JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1980, 13, 571-581 NUMBER 4 (WINTER 1980)

REDUCTION OF POLICE VEHICLE ACCIDENTS THROUGH MECHANICALLY AIDED SUPERVISION

LYNN D. LARSON, JOHN F. SCHNELLE, ROBERT KIRCHNER, JR., ADAM F. CARR, MICHELE DOMASH, AND TODD R. RISLEY

NASHVILLE METROPOLITAN POLICE DEPARTMENT, MIDDLE TENNESSEE STATE UNIVERSITY, AND THE UNIVERSITY OF KANSAS

Tachograph recorders were installed in 224 vehicles of a metropolitan police department to monitor vehicle operation in an attempt to reduce the rate of accidents. Police sergeants reviewed each tachograph chart and provided feedback to officers regarding their driving performance. Reliability checks and additional feedback procedures were implemented so that upper level supervisors monitored and controlled the performance of field sergeants. The tachograph intervention and components of the feedback system nearly eliminated personal injury accidents and sharply reduced accidents caused by officer negligence. A cost-benefit analysis revealed that the savings in vehicle repair and injury claims outweighed the equipment and operating costs.

DESCRIPTORS: occupational safety, accident prevention, police vehicles, vehicle safety, police, tachograph, feedback, behavioral management, supervision, law enforcement

In recent years, the Occupational Safety and Health Administration has spent $119 million annually to enforce laws and to develop programs to improve worker safety (Wolnez, 1977). In spite of such efforts, injuries and accidents have been a frequent and continuing concern in both the public and private work sector. According to statistics compiled by the National Safety Council (1977), a total of 245 million man-days were lost in 1976 due to work accidents. Associated costs of work accidents, including visible and indirect losses, totaled $15.3 billion.

Job performance feedback methods have been identified as an effective approach to facilitate occupational accident prevention. McIntire and White (1975) and Fitch, Hermann, and Hopkins (1976) outlined the concept of feedback methods and behavioral techniques applied to industrial safety programs and discussed the potential benefits of such an approach. Recent investigations have substantiated the effectiveness of feedback methods used to reduce unsafe behaviors in varied work settings. Sulzer-Azaroff (1978) examined the use of written feedback from safety inspection officers to reduce hazardous physical conditions in a university research laboratory. Reductions occurred in both the mean frequency and categories of hazards when feedback was introduced using a multiple-baseline design across three groups of laboratory units. Feedback was also used in a study by Komaki, Barwick, and Scott (1978) to improve worker safety in two departments of a food manufacturing plant. Improvements in observed safe

This study was based on a dissertation submitted by the first author in partial fulfillment of the requirements for the Ph.D. degree at the University of Kansas. The investigation was supported by Tennessee Highway Safety Project Grants 315-76-001-037 and 315-77-001-006 from the Department of Transportation. The authors thank Richard Eck for assistance in the early phases of the research. Appreciation is also expressed to Walter Dellheim and James Tally of AGRO Instruments for providing technical information concerning tachograph recorders. Additional information may be obtained by writing VDO-AGRO, 980 Brooke Road, Winchester, VA 22601. Reprints may be obtained from J. F. Schnelle, c/o Nashville Metropolitan Police Department, 110 Public Square, Nashville, Tennessee 37201.

work practices were demonstrated through staggered introduction of the feedback intervention. When feedback conditions were reversed, safety practices of workers returned to baseline levels. The results of both studies indicated that the delivery of feedback to employees regarding safety practices can reduce accidental injuries and hazardous work conditions.

In certain occupational settings, provision of safety performance feedback is complicated by the remoteness and isolation of job activities. For instance, police officers and security personnel typically patrol vast geographic areas with almost no direct supervision regarding the safe operation of patrol vehicles. Field sergeants and supervisors have few opportunities to observe the driving behavior of officers and are unreliable in detecting inappropriate driving due to the lack of criteria for measuring acceptable performance. In addition, the consequences of both safe and unsafe driving are often distant and sporadic (e.g., safety awards for one or more years without an accident, reprimands following an accident).

A method for increasing supervisory capabilities was demonstrated by Kloss, Christopherson, and Risley (1976) through the use of behavioral technology to measure patrol performance. Security personnel assigned to patrol a low income public housing project in Kansas City were continuously monitored on a number of independent indices of activity. Maintenance of an acceptable frequency and density of patrol vehicle movement was attained by equipping security vehicles with tachograph recorder units. A tachograph is a clock-driven recording device which provides a permanent record of such vehicle functions as speed, distance traveled, nonmovement, and use of emergency equipment. Tachograph recorders have been used for many years in the trucking industry to monitor driving speeds, idling time, use of required rest periods for drivers, and other variables. Although no controlled studies have been performed, safer driving behavior and fewer truck accidents have been attributed to the use of tachographs (Lee & Smallwood, 1979; "Traffic Safety and the Tachograph," 1978).

Tachograph recorders have also been used by a small number of police departments to increase supervision and reduce vehicle accident rates. The opportunity for accidents is perhaps greater for law enforcement personnel than for any other profession, considering that patrol cars travel an average of 1,800 miles per month, are in operation around the clock under all types of weather conditions, and are used in emergency and pursuit driving situations. Turner (1977) presented survey data from 59 police departments that indicated that during 1976, 40% of all 1976-model police vehicles were involved in at least one accident during the year. Vehicles that were totally destroyed and older model vehicles were not included in the survey. Police departments employing tachograph recorders have reported anecdotal evidence to suggest that accidents have been reduced ("Police Trying Data Recorders on Cars," 1974; Wynn, 1973), but similar to application in the trucking industry, no controlled investigations have substantiated the claims.

The present study was designed to evaluate systematically the large-scale use of the tachograph recorder as an accident prevention tool in a metropolitan police department. Various feedback methods indigenous to the police setting were also examined in order to facilitate and maintain safe driving behavior of officers. In addition, the practicality of the procedures was assessed by means of a cost-effectiveness analysis.

METHOD

Setting and Participants

The police department of Metropolitan Nashville and Davidson County, Tennessee, provided a setting for the accident prevention research. High accident rates and negligent abuse of police cars were identified as serious problems prior to the study. In 1974, a total of 324 accidents involving police vehicles were reported. During

1975, 341 accidents injured 75 persons and cost the metropolitan government over $200,000. In past accidents, charges of negligent driving had to be determined by an investigating superior officer based primarily on self-report of the driver. If negligence were determined, disciplinary action would be decided by supervisors in the chain of command based on such factors as the degree of negligence, severity of the accident, and prior accident history of the officer. Disciplinary action could range from an oral or written reprimand to several days suspension without pay. During the one-year period prior to the study, officers in the selected sections and divisions received 7 oral reprimands, 19 written reprimands, and 29 suspensions of one or more days without pay. Such a crisis-oriented approach appeared to be ineffective in preventing or deterring negligent driving and reducing accident rates.

The Nashville police department employs a force of approximately 900 officers and operates a fleet of 224 marked police vehicles. Officers of the Traffic Section (22 officers, 19 vehicles), Patrol Division (350 officers, 162 vehicles), and Canine and Tactical Section (43 officers, 43 vehicles) participated in the study. In each unit, officers work similar hourly amounts and are responsible for enforcing all Tennessee laws. However, each unit is primarily responsible for performing specific tasks: Traffic Section officers are responsible for the enforcement of traffic laws and the investigation of vehicle accidents; Patrol Division officers routinely patrol and investigate all types of law violations in the 533 square miles of Davidson County; and officers of the Canine and Tactical Sections are primarily deployed during specialized investigations, such as drug and building searches, bomb threats, and intensive patrolling operations.

Because the Nashville police department had officially mandated the use of tachograph recorders through a departmental order, participation of officers in the evaluation was a function of the job requirements. Officers were aware of the monitoring characteristics of the tachograph and were active participants in various aspects of the procedures.

Apparatus

Tachograph recorders were first used in Nashville police department vehicles during a study on preventive patrolling (Schnelle, Kirchner, Casey, Uselton, & McNees, 1977). Four tachograph recorders verified that speed was held under 20 miles per hour during patrol. The department's experience with tachographs during the preventive patrolling study proved that the instruments could provide reliable, precise records of a number of previously unattainable vehicle functions.

The electronic tachograph recording unit (ARGO Instruments, Model TCO 15-2) is enclosed in a cylindrical metal housing with a diameter of 5.5 in. (14.1 cm) and a length of 5.5 in. (14.1 cm). The front section or "face" of the housing is secured by a hinge at the base of the cylinder and a key latch at the top. When the latch is opened, the face swings downward, allowing access to the recording styli positioned inside the cylinder and the mounting post on the back side of the face. A disc-shaped paper chart can be mounted on the post and when the face is swung shut, the mounting post and chart slowly turn at the rate of one revolution per 24 hours. The sapphire-tipped styli press against the wax coated chart leaving a continuous and permanent fine line etched on the paper. Each stylus records a unique vehicle function on a separate area of the chart. On the periphery, rate of speed from 0 to 120 miles per hour is recorded. A second stylus etches a thin line when the vehicle is not in motion and a thick line when the car is moving. A third stylus engraves three thickness levels; a thin line indicates nonidling of the engine, a thicker line corresponds to engine idling, and a bold line indicates the use of emergency lights. Cumulative miles traveled is recorded by the upward and downward strokes of the fourth stylus.

According to manufacturer's specifications, rate of speed and cumulative miles traveled are

recorded within ±2% of standard time and distance tests. The electronic quartz clock is accurate to within ±2 minutes per month. All other measures recorded by the tachograph are absolute.

Mechanics of the Nashville metropolitan garage installed tachograph units in the trunks of the police cars and connected all cables to the target vehicle components. Garage personnel are responsible for servicing police department vehicles and were trained to maintain all tachograph equipment. Itemized information on the frequency of repairs and adjustments for tachographs was not computed under the service arrangement. However, an indication of the degree of maintenance problems is evident in a police department report prepared six months after tachographs had been installed in the patrol division vehicles (162 cars) which stated, "after solving a number of mechanical and electrical malfunction [during installation], no problems of major proportion have occurred."

Procedure

No feedback condition. During August 1976, 19 vehicles of the Traffic Section were equipped with tachographs. Traffic Section vehicles were selected for the study due to the severity of past accidents. Traffic officers were instructed to place a blank tachograph chart in the recorder at the start of the eight-hour shift. At the end of the shift, the officer removed the chart from the recorder, filled in his or her name, car number, date, and mileage, and placed the chart in a collection box at the police station. All charts were transferred daily to the principal investigator of the project. For the first three months, no feedback was given to the officers concerning the content of the charts.

Feedback condition. The Feedback phase of the project was initiated three months after the tachographs were installed (November 1976). During a special in-service training session, Traffic Section sergeants were trained to monitor the following measures obtained from the tachograph charts: (a) use of emergency lights on specific calls for service as designated in the Metropolitan Police Department Manual (Note 1), (b) unexplained rates of speed in excess of 65 miles per hour, and (c) unexplained periods of nonmovement that exceeded 30 minutes. Sergeants were instructed to examine the time recorded on all reports and citations to determine when the use of emergency lights, nonmovement periods, and high rates of speed were used appropriately.

Each chart was reviewed and initialed by the officer's sergeant before the charts were sent to the principal investigator. Sergeants were encouraged to provide officers with positive recognition for acceptable charts. When abnormalities appeared on the chart, the sergeant was responsible for discussing the irregularity with the officer and providing corrective feedback to prevent reoccurrence of the problem.

Feedback plus inspections condition. Marked officer-driven vehicles of the Patrol Division were equipped with tachographs that began recording vehicle functions in February 1977. The 142 tachographs for the Patrol Division were acquired through funds appropriated by the Nashville city council. Officers and sergeants of the Patrol Division followed procedures similar to the Feedback phase described for Traffic officers, except that tachograph charts were sent to the Inspections Section rather than the principal investigator. The Inspections Section is responsible for monitoring the quality of the department's job performance and compliance with rules, regulations, and policies. In mid-February, the Inspections Section also began to receive charts from the Traffic Section. All charts were reviewed daily by Inspections personnel. Any charts that showed unexplained deviance were sent to the Assistant Chief of Field Operations. From the assistant chief's office, a copy of the chart and an explanation request were sent to the officer and his sergeant. If the incident was unexcusable, one or both officers received disciplinary action as previously described.

After the Inspections Section reviewed tacho-

graph charts for approximately two months, the need became obvious for a structured form on which the officers could record daily activities. An activity sheet was essential as a supplement to explain the vehicle functions recorded by the tachograph. On the activity sheet, officers recorded the time that an activity was begun and completed, the type of activity, location, report or ticket number associated with the activity, and the officer responsible for driving. Aside from providing a log of activities, the form also served as a prompt for officers to check on the accuracy of the tachograph clock and as a reminder of the information to be entered on the chart.

During February 1978, additional tachograph recorders were purchased with funds appropriated by the Nashville city council. The tachographs were installed in the 43 marked vehicles of the Canine and Tactical Sections and 20 remaining "Extra" vehicles assigned to the Patrol Division. Tachograph charts from these vehicles were reviewed in the same manner as charts from the Traffic and Patrol vehicles. The only procedural change affecting all units was a revision in the reporting method used by Inspections staff. A 10-item checklist was introduced as a standardized feedback form to monitor the supervisory performance of sergeants. At the end of each month, a summary report was prepared on the performance of each sergeant and the report was distributed to the upper-level chain of command at regularly scheduled staff meetings. The feedback form and summary sheet were implemented to facilitate maintenance of the desired levels of supervision and feedback by field sergeants.

Measures

Accident reports. The Tennessee Officers' Accident Report is a legal document filled out by Tennessee law enforcement officers during vehicle accident investigations. Officers are responsible for making determinations on a number of variables, including the position and movement of vehicles, the occurrence of injury, and factors that contributed to the cause of the accident. Each accident report is reviewed and signed by the sergeant in command and also by a clerk at the department's central records office. If errors or omissions are detected by either the sergeant or clerk, the report is returned to the officer for corrections. Data from all police reports are entered on a computer after reviews have been completed.

A computer program was written to tabulate data from reports of accidents involving police vehicles. In order to be included in the analysis, accident reports had to indicate that the police car was being driven at the time of the accident and was not simply parked or stopped. The frequency of all accidents that resulted in physical injury to any vehicle occupants, regardless of causative factors, was tabulated. A second tabulation was performed for all moving vehicle accidents involving police officers in which the reports specified that the driver of the police vehicle contributed to the cause of the accident. In both types of analysis, accidents were tallied from May 1975 to July 1978, for vehicles of the Traffic Section and Patrol Division, and from August 1976 to July 1978, for Canine, Tactical, and "Extra" Patrol Division vehicles. Accident frequency data were divided by the number of miles driven by officers in each section during three-month intervals. The resulting quotients were multiplied by 100,000 to yield the rate of accidents per 100,000 miles. Accidents per 100,000 miles has been used as a standard reporting procedure by the National Safety Council (1977).

Tachograph charts. Measures were also obtained directly from the tachograph charts of Traffic Section vehicles. Two 15-day sample intervals were selected at approximately the midpoint during the No Feedback condition and Feedback condition, representing 17% of each intervention period. A third 15-day sample interval was also selected after three months of the Feedback plus Inspections condition. The specific data retrieved from the charts of each

sample interval consisted of the maximum daily driving speed with emergency lights engaged and maximum speed without emergency lights in operation. Driving speed was assumed to be an important factor related to accidents in metropolitan areas due to the direct relationship between speed, reaction time, and braking distance (Packard, 1974). Driving speed was also considered to be a factor that was highly amenable to modification through feedback.

Charts were manually examined with the aid of a chart analyzer (AGRO Instruments, Model TCO-1076) which magnified the etched lines and measurement scales. A random sample of 20% of the charts was reviewed by a second, independent observer and reliability was determined by dividing the number of agreements (± 2 miles per hour) by the number of agreements plus disagreements times 100. Reliability for scoring maximum speeds from the tachograph charts was 90% without and 88% with the emergency lights engaged.

Cost data. For the largest vehicle group, the Patrol Division, an analysis was performed to determine the cost effectiveness of the tachograph intervention. Direct costs related to all moving vehicle accidents involving Patrol Division officers were collected 18 months prior to and 18 months after the installation of tachographs. Cost data were obtained from Nashville metropolitan garage records of repair and replacement costs for damaged vehicles. If a vehicle was damaged beyond repair, a $5,000 vehicle replacement cost was included in the calculation. Cost data were also collected from the Nashville metropolitan legal services office for claims paid for repairs to other vehicles, plus treatment of physical injury. When claims were received for accidents in which other drivers were at fault, the amounts were deducted from the costs. Total direct tachograph intervention expenditures were calculated and a discounting procedure described by Neeman (1974) and Weisbrod (1972) was applied to determine the yearly opportunity-loss cost during the expected 10-year life of the tachograph recorders.

RESULTS

Figure 1 shows the rate of both physical injury accidents and officer-related accidents per 100,000 miles for officer-driven vehicles of the Traffic Section, Patrol Division, and combined Canine, Tactical, and "Extra" vehicles. Each point on the graph represents the rate for a three-month interval, beginning with May, June, and July, 1975. The rate of accidents that resulted in physical injury, regardless of causative factors, is displayed as open-circle plot points. Accident reports categorize injuries ranging from complaint of pain with no visible injury to death. Complaint of pain with no visible injury comprised 44% of the injuries represented in the figure. Approximately 25% of the injuries involved bruises, abrasions, and swelling, and 31% resulted in bleeding wounds or distorted members. No fatalities occurred during the data collection period. The introduction of tachographs in the Traffic Section is divided into three phases—No Feedback, Feedback, and Feedback plus Inspections. Compared with the baseline rate of .75 accidents, rates varied only slightly under the No Feedback and Feedback conditions (.66 and .60 accidents per 100,000 miles, respectively). The addition of Inspections personnel to monitor the supervisory function of sergeants reduced the physical injury accident rate to zero. When tachographs were introduced in the Patrol Division with Feedback plus Inspections, personal injury accidents were reduced from an average baseline rate of .40 accidents to a rate of .13 accidents per 100,000 miles. The rate of personal injury accidents in the combined group of Canine, Tactical, and "Extra" cars was .68 accidents during baseline and was reduced to an average of .46 accidents per 100,000 miles during the intervention. A noticeable reduction in physical injury accidents did not occur for these vehicles until the second three-month interval.

The rate of accidents in which officers were reported to have contributed to the occurrence of the incident is shown as closed circles in

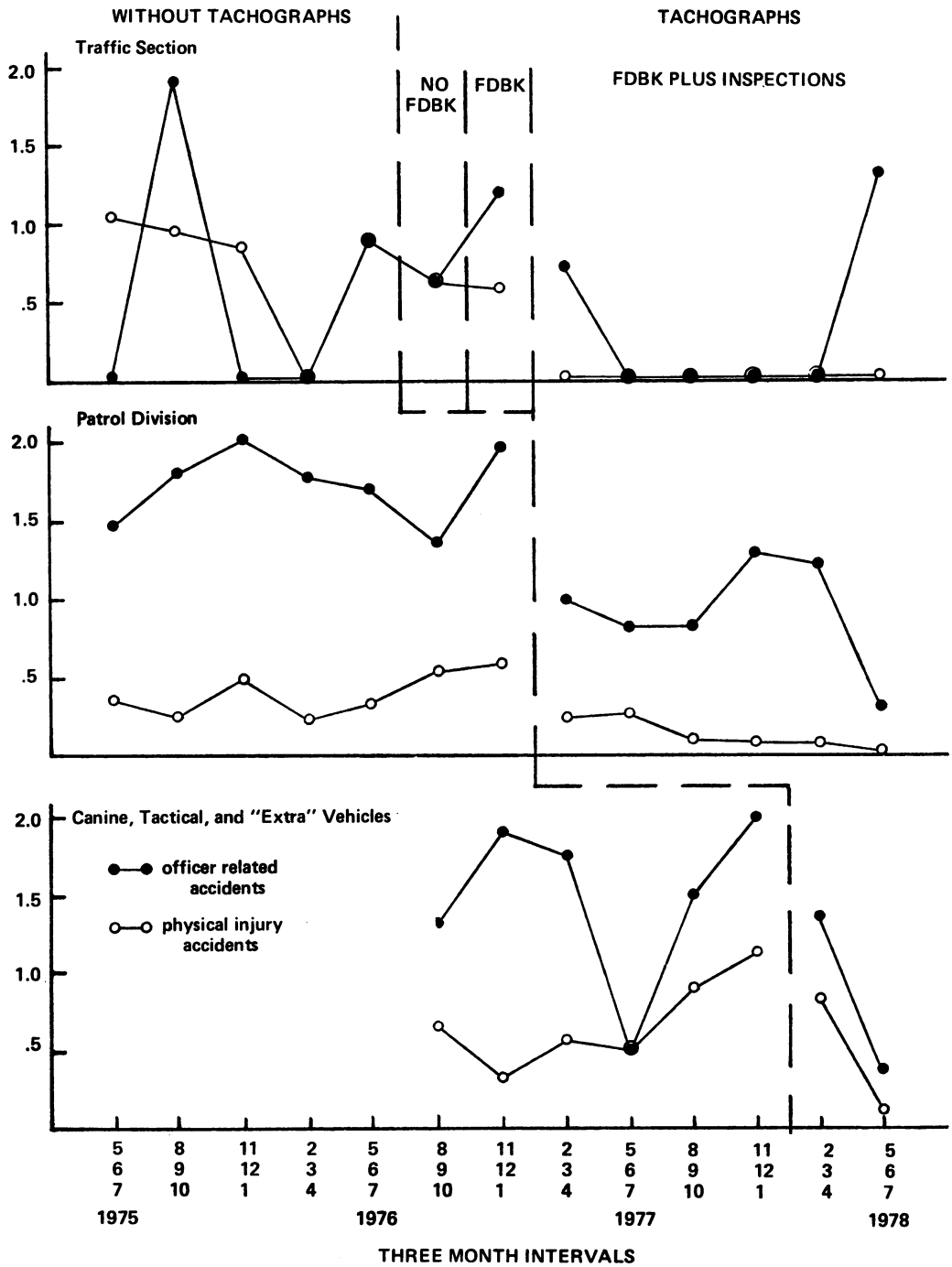

Fig. 1. Rate of physical injury accidents and officer-related accidents per 100,000 miles for officer-driven vehicles of the Traffic Section, Patrol Division, and combined Canine, Tactical, and "Extra" Patrol Division vehicles. The introduction of tachograph recorders is shown in conjunction with No Feedback, Feedback, and Feedback plus Inspections conditions.

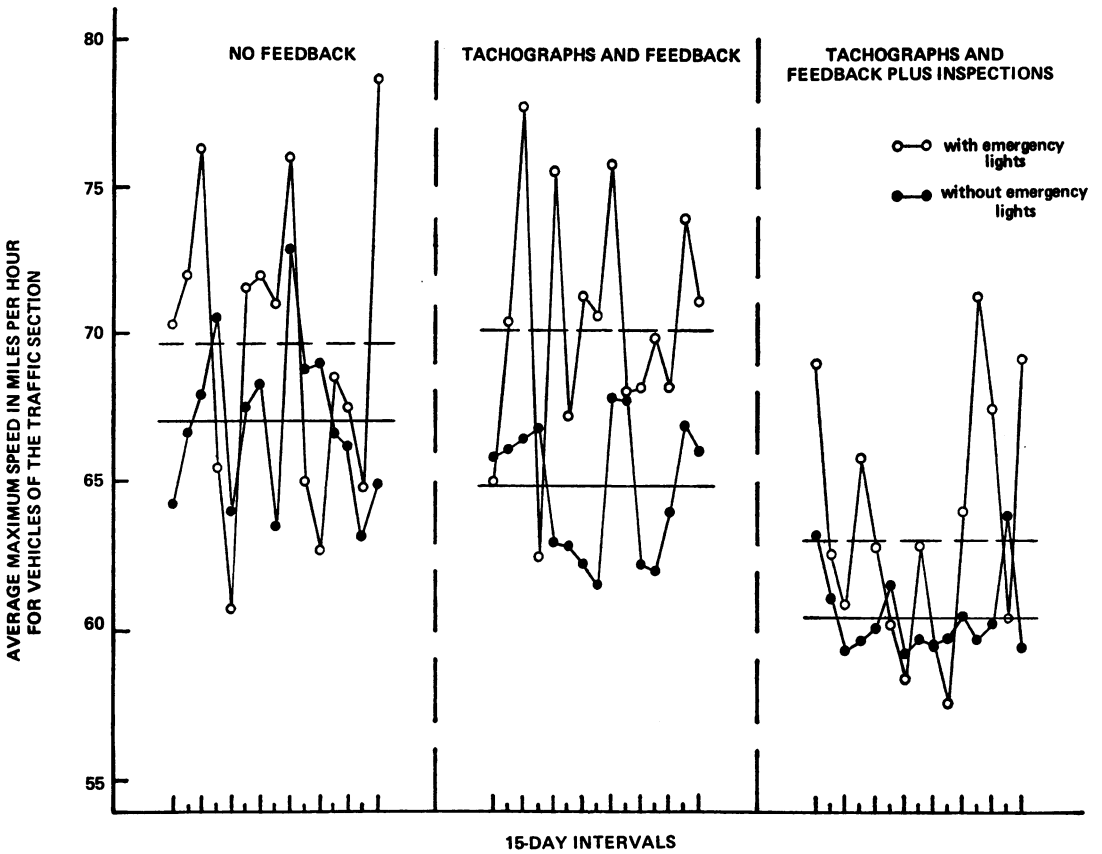

Fig. 2. Mean daily maximum speeds for vehicles of the Traffic Section under both nonemergency and emergency driving situations. The 15-day sample intervals were selected at midpoints of the No Feedback and Feedback conditions, and three months after the Feedback plus Inspections condition. The horizontal line traversing the connected data points indicates the mean speeds for each interval (dashed line = with emergency lights, solid line = without emergency lights).

Figure 1. For vehicles of the Traffic Section, accident rates during baseline were highly variable, ranging from 0 to 1.88 accidents with an average rate of .55 accidents per 100,000 miles. When tachographs were introduced under the No Feedback and Feedback conditions, accidents continued to occur at a level of .66 and 1.21 accidents per 100,000 miles, respectively. When field supervision was monitored by Inspections, the average rate dropped to .34 accidents, including a period of one year in which no accidents occurred. A single accident during the last interval raised the rate to near baseline level. It should be noted that the small number of cars operated in the Traffic Section makes the accident rate measure unduly responsive to numerically small changes in the accident data. In the Patrol Division, accidents occurred at an average baseline rate of 1.72 accidents. The rate dropped to an average of .91 accidents when tachographs were installed with Feedback monitored by Inspections. In the combined group, accident rates dropped over successive quarters under the Feedback plus Inspections condition. The rate of officer-related accidents during baseline was 1.47 per 100,000 miles, but decreased to .85 during the intervention.

Figure 2 illustrates the average maximum speed attained by Traffic Section officers during three separate 15-day intervals. Average maximum speed with emergency lights (open circles) and average maximum speed without emergency

lights (closed circles) are shown for each day. Each interval sampled road speeds under different tachograph feedback conditions. Nonemergency maximum speeds appeared to reduce gradually from the No Feedback condition (67.0 mph interval average) to the Feedback condition (64.8 mph) and the Feedback plus Inspections condition (60.4 mph). Under emergency driving conditions, the only condition that appeared to reduce maximal speed was the Feedback plus Inspection condition (63.1 mph interval average) as compared to No Feedback (69.6 mph) and Feedback (70.1 mph).

Table 1 displays the accident costs for vehicles of the Patrol Division in three, six-month intervals before and during the Feedback plus Inspections intervention. A large reduction in repair costs is evident, considering that the total change from $67,309 during the 18-month baseline to $23,724 during the intervention period represents a savings of $28,805. This savings is to be contrasted to total program costs for the Patrol Division, which consisted of the following cost categories: Tachograph purchasing costs, $59,929.70; mounting hardware, $6,039.10; chart analyzers, $437.50; and installation, $2,005.47. The recurring operating costs of the program are $2,805.00 as reflected by $2,159.80 for repairs (based on the average cost) and $645.20 for charts. If the one-time intervention costs are discounted at interest rates at the time of purchase and spread over the 10-year expected life of the tachograph, then the yearly opportunity-loss cost that occurs due to the $68,411.60 initial expenditure becomes $9,988.09. Thus, the most accurate estimate of program cost for an 18-month period combines maintenance costs plus $14,982 intervention costs for a total cost of $19,189.50. This latter amount is well exceeded by the estimated savings of $23,724.00 per 18-month period. Thus, the total system based on the largest vehicle group appears to be cost effective.

DISCUSSION

The most salient result of the tachograph program was the virtual elimination of personal injury accidents in a fleet of 224 police vehicles driven more than 4,000,000 miles per year. The rate of accidents that are reportedly caused by the negligence of police officers was also substantially reduced.

These reductions in accident rates were achieved only when the Inspections Section personnel monitored the procedures of the tachograph program. Reliance on field sergeants alone to provide feedback had little effect on the frequency and severity of accidents. Supervisors generally develop a close working relationship with line-level personnel and seek to retain acceptance by the group. Under such conditions, enforcement of quality control, safety, or any other type of procedure becomes difficult if such procedures are viewed by the staff as limitations arbitrarily imposed by the supervisor. By monitoring the supervisory functions of line-level supervisors, either through an external evaluation team or an existing organizational component (e.g., the Inspections Section), enforcement of procedures acquires a different rationale. Instead of the supervisor being viewed by staff as

Table 1

Comparison of accident costs associated with officer-driven vehicles of the Patrol Division 18 months before and after the tachograph intervention.

Prior to tachograph intervention			*After tachograph program*		
Aug. 1975-Jan. 1976	*Feb. 1976-July 1976*	*Aug. 1976-Jan. 1977*	*Feb. 1977-July 1977*	*Aug. 1977-Jan. 1978*	*Feb. 1978-July 1978*
$17,932	$28,375	$21,402	$5,754	$7,360	$10,610

personally responsible for enforcement, the supervisor's performance becomes a function of upper-level management. Monitoring of specific supervisory tasks thus increased the likelihood that procedures will be followed without alienating the supervisor from the staff.

The tachograph intervention also provided the police department with an objective performance measure that can be used in personnel evaluations. For example, the monthly summary report prepared by the Inspections Section is being used informally to identify sergeants whose officers perform consistently above or below average on several tachograph measures.

The role of disciplinary action cannot be ignored as an influential variable in this study. The quasi-military structure of the police profession accentuates behavioral control through punitive means and the threat of disciplinary action was undoubtedly associated with the provision of feedback. In actuality, however, no disciplinary action occurred during the period of the study as a direct result of the tachograph program procedures. Disciplinary action continued to be taken as a consequence for officer-related accidents at approximately the same rate as prior to the study. In almost all cases, data from the tachograph charts were used as evidence by upper-level supervisors in determining negligence under the No Feedback, Feedback, and Feedback plus Inspections conditions.

At the onset of the program, the officers generally reacted with discontentment, referring to the tachograph recorder as an "iron sergeant." Members of the police union initially discussed means of resisting the installation of the tachographs, but as the program continued, the resistance and complaints began to diminish. Fifteen separate incidents of tampering occurred shortly after the recorders were installed in the Traffic Section and Patrol Division. The Metropolitan Police Department Manual (Note 1) warned against the modification of any departmental equipment and the incidents were consequated with disciplinary action. After three months of operation, no more incidents of tampering were detected in any section by Sergeants or Inspections staff. At the end of the data collection period, the use of tachographs had become routine, and most officers supported the recorders as accident prevention tools. In several cases, the tachographs charts had also benefited officers by providing documentation that disproved false accusations by citizens or supervisors regarding job performance and vehicle operation.

The reduction in accident rates was probably related to a number of changes in driving behaviors affected by the tachograph intervention. Speed has been suggested as one important driver variable associated with accidents ("Why Auto Deaths Plummeted in '74," 1975), although some controversy exists as to the accident reduction claims attributed to the national 55 mph speed limit law (Taylor, 1978). Other factors are cited that may have been influential in reducing national highway deaths since 1974 (i.e., safer vehicles, changes in the driver population, alternations in reporting procedures), but even critics of the 55 mph limit do not view speed as being unrelated to automobile accidents, particularly those accidents that occur off the interstate system in urban traffic. Because the setting of this study was confined to the streets and highways of metropolitan Nashville, speed was an influential variable in the safe operation of vehicles. Higher rates of speed require greater reaction time and increased braking distance (Packard, 1974), which becomes more critical with congested traffic and complex street conditions. The reduction in average maximum speed of Traffic Section vehicles under emergency and nonemergency driving was most apparent when feedback was monitored by Inspections personnel. Both physical injury and officer-related accidents were also reduced under this condition, indicating that speed was one measurable driving variable associated with accident prevention.

The rough cost-benefit analysis that was done indicated that the total system appears to be cost effective. A more refined analysis would have to take into consideration such additional

cost variables as potential increased maintenance that might occur as the tachograph program progresses. In addition, savings estimates might also change over time, due to program effect changes past the 18-month period reported in this evaluation. Savings that result from decreased physical injuries in all such accident situations would also have to be estimated, even though such estimates would be difficult to quantify in cash terms. Furthermore, accidents involving loss of work-time injury, although obviously critical, do not occur at a righ rate for that class of accidents involving officer negligence. Thus, the impact of this program on this low-rate measure would have to be tracked over long time periods. Nevertheless, at best, the cost-effectiveness analysis that was completed indicates that the tachograph program can be potentially cost effective for long time periods and was actually cost efficient for an 18-month period.

In summary, the tachograph program in the Nashville Police Department was shown to be a very effective and cost-efficient method for reducing the frequency and severity of police vehicle accidents. The provision of monitored supervisory feedback was found to be an important component in conjunction with the tachograph records. On a broader scale, the research has demonstrated that feedback systems can provide a methodology for the development and maintenance of effective occupation safety programs, even when remote job functions are performed.

REFERENCE NOTE

1. Metropolitan Nashville and Davidson County Police Department. *The metropolitan police department manual.* Nashville, Tennessee, 1975.

REFERENCES

Fitch, H. G., Hermann, J., & Hopkins, B. L. Safe and unsafe behavior and its modification. *Journal of Occupational Medicine,* 1976, **18,** 618-622.

Kloss, J. D., Christopherson, E. R., & Risley, T. R. A behavioral approach to supervision. *Security Management,* 1976, **20,** 48-49.

Komaki, J., Barwick, K. D., & Scott, L. R. A behavioral approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant. *Journal of Applied Psychology,* 1978, **63,** 434-445.

Lee, P., & Smallwood, R. The tachograph: Still out in the cold? *Management Accounting,* 1979, **57,** 16-17.

McIntyre, R. W., & White, J. Behavior modification. In B. L. Margolis & W. H. Kroes (Eds.), *The human side of accident prevention.* Springfield, Ill.: Charles C Thomas, 1975.

National Safety Council. *Accident facts, 1977 edition.* Chicago: National Safety Council, 1977.

Neeman, W. B. Benefit-cost analysis and the evaluation of mental retardation programs. In P. O. Davidson, F. W. Clark, & L. A. Hamerlynch (Eds.), *Evaluation of behavioral programs.* Champaign, Ill.: Research Press, 1974.

Packard, C. *Sports illustrated safe driving.* Philadelphia: J. B. Lippincott, 1974.

Police trying data recorders on cars. *Birmingham Post-Harald,* Birmingham, Alabama, November 8, 1974, p. A4.

Schnelle, J. F., Kirchner, R. E., Casey, J. D., Uselton, P. H., & McNees, M. P. Patrol evaluation research: A multiple-baseline analysis of saturation police patrolling during day and night hours. *Journal of Applied Behavioral Analysis,* 1977, **10,** 33-40.

Sulzer-Azaroff, B. Behavioral ecology and accident prevention. *Journal of Organizational Behavior Management,* 1978, **2,** 11-14.

Taylor, R. Why you shouldn't believe the feds body count. *Car and Driver,* May 1978, pp. 75-83.

Traffic safety and the tachograph. *National Safety,* September-October 1978, pp. 2-4.

Turner, R. H. Future uses of the most dangerous police weapon, the automobile. *Transactions of the National Safety Congress,* 1977, **8,** 40-46.

Weisbrod, B. A. Deriving an implicit set of governmental weights for income classes. In R. Layard (Ed.), *Cost-benefit analysis.* Baltimore: Penguin, 1972.

Why auto deaths plummeted in '74. *U.S. News and World Report,* January 6, 1975, p. 21.

Wolnez, G. Loss control seminar. *Transactions of the National Safety Congress,* 1977, **8,** 26-39.

Wynn, E. R. The "third-rider" in Greensboro patrol cars. *Law and Order,* August, 1973, pp. 92-93.

Received April 29, 1979
Final acceptance April 2, 1980