19. MONITORING TRAFFIC BEHAVIOUR IN THE CONTEXT OF AN EVALUATION OF A NATIONAL TRAFFIC POLICE FORCE

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19.1 INTRODUCTION

Until recently, police traffic operations in Israel were coordinated by local and district commanders of the national police force as part of their many other duties. At the district level there were personnel and sub units specializing in traffic related services but there was no national level command, control, and communication structure dedicated to traffic enforcement and other traffic operations

In 1991 a National Traffic Police (NTP) force was established as an operational branch at the national police headquarters in Jerusalem, and all existing traffic units came under its direct command. (The transfer was gradual: first some of the rural districts, then the rest and, finally, the remaining urban districts.)

The NTP introduced an organizational change that put traffic police officers and traffic operations under a separate, nationally coordinated command. In addition, it entailed an increase in resources -- manpower, vehicles and associated enforcement and other equipment. For example, the traffic units in the two districts that have been changed first were nearly doubled in size.

The NTP was empowered and expected to experiment with, and modify strategies and tactics of traffic operations and active enforcement in order to achieve, efficiently, a higher level of traffic safety on Israeli roads.
The Transportation Research Institute is evaluating the total operation of the NTP in order to help improve NTP's functioning and to provide data for those required to determine its success.

The evaluation program was designed to monitor the organizational changes and their impact on NTP functioning and traffic operations; to monitor changes in enforcement activity; to measure changes in traffic or drivers' behaviour and relate them to police actions and; eventually, to asses changes in traffic accidents that might be attributed to the new NTP.

The present report is confined to the monitoring of traffic behaviour during the first phase of the project, when the NTP had jurisdiction over two rural districts, covering about 2500 km. of roads. These roads include all the major, high volume highways in Israel and they accounted for 2600 injury accidents in 1991.

19.2 METHOD OF TRAFFIC BEHAVIOUR MONITORING

19.2.1 Overall approach

The national scope of the NTP and the comprehensive nature of its operation required special methodological considerations with regard to what, where, when, whom, and how to observe and monitor. It was obvious that it would be impossible to monitor every desired driver behaviour (or traffic characteristic) or that the monitoring could be performed at every road and during all times.

Yet the monitored behaviours should represent what happen on the road network much of the time, and indicate whether there are changes in the behaviour over time or locations. As well, it has to be shown that such changes could be attributed to the NTP and that they are, eventually, related to improved safety.

The general approach in designing the monitoring system was to use a large sample of representative road sections and take repeated measures of the set of chosen behaviours. Some behaviours would be automatically collected over longer periods of time while more complex types of behaviours would be manually collected over shorter periods overlapping the automatic records. Knowing the importance of traffic volume in determining most other traffic characteristics it was decided to always record traffic volumes along with other measurements.

The large number of observation sites recognized the large variability in traffic behaviour due to local differences in traffic volume, vehicle mix, roadway characteristics, visibility, weather conditions and a host of other attributes. At the same time an effort was made to reduce the uncontrolled variance by limiting the variety of observation sites and by following a procedure of repeated observations under as similar conditions as practically possible.

19.2.2 The monitored behaviours

The behaviours to be monitored were selected according to the following criteria:

- the behaviour is enforced, (at least in principle), by the police;
- the behaviour is associated, (at least in principle), to safety;
- the behaviour can be reliably monitored and quantified;
- the behaviour can be measured with simple portable equipment;
- the behaviour does not require post- collection analysis (e.g., video interpretation);
- the behaviour can provide sufficient data for statistical analysis and inference.

The traffic behaviours that were selected for monitoring can be divided in two groups:

* Speed and Following Distance, that are measured on road sections;
* Approach Speed on the non priority road, and the Friction Between Turning Vehicles, that are measured at non signalized T junctions.

The interactions between turning vehicles take on three possible Levels of Friction: None, High, and Medium.

19.2.3 Monitoring sites

The sampling, for selecting the observation sites, was done from a list of over 200 road sections. The list was independently compiled by the police prior to the establishment of the NTP. The road network was divided into 10 km to 20 km sections, based on traffic volume, annual accident rate and practical patrolling considerations. At any given time, only some of the sections are actually assigned patrol cars or other enforcement resources.

In the first phase of the monitoring, reported here, 24 road segments were selected from among the road sections with ADTgreater than 5,000 vehicles. In order to provide representation for the various NTP field units, different geographical areas, and different types of roads, the sampling was not random but in clusters to accommodate the above constraints. In each of two NTP districts there were 12 sections, and another 4 in a third, not yet incorporated into the NTP command, police district.

The actual observation site in each road section was selected following on- the- road survey. A non signalized junction with sufficient volume of traffic was located and checked for the monitoring conditions. Traffic behaviour at road sections was monitored on the main road leading to the junction but at a distance far enough to ensure independent behaviour.

The sampling, site selection, and actual observations were carried out independently of any planned or actual police activity at the road sections.

19.2.4 Monitoring procedure

During phase I, data were collected by the same team of observers who visited each site five times, once every other month. Figure 1. shows a typical layout of an observation site.

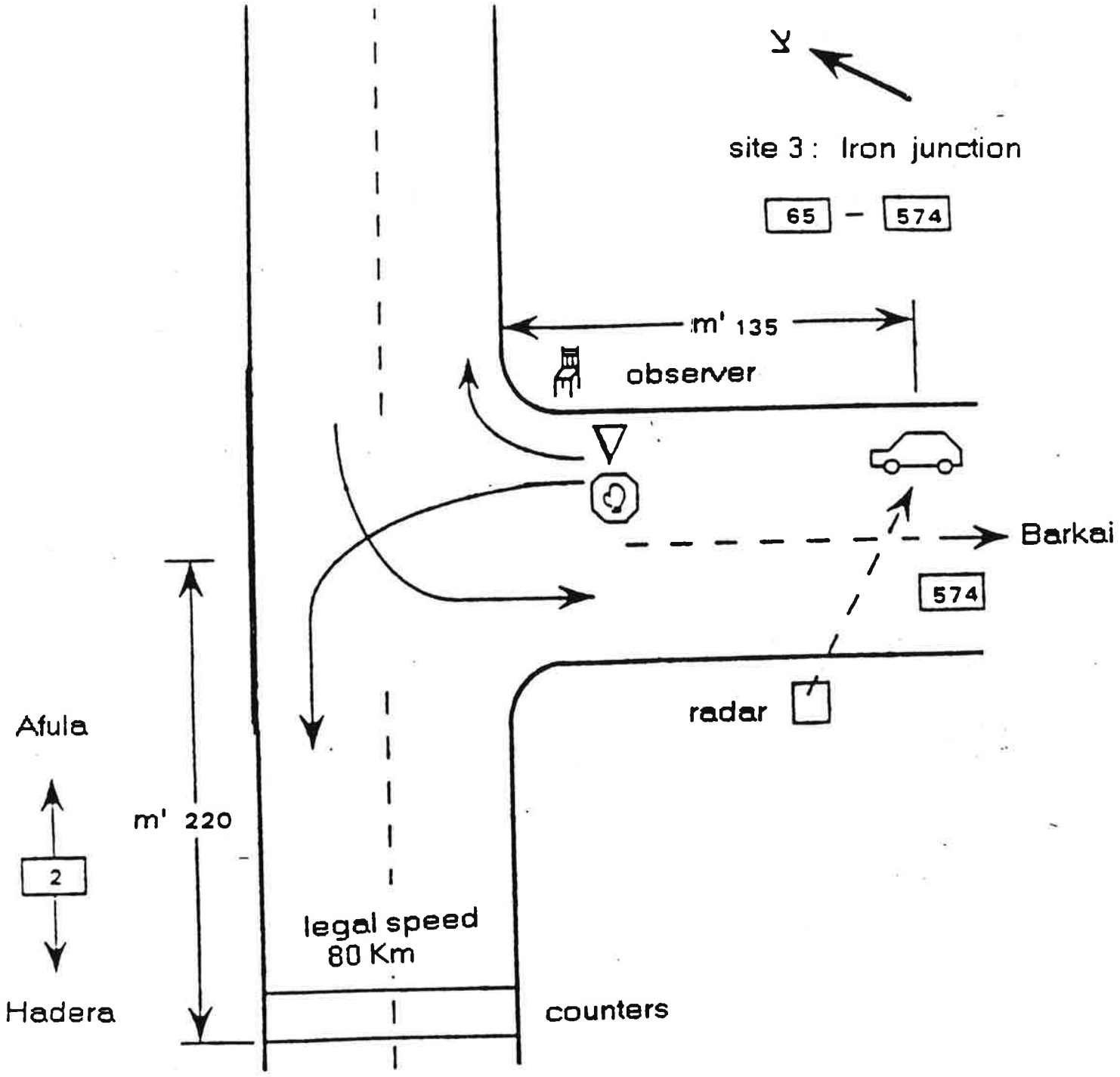
Vehicle volumes, speeds, and following distances on the main road were recorded by electronic Traffic Counters with pneumatic tubes placed 3 m apart. The counters were positioned over 200 m away from the junction, before the beginning of turning lanes or no passing zones. Counters were left for the whole day and, often, overnight and the next day. Data were unloaded into portable computer at the site.

Approach speed on the minor road was measured with a hand operated, portable radar (speed-gun) from inside a parked vehicle. The radar was aimed at a fixed point on the road so that an approaching vehicle would trigger the radar at a specified point from the junction. The point was at a distance where most vehicles begun slowing down slightly. Only free moving vehicles were measured. At least 120 readings per measurement period were taken at each site.

The level of friction at the junction was assessed by an observer positioned at a convenient spot overlooking the junction. The observer used a set of manual counters attached to a clip board to count and classify the turning maneuvers at the junction. Included in the count were all vehicles outgoing the minor road and left turning vehicles form the main road.

Right turning vehicles from the minor road could be in conflict with traffic coming from the left , on the main road: left turning vehicles from the minor road could be in conflict with traffic, in both directions, on the main road; vehicles making a left turn from the main road could be in conflict with oncoming traffic on the main road, with vehicles turning left from the minor road, or with vehicles turning into the minor road from the main road.

Figure 1 Schematic layout of traffic behaviour measures at a junction



Each turning maneuver was classified into one of three categories depending on the amount of friction it generated in traffic at the time of its execution.

Normal friction event included cases when there was no conflicting traffic in the vicinity of the turning vehicle or when each vehicle seemed to act according to priority rules accepted by the other vehicles. There was no indication of last second changes in speed or lane position by either turning or straight going vehicles and no apparent interference with traffic on the main road.

The ***High friction*** category included those obvious cases when the turning event generated - emergency reactions, abrupt lane or speed change, by one or more vehicles in the vicinity of the junction in order to prevent a possible collision.

The ***Medium friction*** category was a default category to accept events that were clearly neither of the other two. Preliminary trials suggested that it was best not to define this category in more specific detail.

During field training, examples of the categories helped defining them by way of induction. A minimum of 30 turning maneuvers per direction were observed at each measurement period for a total of over 150 per junction at a time, (turning volumes were not equal.)

The positions of equipment and observers were paint- sprayed and documented in order to assure similar data acquisition conditions in each round of measurements.

19.3 PRELIMINARY RESULTS

19.3.1 Overview of analysis approach

The purpose of the analysis was to detect meaningful changes in the behavioural measures of traffic, from the onset of the NTP project until the last (5th) round of field measurements. It took the NTP few months to restructure, reorganize, train new officers, acquire new vehicles, develop new operational procedures, and make other adjustments. Therefore, it was expected that the first round of observations represented a base line condition, after which some (hopefully positive) changes would take place as a result of NTP's stronger impact on traffic.

Specifically, the analyses were to find, across five repeated measurement rounds, a trend of change in the following summary measures:

* average speed on main roads;
* % of vehicles moving at speeds higher then the legal speed limit (90 km/h);
* % of following distances smaller than 1 sec or 2 sec;
* average approach speed to a junction, on the minor road;
* % of high and medium friction turning maneuvers at junctions.

In order to relate changes in traffic behaviour to police enforcement, a crude measure of "enforcement level" was obtained for each site. It was based on the mean number of patrolling shifts per week, assigned to the road section, during the month preceding the field measurements.

As noted earlier, traffic volume has a major influence on the momentary values of other traffic characteristics. Therefore, automatic recordings of volumes and speeds were made for many hours and the repeated data for each site were collected under as much similar conditions as possible.

Based on data from all measurement rounds, a "common window of analysis" was identified for each site such that during similar hours of the day, during all measurement rounds, traffic volume was about the same. In most instances, it was a 2.5-3.0 hours afternoon period, just after the noon peek hour and prior to the next evening peak.

The off- peak period is not claimed to represent the whole 24 hours day, but it allows a better comparison of the behavior parameters over time, and during periods of free flowing traffic. It should be noted that at most sites, there was a lot of traffic throughout the day and off- peak volume is just that and not very low volume.

The final element in the analysis concerns the way results from each site and each round of measurements were combined to test the hypotheses about changes in behaviour over time.

Statistical tests were first performed at the single site level. Speed values for five measurement periods were tested in a one way ANOVA for repeated measures. Analysis for contrasts tested for the direction of change (+, 0, -; or pos, n.s, neg), in three comparison periods: 1st to 2-5; 1-2 to 3-5; and 1-3 to 4-5. For example, the 1-2 to 3-5 contrast compared the mean speed during periods 1 and 2 to mean speeds measured during the later periods 3,4,and 5.
The data of the other measures -- % over speed limit, % following distances < 2 sec; % H+M friction at junction -- were cross tabulated according to the different periods compared, and tested with a χ^2 test for significance of the differences.

Even if it the NTP has had a positive effect on all the measures, it is clear that one can not expected to find its impact every time and at each measurement site. Random variation and a host of uncontrolled factors contribute to the measured differences in the data at each single location. However, since every site was just a member of a sample representing a larger population it is necessary to look at the whole sample.

The last step in the analysis consisted of listing all the sites (or a sub- group of sites) and tabulating the direction of change for each comparison period. The list of "+" and "-" was then tested by the Binomial test for the statistical significance of the predominant trend, be it a "+" (positive effect of enforcement), or a "-" (negative effect.) A "0" (n.s , not significant difference) does not count in the calculation and the size of the sample is reduced accordingly.

A priori, there was only very small chance for the NTP to have a discernible impact on traffic behaviour on a national scale. Therefore, the analysis was designed to enhance the possibility of finding any positive effects of enforcement on traffic behaviour (if the effects were indeed there.)

19.3.2 Changes in speed

Table 1 is a summary table of mean speeds on the main road at 17 sites that are on two lane highways. The table also shows the trends of speed change based on the ANOVA and tests for contrasts. The last column reflects an, rather liberal, integration of the three sets of trends. Even so, a Binomial test for the significance of having 9 out of 12 comparisons positive by chance, shows that it is likely at a probability of p = .073 (one-tail.) This outcome may be interpreted as encouraging or discouraging depending on other results and our ability to make sense of the more detailed data. However, examination of the table suggests that the latter may not be easy. The differences between sites are relatively large and quite consistent. The differences between measurement rounds are, usually, less than 5% but not very consistent.

Table 1: Mean speed by site, measurement period, and direction of speed change

Mean speed (km/h) on main road					Direction of speed change			
Site ID	Period 1	Period 2	Period 3	Period 4	Period 5	p1/p2-p5	p1-2/p3-5	p1-3/p4-5	Overall
1	74.85	76.33	76.33	75.36		n.s	n.s	neg	neg
3	79.71	72.99	77.97	80.42	76.85	neg	neg	pos	n.s
4	75.75	74.22	73.69	74.00		pos	pos	pos	pos
5	75.29	71.82	70.26	72.88		n.s	pos	pos	pos
6	78.13	77.79	77.53	76.27	78.78	n.s	n.s	n.s	n.s
7	75.11	76.12	74.23	74.21	74.40	pos	pos	n.s	pos
8	67.08	68.08	65.42	65.17	64.07	pos	pos	pos	pos
9	66.73	67.59	67.49	66.79	68.59	n.s	n.s	n.s	n.s
10	79.58	76.30	77.22	76.56		pos	pos	pos	pos
11	70.50	73.07	66.39	70.89	63.51	pos	pos	pos	pos
12	83.06	79.95	82.36	81.61		n.s	n.s	pos	n.s
15	67.98	73.41	67.74	68.08	69.37	n.s	pos	neg	n,s
16	70.45	70.30	69.05	71.83		neg	n.s	n.s	neg
17	83.65	83.67	86.38	82.75	83.72	pos	n.s	n.s	pos
23	66.22	65.61	65.97	66.15	67.80	neg	n.s	n.s	neg
27	80.49	82.42	81.17	77.60	79.71	pos	pos	n.s	pos
28	78.93	80.28	79.01	74.76	74.90	pos	pos	pos	pos

Approach speeds on the minor roads have changed even less than speeds on the major roads connecting with them. The table of results looks very similar to table 1, only with generally lower speed values. In 25 sites with relevant data, 10 showed decrease in speed over time, 7 showed an increase, and in 8 sites there was no clear change. The Binomial test indicates p = .315 to get such result by chance.

19.3.4 Changes in % speeding and % following too closely

Generally, there was no significant change in the values of these measures across the five periods. Only few of the individual comparisons were significant in the χ^2 test and, consequently, the predominant trend was "no change". The % of vehicles going over 90 km/h (speed limits are 80 or 90) varied from as low as 1% to as high as 35%.

The expectation that this measure will be more sensitive to enforcement effect was not fulfilled. In retrospect, it is not surprising in view of the, inevitable, larger variance in the high tail end of a speed distribution. The mean is actually a more reliable measure.

The % of vehicles following at a distance of 2 sec or less hovered around the 20% value. It was clearly volume dependent; up to 27% at the site with the highest traffic volumes and down to 10% at the lower volume scale.

19.3.5 Changes in level of friction at junctions

Table 2 presents the results of the friction measurements at 25 junctions, during 5 measurement rounds, and the direction of change. The data were aggregated across the three turning manoeuvers. Each entry represents the % events that were at a High and a Medium level friction.

The values range from 1% to 10%. As expected, most of the events were of Medium friction. As with the other measures that refer to a percentage at an upper end of a distribution of behaviour, also here the variability between repeated measurements is high. There is a clear difference between sites, some of which is related to traffic volumes. However, much of the difference in % of friction, between sites, seemed to reflect the nature and quality of the geometric design at the junctions, lane markings, location of bus shelters on the main road, traffic mix, and visibility at all legs of the junction.

At 17 out of 25 junction there was no significant change between periods. Of the 8 sites that showed a relatively consistent trend of change, 7 were in a positive direction, less friction at later periods of measurement (one tailed $p = .035$.)

Table 2: Level of friction at junctions by site, measurement period, and direction of change

	% friction at High +Medium level					Direction of change in level of friction			
Site ID	Period 1	Period 2	Period 3	Period 4	Period 5	p1/p2-p5	p1-2/p3-5	p1-3/p4-5	Overall
1	7.43	10.88	8.96	5.70		n.s	n.s	n.s	n.s
2	8.85	7.32	6.15	7.14	5.00	n.s	n.s	n.s	n.s
3	7.17	9.41	7.47	3.13	4.86	n.s	pos	pos	pos
4	7.90	7.81	4.62	4.90		pos	pos	pos	pos
5	5.50	8.10	5.60	6.88		n.s	n.s	n.s	n.s
6		4.64	2.94	3.54	4.90	n.s	n.s	n.s	n.s
7	7.20	10.48	5.46	5.27	5.78	n.s	pos	pos	pos
8		7.17	5.96	3.65	4.51	n.s	n.s	n.s	n.s
9	6.45	8.44	4.63	5.21	5.00	n.s	n.s	n.s	n.s
10	6.10	7.58	4.79	6.02	6.25	n.s	n.s	n.s	n.s
11	6.16	5.06	4.49	2.73	4.29	n.s	n.s	n.s	n.s
12	6.33	7.04	2.26	4.00		n.s	pos	n.s	pos
14			3.07	4.26	3.09	n.s	n.s	n.s	n.s
15	8.20		5.74	3.77	6.07	pos	pos	pos	pos
16	1.48	5.88	4.02	2.75	1.48	n.s	n.s	n.s	n.s
17	6.96	1.77	1.83	1.46	2.99	pos	n.s	n.s	pos
18	10.00	9.29	8.09	6.70	8.36	n.s	n.s	n.s	n.s
21	8.97	6.72	6.49	5.33	9.37	n.s	n.s	n.s	n.s
22	4.24	4.53	2.80	4.51	5.23	n.s	n.s	n.s	n.s
23		3.14	6.26	6.07	6.46	n.s	neg	neg	neg
24	10.20	8.81	8.05	6.02	8.26	n.s	n.s	n.s	n.s
25	8.51	8.93	8.60	6.85	3.57	n.s	n.s	n.s	n.s
26		6.59	5.78	3.29	3.87	n.s	n.s	n.s	n.s
27		2.13	5.57	4.60	5.26	n.s	n.s	n.s	n.s
28	78.93	4.08	3.75	0.68	2.38	pos	pos	n.s	pos

19.3.6 Did enforcement influence traffic behaviour?

So far, analysis of the results for each measure and across all relevant sites showed no significant changes between periods, with the possible exception of the friction measure. However, it was also shown that there were large differences between sites. Some showed a fairly consistent trend of improvement on all or some of the measures, many showed no change or inconsistent trend, and few showed a negative trend of change. Is there some commonalty between the subgroups of sites that can explain the differences? Table 3 shows an attempt to relate the predominant trend of change at a site to an enforcement variable.

Table 3: Sites, by level of enforcement and direction of change in Traffic Behaviour

Level of Enforcement	Positive change	No change	Negative change	Total
HIGH				
14+	**5**	**1**	**1**	**7**
MEDIUM				
11-13	**0**	**5**	**2**	**7**
LOW				
> 10	**2**	**2**	**2**	**6**
TOTAL	**7**	**8**	**5**	**20**

The 20 sites with data on most of the measures for most of the periods, were classified, according to the trend of change on all the measures, to three categories: positive, no change, and negative.

The same sites were independently classified, on the basis of police operational records, according to the level of enforcement that was assigned to the road section which included the site. The level of enforcement was measured by the mean number of patrolling shifts (typically a single patrol car for a 10- 20 km section, for 8 hr workday) per week during the month just preceding the measurement at a site. The Medium level of enforcement, 11-13 shifts a week, represented the standard enforcement practiced by the police even before the NTP came into being. Lower priority sections were patrolled less frequently.

The NTP tried to boost the enforcement level to more shifts, through permanent increases in resources and by temporarily reallocating forces from some sections to others. In practice, it was possible to increase the level of enforcement over the standard level only at some sections while at others the level remained low.

Table 3 shows the number of sites associated with each level of enforcement and the direction of change that has occurred in the behavioural measures.

The sites that are on roads which were subjected to a relatively high level of enforcement tended to show mainly a positive effect (5 out of 7); sites with the medium, standard enforcement concentrated in the no-change category (also 5 out of 7); and the 6 sites with lower then standard enforcement level split evenly between the three categories of change.

The result is intriguing but must be considered very tentative in view of the small number of cases in the table. The relationship suggests that it may take much more than a low or medium level of enforcement to have a reasonable chance of influencing traffic behaviour, in terms of the measures evaluated in the present study. It is also clear that more attention must be given to **what** police are doing in the process of enforcement and how to increase its impact apart from increasing manpower and vehicles on each road.

19.5 CONCLUSIONS

1. The monitoring system of behavioural measures provides useful information that supports and complements other aspects of the evaluation programme for the NTP.

2. The study demonstrated the importance of using a large number of observation sites in order to draw valid conclusions about the overall effect of a large scale police activity. The variability in traffic behaviour and the large site- specific effects require large samples of sites. On the other hand, the regularty of traffic behaviour at a given site, allows the use of shorter observation intervals.

3. The level of friction at junctions proved to be as useful as other, more traditional behavioural measures. It focuses on junctions, were at least half of the accidents take place, and it generates a lot of data in a short time. It does not depend on special equipment and does not require prolonged training.

4. In the context of an evaluation based on statistical inference from a large sample, measures that reflect the extremes of a distribution of behaviour (such as % of speeding over 90 km/h) may have less discriminating power than modal measures, due to their variability.

5. There is some indication in the data that higher than the usual level of police activity in a generally targeted area, may result in improved traffic behaviour.

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