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THE EFFECTS OF ROAD MARKINGS ON DRIVER BEHAVIOUR

NTRC-92

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C O N T E N T S

1. INTRODUCTION

In the United Kingdom (U.K) and other developed countries road signs and markings are widely used to control the movements of traffic. Not only are they an effective aid to traffic management but also a number of studies (DUFF 1971, Wilson 1978, Kerny 1978) have demonstrated that improvements in signs and markings have brought about considerable reductions in accidents when introduced at appropriate hazardous locations.

In many developing countries including Pakistan signs and markings are used less frequently than in developed countries. One might therefore expect their potential for improving traffic safety and reducing accidents to be greatest in those countries where their use is relatively scarce.

However the success of such non-self enforcing devices is very much dependent upon road users attitude towards understanding the information conveyed and responding appropriately. Unfortunately much of the data available at present indicates that driver behaviour in developing countries including Pakistan is often not condusive to yielding the desired results.

For example an international comparison of road user behaviour (Jacobs, 1981) showed that drivers in a number of Third World Countries were less likely to stop at red traffic signals and for pedestrians on marked crossings than they were in the UK.

In Pakistan observations at intersections (SWATI, 1980) indicated that not only did many drivers not stop at red signals or for pedestrians on crossings but also that up to 97 percent did not stop at stop Signs (no road marking present) and similarly upto 78 percent disobeyed lane markings and turned from the wrong lane.

Since above observations were carried out to investigate the effects of enforcement and data relating to the effect of road markings were not collected. Therefore this study was carried out with the specific aims of obtaining information about the impact of new road markings when laid according to international standards. In particular road markings were painted at selected sites in the Rawalpindi-Islamabad area to determine to what extent they could be used to improve driver stopping behaviour, lane discipline, positioning and overtaking behaviour.

2. OBJECTIVES

The objectives of the study were:

A. To determine whether the introduction of:-

1) Stop lines at intersections would increase the proportion of drivers stopping on minor roads.

2) Lane lines and direction arrows would lead to a decrease in turing violations.

3) Continuous white lines along the centre of the road at hazardous locations (eg bends) would lead to decrease in dangerous overtaking manoeuvres.

B. To determine what:-

1) Proportion of drivers noticed the newly installed markings.

2) Proportion of drivers knew the meaning of the markings.

3) Factors were related to driver error and to their knowledge of the markings.

3. SCOPE OF THE STUDY

12 sites were selected within the cities of Rawalpindi and Islamabad, Grand Trunk Road (N-5) and the Islamabad Highway.

The surveys were carried out in April, May, and June, 1983 and the new road markings introduced in the middle of the period.

4. METHODOLOGY

3 groups of 12 sites were selected as follows:-

1. Hazardous locations such as bends or crests (brow of a hill) requiring continuous centre line marking to prevent dangerous overtaking.

2. Intersections with stop signs requiring double stop lines at the mouth of the junction to reduce non-stopping violations.

3. Intersections requiring centre lines or lane lines and direction arrows to improve lane discipline and turning behaviour.

From each of these groups 8 sites were selected at random for treatment with new markings (see fig.1) 4 site where no improvement was made, acted as controls.

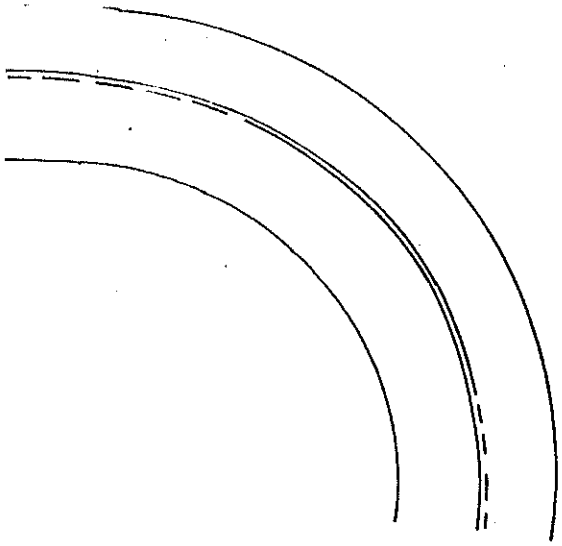
At every site observations were made of driver error before and after the new markings were introduced. Details of the types of error observed are shown in Table-1.

The observations were collected on specially designed forms over a period of 6 hours on one day before the improvements and then for the same period on the same day of the week after the improvements were completed.

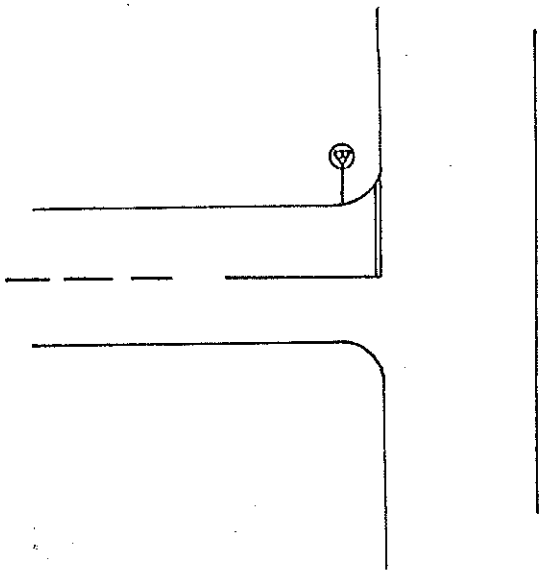
To assist observers with regard to noting the overtaking violations in the before situation and at control sites, fine broken lines were painted down the centre of the road and marks were made at the edge of the carriageway to indicate where the overtaking ban was to begin and end.

Similarly to help spot the turning position errors accurately (e.g cutting corners when turning right) a small metal plate was nailed to the road at the spot where the double stop lanes would meet the centre line of the road.

1. Centre line markings



2. Stop line markings



3. Lane Line and direction arrow markings

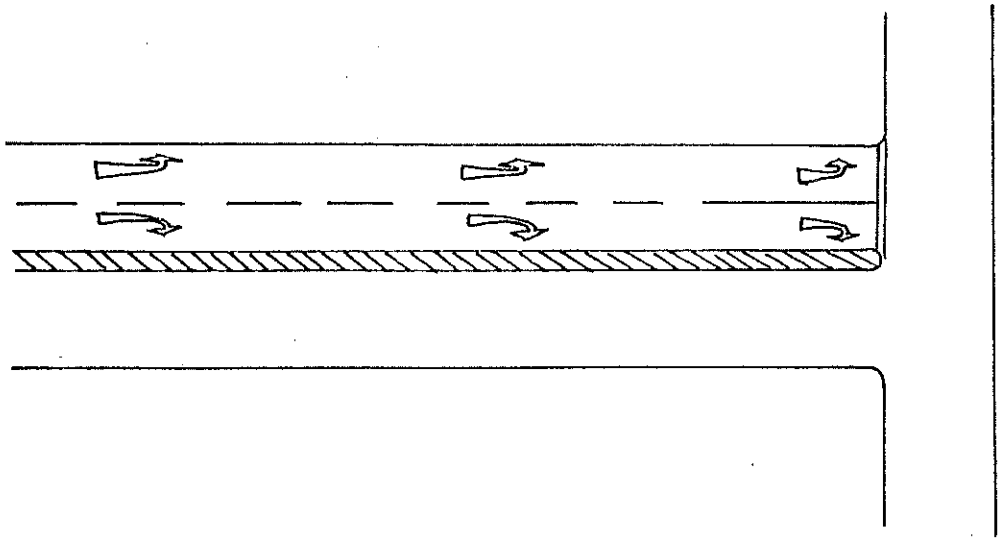


Fig. 1 3 types of road marking introduced.

TABLE-1 DESIGN OF DRIVER ERROR SURVEY

SITES		DRIVER ERROR OBSERVED	EXPERIMENTAL SITES			CONTROL SITES		
			NUMBER OF SITES	NUMBER OF VEHICLES		NUMBER OF SITES	NUMBER OF VEHICLES	
				BEFORE	AFTER		BEFORE	AFTER
AT DOUBLE WHITE LINE SITES		1. CROSSED COMPLETELY TO WRONG SIDE	16 *	18140	18671	8 †	11438	11310
		2. CROSSED OR PARTIALLY CROSSED	16 *	"	"	8 †	"	"
		3. OVERTOOK	16 *	"	"	8 †	"	"
AT DOUBLE STOP LINE SITES		1. FAILED TO STOP	8	15826	15939	4	10073	10919
AT CENTRE LINE & LANE MARKING SITES	TURNING RIGHT FROM MAJOR ROAD	1. ANY POSITION ERROR	8	10397	10535	4	3027	2965
		2. COMPLETELY IN WRONG LANE OR WRONG SIDE	8	"	"	4	"	"
	TURNING LEFT FROM MINOR ROAD	3. ANY POSITION ERROR	4	1638	1866	2	4673	4705
	TURNING RIGHT FROM MAJOR ROAD	4. ANY POSITION ERROR	2	573	629	1	871	2066
		5. COMPLETELY ON WRONG SIDE	2	"	"	1	"	"

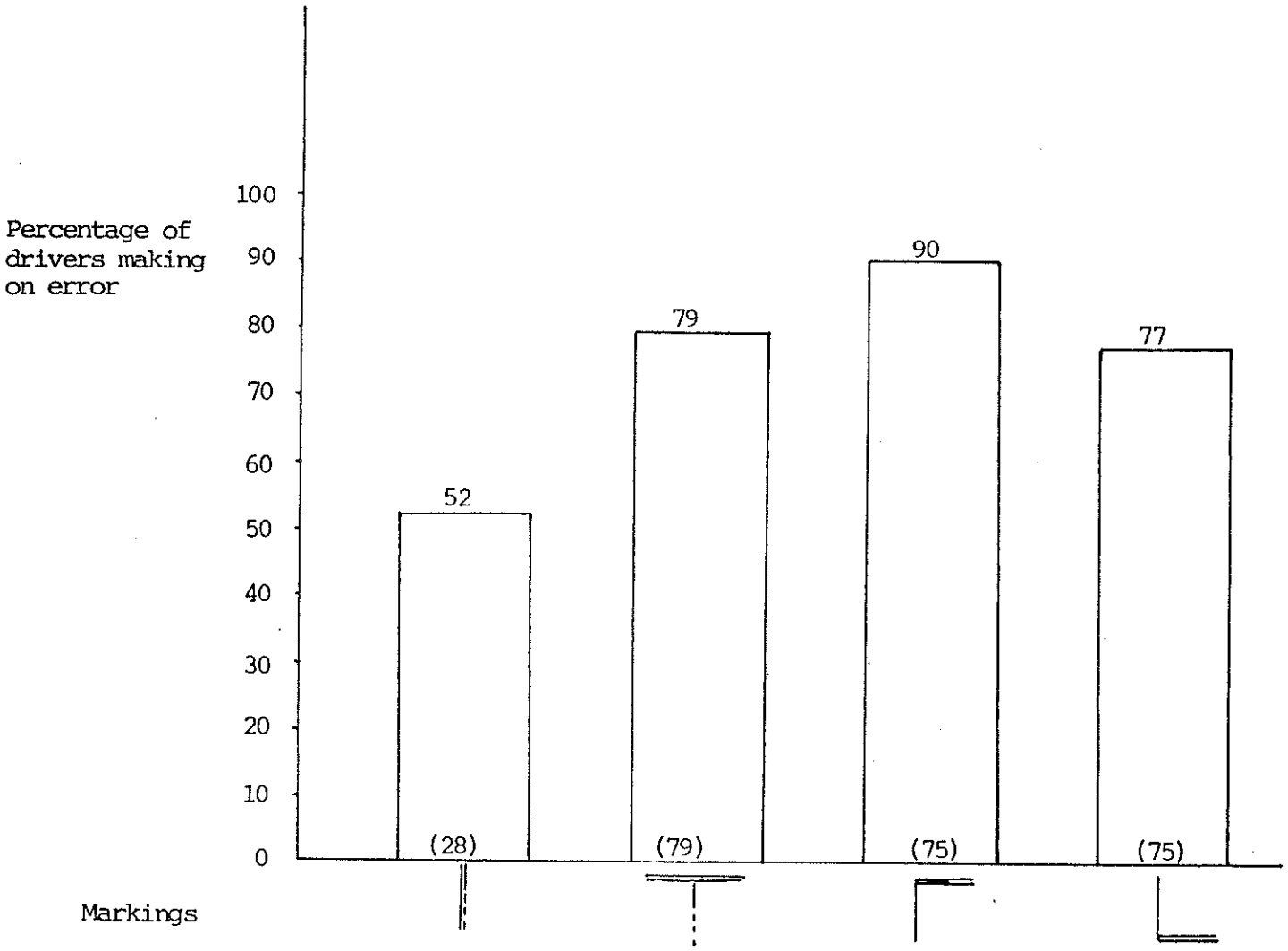
* 8 SITES IN 2 DIRECTIONS

† 4 SITES IN 2 DIRECTIONS

In addition to collecting data on behaviour, 840 interviews were carried out at 4 experimental sites (1 from group 1, 1 from group 2 and 2 from group 3) after the markings had been introduced. For one day drivers were stopped at random immediately after passing through the site and asked to pick out the markings they had just seen from an illustrated check list. They were then asked the meaning of all the markings shown and a few other relevant questions relating to their driving experience and biographical data. Whether or not they had committed a driving error at the site, was also noted.

Although the interviewers were instructed to select the next driver to pass after each interview was completed it was possible that some had a tendency to stop those who had just committed an error rather than whoever was next. A comparison of error recorded in the interview with those in the observation surveys (see fig.2) indicated that this tendency did exist at the centre line and stop line sites but not at the two in the other group.

Also an analysis of the vehicles driven in the interview survey indicated that the traffic mix varied from site to site and in particular the percentage of buses or trucks was much higher at the 'no overtaking' sites than at the others (68 percent compared to 5 percent of the vehicles).



Markings				
errors	crossed continuous line	Position & stopping errors on leaving	Stopping errors	Position errors on entering
Sites	2	15, 28	18	28
n	201	336	204	96

( ) = % error from the observation data at the same sites after the markings were introduced.

*

Fig. 2 The errors made by drivers in the interview Survey.

5. RESULTS

5.1 Driver error before and after road markings introduced.

The over-all levels of driver error before and after the introduction of the markings at each group of sites are shown in Figures 3 to 6.

At centre line marking sites (Fig. 3) there was a small but statistically significant * drop in the percentage of drivers crossing the centre of the road (4.2 percent) and in the percentage of drivers who completely crossed the centre (1.1 percent).

However, there was no statistically significant change in the overall level of overtaking and it would appear that the markings prevented some driver from cutting bends but they had no effect on overtaking behaviour.

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* The term 'statistically significant' is used when the probability of a difference occurring by chance has been determined as 1 in 20 or less by a statistical test. In the case of the driver error data the Chi Square test was used to determine whether the changes at experimental sites were different from those at control sites.

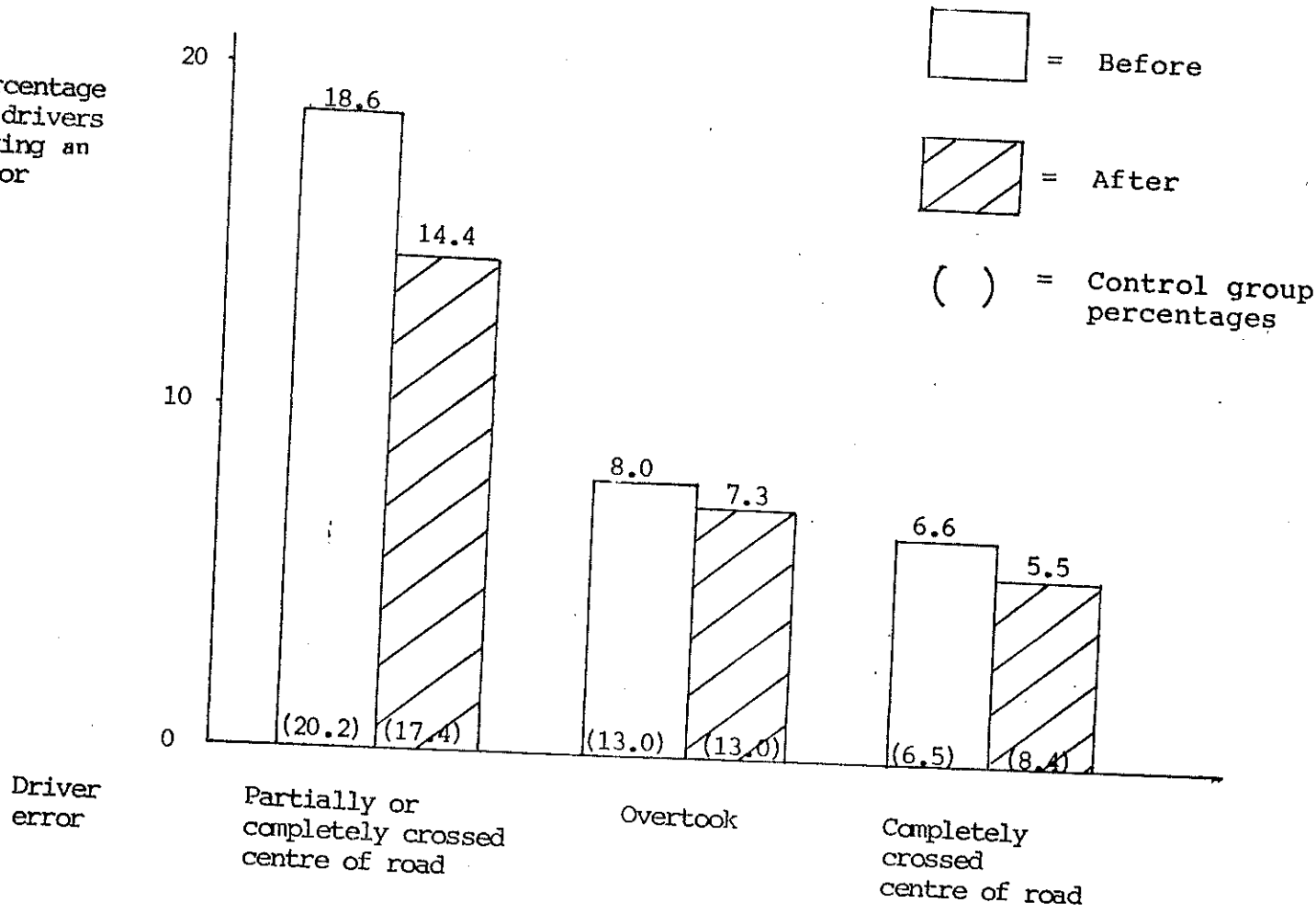


Fig. 3 Driver error before and after centre line markings introduced.

Analysis of the changes at individual sites indicated that there were reductions in driver positioning errors (partially or completely crossed centre line) at 9 of the 16 sites (max drop 21.2 percent) whereas only 3 sites showed an improvement on the other two error measures.

Therefore although there was a general improvement in driver behaviour, there is no surety that new 'no overtaking' markings would lead to improvements at every site. Also even after the markings had been introduced, the violation levels still remained high at some sites (28.2 percent crossed the continuous line at the worst site).

At intersections, the markings resulted in a small improvement in drivers positioning when turning right (6.3 percent drop in errors, Fig. 4) but positioning when turning left (Fig. 4), stopping (Fig. 5) and positioning when entering marked roads (Fig. 6) were unaffected (that is the change was not statistically significant when compared with that of the control groups).

As with the 'no overtaking' sites the amount of improvement varied from site to site and only 5 out of 8 showed a statistically significant reduction in right turn position errors (max reduction 17.1 percent) and again one cannot be certain that the introduction of road markings at intersections would bring about improvements at every site.

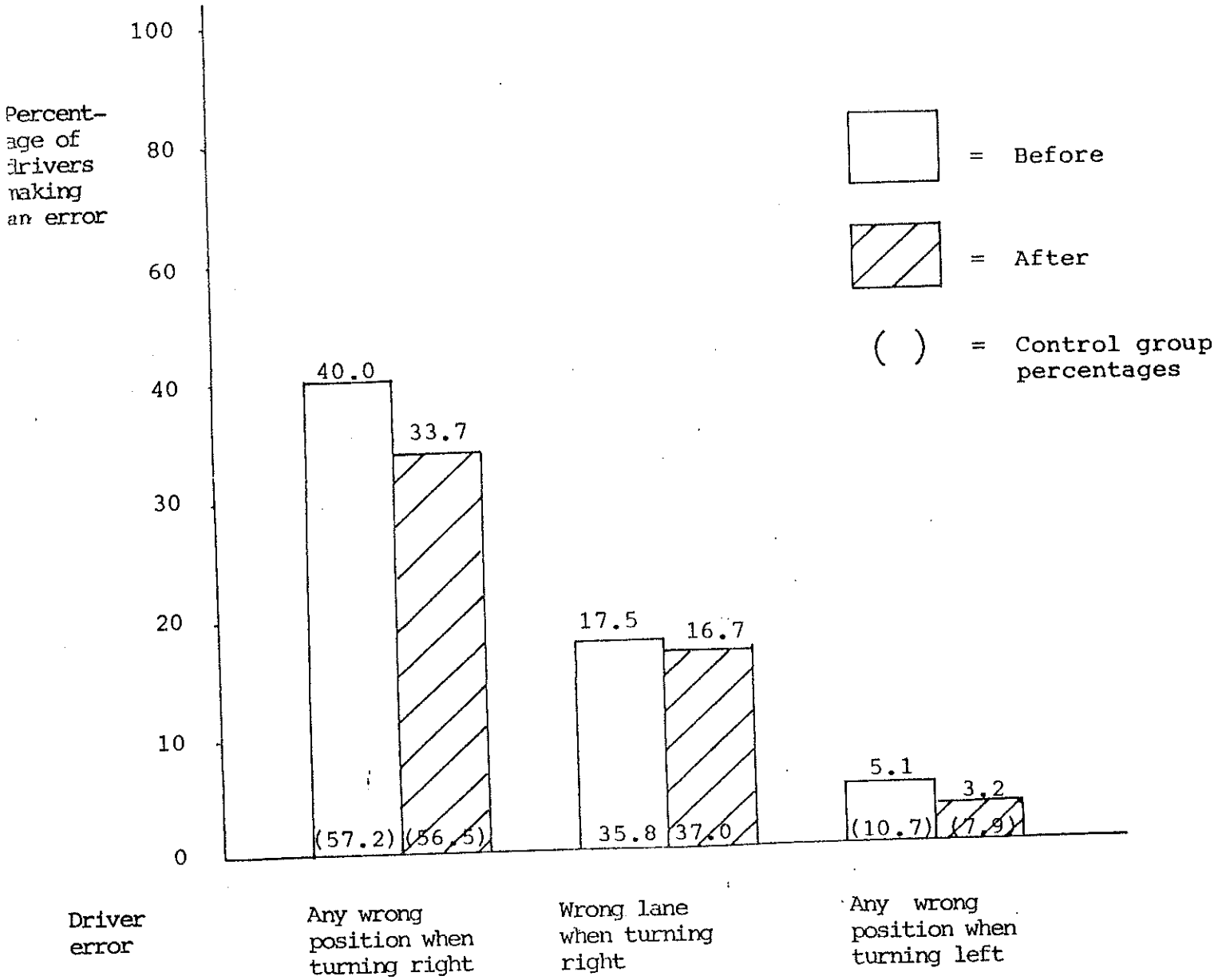


Fig. 4 Driver error before and after lane markings and direction arrows introduced

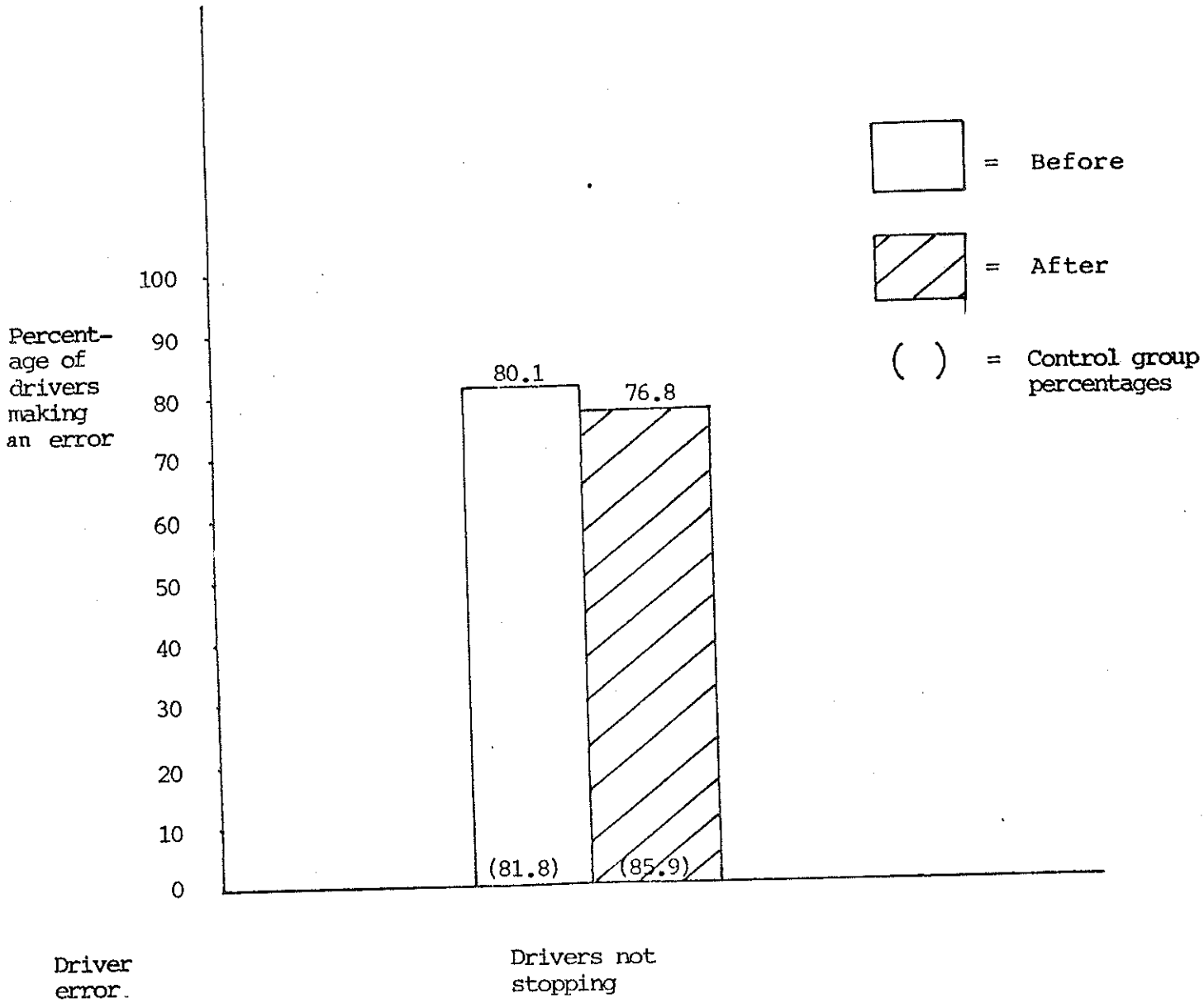


Fig. 5 Driver error at double stop line sites

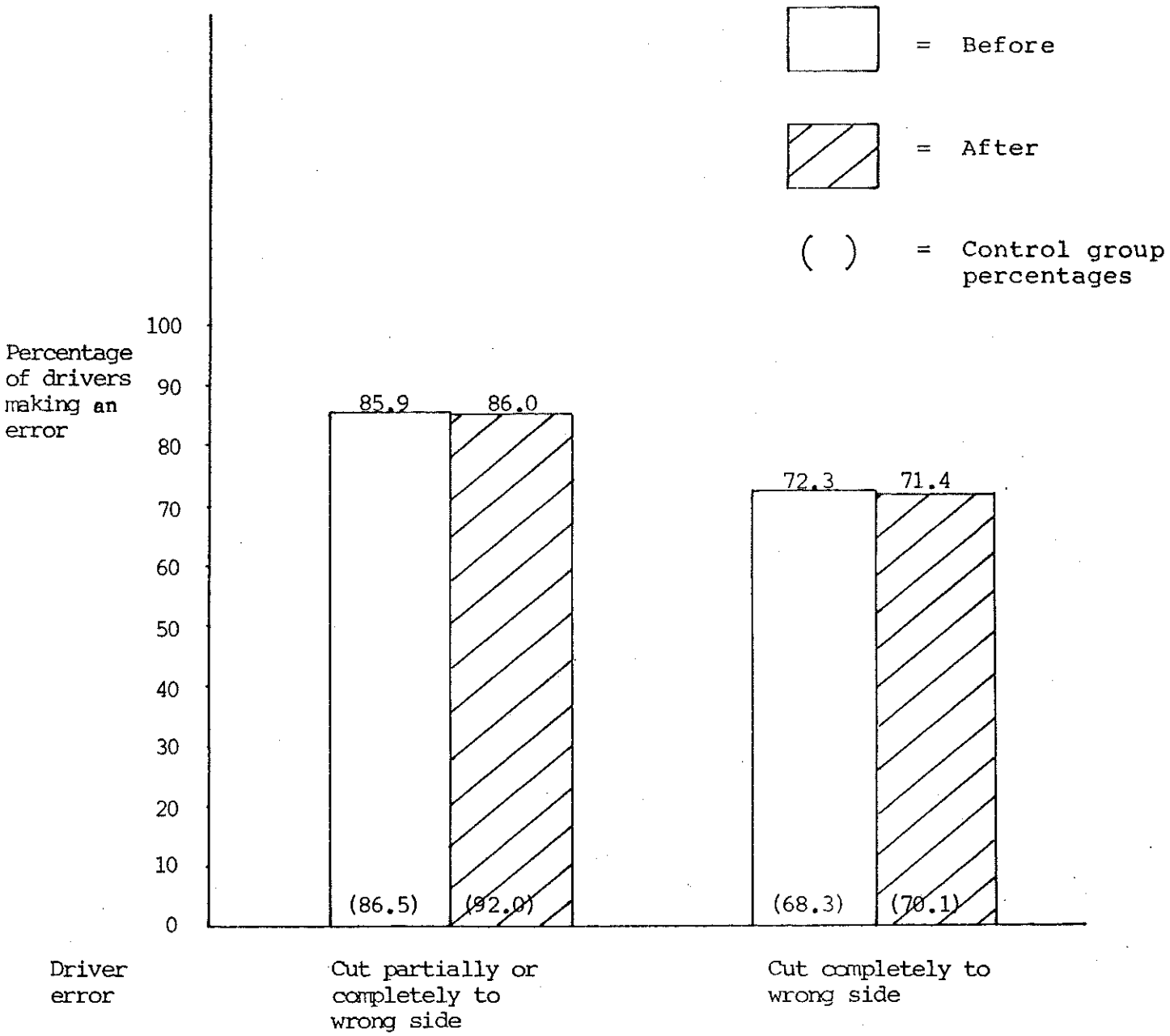


Fig. 6 Driver error at marked intersections: Drivers turning into marked road.

Of the 4 main error types measured at the marked sites 'cutting the corner into the marked road' was the most frequent (86 percent) followed by 'not stopping' (77 percent) turning right incorrectly from the marked road (34 percent) and 'crossing the continuous centre line (14 percent).

Not only was cutting the corner standard practice but at single carriageway sites it was common for drivers when turning right to enter the road completely on the wrong side (75.2 percent at one site) and the markings had no effect on such behaviour.

'Non-stopping' violation levels were fairly consistant from site to site (range 78.6 to 90.5 for 7 of the 8 sites) and the levels were alarmingly high considering that all sites had stop signs and double stop lines!

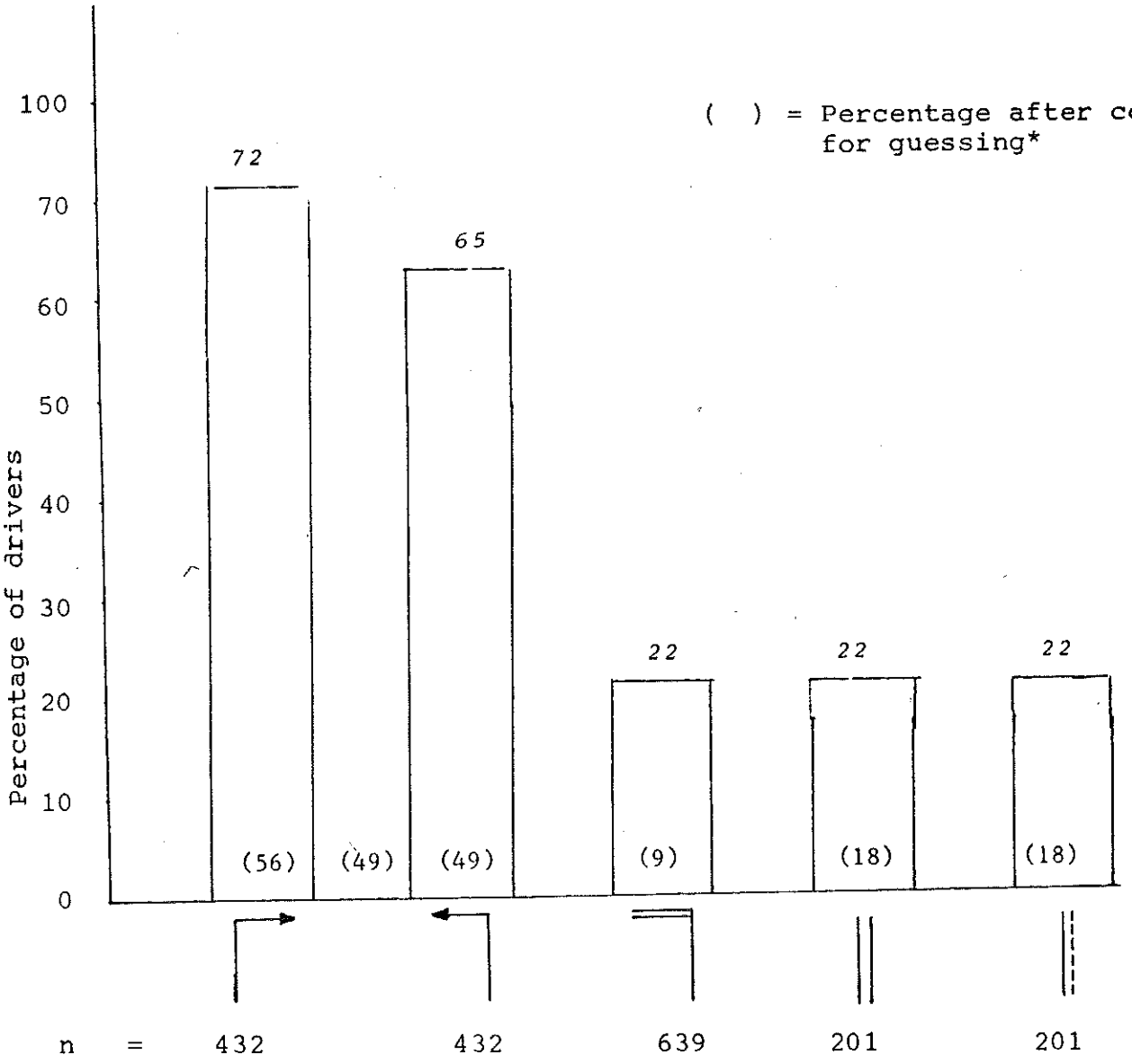
On the other hand the standard of driver positioning behaviour when turning right from the marked road varied considerably from site to site (96.5 to 5.3 percent) and the worst sites were those with no median barrier to force drivers to keep to the left of the centre of the road.

5.2 Drivers knowledge and ability to identify road markings.

From Fig. 7. it can be seen that about two thirds of the drivers were able to identify the direction markings from the check sheets but only about a fifth could identify the stop lines or the centre line (no overtaking) markings. The true levels of identification were probably even lower as some of the drivers were guessing which markings they had just seen (the levels corrected for guessing are also shown in Fig. 7) but whether or not guessing is taken in to consideration the results suggest that the majority of drivers paid no conscious attention to the centre line markings and stop lines as they drove through the sites.

Knowledge levels were also poor (see Fig. 8) and as above the drivers did better on the direction arrows up to 60 percent gave the correct meaning than on the other markings (as low as 29 percent correct).

In Fig. 9 the knowledge and identification results have been combined and it can be seen that just over half the drivers knew and identified the direction markings correctly whereas only a very small proportion knew and identified the Stop and No Overtaking lines correctly (between 15 and 17 percent).



* Percentage identifying makings after correcting for guessing = percentage identifying markings - percentage at appropriate sites identifying wrong markings

Fig 7 Identification levels for different road markings.

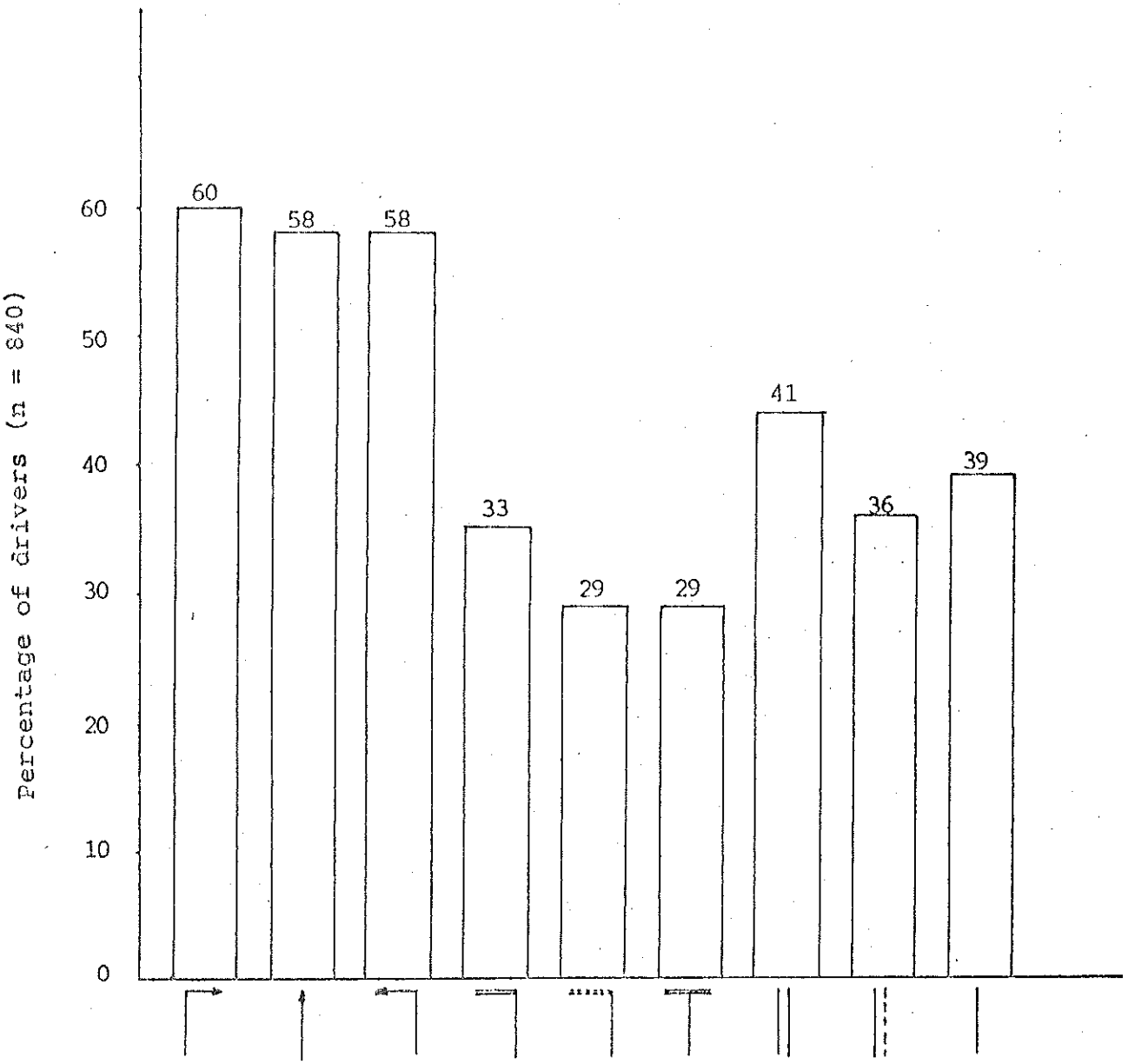


Fig 8 Percentage of drivers who gave the correct meaning for each road marking.

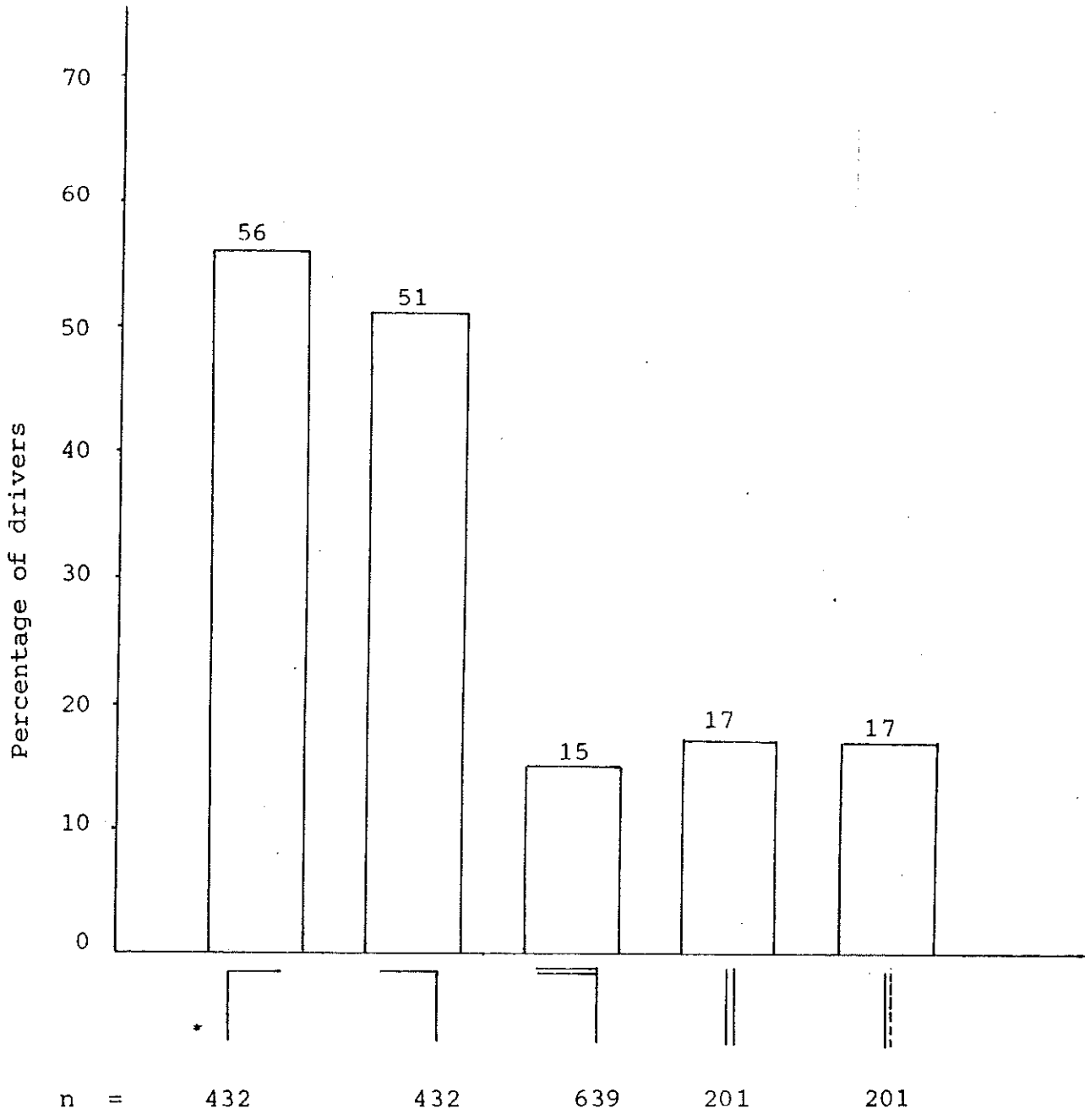


Fig 9 Percentage of drivers who identified the marking and gave the correct meaning.

Given these low levels of knowledge and identification it is not surprising that the markings had little or no effect on driver behaviour.

5.3. Variables related to driver error

From the interview results, 6 variables were found to be related to driver error. Details of these are given in Table-2.

The largest range of error levels was found between sites (38 percent) and this result was not unexpected as the type of error measured was different from one site to another. Thus the site with the lowest percentage of drivers making an error was the one where 'No Overtaking' errors were recorded (52 percent) whereas the highest was the one where "Non Stopping" was measured (90 percent). These differences therefore support the results from the observation surveys (section 5.1) which indicated that drivers were more likely to commit Non-Stopping errors than overtaking errors.

The reported difference between interviewers as regards levels of driver error was surprising, but when the results were examined at individual sites, the difference was found to be spurious i.e. it was due to some interviewers being used at one site and not at another rather than to any inherent difference between interviewers.

Although the other 6 variables, where each related

TABLE 2

Drivers Reasons for Making Errors at Road Markings

Reason given for making error	Drivers	
	Number	Percentage
1. Road was clear	188	30
2. In a hurry	166	26
3. Did not see the Markings	80	13
4. Always drove that way	17	3
5. Other reason(eg stranger)	129	20
6. No reason given	51	8
Total	631	100

to driver error individually, further analysis (step wise multiple regression) taking into account their variation with each other (covariance) indicated that the variation in driver error was best explained (highest percentage of the variance accounted for) by a combination of just 3 variables. These were site, type of vehicle driven and a combination of drivers knowledge and their ability to identify the markings.

From figures 10 which shows how these 3 variables interacted, it can be seen that the type of vehicle associated with the highest percentage of errors is different from one site to another. At the 'no overtaking' site, buses were the worst offenders (27 percent more bus drivers made errors) whereas at junctions, motorcycles were the worst at positioning (14% more made errors) and at stopping (7 percent more made errors).

Even though the drivers who knew and identified some of the markings correctly were better at positioning (up to 20 percent fewer errors) and at stopping (up to 9 percent fewer errors) than those who did not, many of them still made errors (86 percent at the stop line sites, 68 percent at the lane marking sites and 49 percent at the 'no overtaking' sites).

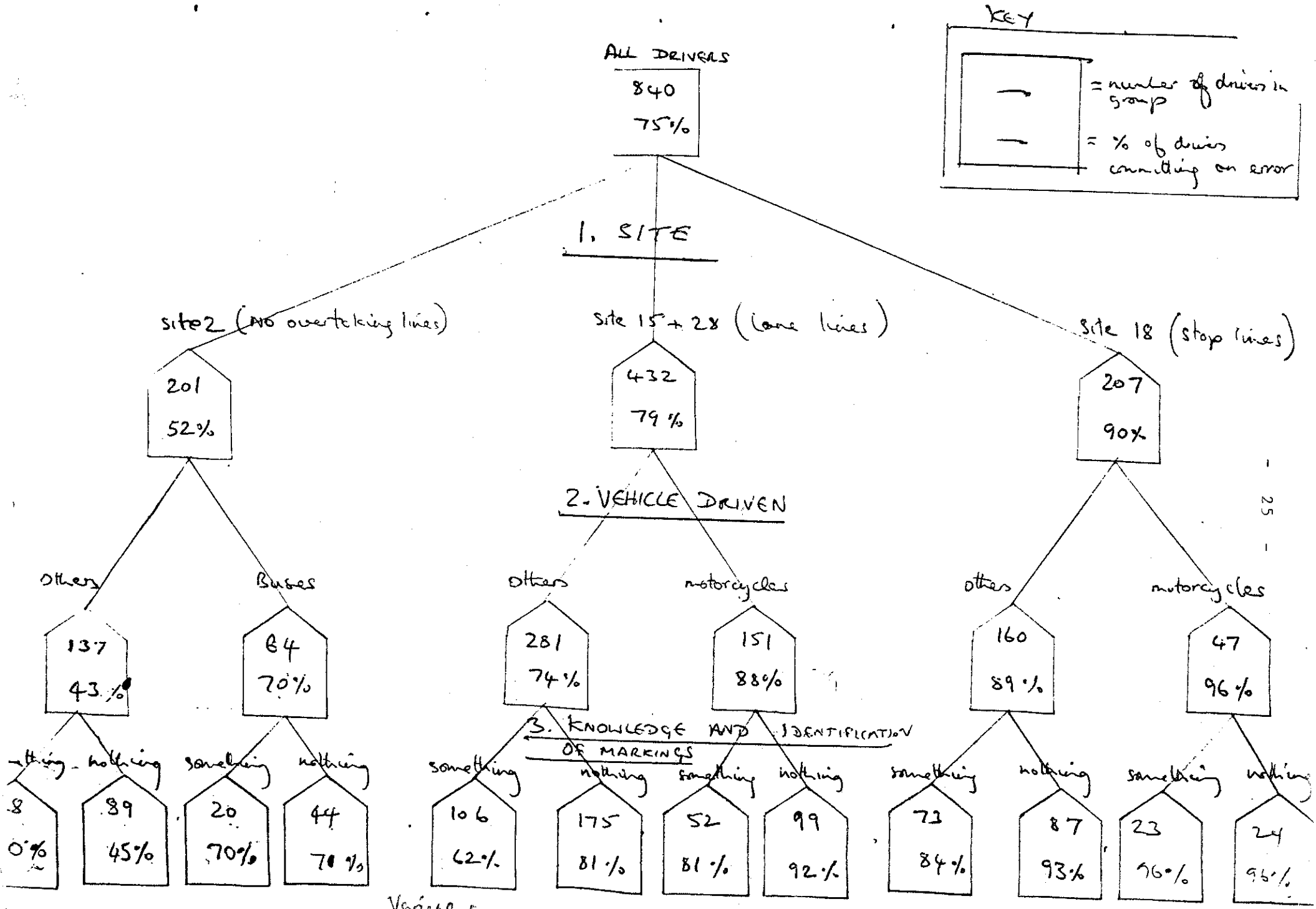


Fig 1a Variables ~~Factors~~ related to driving errors.

In addition to providing the data for the above, the interviews also gave some information on the dirvers reasons for making errors. From the results shown in Table-3 it is evident that the two most common reason given were 'because the road was clear' (30 percent) and 'because they were in a hurry' (26 percent).

Although neither of these 'excuses' can really be used to justify disobeying a mandatory sign or marking, the former does indicate that there is a possibility that give-way signs may be more appropriate than stop signs at some junctions where traffic flows are light. At present give-way signs are not in much use in the Islamabad-Rawalpindi area, and even though stop signs may be easier to understand and enforce, there is always a danger that drivers will not respect them if they are introduced at in appropriate sites.

TABLE 3

Variable related to Driver Errors

Variables *	Best Groups		Worst group	
	Group name	% of drivers making an error	Group name	% of Drivers making an error
1. Site (4)	Site 2	52	Site 18	90
2. Interviewer (4)	Interviewer 3	70	Interviewer	89
3. Type of Vehicle driven (2)	Trucks	49	Others	78
4. Owner/Professional driver (2)	Professional	70	Owner	78
5. Type of Driving licence (2)	Full	74	Provisional or none	88
6. Proportion of Markings identified-corrected for guessing (3)	100%	65	0%	78
7. Knowledge of marking (3)	Knew 8 or 9	68	Knew 5 or less	78
8. Knowledge and identification combined (3)	Knew & Saw all markings	66	Knew & Saw no markings	79

* Only statistically significant relationships have been included in the table (Chi Square test)

( )-Number of groups of drivers formed by the variable.

5.4. Variables related to identification and knowledge of road markings.

From Table 4 it can be seen that 6 variables were found to be individually related to the drivers ability to identify the signs.

The variable which produced the largest range of differences was site (58 percent) and this reflected the differences between drivers ability to identify the different types of marking present at each site. Thus the site with the direction arrows had the highest identification levels whereas the site with only double stop lines had the lowest.

Identification ability was also found to be dependent upon which interviewer (out of 4) had asked the questions and one interviewer consistantly recorded higher identification scores (up to 15 percent highest) at all the sites. The same interviewer also recorded higher guesing levels than the others and it would appear that he encouraged drivers to give more responses perhaps by more prompting than did his counterparts.

Further analysis (stepwise multiple regression) of the interview data taking into account the covaration between the 6 variables indicated that the ability to identify the markings was related to just 4 variables (i.e. the combination which accounted for the highest

TABLE 4

Variables related to drivers identification of markings

Variables *	Correction	Best Group		Worst group	
		Group Name	% of drivers identifying some or all markings	Group name	% of drivers identifying some or all markings
1. Site (4)	Uncorrected	Site 15	81	Site 18	23
	Corrected	Site 15	60	Site 18	14
2. Interviewer (4)	Uncorrected	Interviewer 1	61	Interviewer 3	46
3. Type of vehicle driven (3)	Uncorrected	M/cycles	62	Trucks	36
	Corrected	M/cycles	47	Trucks	31
4. Owner/professional driver(2)	Corrected	Professional	45	Owner	36
5. Site familiarity (4)	Uncorrected	Every-day	57	First time	38
	Corrected	Every-day	43	Less than once a week	29
6. Knowledge of markings (2)	Uncorrected	Knew some or all	63	Knew nothing	25
	Corrected	Knew some or all	47	Knew nothing	18

* Only statistically significant relationships have been included in the table (Chi Square Test)

( ) = Number of groups of drivers formed by the variable

percentage of the variance). These were site (in effect the type of marking), interviewer,[1] driver knowledge of the markings and the driver's status (professional or owner driver). The other 7 variables, type of vehicle driven and site familiarity were not related to identification ability after taking the above 4 variables into account.

From Fig 11 which shows one way of the 4 variables interacted with identification ability, it can be seen that the professional drivers were better at identifying the markings than the owner drivers at all the sites (up to 44 percent more professional drivers identified some or all of the marking correctly) except the one which only had stop lines. Also the drivers who knew the correct meaning of some or all of the markings did better than their counterparts at all the sites (maximum difference of 45 percent at one site).

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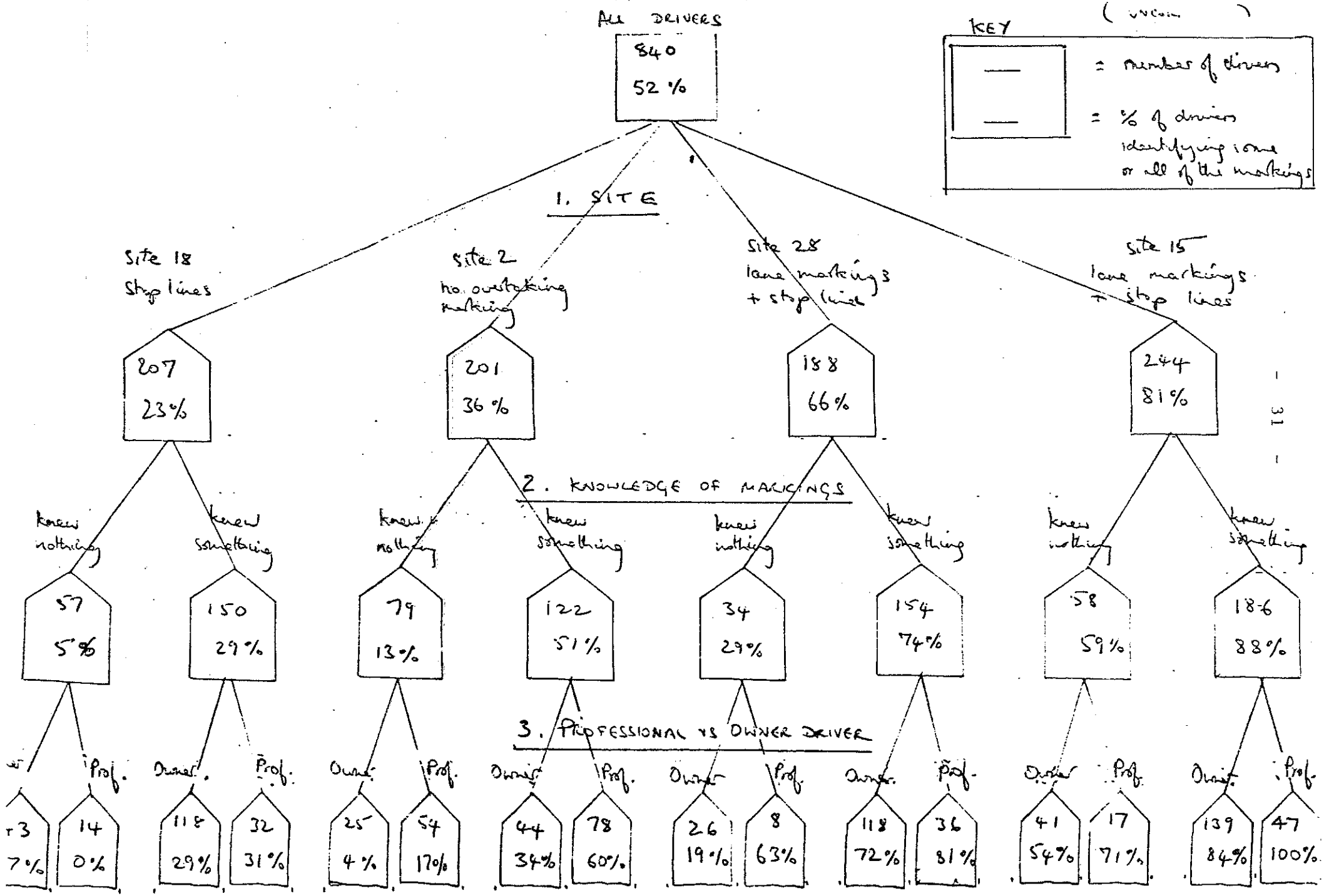
1 The interviewer variable was omitted to prevent the figures from becoming too complex. Also corrections guessing have not been shown. However the corrected values gave a similar picture except that the percentages were all some what lower and the interviewer was not a related variable.



11 Variables

Fig 6 Factors related to drivers identification of road markings

8 variables were found to be related individually to drivers knowledge of the 9 road markings tested (see Table 5). These included some variables that one would expect to be related to knowledge such as education and overseas driving experience and others such as site which were unexpected and were probably due to other difference between drivers at the different sites rather than any inherent difference between the sites (i.e. the relationship between site and knowledge was spurions).

The latter explanation was confirmed by a step wise multiple regression analysis which indicated that a combination of 4 variables best explained the variation in drivers knowledge. These were interviewer, driver status (professional or owner), education (literate or illiterate) and overseas driving experience (some of none).

The other variables including readership of the highway code were not related to knwledge after taking the above into account.

From fig. 12 it can be seen that the educated owner drivers with overseas experience always did better than the drivers with the opposite characteristics and the lowest average knowledge score out of ten was 1.2 for the uneducated professional drivers whereas the highest was 4.6 for the educated owner drivers with overseas experience (excluding the drivers interviewed by interviewer 4).

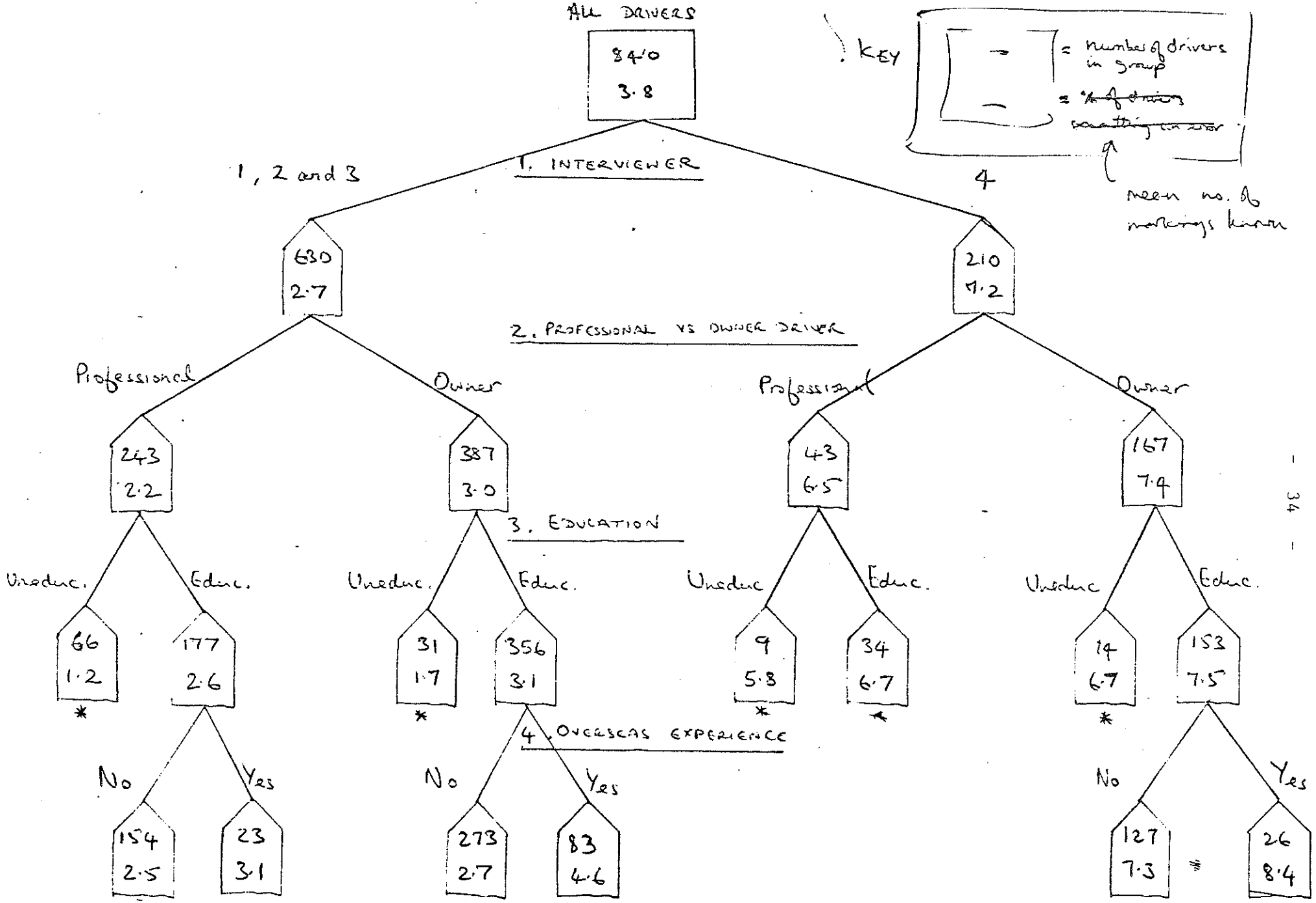
TABLE 5

Variables related to Drivers Knowledge of a Road Markings

Variables *	Best group		Worst group	
	Name	Mean Score	Name	Mean Score
1. Site (4)	Site 28 (Urban)	4.7	Site 2 (Rural)	3.0
2. Interviewer (4)	Interviewer 4.	7.2	Interviewer 2	2.3
3. Vehicle driven (2)	Vehicle except buses & trucks	4.0	Buses & Trucks	3.0
4. Owner/Professional drivers (2)	Owner	4.4.	Professional	2.9
5. Type of driving licence (2)	Full licence holder	4.0	Professional or no licence	1.8
6. Overseas driving experience (2)	Driven overseas	5.0	Not driven	3.6
7. Education (2)	Educated	4.1	Not educated	2.3
8. Readership of the Highway Code (2)	Read it	4.1	Not read it	3.0

* Only statistically significant relationships have been included in the table (Kruskal - Wallis test, probability less than 0.005 in all cases)

()= Number of groups of driver formed by the variable.



= Groups too small to subdivide

Fig. 8 Variables related to driver knowledge of road markings

It is interesting to note that although the professional drivers were better than the others at identifying the markings, their knowledge was poorer than that of the owner drivers and the latter difference persisted even after education and overseas driving experience were taken into account.

Also from the figure it is clear that one interviewer recorded far higher scores than the other 3. Although some of this difference can be attributed to the relatively high percentage of owner drivers interviewed by him (80 percent compared to 61 percent for the other 3 interviewers) there is still some difference remaining which is probably due to him giving the drivers more prompting than the others. However the latter interviewer is not the same as the odd one out in the identification analysis.

6. DISCUSSION AND CONCLUSIONS

The observations of driver behaviour indicated that extremely high proportions of drivers were making incorrect right-turns at junctions. For example 86 percent cut corners when turning into minor roads and 40 percent when leaving the minor road.

Also it was very common for drivers to disobey stop signs (80 percent) and many drivers were observed to cross the centre of the road at bends with restricted sight distances (19 percent).

The introduction of markings at these site had very little overall effect on these types of driver error but a small significant improvement was found in the percentage of drivers crossing the centre of the road at bends (from 18.6 to 14.4 percent) and in right turn position errors from minor roads (40.0 to 33.7 percent). However at individual sites improvements were found in the former type of error at only 9 out 15 sites and at only 5 out of 8 sites in the latter. Therefore one cannot be certain that markings would reduce these 2 types of error at individual sites.

From the interviews it was found that many of the drivers were unable to identify which markings they had just seen & give their correct meaning. For example only 56 percent of the drivers correctly identified and knew the meaning of the direction arrows whereas very few identified and knew the stop and 'no overtaking' markings (15 - 17 percent). Consequently it is not surprising that the markings had little or no impact on behaviour.

One way to make the markings more effective might be to improve the knowledge of drivers by providing better training particularly for the professional drivers who knew fewer markings than the owner drivers (2 compared to 3 out of 9). However the results of this study suggest that improved knowledge on its own is unlikely to make much difference as many of the drivers who knew and identified some or all of the markings correctly, still made errors (86 percent at the stop line site; 68 percent at the 2 lane marking sites and 40 percent at the 'no overtaking' site).

However evidence from another study (Swati, 1980) indicated that positioning and not stopping errors were reduced from 28 percent and 63 percent to 5 percent and 11 percent respectively after improvements in traffic policing were introduced at sites with signs and markings.

Therefore it would appear that road markings do have potentail for improving driver behaviour in Pakistan but only if they are backed up by training and in particular by enforcement..

Also road markings and signs must be used appropriately if they are to be respected. The most common reason given by drivers for disobeying a marking (and sign) was that they could see the road ahead was clear (30 percent) and, as many of the junctions with stop signs had little traffic and good visibility, it is possible that give way signs would have been more appropriate.

In addition to markings alternative, engineering countermeasures could also be considered for improving the driver behaviour observed in this study. For example measures such as central island refuges with bollards could be introduced at intersections to prevent corner cutting. Unlike markings these would be self enforcing and they would therefore not require a police presence. In addition they would provide protection for pedestrians crossing at intersections and if lighting was a problem the bollards could be reflectorised.

Other measures to reduce driver error have already been introduced in Pakistan for example speed control humps are evident at a number of intersection in Islamabad. However although every effort is being made to improve road safety more research is needed to determine the optimum methods of reducing the alarmingly high levels of driver error demonstrated by this study.

7. ACKNOWLEDGEMENTS

The work described in this report forms part of the joint research programme of the National Transport Research Centre (Chief, Mr. M. Sadiq Swati) and the Overseas Unit (Unit Head: Mr. S. Yerrell) of the Transport and Road Research Laboratory (UK).

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