A steering committee composed of representatives from the CHP, Caltrans, the Office of Traffic Safety, and the public at large was responsible for overall project guidance and for approving the products of major project tasks. In addition to J.E. Smith, other members of the steering committee were William Oliver of the CHP Sacramento Office, David Roper of Caltrans District Office, Thornton Piersall of the League of California Cities, David Grayson of the Automobile Club of Southern California, and G. Van Oldenbiek of the Office of Traffic Safety. Valuable contributions were also made by Jesse Glazer of Crain and Associates and Adolf D. Oliver of the Institute of Transportation Studies, University of California.

REFERENCES

1. J.W. Billheimer and G. Fondahl. Study Design

A multivariate time series design was used, and a media information campaign to deter accidents. An impact evaluation was performed to determine what reductions had occurred during the first 22 months of implementation. A multivariate time series design was used, and a comparison group was selected. The Box-Jenkins technique was used. The analysis identified a statistically significant reduction of 14 injury accidents/month for Boise. This represents a 17 percent reduction from the base period. No significant reduction occurred in the comparison group. An estimated $1 600 000 in accident costs was avoided, and the total program cost was $788 000. Both traditional enforcement and media influence were determined to be essential elements of this successful program. Improved coordination and communication with other local agencies are also believed to have contributed significantly to the program.

The results of an impact evaluation of the first 22 months of a Selective Traffic Enforcement Project (STEP) implemented in Boise, Idaho, on October 1, 1979, are presented in this paper. The project was partially supported by federal highway safety funds under Section 402 of the Surface Transportation Assistance Act of 1966. The project evaluation was undertaken by the Idaho Office of Highway Safety. The methodology used in the study was selected to provide answers to the following questions:

1. Has there been a measurable reduction in injury accidents that can be correlated with implementation of STEP in Boise?
2. If such a reduction did occur, can it be reasonably attributed to STEP?
3. What were the relative cost savings to Boise citizens?

REVIEW OF LITERATURE

Identifying effective elements of STEP has been a matter of national concern since passage of the Highway Safety Act of 1966. That Act provided federal funds for implementation of improved police traffic-enforcement routines that would be effective in reducing the number of traffic accidents. This review addresses several evaluations that deal with the traditional enforcement model of compliance (i.e., strict sanctions induce high compliance) and the contextual model of compliance (i.e., compliance is influenced by the attitudes of peers and by social norms).

The traditional enforcement model was explored by Hauer and others (1) in a study that examined speed reductions induced by conspicuous enforcement (a clearly visible, stationary police cruiser). The study involved four experimental locations, each paired with a corresponding control site. Two dif-
fferent levels of conspicuousness and durations of enforcement were tested. The authors concluded that conspicuous enforcement resulted in marked reduction in average speed at the site of enforcement. In fact, this improved compliance yielded an average speed that was close to the posted speed. The study by Hauer and others also provided a valuable discussion of both distance and time halo effects. Although the study admirably addressed compliance responses to enforcement, it did not address the link between improvements in compliance and changes in accident experience.

The relation between traditional enforcement and accident experience was discussed by Bensen and Cooper (2). Using four years of computerized accident records, they estimated expected accident rates for 1800 locations. The estimates accounted for trends and seasonal variations. In addition, a high-accident-location (HAL) list was issued every 28 days giving the 20 street sections that had the largest number of accidents during the prior observation period. The officers were asked to devote special attention to those sections in addition to the site of enforcement. As a result, during each observation period some sections received higher-than-normal enforcement. It is not clear from the report whether or not the officers were advised of the driver actions that were contributing most heavily to accidents. For the sections that appeared on the HAL list, accident experience after increased enforcement was compared with expected accident experience. Hauer and Cooper reported that after a section appeared on the HAL list there was a statistically significant reduction in the number of accidents and concluded that the reductions were related to increases in enforcement.

The contextual model of compliance was discussed by Kohfeldt and Likens (3), who attempted to contrast the relative impacts of traditional enforcement and contextual efforts on compliance. The compliance data studied were quarterly 55-mph compliance data for Missouri. Enforcement data were the quarterly speed citations reported by the State Highway Patrol. The media (contextual) measure was collected from the State Library clipping service and an independent search of major St. Louis and Kansas City newspapers. The statistical method used was regression analysis. Based on these analyses, the authors reached the following conclusions:

1. The traditional model of enforcement and compliance is weak. In fact, ticketing (enforcement) follows noncompliance instead of compliance following enforcement.
2. The contextual model of media influence and compliance is strong. In other words, what matters most in securing compliance is widespread public attention to proscribed behavior.

They further suggested that public attention should be assigned a central role in any theory of compliance. The authors assumed that driver perception of certainty of enforcement was directly proportional to the number of speed arrests. This is an unfounded assumption because the number of tickets does not necessarily represent the level of enforcement. This assumption could likely have resulted in the authors' conclusion that speed arrests follow noncompliance instead of compliance following arrest. A better measure for enforcement would have been hours of patrol. Such a measure is probably available and might substantially alter the authors' conclusions. Despite the deficiency in the enforcement model, the authors' conclusions on the contextual model seem entirely valid.

Bensen (4) reported the results of a countermeasure that included both traditional enforcement and contextual influences. His study involved a before-and-after analysis of two North Dakota counties. The traditional enforcement project also included extensive coordination with other public agencies such as the prosecutors and the courts. A correlation study revealed an inverse relation between levels (hours) of enforcement and numbers of accidents. Bensen stressed the importance of quality rather than quantity of enforcement (tickets). He concluded that the planned public information program coupled with a highly conspicuous enforcement effort (well-marked police vehicles) will improve compliance and reduce accidents.

There is considerable support for the contention that both traditional enforcement and contextual efforts are important contributors to an effective highway safety program. Improved interagency coordination and communication also appear to aid such a program.

BACKGROUND AND PROJECT DESCRIPTION

Boise is a rapidly growing community of about 100,000 people (5). It is the state capital and is by far Idaho's largest city. Before the implementation of STEP, Boise routinely ranked either first or second in the state for injury accidents per thousand people. This problem was compounded by the low manpower level of the Boise Police Department (BPD). Boise had about 1.3 officers per thousand people, much lower than the national average of 2.3 officers per thousand people for cities of comparable size (6). Furthermore, because the BPD had not assigned specific responsibility for traffic enforcement to any division or section, traffic enforcement was relegated to random responses to traffic accident problem areas. There was no accident records system that would allow the BPD to identify times or areas with high accident rates or typical accident causation factors. These limitations combined to inhibit the city's ability to respond effectively to its traffic accident problems.

To address these problems, Boise implemented a STEP project. Eight officers were hired in addition to the 4 officers already on staff to form a 12-man STEP unit, which was supervised by 3 sergeants. The supervisors divided the unit into 4 teams, which were assigned to specific geographic areas. The STEP project also included a strong public information and education component. The public was advised of hazardous locations, the types of unsafe driver actions that were observed there, and the type of enforcement activity that would be used to discourage such actions. Media coverage was extensive. Radio gave the most complete coverage; three local radio stations carried STEP advisory messages twice daily. Representatives of the local driver education classes reached newly licensed drivers and for local civic action groups to reach the older drivers. The public information and education efforts successfully portrayed the BPD as being genuinely interested in safety instead of just writing tickets.
Effective liaison was also established with the Fourth District Magistrate Court, the Ada County Highway District, and the Boise School District. These improved lines of communication proved very beneficial. The Magistrate Court streamlined its citation-handling procedure, which was critically important because STEP resulted in a twofold increase in citations for hazardous moving violations. The BPD pointed out several locations where engineering deficiencies contributed heavily to accidents. Prompt attention to these areas by the Ada County Highway District often significantly reduced the workload of the BPD. As mentioned earlier, BPD contributions to driver-education classes concentrated attention on unsafe driver actions.

Intermediate-level evaluation data are not complete because the BPD did not have a citation record system before implementation of STEP. The BPD estimated the number of citations for hazardous moving violations for calendar year 1978 at 10,157. The estimate was based on radio clearance codes. The number of citations for hazardous moving violations issued in calendar year 1980, the first full year of implementation, was 23,641; 1981 yielded 20,677 citations. This indicates about a 100 percent increase in enforcement activity; however, this might be questioned because it is based on an estimated activity level for 1978.

Another indicator of increase in enforcement activity is the annual number of arrests issued by the BPD for driving under the influence (DUI), as reported in the Idaho Uniform Crime Report for the years 1975-1980. A corresponding value was reported by the BPD for 1981. The problem of driving and alcohol was identified as one of Boise's most significant problem areas and is probably a good indicator of overall enforcement activity both before and after STEP was implemented.

The table below gives the number of DUI arrests for 1975-1981:

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of DUI Arrests</th>
<th>Year</th>
<th>No. of DUI Arrests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>415</td>
<td>1979</td>
<td>769</td>
</tr>
<tr>
<td>1976</td>
<td>404</td>
<td>1980</td>
<td>1468</td>
</tr>
<tr>
<td>1977</td>
<td>515</td>
<td>1981</td>
<td>1824</td>
</tr>
<tr>
<td>1978</td>
<td>501</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is significant that 415 of the 769 DUI arrests made in 1979 were made in the three-month period after the implementation of STEP. This implies nearly a 200 percent monthly increase in DUI enforcement activity after implementation of STEP in Boise. Both DUI arrests and citations for hazardous moving violations indicate a sharp rise in the BPD's overall enforcement activity coincident with STEP implementation.

**METHODOLOGY**

**Data**

All accident data used in this study were retrieved from the Idaho Transportation Department (ITD) accident data base. This is the official state accident data base, and all Idaho jurisdictions contribute to it. Injury accident data were used because a change in the reporting level for property-damage accidents occurred during the study period, which made the data on total accidents less reliable.

Exposure data in terms of statewide vehicle miles of travel (VMT) were also collected from ITD. The actual values were derived from fuel consumption and yearly average fuel economy figures.

Monthly data were collected for each variable. The study period was from January 1974 through July 1981. This provides a 22-month intervention period and a 69-month base period. A lengthy base period was selected for the analysis because of the relatively low monthly values for Boise injury accidents.

**Design**

The evaluation uses a quasieperimentally interrupted time series design. A comparison group was used to help predict what might have happened in Boise without the implementation of STEP. Selection of a comparison location was difficult because Boise is unique in Idaho due to its population and urban makeup. Comparable cities in other states are no better because virtually all northwest regional cities of this size have experienced some effects of highway safety programs during the study period. The comparison group finally selected was all of Idaho except those jurisdictions that had an impact-type highway safety project during the study period. The comparison group finally selected was all of Idaho except those jurisdictions that had an impact-type highway safety project during the study period. This group is referred to as non-STEP. Admittedly, this group is not an ideal comparison group because of differences in population, urban-rural makeup, and exposure, but it is still believed to be the best available indicator for what might have happened in Boise without STEP.

Analysis of Boise and non-STEP data pointed out a need to relate injury accidents to some risk or exposure variable. Monthly statewide VMT was selected as the best available measure of exposure.

The evaluation designs for Boise and the comparison group can be modeled as shown in Figure 1.

**Analysis Technique**

The Box-Jenkins time series approach (8) was used to estimate transfer function and time series parameters. This technique accounts for the dependent-series seasonal and trend characteristics and thereby provides accurate estimates of the relations of dependent series to independent series. To quantify the impact of the STEP period on Boise and non-STEP injury accidents, this research considers zero-order transfer functions in multivariate models. The general form of the model is

\[ Y_t = \beta X_t + \omega_t + \epsilon_t \]

where

- \( Y_t \) = monthly injury accidents at time period \( t \)
- \( \beta \) = function that relates the independent variable \( X_t \) to the dependent variable \( Y_t \)
- \( X_t \) = monthly exposure (VMT)
- \( \epsilon_t \) = impact of Boise STEP--i.e., average monthly change in \( Y_t \)
I_t = dummy variable for presence of Boise STEP (when t < 69, I = 0; otherwise, I_t = 1); and
N_t = noise, stochastic background variation.

The t-test is used to determine parameter significance. Parameters are accepted at the 95 percent confidence level.

RESULTS

Findings

Exposure Series

Figure 2 shows the exposure series used in these analyses. The intervention point is referenced in the figure. Note the large jump in exposure in 1978 and then a return to pre-1978 levels. This trend also appears in Boise and non-STEP data.

Table 1. Exposure data.

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<thead>
<tr>
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</thead>
<tbody>
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<td>415</td>
<td>380</td>
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<tr>
<td>February</td>
<td>366</td>
<td>350</td>
<td>387</td>
<td>407</td>
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<td>477</td>
<td>452</td>
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<td>475</td>
<td>358</td>
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<td>542</td>
<td>523</td>
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<tr>
<td>May</td>
<td>492</td>
<td>496</td>
<td>516</td>
<td>512</td>
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<tr>
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<td>524</td>
<td>586</td>
<td>576</td>
<td>660</td>
<td>625</td>
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<tr>
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<td></td>
</tr>
<tr>
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<td>592</td>
<td>600</td>
<td></td>
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<tr>
<td>November</td>
<td>446</td>
<td>432</td>
<td>483</td>
<td>486</td>
<td>576</td>
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<td>477</td>
<td></td>
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<tr>
<td>December</td>
<td>446</td>
<td>428</td>
<td>477</td>
<td>479</td>
<td>530</td>
<td>478</td>
<td>496</td>
<td></td>
</tr>
</tbody>
</table>

Monthly values for Idaho VMT for the period January 1974 through July 1981 are given in Table 1. The data were derived from annual VMT, average annual fuel economy, and monthly fuel consumption. The univariate time series model for the data is:

\[
(0.08) (0.05) \\
(1 - B)(1 - B^4)Z_t = (1 - 0.59B)(1 - 0.8B^12)a_t
\]

where

- \(Z_t\) = monthly VMT,
- \(B\) = back-shift operator, and
- \(a_t\) = noise.

Strong seasonality is obvious. No deficiencies were discovered in residual analysis.

Boise Series

The Boise series is shown in Figure 3. Again, the

Figure 2. Exposure series (VMT).
The final multivariate model of the Boise series is
\[ Y_t = 0.117X_t - 14.061 + \left[ \frac{(1 - 0.66B^12)}{(1 - B^12)} \right] a_t \]  
(4)
where
- \( Y_t \) = Boise injury accidents for time period \( t \),
- \( X_t \) = exposure (VMT) for time period \( t \),
- \( I_t \) = presence of intervention in time period \( t \),
- \( B \) = back-shift operator, and
- \( a_t \) = noise component of \( Y_t \) after explained variance is removed.

Note that the term \( N_t \) of the general model is equivalent to the expression \( \left[ \frac{(1 - 0.66B^12)}{(1 - B^12)} \right] a_t \).

The standard error of each parameter estimate is indicated in parentheses above the estimate. A delay of three months was identified for the impact of STEP, as indicated by the term \( I_{t-3} \). All parameters were estimated using a regression procedure.

Table 2. Boise injury accident data.

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<td>102</td>
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<td>October</td>
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<td>92</td>
<td>114</td>
<td>91</td>
<td>72</td>
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</tr>
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</table>
Figure 4. Non-STEP series (injury accidents).

Table 3. Non-STEP injury accident data.

<table>
<thead>
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<td>449</td>
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<td>571</td>
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<td>411</td>
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<td>483</td>
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<td>391</td>
<td>472</td>
<td>494</td>
<td>486</td>
<td>455</td>
<td></td>
</tr>
</tbody>
</table>

Parameter estimates were significant at the $\alpha < 0.01$ level. Residual analysis revealed no model deficiencies.

Non-STEP Series

Figure 4 shows the comparison group, the non-STEP series. As before, the intervention point is referenced, but this time there is no obvious shift in level after the intervention. In fact, these data closely follow the exposure data.

Table 3 gives monthly injury accident data for non-STEP Idaho communities for the period January 1974 through July 1981. The univariate time series model for the data is

$$\begin{align*}
(0.08) (0.04) \\
(1 - B)(1 - B^{12})Z_t &= (1 - 0.69B)(1 - 0.87B^{12})a_t \\
\end{align*}$$

where

$Z_t = \text{monthly non-STEP injury accidents}$,

$B = \text{back-shift operator}$, and

$a_t = \text{noise}$.

Strong seasonality is obvious. No deficiencies were discovered in residual analysis.

A model similar to the Boise multivariate model was selected for this series. The model is

$$Y_t = 0.46X_t - 8.00l_{-3} + [(1 - 0.7B^{12})/(1 - B^{12})]a_t$$

where

$Y_t = \text{non-STEP injury accidents for time period } t$,

$X_t = \text{exposure (VMT) for time period } t$,

$I_t = \text{presence of intervention at time period } t$,

$B = \text{back-shift operator}$, and

$a_t = \text{noise component of } Y_t \text{ after explained variance is removed}$.

Note that the term $N_t$ of the general model is equivalent to the expression $[(1 - 0.7B^{12})/(1 - B^{12})]a_t$. 
The standard error of each parameter estimate is indicated in parentheses above the estimate. Both the exposure parameter and the seasonal moving average parameter are significant at the $a > 0.01$ level. The estimate for the reduction due to $I_t$ is not significant and so must be eliminated from the model. Residual analysis revealed no model deficiencies.

**Interpretation of Findings**

After implementing its STEP program, Boise sustained a reduction of 14.1 injury accidents/month. A total of 268 injury accidents were forestalled over the study period. The observed three-month delay in this reduction is entirely reasonable when one considers start-up time for public information and liaison activities. It is interesting to note that there was an immediate sharp increase in the traditional enforcement component (ticketing), but apparently this effort by itself did not achieve immediate reductions in accidents. It was not until the reduction by improving communications. This allowed and activity in the contextual areas both appear to

The Boise STEP achieved its objective of reducing injury accidents. It is reasonable to attribute these reductions to implementation of STEP because no such reduction was observed where STEP was not used. Increases in traditional enforcement at HALs and activity in the contextual areas both appear to be important elements of this successful program. In addition, coordination activities with other agencies, specifically the local court and the local engineering jurisdiction, facilitated accident reduction by improving communications. This allowed all agencies concerned to develop and pursue common highway safety objectives.

### Cost-Effectiveness

The monthly reduction in Boise injury accidents was 14.1. This represents about a 17 percent reduction from the base period average. The cumulative reduction over the study period was 268 injury accidents. Based on the Boise base period injury severity distribution, this yielded an estimated economic cost savings of $1,600,000, an estimate calculated from National Safety Council estimating procedures. The total cost of implementation for the study period was $788,000. This yields a favorable benefit-cost ratio of 2.0. In other words, for every dollar spent $2 was saved.

**REFERENCES**


**Analysis of Selective Enforcement Strategy Effects on Rural Alabama Traffic Speeds**

JAMES N. HOOL, SAEED MAGHSOODLOO, ANDREW D. VEREN, AND DAVID B. BROWN

A study is described that was undertaken to examine the effects of patrol tactics on vehicle speeds, to identify the best patrol tactics of those studied, to identify general speed trends over time, and to examine the effects of an areawide selective enforcement program implemented by the Alabama State Highway Patrol. Both two- and four-lane roads were examined. Six patrol tactics were investigated—four single-vehicle tactics and two dual-vehicle tactics. All data were gathered from a radar-equipped van operated in a moving mode. Vehicle speed characteristics examined included mean speed, 85th percentile speed, and speed variance. Mean speeds were more affected by patrol tactics than were 85th percentiles or variances. Statistically significant reductions in average speeds were obtained with all tactics that used marked patrol vehicles. The largest reductions in average speed occurred with the stationary tactic. Significant reductions in 0.85th percentile speeds were obtained for all tactics on the four-lane road but for none of the tactics on the two-lane road. Variance were generally not affected on the four-lane road, whereas on the two-lane road they increased for five of the six tactics studied. Overall, the most effective tactic was the marked stationary vehicle. The unmarked patrol vehicle, even when issuing citations, had little, if any, effect on the speed parameters. A greater halo effect on speeds occurred on the two-lane than on the four-lane road. The general areawide selective enforcement program may have reduced mean speeds on the four-lane road but did not affect speeds on the two-lane road. No trends or cumulative effects on speeds were found during the three-month selective enforcement period.

An investigation of the short-term effects of a selective enforcement (SE) program on rural highway vehicle speeds in Alabama is described in this paper. A dual-lane highway (US-280) and a four-lane Interstate (I-85) were studied, and for each type of