepts the driver's opinion. Perhaps in many cases, the driver's statement is the only information on which he can base an opinion. But the inference can also be made that practically the same results would be obtained by having drivers themselves report the contributing factor as having the investigators do it, at least in single-vehicle accidents.

The most common disagreements were 21 accidents in which police considered sleep and alcohol to have been a factor, whereas drivers offered less culpable explanations. These have been discussed elsewhere.

*Skill.* More than other kinds of accidents, "single-vehicle" accidents suggest a failure of the driver to control his vehicle. That would generally mean lack of skill either in driving strategy in anticipation of possible hazards or in tactics in coping with actual hazards. Yet among the 850 single-vehicle accidents, investigators indicated only six in which lack of skill was a contributing factor, and in only four cases did drivers suggest lack of skill. But "lack of skill" was not specifically listed to be checked in the supplementary report. As an unquestionably prominent factor in single-vehicle accidents, it was purposely omitted to determine to what extent investigators or drivers might mention it as a factor in accidents without having it suggested by listing. Compare the very few cases in which lack of skill was mentioned with the frequent occurrence of accidents which clearly appear to involve such lack of skill as too much steering, braking on slippery surfaces, and inability to cope with a trailer. The comparison strongly suggests that investigators try to use only the categories specifically called for on the report form and shun the opportunity to record "other." This means that to get more reliable analysis of contributing factors, report forms should either be elaborated to include very long lists of categories or should mention no specific categories. In the latter case, investigators would probably resort to stereotypes of their own or their department's, especially stereotypes which conform to classifications of law violations.

But, as mentioned earlier, skill does appear more prominently in the opinions as to how the accident would have been prevented.

*Combinations of contributing factors.* Variation among states is considerable in the proportion of accidents in which investigators expressed no opinion about contributing factors. These variations are doubtless partly and perhaps largely accounted for by differences among investigators—differences mainly in training for investigating and forming opinions. That is to say, it is probable that two investigators with the same information about an accident would apply different techniques and standards and so come up with different conclusions about contributing factors.

The accidents for which no factor was named vary from 5.4 percent in Texas to 31.5 percent in Missouri. Accidents in which two or more are suggested vary from 10.3 percent in Oklahoma and New Mexico to 45.9 percent in Texas. In other words, Texas leaned toward multiple factors. Missouri investigators seemed reluctant to offer opinions.

Most accidents, when skillfully reconstructed and analyzed, appear to have numerous contributing factors which *combine* to cause them. Four or five factors are common and sometimes the number goes to a dozen. But in the reports of these accidents, one factor seemed to be the rule. Only 16.5% listed more than one and 17%, none. This suggests that these investigations are too brief and the investigators insufficiently trained to do more than a superficial job of determining the combinations of factors that cause accidents. In a very few cases three or four factors were indicated. One accident was listed with five.

By all means the most common combination is sleep and alcohol (23 accidents). It is, perhaps, logical that these might combine. For several reasons, people who had been drinking might be more likely than others to doze while driving.

The second most common combination, distraction and sleep (10 accidents), makes no sense. If a person is sleeping he is not subject to the usual distractions; conversely, if he actually was distracted he was probably not sleeping.

The next most common combinations are sleep and tires and confusing and slippery (each with six accidents). Neither of these is a very convincing combination. Certainly it seems unlikely that a driver would both doze and experience a tire failure although it may be argued that the sleepy driver is less able to cope with a tire failure because he has to awaken first.

A considerable number of the combinations given are not complementary contributing factors. Complementary factors are those which go together like tire failure and lack of skill. This fact suggests that many of the reported combinations are actually speculative alternatives, not real complementary combinations. Thus the investigator could have meant that the accident might have been due to a slippery road *or* a tire failure rather than a slippery road *and* a tire failure.

The factor which most commonly combines with others is a wet or slippery roadway. It is combined with almost every other listed factor, but it particularly complements lack of skill, distractions, and driver asleep.