Table 4. Proposed enforcement program: main-line HOV lanes and San Francisco-Oakland Bay Bridge.

Route	Person Hours per Year			Total Cost ($)
	Special Enforcement	Routine Enforcement	Total	
Marin County US-101	4800	[a]	4800	111 600 (overtime) to 180 000 (new personnel)
Alameda County I-580	64	384	448	10 070
San Bernardino Busway	448	1920	2368	53 328
San Francisco-Oakland Bay Bridge	256	120	376	8628

[a]Negligible.

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 07, William Schaeffer of the Caltrans Sacramento Office, Thornton Piersall of the League of California Cities, David Grayson of the Automobile Club of Southern California, and G. Van Oldenbeek of the Office of Traffic Safety. Valuable contributions were also made by Jesse Glazer of Crain and Associates and Adolf D. May of the Institute of Transportation Studies, University of California.

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Evaluation of Boise Selective Traffic Enforcement Project

GREGORY J. SALI

Boise, Idaho, implemented a Selective Traffic Enforcement Program (STEP) in October 1979. Before that time, the city typically had one of the worst accident rates in the state. The objective of the program was to reduce the number of injury accidents occurring in Boise. The program included both enforcement 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 different levels of conspicuity and durations of enforcement were tested. The authors concluded that conspicuous enforcement resulted in marked reductions in average speed at and near 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 Hauer 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 enforcement attention to those sections. 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 Kohfeld 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 speed arrests. 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. No comparison group was cited. The 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 a well-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.

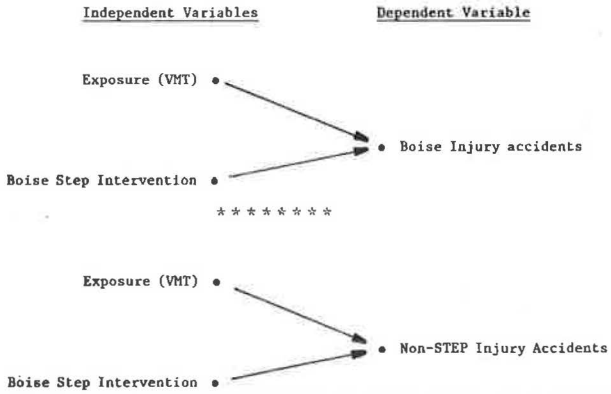
BACKGROUND AND PROJECT DESCRIPTION

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. This induced a "beat pride" and encouraged the individual officers to become familiar with the particular problems of their areas of responsibility. It also produced a competitiveness among the officers to see whose area would have the most improvement. An accident and enforcement records system was established to aid in problem identification. Additional enforcement was focused on problem locations at the times when accidents typically occurred, and officers gave special attention to the types of driver violations that were resulting in accidents.

The Boise 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. Presentations were made for local driver education classes to reach 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.

Figure 1. Design of evaluation procedure for Boise STEP.



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 (7). 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:

Year	No. of DUI Arrests	Year	No. of DUI Arrests
1975	415	1979	769
1976	404	1980	1468
1977	515	1981	1824
1978	501		

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 quasiexperimentally 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. 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

$$Y_t = v(B)X_t + W_o I_t + N_t \quad (1)$$

where

Y_t = monthly injury accidents at time period t;
$v(B)$ = function that relates the independent variable X_t to the dependent variable Y_t;
X_t = monthly exposure (VMT);
W_o = impact of Boise STEP--i.e., average monthly change in Y_t;

I_t = dummy variable for presence of Boise STEP (when $t \leq 69$, $I = 0$; 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.

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:

$$(1 - B)(1 - B^{12}) Z_t = (1 - \underset{(0.08)}{0.59}B)(1 - \underset{(0.05)}{0.8}B^{12}) a_t \quad (2)$$

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).

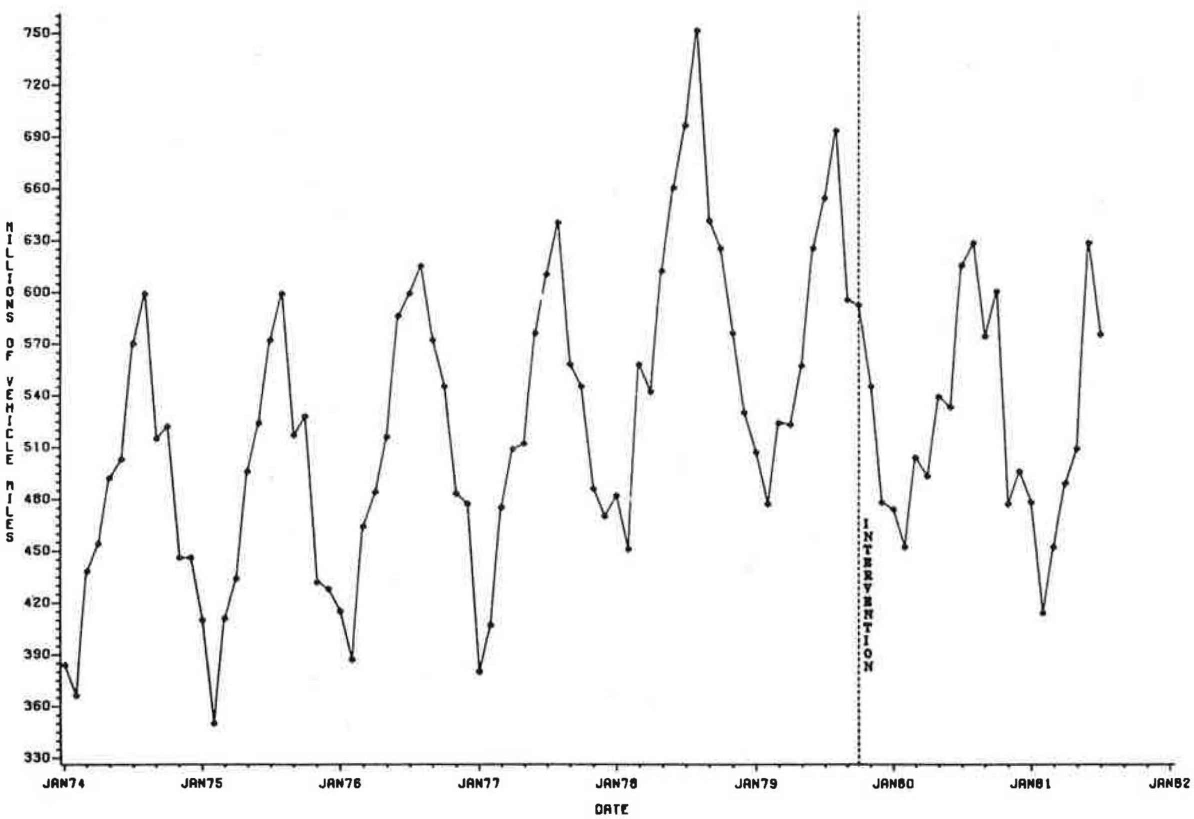


Table 1. Exposure data.

	VMT							
Month	1974	1975	1976	1977	1978	1979	1980	1981
January	384	410	415	380	482	507	474	478
February	366	350	387	407	451	477	452	414
March	438	411	464	475	558	524	504	452
April	454	434	484	509	542	523	493	489
May	492	496	516	512	612	557	539	509
June	503	524	586	576	660	625	533	628
July	570	572	599	610	696	654	615	575
August	599	599	615	640	751	693	628	
September	515	517	572	558	641	595	574	
October	522	528	545	545	625	592	600	
November	446	432	483	486	576	545	477	
December	446	428	477	479	530	478	496	

intervention point is referenced. As in the exposure data, there is a large jump in 1978 and then a return to pre-1978 levels. Note, however, the obvious shift in level after the intervention, which is clearly below any prior study level.

Table 2 gives the monthly values for injury accidents in Boise for the period January 1974 through July 1981. The univariate time series model for the data is

$$(1 - B)(1 - B^{12}) Z_t = (1 - \underset{(0.07)}{0.74}B)(1 - \underset{(0.04)}{0.87}B^{12}) a_t \quad (3)$$

where

Z_t = monthly Boise injury accidents,
B = back-shift operator, and
a_t = noise.

The model indicates a highly seasonal series. No deficiencies were discovered in residual analysis.

The final multivariate model of the Boise series is

$$Y_t = \overset{(0.024)}{0.117}X_t - \overset{(-2.7)}{14.06}I_{t-3} + [(1 - \overset{(0.09)}{0.66}B^{12})/(1 - B^{12})] a_t \quad (4)$$

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 $[(1 - 0.66B^{12})/(1 - B^{12})]a_t$.

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 parame-

Figure 3. Boise series (injury accidents).

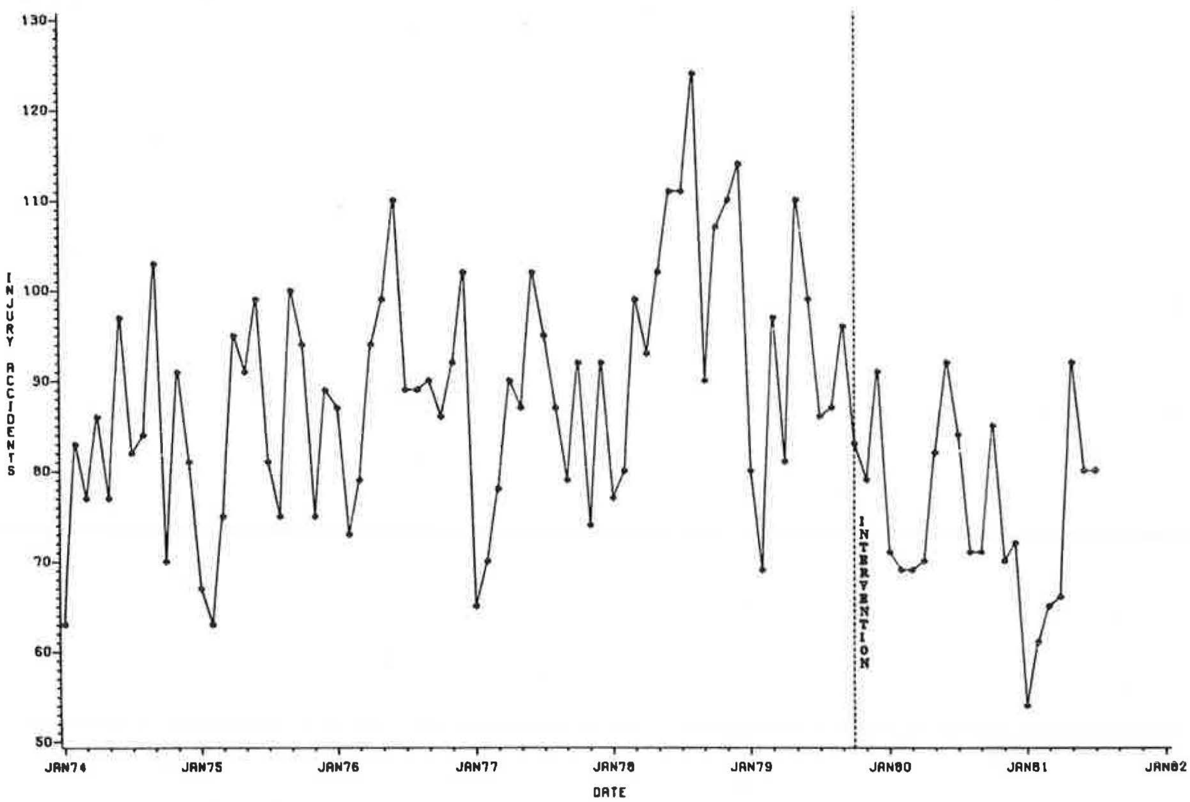


Table 2. Boise injury accident data.

	No. of Injury Accidents							
Month	1974	1975	1976	1977	1978	1979	1980	1981
January	63	67	87	65	77	89	71	54
February	83	63	73	70	80	69	69	61
March	77	75	79	78	99	97	69	65
April	86	95	94	90	93	81	70	66
May	77	91	99	87	102	110	82	92
June	97	99	110	102	111	99	92	80
July	82	81	89	95	111	86	84	80
August	84	75	89	87	124	87	71	
September	103	100	90	79	90	96	71	
October	70	94	86	92	107	83	85	
November	91	75	92	74	110	79	70	
December	81	89	102	92	114	91	72	

Figure 4. Non-STEP series (injury accidents).

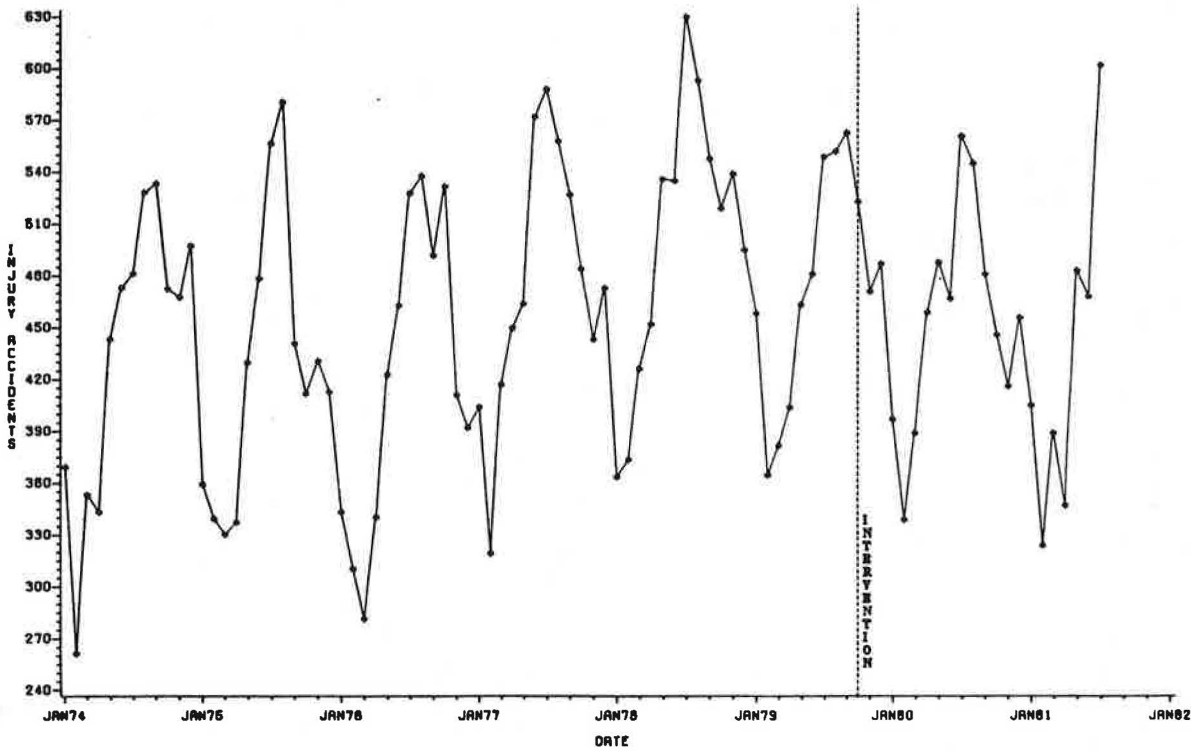


Table 3. Non-STEP injury accident data.

	No. of Injury Accidents							
Month	1974	1975	1976	1977	1978	1979	1980	1981
January	369	359	343	403	363	457	396	404
February	261	339	310	319	373	364	338	323
March	353	330	281	416	425	381	388	388
April	343	337	340	449	451	403	458	346
May	443	429	422	463	535	462	487	482
June	473	478	462	571	534	480	466	467
July	481	556	527	587	629	548	560	601
August	528	580	537	557	592	551	544	
September	533	440	491	526	547	562	480	
October	472	411	531	483	518	522	445	
November	467	430	410	442	538	470	415	
December	497	412	391	472	494	486	455	

ter 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

$$(1 - B)(1 - B^{12})Z_t = (1 - \overset{(0.08)}{0.69}B)(1 - \overset{(0.04)}{0.87}B^{12})\, a_t \qquad (5)$$

where

Z_t = monthly non-STEP injury accidents,
B = back-shift operator, and
a_t = 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

$$Y_t = \overset{(0.09)}{0.46}X_t - \overset{(10.5)}{8.0}I_{t-3} + [(1 - \overset{(0.09)}{0.7}B^{12})/(1 - B^{12})]\, a_t \qquad (6)$$

where

Y_t = non-STEP injury accidents for time period t,
X_t = exposure (VMT) for time period t,
I_t = presence of intervention at 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 $[(1 - 0.7B^{12})/(1 - B^{12})]a_t$.

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 $\alpha < 0.01$ 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 public information and liaison activities were under way that the maximum reductions occurred.

There was no significant reduction in injury accidents for the non-STEP group during the period of intervention in Boise. This was the expectation and is entirely logical because there was no additional effort to reduce accidents in these areas.

CONCLUSIONS

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.

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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 0.85 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 0.85 percentile speeds were obtained for all tactics on the four-lane road but for none of the tactics on the two-lane road. Variances 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