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Session 1: Context and scope of traffic-safety theory

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SESSION 1: CONTEXT AND SCOPE OF TRAFFIC-SAFETY THEORY

Summary of the paper presented by the additional speaker

Niels O. JØRGENSEN, Technical University of Denmark
Is public transport safer than private transport?

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IS PUBLIC TRANSPORT SAFER THAN PRIVATE TRANSPORT?

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1. Background

The question underlying this paper is: should public transport policy be considered part of the general traffic safety policy?

The question is relevant if substituting car trips by bus trips in an urban area changes the overall safety situation. Clearly, when considering this question comparisons should be made between door-to-door trips by different travel modes.

Earlier studies from big cities in Nordic countries indicated that bus or subway trips were not much safer than car trip. This is so because a pedestrian walking to and from a public means of transport is subject to a high risk which offsets the benefit of riding a fairly safe public transport vehicle (Jørgensen 1975, Forsström 1982).

However, data behind these studies are about 20 years old. Road safety in general has changed significantly since then. Have these changes also changed the relative safety of car trips compared to bus or subway trips?

2. Model concept

This question can hardly be answered in general. The answer must relate to a given urban area and the transport system of that area. A very crude model of the transport system and the urban structure of Copenhagen is outlined, fig. 1

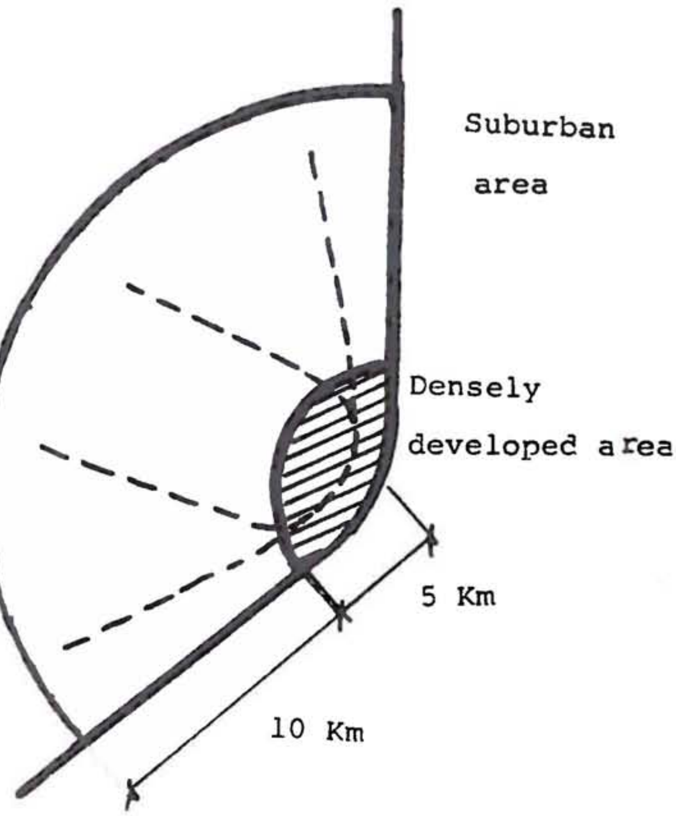

Fig. 1. A crude model of the Copenhagen area. It is assumed that bus services are fairly uniform over the area. Suburban trains are servicing only corridors ("fingers").

The approach taken in this paper is the following: For each of the two area types a set of injury rates (injured per million kilometers of travel) are set up. They apply basically to these travel modes: pedestrians, cycle riders, car drivers, bus riders and train riders.

Injury and death rates for trips which might be substituted are computed by adding up the rate of injury or death per kilometer of travel for each relevant travel mode multiplied by the relevant distance. Two typical standard door-to-door trips are defined.

Each traveller is exposed to injury at the rate computed as outlined. However, the traveller also exposes other road users to injury. This exposure to "others' depend very much on the travel mode. The comparisons between travel modes is made in terms of both own rates and rates for "others".

Conceptually this way of modelling only covers changes in injury or death rates due to marginal changes in travel mode choice. Substantial changes might change the underlying injury rates due to changes in street traffic volumes etc.

3. Results

From traffic survey data two standard trips were defined:

1. A 5 km trip taking place entirely inside the densely developed area.

2. A 12 km trip of which 4 km runs through the densely developed area and 8 km in the suburban area.

These two trips would be typical journey-to-work trips.

The 5 km trips is considered in the following transport modes and sub-distances:

Main mode	Kilometers				Total
	Walking	Cycling	In Car	In Bus	
Car driver	0.2	-	4.8	-	5.0
Bus rider	0.8	-	-	4.2	5.0
Cyclist	-	5.0	-	-	5.0

The 12 km trip is considered in the following transport modes, sub environments and sub-distances (D=dense, S=suburban):

Main mode	Kilometers								Total
	Walking		Cycle	In car		In Bus		In Train	
	S	D	S	S	D	S	D	S/D	
Car driver	-	0.2	-	8.0	3.8	-	-	-	12.0
Train-walk	0.7	0.6	-	-	-	-	-	10.7	12.0
Train-cycle	-	0.6	1.2	-	-	-	-	10.2	12.0
Bus rider	0.4	0.4	-	-	-	7.6	3.6	-	12.0

Figures for injury and death rates are given in the full paper.

The main results are as follows

5 km trip   Injuries per million trips

Main mode	Own rate	Others	Total rate
Car driver	1.4	1.5	2.9
Bus rider	1.2	0.4	1.6
Cyclist	6.5	0.5	7.0

12 km trip   Injuries per million trips

Main mode	Own rate	Others	Total rate
Car driver	2.8	3.1	5.9
Train-walk	0.9	0.1	1.0
Train-cycle	1.7	0.1	1.8
Bus rider	1.1	1.0	2.1

Discussion

The use of a very crude urban structure and transport system model reduces the value of the results. However, available data can hardly support a more differentiated model of this type.

Also, injury rates are developed from different data sources and with categories not exactly matching those of the calculations.

With available data, which refer to about 1985, it appears that cycling and car driving are the least safe means of transport in typical journey-to-work trips.

There is a considerable potential for improving travel risk by changing the modal distribution of travel from car and cycle to bus and train, particularly where there is easy access (short distance) to train and bus and where the total travel distance is long. The earlier studies based on data from about 1965-1970 did not point so clearly to public transport as a safe transport.

The calculations performed must be considered specific to the actual urban area under study so that results may not be generalized directly to other cities. It should be noted though, that the earlier Nordic studies gave similar results for different cities.

This model does not allow for an estimation of the effects of moving - say - 20% of all car drivers into public transport. More complicated models would be necessary.

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Risk evaluation

EVALUATING THE CLOSING DOWN OF PRIMARY SCHOOLS

A method for assessment of accessibility and safety of a new schoolroute.

Drs. Enne de Boer *)

SUMMARY

Changes in general policies concerning public facilities may have an impact on traffic safety. This is most certainly so with educational policy.

In the Netherlands the entire educational system is on the move. The general tendency is, apart from creating better equipped institutions, to enlarge the size of the individual school.

The Ministry of Education prefers to deny potential safety effects. It can do so because protests and even expert opinions are often unsystematic or even downright subjective. There is a need for quick and simple methods to assess beforehand the safety of the situation after closure beforehand. The author has made several such efforts.

For the primary-school problem a normative method assessing the accessibility of the new school was developed in a study commissioned by an official committee representing all institutional interests. The method evaluates both the present situation of traffic and transport on the new school route and the potential for cheap improvement.

Because of the unusual character of the project an extensive survey of international literature was made. Danish and German contacts proved to be especially useful. Traffic safety institutions were consulted to see whether they could support the idea of developing a simple normative method. The results were in general positive.

We found two existing methods: one Dutch, one Finnish. The number of infrastructural and traffic factors which were acknowledged to cause danger proved to be surprisingly small. It also proved possible to design generally accepted minimum values for these factors. These standards (concerning for instance speed and intensity of motor traffic) form the basis for the method. If on

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the route to an alternative school the score on one of these factors exceeds this standard anywhere, the route is considered not acceptable in its present state. Danger however is not only a matter of unsafe factors. Danger can be increased by combinations of factors in situations or by a successions of dangerous situations along a route. This implies that combinations of acceptable values may be unacceptable: acceptable factors combining into unacceptable situations, acceptable situations combining into unacceptable routes. To take account of this, some form of multi criteria analysis is required. The level of acceptability for situations was defined, after weighing factors, as two third of the summarized maximum factor scores, scores which were normalized for this purpose. For the combination of situations along the routes the acceptable mean "situation-score" is defined at an ever lower level as the number of situations increase. In practice this implies that on the basis of indisputable factor-criteria (like no unprotected crossing on roads carrying more than 10.000 cars a day) an assessment of routes can be made resulting in a rejection of even moderately unsafe situations.
Of course the results have no absolute value. The method does, however, distinguish schools that cannot be closed and schools that cannot be defended from closure, of least from the perspective of traffic safety. Without doubt there is a gray area in between, requiring further research. The importance of having one generally accepted assessment system however should not be underestimated: it is a sound and maybe the only basis for safeguarding the safety interests of vulnerable children in general decision-making.
The method was tested in 40 cases. It yielded results which only in a few cases caused some doubt.
The method is used in actual policy making at least at a regional level.

BACKGROUND

In the Netherlands local decline of birthrates is a threat to the survival of many primary schools. If the number of pupils drops below a nationally defined standard, taking account of its geographical position, it has to be closed down. For relatively isolated schools this standard is very low: it goes down as low as 23 pupils for the last school in a village. Even then schools can be saved with an appeal to "special circumstances", amongst others (extreme) inaccessibility of the nearest school and danger of the road to that school.

In 1984 a new type of primary school was introduced and the opportunity was taken to screen the total supply of schools after years of tolerating schools which were too small. Several hundreds of them had to be closed down. Numerous others were kept open on the basis of an appeal to danger. The Ministry of Education was rather unhappy about this. After having consulted the usual Dutch standing committee of participants in policy-making (with representatives of provinces, communities and unions of private, but publicly financed schools) it decided to carry out a few experiments with pupil transport as an alternative for a dangerous schoolroute. If these so-called "accessibility experiments" were to be a success a special regulation for providing pupil transport instead of financial support for the local school could be introduced. The standing-committee formed a project-team with staff of its member-organizations having experience with pupil transport. The planning sociology group of Delft Technological University (TUD) was enlisted as a consultant, because it had reorganized pupil transport in the province of Zeeland shortly before (E. de Boer 1985).

The project-team decided to do its work carefully. We were asked to survey a number of recent closures in order to find out whether accessibility problems had occurred, whether these had been observed or just imagined and whether adequate solutions, if any, had been found. The results were rather alarming. In eight cases out of eleven we found problematic situations. Only in four cases had these problems been foreseen and solved adequately. (De Boer and van der Veen, 1986). Complaints about unsafe routes to substitute schools had been shown to be realistic and solutions had proved not to be self evident.

The Ministry therefore wanted to go further with experiments and we consequently made a proposal for future operations. The project-team, however, looked much further forward and wanted to know under what kind of circumstances a transport solution would be justified. Since the grounds for our judgments in the eleven case-studies were rather vague - these were only expert judgments made under time pressure - the project-team asked us to develop explicit criteria for the acceptability of new school routes resulting from closures. In fact it was asking for accessibility criteria for decision making on closures as such. We were quite surprised at such a scientifically difficult request and at the same time thrilled with the idea of being able to introduce traffic safety in a both objective and normative way into the debate on school closures. Our sponsors were apparantly more confident about the result, than we were ourselves. They knew we had undertaken a quantification of accessibility costs of secondary schools closures, that had not been criticized. (E. de Boer 1984). We were only too well aware of how scientifically dangerous or even irresponsible a comparative assessment of safety on different schoolroutes can be and of how little we had been exposed to professional scrutiny. Experience in designing and evaluating a method for comparative assessment of an equally elusive phenomenon, severance or barriereffects of main roads had however taught us that, even in cases of hopelessly fragmentary knowledge, it is possible to produce widely accepted results and, what is more important, it had shown us how to proceed to produce these (de Boer, Hendriks a.o.1984) 1). It is the dangerous art of compromising between science and social technology, between the truthful and the useful.

PREPARATIONS

Our previous experience was restricted to comparative methods. Now we had to construct some kind of empirico-normative system with all its inherent dangers of being rejected both from a theoretical and empirical perspective, and from a normative perspective, selling ourselves and traffic safety to a Ministry of Education interested only in closing down schools. Because of this last danger we first explored the attitudes of traffic safety institutions to our endeavours to design an assessment system and moreover one, intended to prevent only abnormal danger instead of to improve upon "normal" and no doubt not fully adequate, safety. It was clear from the very beginning that the Ministry of Education would not accept the cost of an active safety policy. This was also clear to the Ministry of Transport's Traffic Safety Directorate represented in the project-team, which therefore became an important ally. We consulted both traditional organizations in the field of traffic safety and more radical ones. The reactions of their staff were quite encouraging. The old and conventional "Safe Traffic Netherlands" (Veilig Verkeer Nederland, VVN) welcomed the idea of criteria as a handy instrument for its own consultancy and even more as a breach in the Education Ministry's notorious defense against safety arguments in policy-making. The radical organisation "Stop child-murder" had itself recently. designed a comparative method. This method was not fit for our purpose, not only because of its comparative non- normative nature, but also because of certain shortcomings 2). On the scientific side we surprisingly met with equal enthousiasm. The reaction from our contact in the German "Bundes-anstalt fur Straszenwesen" was "I wish we had had a similar instrument during the seventies with their massive closures" 3).

Through a series of national and international contacts we tried to find existing methods, and scientific evidence for the variables to incorporate and if possible for the critical values of these. Apart from Dutch sources German and especially Danish sources proved to be useful.

The Dutch research carried out by prof. Michon's Transport Research Centre (Verkeerskundig Studiecentrum) in Groningen is perhaps the best evidence of what the abilities of children in traffic are. In normal daily practice they perform better than in experimental situations, perhaps because they have learned how to behave on well-known routes like the schoolroute. In Germany the long routes to school in a strongly car-oriented society have led to a special concern for the journey to school during recent years. A series of handbooks for improving existing routes contain, even more than similar Dutch ones, more or less explicit criteria. An association such as ADAC purely devoted to car drivers has issued a good booklet on the "safe journey to school" (der sichere Schulweg) and an unequalled one on the schoolbus.

Danish inquiries yielded much more than similar Swedish ones, in spite of the fact that we used comparable entrées. Professor Jørgensen of the Danish TU produced from his personal archive an anonymous Finnish method in the Swedish language. It betrayed its nordic origin, for instance by taking account of snow-ploughs on the route. This method was alas also comparative, its outcome being a score, a dimensionless number without any qualification in terms of acceptability. This was even the case for individual variables like speed. The Dutch method had the same flaw, which made of them unfit for a normative approach. The importance of expressing safety in explicit criteria was underlined by the experience with an article in the Danish law on public schools, requiring a safe route to school or pupil transport. Appeals to it were often rejected through lack of evidence. Evidently it was uncertain what kind of facts could serve as evidence. In Denmark as everywhere distance criteria form the prime basis for pupil transport. The standard distance criteria show a large variety, probably because there is hardly any rational basis for them. They rest on tradition, like the Dutch standard of 4 km. "over the shortest passable road": one hour's walk on a dry and level road. Undoubtally passable does not necessarily mean safe. However, in spite of their being arbitrary, distance criteria can be used as part of accessibility criteria, because of their level of acceptance.

THE STATE OF THE ART

The situation we found ourselves in after our initial enquiries might be called socially encouraging: we were unlikely to be morally crucified for undertaking the study. Scientifically and methodically it did not give sufficient discouragement to make us give up. In summary:

- There was no method available which with modest adaptation might be adopted.
- There was no theory, not even the simplest one on safety of routes. The methods we found, including a crude Swedish one of the Department of Traffic Safety ("Trafiksäkerhetsverket") were not based on any explicit theory. In two of the methods scores for individual traffic situations of an equally mysterious origin were simply added.
- On the other hand it was clear that the number of factors commonly regarded to cause danger was rather restricted.
- For at least some of these (like speed) it was possible to define commonly agreed critical values.
- For the interplay of these factors, creating greater danger in specific situations, some indications could also be found.

PREREQUISITES FOR ACCEPTABILITY

Accessibility criteria, (or a method as it has sometimes been called, not only for stylistic reasons, but also because, no doubt, some kind of calculus will be required), intended for ex-ante evaluation of school routes has to comply with two types of demands, in order to be accepted for decision-making. It needs to be credible on the one hand, and workable on the other hand. These demands are in our case less contrasting than they seem to be at first sight. When the level of knowledge is modest, and when scientific and social choices have to be made, the structure of the method should be simple and its procedures transparent. The following demands should be met:

- Development of a simple theory on the causation of danger on a route
- Translation of this theory into a straightforward evaluation procedure.
- Incorporation of only the most essential variables which should be easily measurable.
- Defining critical values for these on sound scientific grounds, well founded common sense or simply on legal rules.
- Incorporating safety margins into the "foundations" of the calculus, exceeding values implying "bestial" unsafety.
- Logical or understandible combination of variables producing consequent safer values for individual variables.
- Face-validity or rather defensibility of the outcomes from the points of view of both safety and, unavoidably, closability.
- Conservatism with respect to outcomes, leaving some room for further defenses, using factual accidents as an argument for instance.

ACCESSIBILITY: DISTANCE, TIME AND SAFETY

Hitherto accessibility and safety have been talked of rather loosely and seemingly interchangeable, but of course accessibility is the larger concept. Distance is an important factor in accessibility, affecting travel time and safety because of duration of exposure. For this reason and because it is

easily measurable, it is often used as a criterion for closing down schools: the larger the distance to the next school, the lower the minimum number of pupils allowed. Recently the Dutch government shortened these critical distances in an effort to stem the stream of complaints about danger from traffic. However, distance is too unreliable an indicator of danger. Short routes in urban areas may be less safe than longer ones in rural areas for instance. One might however assume that long distances are inherently too unsafe for young children (8-10 years) to go to school on their own. This is internationally acknowledged in distance standards for (reimbursement of) pupil transport. One practical limit for safety evaluation therefore is such a widely accepted standard; in the Netherlands 4 km for the whole of the primary school (4-12 years). Unfortunality decentralization of policy-making in this field has made this standard somewhat less self-evident.
If for any reason a shorter journey to school is still found to be too unsafe, distance and time are important factors in assessing traffic improvements or transport alternatives: detours, waiting times and comparatively long-lasting journeys might make these unacceptable for the children and therefore useless. We have taken this into account in our system, but it will be ignored in the remaining part of the paper, as will be the safety of the means of transport itself, of the route to the bus-stop and of the direct school-environment. This is because the safety assessment of routes is the most important element of the method.

A SIMPLE THEORY ON SAFETY OF ROUTES.

It is quite impossible to investigate the danger of a new school-route by analyzing accidents and conflicts, not only because it is not yet a school route but also because this approach requires too much time and money for decision-making on closures. Investigating subjective safety will not do either. It is too subjective for a debate and is in any case seen as too emotional by the educational authorities. One is therefore left with indicators, measurement of factors, like bad sight, that are proven to be causes of danger. Danger may be caused by three different elements: by the value taken on by an individual variable, by the combination of values of different variables in individual traffic situations, and by a succession of high situational scores along a route.

It is quite obvious that a school-route may be rejected in its present state because at one or more places critical values of certain variables are exceeded. The idea of small children having to cross unprotected roads with speeds exceeding 100 km/hour is unthinkable. It is essential that the degree of protection offered by facilities such as pavements should be specified.
It is quite obvious too, that a situation in which only one variable reaches a high value, is less dangerous than one in which more of theme are reaching critical values. Unfortunality it is not really possible to predict the level of danger resulting from the interplay of variables (apart from the relation between restricted visibility and speed). Therefore a simple device is needed for defining an overall-score on the variables and setting a lower maximum on "average scores" than on individual ones. This appraisal should of course also do justice to the three fundamentally different route elements: following a road, crossing it and going across crossroads.
It is perhaps somewhat less obvious that confrontation with a sequence of unsafe traffic situations is a further addition to danger and the to unacceptability of a school-route. However there is no doubt that the accident risk is increased by repeated exposure to similar (or dissimilar) danger. This implies that one situational score which is acceptable as such may be rejected as an average for a route. The device for setting a lower maximum on this average had preferably to be the same one as in the previous stage in order to minimize the arbitrariness of the whole. The reduction should also be dependent upon the number of unsafe situations en route: the more the less acceptable.

THE RESULTING ASSESSMENT PROCEDURE

Such a three-level-theorem allows for an efficient three stage assessment of safety as depicted in figure 1. In a first round the route may be explored superficially to find the places where critical values of individual variables might be exceeded. If after measurement this proves to be the case, further assessment is superfluous. Instead the possibility of counter-measures and of a transport alternative will have to be considered. If a transport solution is feasible (public transport might even be suitable in its present state!) closure is acceptable, because all known and as yet unknown problems are solved at once. An traffic solution, like a traffic being is inevitably local and in the next step, assessment of situations in character.

Lower values may be required even at the same spot let aline at other spots. Again a broad inspection will produce a list of potentially unacceptable situations, for which measurement of all variables is required this time. The search for solutions is then repeated, and in case non-transport ones are propaged and in the case that no problems have yet been found the third, and most extensive analysis begins. Yet even then it is not necessary to scrutinize the entire route because parts of it may prove to be acceptable at first sight (footpath or bikeway present e.g.), after a simple calculus (cul-de-sac) or after a brief measurement: very low intensities and speeds.
The traffic solution alternative might be thought to be preferable because it gives the children an opportunity for an independent journey to school. In a procedure like this assessment can be stopped if a reasonable transport alternative exists or can be organized. Finding a traffic solution on the level of single variables is no guarantee for acceptable situations or routes and therefore more analysis has to be done. In this case however the preference for tendency towards transport solutions is partly ficticious and partly real: the purpose of this method is to judge closability and not specific accessibility measures; it is meant to prevent the worst danger, which makes transport alternatives, which ideally prevent confrontation with danger, preferable for longer distances.

VARIABLES AND VALUES

Considerable trouble was taken to find out which variables are relevant for the safety of a route. Their number proved to be surprisingly small, the most important ones being traffic intensity, speed and visibility. Apart from visibility, a number of distance and space variables are no doubt relevant though mentioned somewhat less often in literature. These are the total length of the journey, the length of a stretch of road (one situation) followed, the width of a road (for cyclists to ride on, for pedestrians to cross in one time) and the presence of sepraate facilities for those traffic participants, either for riding on or for walking and crossing.
Intensity contributes to the chance of conflicts for children cycling on the road and for children crossing. The latter are taking more risk with higher intensities because of long delays. A value of 2000 motor-vehicles a day we held to be acceptable, a value of 10.000 vehicles completely unacceptable.

Speed is a self-evident contributor to frequency of conflicts (children have difficulties estimating speeds!) and to their gravity. Acceptable speed: 30 km per hour; rejectable speed 80 km. (the maximum allowed on Dutch roads apart from motorways). Danger increases rapidly quickly above 50 km. per hour. For pedestrians walking along a road 30 km. is the maximum without footpaths.
Visibility is an absolute requirement for crossing, the length of the sight lines needed depending upon the highest speeds registered.
Crossing distance is important for the acceptability of gaps in the traffic flow. A distance of 3 metres is acceptable, one of 12 metres unacceptable. This might be considred rather strict in comparison with the previous criteria. Yet wide roads are generally resented, and the problem can be solved easily by making an island in the middle, and by restricting locally the space for riding and parked vehicles.
Width of the road has an impact on the safety of cyclists, narrow (4 m. and less) and wide ones (7,5 m and more) allowing for higher intensities because in either case they will be confronted with traffic in one direction only, which moreover cannot cause many conflicts any more. In these cases the intensity registered is taken only half as serious like (for crossing) in the case of a resting-place in the middle of the road.
Length of a stretch of road (one continuous situation) is of relevance because of the duration of exposure which is only partly outweighed by adaptation to the situation.
Total length of the school-route Some kind of distance limit is required. In our system of criteria 4 km. is chosen because it is the traditional criterion for pupil transport in The Netherlands.
Facilities, which have been mentioned at various points must of course be taken into account. Footpaths, separate bikeways, tunnels and bridges are sufficient measures along or across the road respectively. Other measures like traffic lights must somehow be given a danger reduction value. These are relevant when judging more than one variable i.e. for judging situations.

SITUATIONS: INTEGRATING VARIABLES IN A CALCULUS AND PUNISHING EXTREME SCORES

A major problem of assessing safety on the basis of indicators or constructing a general acceptability criterion for situations or even routes is incomplete knowledge about the interplay of variables. Only some of these could be expressed with reasonable reliability in one real value: combining speed, intensity and crossing-length may yield a certain chance, a mean delay for a sufficient gap in the traffic flow. The general problem though cannot be solved this way. The only way out is to choose some form of multi-criteria analysis as described by Voogd (1983) for instance. As a rule these are used to combine different arguments, which are not comparable into one; the most limited form being a presentation of all facts in one table, the most far-reaching one being a translation into a monetary balance. In this case multi-criteria analysis is to be used for "comparables", arguments leading to one kind of conclusion: a degree of safety being acceptable or not. Arithmetic simplicity is required because of the limited level of knowledge. A numerical score is nevertheless preferable as an outcome for the sake of clarity. Of course the outcome is nothing more than the result of the best possible combinatorial reasoning and agreement on limits.

The *first step* to be made is expressing all variables in a similar way. This can be done most easily by normalizing them: assigning a score of 0 to the lowest possible value (e.g. 2000 motor-vehicles) and a score of 1 to the highest possible one (10.000 or more), and intermediate scores to intermediate values on a proportional base, or disproportionally if necessary, as in the case of speeds.

The *next step* is to weigh variables. For crossing for example speed may be thought to be of more importance than intensity.

The *third step* is to assign correction values to special circumstances like width of the road and facilities present in the situation.

The *fourth step* is designing a formula to calculate a summary score. Given the previous steps this is rather easy. The formula's we made are presented in figure 2. Different formula's are used for longitudinal, transversial and cross-road-problems. In fact the latter case is only crossing one arm of a cross-road. Crossing a second arm requires seperate assessment because conditions can be quite different there.

An equal maximum score for different types of situation is a prerequisite for constructing a route score. The maximum score for every type of situation is decided by intensity, speed and (crossing) distance. Correctional factors may increase or decrease the score. The figure in the denominator limits the possible score to 1 (L and T) or 1.5 (C).

The maximum score accepted for any given situation is 0,66, which implies that problems in crossing at crossroads are punished more heavily than other elements of the route. The reason for this is the large degree of complexity at crossroads. Defining a 0,66 standard was of course difficult because of its arbitrariness. After a few exercises and practical tests we decided to choose this very simple standard. It implies that no route with a length/speed of 80 km/h. and 10.000 vehicles will be accepted. Transversially combinations of for instance 60 km/h and 6500 vehicles per hour or 50 and 9500 vehicles are however accepted but only for (impossibly) narrow roads (see figure 3). The moderating effect is evident but these combinations indeed are still looking rather dangerous. It should not be forgotten though that only one such situation will be tolerated on any one route.

ROUTES - INTEGRATING SITUATIONAL SCORES IN A CALCULUS AND PUNISHING RATHER MODEST SCORES

The question of how to make a route-assessment was now quite simple. A route is a succession of situations some of which are innocent or at least completely acceptable (score 0) and some of which are less acceptable (scores 0,0 to 0,65). The unacceptability of the route increases with the number of less acceptable situations. A route with only one such situation (0,65 e.g.) should be judged more rigorously. In a way it is logical to use, in the case of a "normal" number of "less acceptable situations", the same two-thirds-weighting as for single situations, which means that for a somewhat longer route only 0,66 x 0,66 or less than 0,44 of the original variable score will be tolerated.

EVALUATION AND IMPLEMENTATION

Both the Ministry of Education and the Project-team were interested less in the structure and content of the method than in its results. For them the question was above all: how many schools could be closed upon application of the method, and, more specifically, what will be the net-result in financial terms, resulting from savings on schools and costs for traffic and transport.

We took a stratified sample of 40 out of 600 schools which were too small, regarding three characteristics of individual schools: size (decisive for transport cost), distance (decisive for transport need) and geographical position (important for traffic-measures). A great part of the cases were taken from a list of the (non-expert) Educational Inspection indicating schools causing "very serious" or "insurmountable" accessibility problems upon closure. These proved upon application of the method hardly to differ from the other cases, which in itself proved the utility of an objective method.

The result of this rather extensive application could be called not 'unfortunate'. An estimated 25% of all schools could be closed down without causing accessibility problems at all. Another 25% would cause so much problem that closure would hardly be attractive from a financial perspective, i.e. it would cost at least half as much as the mean savings per school. The remaining 50% might disappear after taking affordable measures. Especially the smaller rural schools could be readily closed utilizing pupil transport. The larger urban schools, for which transport is more expensive and more inadequate proved to be more difficult.

The method and its results were presented in the standing committee and were received not unfavourably. In the mean time the Ministry however had decided to design more lenient pupil - and distance - criteria in order to get rid of "special circumstances," amongst which traffic safety. This might be called a rather naive idea considering the tradition of decision-making on closures. The Secretary of State for Education did not want to be accused of neglecting safety alltogether and asked us to make a guide for creating a safe journey to a new school intended for local use. Given the short time-lapse between the decision on closure and the actual closure - often less than 6 months - the text had to be aimed at stimulating action. After our slightly disappointing experience this at least was some fun.

We had no reason for great disappointment. In The Netherlands responsibilities for opening up or closing down primary schools are divided in a rather strange way: the Ministry is responsible for private schools which mostly have a religious background but are normal in every other respect (financially too); the Province, a lower level of government, supervises the communities and their schools. At a previous stage both educational and safety officials had agreed at an interprovincial level to use our criteria. They followed the altered policy of the Ministry and they even went somewhat further with respect to distance criteria. Because of this and because of the supposed difficulty of the method (any method one hasn't used is difficult, especially for those not used to methods at all or not even familiar with the subject) it moved more or less to the background. Some provinces however do use it more or less actively, some communities are using it too in their defense. The Province of Overijssel is undoubtedly the most active one. Our most recent assignment came from that Province. We had to pass sentence on the primary schools of Beerzerveld, Ossenzijl and St.-Jansklooster.

Designing a method on accessibility might lead in the end to becoming an executioner. In traffic safety however one can never deny moral responsibility. Fortunately this kind of science has its restrictions too. We have warned strongly against mechanical use of the method. In the case of strongly contrasting values on different variables (very low intensities, too high speeds) the face-validity of the result is not entirely convincing. In the case of situational scores approaching critical values it is absolutely necessary to see whether specific circumstances may leadt to firmer conclusions.

NOTES

1) The method and its background have been summarized in: E. de Boer, 1986, Estimating severance caused by main roads.
2) For instance it takes account only of crossing a road, not of following it, which can be dangerous as well. The variables in the method are, however similar to those in our method.
3) In Germany educational arguments led to the closure of all smaller schools and thereby to massive and costly pupil transport (at least 2 billion Marks a year) and massive safety problems when impoverished authorities tried to withdraw it.
4) Tradition however has a force of its own as Swedish experiences have shown. Moreover the Dutch Association of Local Authorities (VNG) has designed a model by-law to ensure a high degree of uniformity in community policies.

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Figure 1. The outline of the assessment procedure

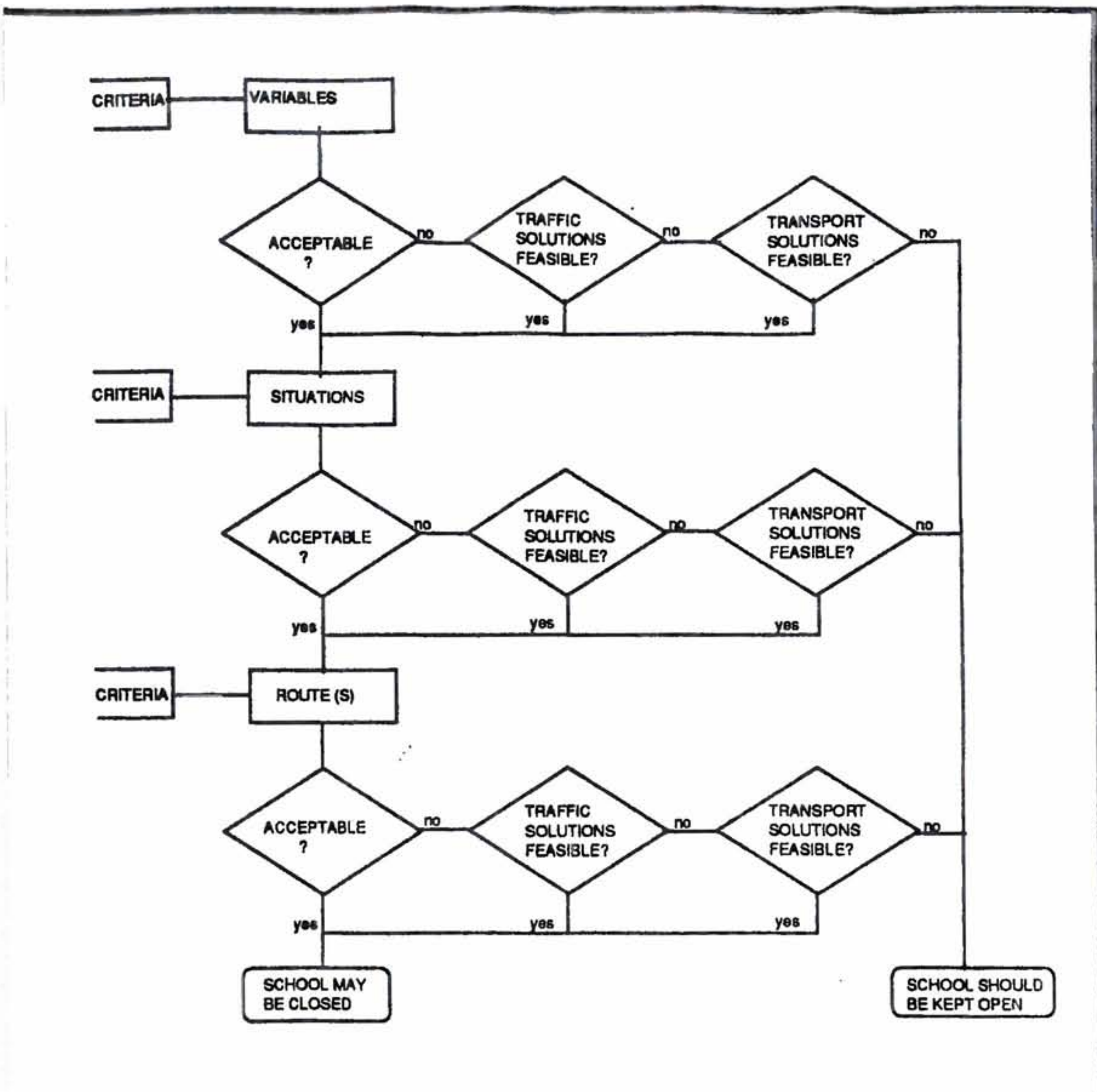


Figure 2. Criteria for different types of situation

LONGITUDINAL

- INTENSITY
- VELOCITY
- WIDTH OF THE ROAD
- DISTANCE
- FACILITIES

$$L = \frac{((l_1 \cdot c_w) + V_l) \cdot d \cdot c_f}{2} < 0{,}66$$

TRANSVERSIAL

- INTENSITY
- VELOCITY
- CROSSING DISTANCE
- SIGHT LINE
- FACILITIES

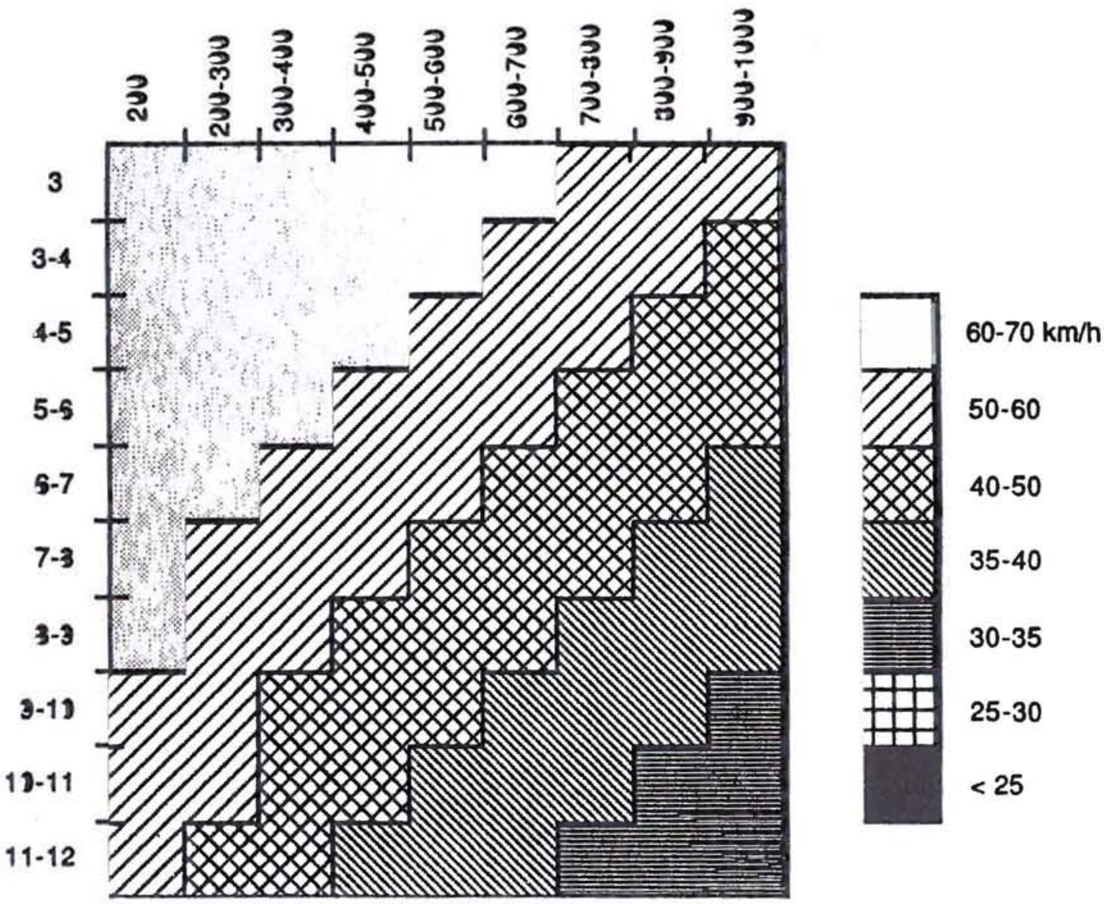
$$T = \frac{((2 \cdot V_t) + l_t + C_t) \cdot S \cdot c_f}{4} < 0{,}66$$

ARMS OF CROSS-ROADS

- INTENSITY
- VELOCITY
- CROSSING DISTANCE
- SIGHT LINE
- FACILITIES

$$C = \frac{(V_t + l_t + C_t) \cdot U \cdot c_f \cdot c_c}{3} < 0{,}66$$

Figure 3 The maximum speed (85%) allowed on roads to be crossed unprotectedly given the intensity and the crossing distance.



DEEPENING THE ENVIRONMENTAL ANALYSIS IN RESIDENTIAL AREA WITH THE CONSCIOUS MEASURES

by Takashi NISHIMURA (Osaka City University, Osaka, Japan) and
Hiroyuki TAKAI (Kinki University, Hiroshima, Japan)

1. Introduction

Generally, the traffic environments are analyzed by the physical measures such as the traffic accidents rate, traffic noise level and so on. To deepen the environmental analysis, resident's evaluation for the physical environment will be usefully considered. To introduce the resident's evaluation it is practical to make several conscious measures based on the surveys by questionnaire. Such conscious measures which will be considered to be essential in analysis of the traffic environment of the residential area are designed to meet the aims of analysis.

As the examples of the conscious measure, uneasiness for traffic accidents, nuisance for traffic noise, feeling for traffic convenience, comprehensive evaluation for the whole traffic environment etc. are introduced which can not be expressed by the physical measures, therefore thought to be used effectively together with physical measures. After the conscious measures were calculated from the results of the resident's feeling survey, the characteristics of the conscious measures were examined by the multivariate statistical analyses and some prediction models were developed for major conscious measures in relation to the other conscious measures or fundamental factors of area such as the land use, road system, traffic volume, residential house type, population and others. Then traffic environmental evaluation system were built for the comprehensive measures of the traffic environment, otherwise the comprehensive evaluation would not be possible because proper physical measure for comprehensive evaluation would not be found.

2. Fundamental surveys

For the typical residential areas of various types ranging from high population density to low density, some fundamental surveys were planned to obtain the actual conditions of the areas which included following items.

(1) Conscious measures;
Resident's appraisal for the various sides of traffic environment (by questionnaire), uneasiness for traffic accidents (this measure is expressed by the ratio of the residents who feel uneasy or risky on the roads around their residence to the all residents surveyd, similar to other measures), overall nuisance for traffic (ratio of the residents who feel nuisance by traffic), feeling for traffic volume (ratio of the residents who feel traffic volume is too much), nuisance for parking, traffic noise, traffic vibration, air pollution, uneasiness for children's outdoor playing (ratio of the residents who feel uneasy or risky in children's outdoor playing on the roads around residences), willing to remove residence (ratio of the residents who feel better to remove their residence to avoid the traffic nuisnace), comprehensive "good" evaluation (ratio of the residents who feel the traffic environment is good generally) and comprehensive "bad" evaluation.

(2) Physical measures;
1) fundamental measures of area
population and employee, land use type, density of business firms, road system (width, side-walk, density), etc.
2) environmnetal measures,
traffic accidents rate, traffic noise level, etc.,
3) traffic flow,
volume of vehicle traffic, bicycles, pedestrians and parking, speeds distribution, heavy vehicle ratio etc.,

4) traffic regulation,
one-way, low-speeds, parking prohibition, heavy vehicles prohibition, no vehicles (pedestrianization), etc..

These surveys were carried out in 32 residential areas in Osaka Pref. and in Hiroshima City. About 5,700 families and 12,000 members of the families were sampled, corresponding to about 80 percents of answering. Averaged sampling ratio was about 6 percents.

From Table 1, actual features of the high density residential area in Japan with heavy traffic on the narrow streets will be outlined. And also the resident's averaged feeling for the various sides of environment will be explaind in Table 2.

3. Analyses on the conscious measures

Several analyses on the conscious measures were attempted by statistical methods in relation to the other conscious measures and physical measures. They were classified as below;

(a) conscious measures X conscious measures,
(b) conscious measures X physical environmental measures,
(c) conscious measures X fundamental physical measures,

(1) Correlation between the conscious measures

Generally speaking, relations between each pair of the conscious measures have considerably high value of the coefficients of correlation each other. Some examples of the relations are shown in Figure 1.

A result of the cluster analysis is also shown in Figure 2, which shows the grouping characteristics of the conscious measures by the coefficient of correlation between groups. Uneasiness for the traffic accidents, overall nuisance for traffic, nuisance for traffic noise and comprehensive evaluations for the traffic environment are grouped in a large cluster, and slightly apart from other independent measures such as nuisance for parking, nuisance for traffic vibration etc..

(2) Relationships between the conscious measures and physical environmental measures

The conscious measures are also related to the physical measures. Here two examples of such relations are shown. One is a relation between the comprehensive "good" evaluation for the traffic environment and the actual traffic accidents rates in 16 residential areas as shown in Figure 3.

This shows a considerably close correlation and the usefulness of the conscious measures. The other example is the relation between the nuisance for the traffic noise and the actual noise levels in the areas as shown in Figure 4. This relation shows also a resonable correlation and the general importance of the conscious measures.

(3) Relationships between the conscious measures and fundamental physical measures

Conscious measures are also expected to be influenced and formed by the actual physical conditions. The simple correlation coefficients between the conscious measures and various physical measures are shown in Table 3. General level of correlation coefficient is considerably low compared with the relations stated above, but many pairs of significant relations are observed.

The density of employees in daytime, ratios of floor use for residential use, shares of the narrow road width less than 4 meters,and average road width are in relatively high correlations with conscious measures.

Table 1. Actual features of the residential areas (physical measures)

ITEMS	MEAN	COEFFICIENT OF VARIATION (STD/MEAN)
area size (ha)	70.01	0.365
population (1000 persons)	10.01	0.367
area of road (ha)	9.34	0.488
area of park (ha)	0.92	0.962
area of building (ha)	18.64	0.299
area of residential land use (ha)	35.68	0.398
area of commercial land use (ha)	2.78	0.754
area of industrial land use (ha)	2.41	2.252
average road width (m)	5.71	0.28
traffic accidents density (accidents per ha per year)	0.41	0.48
fire hydrant density (per ha)	1.41	0.18
fire density (per ha per year)	0.65	0.36
max traffic volume (per 12 hrs)	5777.01	
max volume of heavy vehicles (per 12 hrs)	204.01	
max volume of bicycles (per 12 hrs)	778.81	
max volume of pedestrians (per 12 hrs)	1813.6	
one-way regulation rate (%) (rate of regulated road length)	22.91	0.61

Table 2. Actual features of the residental areas (conscious measures)

ITEMS	MEAN (%)	COEFFICIENT OF VARIATION (STD/MEAN)
uneasiness for traffic accidents	78.2	0.14
overall nuisnace for traffic	57.2	0.29
feeling for traffic volume	62.1	0.34
nuisance for parking	29.4	0.63
willing to remove residence	63.7	0.28
nuisance for traffic vibration	44.8	0.43
nuisance for exhaust gas	60.3	0.35
uneasiness for children's outdoor playing	64.6	0.26
willing to remove residence	24.1	0.65
comprehensive "good" evaluation	40.1	0.46
comprehensive "bad evaluation	17.9	0.81

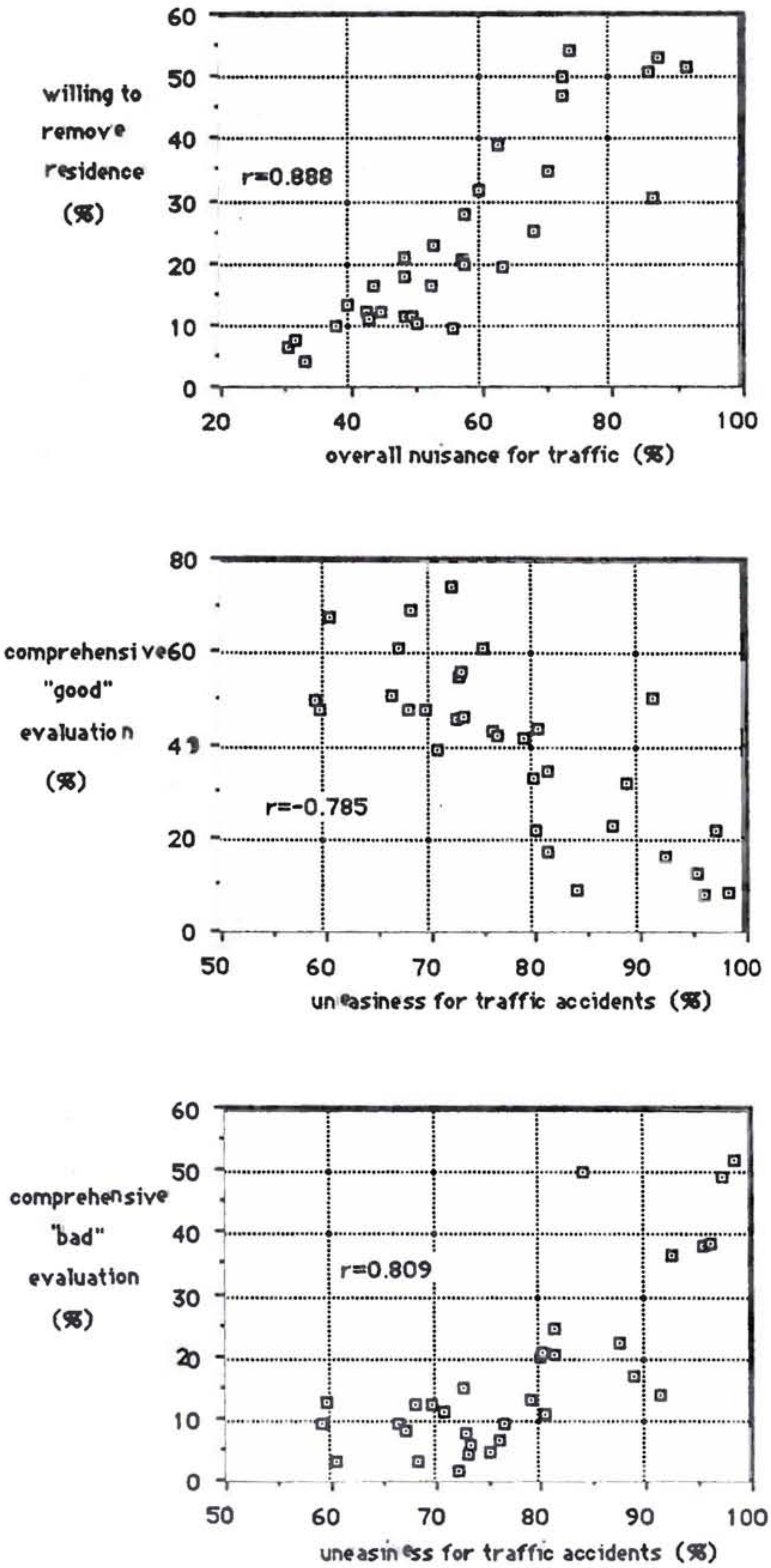


Figure 1. Examples of the relations between the conscious measures

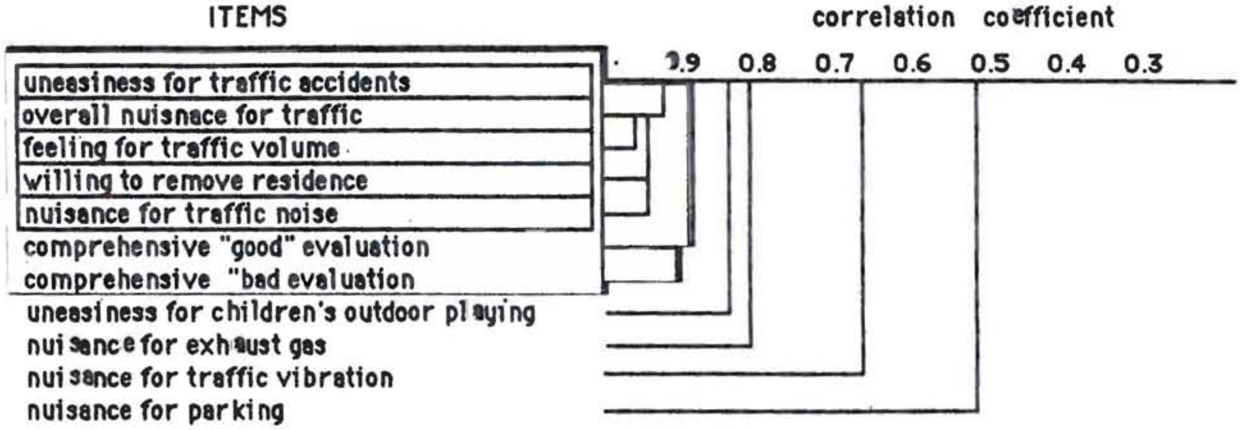


Figure 2. Result of the cluster analysis for the conscious measures

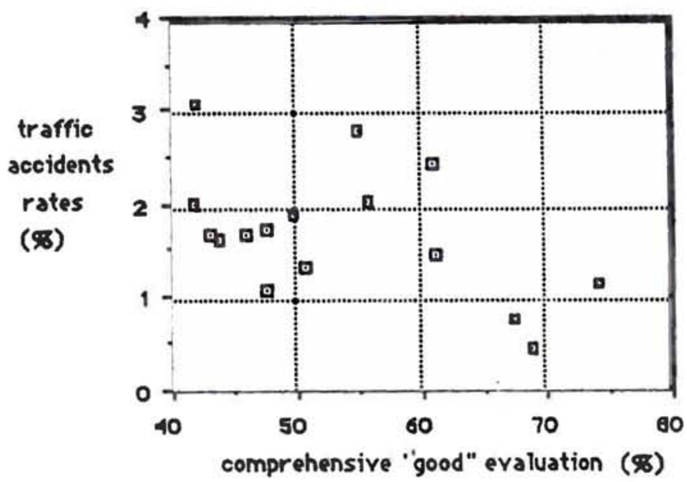


Figure 3. Relation between the comprehensive evaluation and the actual traffic accidents ratio

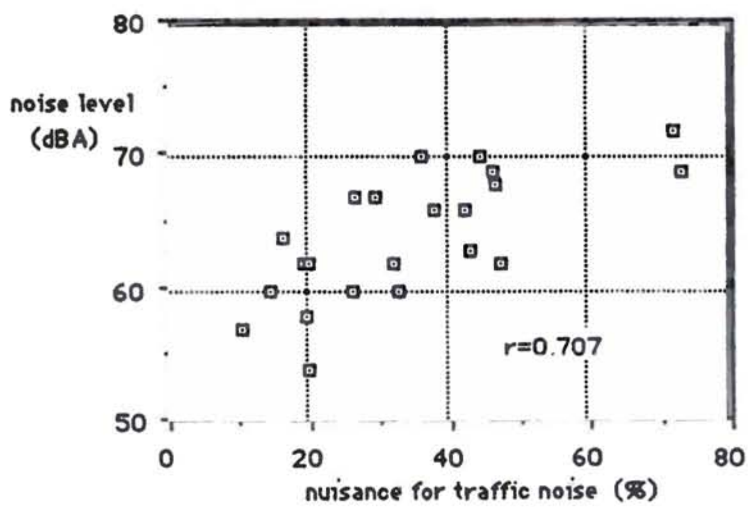


Figure 4. Relation between the nuisance for traffic noise and actual noise level

conscious measure / physical measure	nuisance for parking	uneasiness for traffic accidents	overall nuisance for traffic	nuisance for traffic noise	uneasiness for children's outdoor playing	comprehensive evaluation "good"
population density	-0.265	-0.357	-0.247	-0.279	-0.366	0.308
employee density	0.596	0.517	0.617	0.68	0.308	-0.262
park area ratio	0.329	0.162	0.171	0.298	0.319	-0.011
volume of total floor	0.473	0.362	0.471	0.529	0.306	-0.071
residential use ratio	-0.482	-0.279	-0.381	-0.475	-0.209	0.247
residential floor ratio	-0.521	-0.579	-0.556	-0.691	-0.581	0.411
fireproof wooden house ratio	0.523	0.611	0.371	0.449	0.518	-0.078
residence density	-0.236	-0.385	-0.187	-0.258	-0.434	0.256
road density	-0.288	-0.277	-0.318	-0.451	-0.313	0.088
average road width	0.605	0.591	0.511	0.634	0.601	-0.043
ratio of road area less than 4 meter width	-0.585	-0.814	-0.567	-0.738	-0.815	0.209
one-way regulation ratio	0.529	0.668	0.428	0.567	0.494	0.016

(note: 10%, 5%, 1% significance level is 0.423, 0.493, 0.615 respectively)

Table 3. Correlations between conscious measures and physical measures (simple coefficients of correlation)

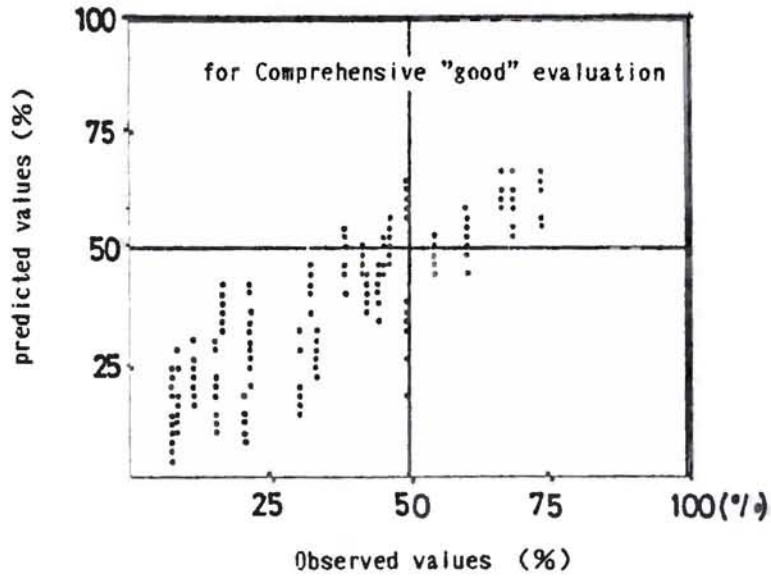


Figure 5. Comparison of the observed comprehensive "good" evaluation with the predicted values by the many multiple regression models

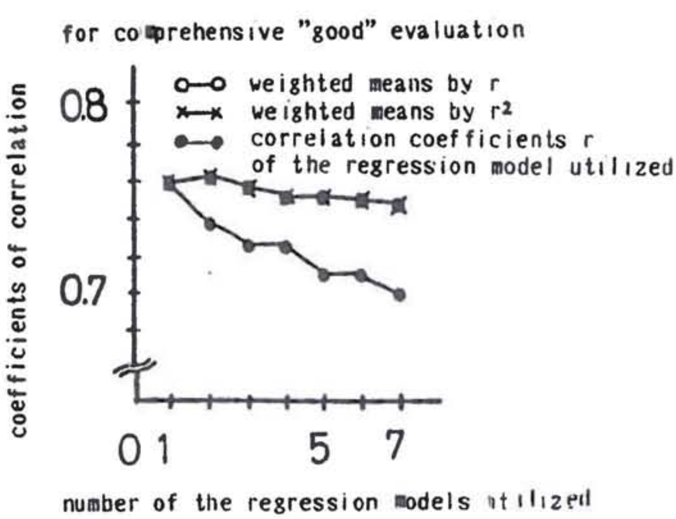


Figure 6. Correlation coefficients of the predictions by weighted mean by the numbers of models used

4. Traffic environmental evaluation model

To build the evaluation model for the traffic enviroment, prediction model for the environmental measures have to be developed based on the physical measures of the residential areas. Here two types of the prediction models were developed by the fundamental groups of physical measures.

One is the model for the partial sides of the traffic environment, and the other is the model for the comprehensive evaluation for the whole traffic environment, and which caused the possibility of the comprehensive environment evaluation through the conscious measures, otherwise the comprehensive evaluation will be difficult for the lack of the proper physical measures.

Here a case for the comprehensive "good" evaluation is explained for an example. The prediction model for the environmental measure is constructed by several ways, such as the multiple regression analysis, statistical quantification theory or other statistical methods.

Stating about the multiple regression analysis, there are two directions about the way of combing the independent variables (physical measures). One is the large model which includes many factors, with relatively high coefficient of regression. If a resonable model is developed, this method is desirable, but it is usually not easy to build good large models. The other is the small model approach which includes a few numbers of the independent variables, but builds many small models. These small models are easy to be built, but the level of significance of each model descends. Merits of this approach is to be able to cover almost all factors (physical measures) concerned through small models.

Here the latter approach was adopted and some regression models for the comprehensive "good" evaluation for the traffic environment were developed, based on the fundamental physical measures. The same numbers of the predicted values as the prediction models were obtained which distributed in some range as shown in Figure 5. To synthesize these values weighted means by the multiple regression coefficients of each model were calculated as shown in Figure 6, where the weighted means by correlation coefficients "R" and by the coefficients of determination "R^2" are shown with the basic correlation coefficients used.

These results of the synthesis by weighted mean method by correlation coefficient showed to be able to keep the high correlation between the synthesized values and actual obsereved values. Then the small model approach is considered to be practical in the environment evaluation and improvement problem.

5. Conclusion

The conscious measures were introduced in the evaluation of the traffic environment in the residential areas and analyzed on their characteristics of the environmental measures. The major results are summarized below.

1) The conscious measures are able to be created in any interested points in the environment freely and surveyed by questionnaires for the residents.
2) The comprehensive evaluation measures for the traffic environment are able to be settled as the important measures in the environmental analysis and improvement.
3) The conscious measures were related each other at considerable high level of the correlation coefficients and made some major interrelated groups and some independent individual measures.
4) The conscious measures were also related to the fundamental physical measures (population, land use, architectual building, road system, traffic flow, traffic regulation etc.), and that suggested possibility of improving the evaluation for the traffic environment through the controlling of the fundamental physical measures.

5) The conscious measures were closely related to the physical environmental measues, that suggested the utility and importance of the conscious measures.
6) The prediction models for the conscious mesasures were developed based on the fundamental physical measures. The small model approach was attempted, which had a purpose to reflect the physical conditions of the area to the environmental measures through many small regression models. It was shown that the method was practical.

Summarizing the study, the conscious measures are interesting measures and it was testified to be useful in environmental analysis to introduce the resident's feeling and evaluation. These approach should be attempted in various environmental problems to discuss the roles of the conscious measures.

Acknowledgment:
We are gateful to the Municipal Governments and Police Departments in Osaka and Hiroshima, and other cooperative organizations and persons for their helps in the study.

UNDERSTANDING DRIVERS BEHAVIOUR : SOCIOLOGICAL THEORIES AND SURVEYS.

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The aim of this paper is to show how research in road safety and especially the driver behaviour can be clarified by social sciences theories and data.

We will start with the three following assumptions which ,I hope,will make this approach more obvious and clear.

1 driving a car is (in part) a social activity
2 road safety is (in part) a social fact of life
3 a road accident is (in part) a social event.

1 We know that car driving is in most cases determined by the social structures.It is to fulfill their social roles and to satisfy social obligations that people travel :the road traffic system is a means to an end.
Furthermore,everything that surrounds driving,for example the highway code, and everything that controls it:police,insurance companies, are the product of this very same society and are the result of a social action.

Next ,we must accept the fact that driving a car is one aspect of our social world, of our culture and that the attitudes that guide driving are part of our cultural make up, a part of our cultural heritage which we received and which is continually reinforced : driving is subject to all sorts of cultural and social influences.
Furthermore,the car is not only a means of transport but also a consumer goods.As such, it is an element of the drivers social status. In these conditions,if the vehicles are a reflection(more or less clear) of social belongings, then we can consider traffic space as a social surrounding which,as such , is characterised by some interactions(Wilde,1976),exchanges and conflicts.This means that we can very well conceive that traffic is structured by social dynamics.

2 the need for safety is not in itself a fact of society.What it is,is the taking over of the responsability for road safety by the social institutions and the administrative authorities.The socialization of road safety is a recent event. L'Hoste(1980) showed that in France it became a state affair within the ideological context of Chaban-Delmas's neo-gaullian new society. If as Emile Durkheim believes (ed.1970) "in order that the collective feelings penetrate people minds they have to obtain a higher intensity than the one they had up to then and the community in his entirity has to feel them with greater strength." so we must consider that road safety is built up as a social value, if not,it would not exist.

3 as for accidents,we know that their regularity is determined by the structure of social activities. As we know these activities (work,homelife,hobbies...) and we know how the car allows them to be satisfied we can forecast accidents both in time and space : we know that on the roads accidents are more frequent at holiday time,that they vary according to the days of the week and hours.(Setra,1987).We cannot really claim they are unpredictable or in 90% of the cases caused by human error because,to be fair,we would then have to say they are in 90% of the cases caused by social reasons!

THE SOCIAL "COMPONENT" OF THE ACCIDENT;

As we get used to accept the human error in the accident causation, we cannot very well see what is the social component.For example,let us reconsider the human factors usually detected in accidents : misperception of traffic,hazard,driving excessively fast,failing to give way to other road users,close following,improper overtaking,impairment by alcohol...In a very narrow deterministic view, driving mistakes are conceived as accident factors.However,the obviousness contained within this deterministic outlook mights hide other phenomena.For example,it is interesting to know how mistakes are encouraged.In our examples some social motivations may be the cause of the error :fulfilling social obligations can be the reason for speeding or for overtaking in a dangerous way(Giscard,1961) and we know how the impairment by alcohol is linked to social life(Biechler-Fretel,Danesh-Pajou,Elouadrani,1987).
The social element "contained" in the accident can be perceived in so far as we agree that human behavior is subject to different influences and controls : in other words,the driver is not exclusively sensitive to the stimuli of his most immediate surrounding.The driver psychology has to accept that there is a social control over motor and cognitive functions..

Let us take another example where one can easely understand this social effect.It has been shown in France(Brenac and Postel, 1987,Fontaine,1987) that male drivers are a higher risk group than female drivers. In Great-Britain Broughton(1986) has shown that total equivalents to approximately 5% of the male driving population and 1% of the female driving population are convicted of traffic offense each year.These differences can be explained by several factors espacially the types of route taken by each person but a sociological explanation can also be given.Such differences between males and females can be understood if masculinity and feminity are considered not only as biological or physiological characteristics but also as social attributes.We will suppose that these attributes are established by social rules which fix people in quite rigid roles (Parlee,1983).We can easily admit that in our society man's positive image is as much related to risk as woman's image is related to safety (Barjonet,1987).Let us then suppose that such images work as behavior models.

In these examples, the accident is considered as being caused by external events ,foreign to the traffic situation.But we can also maintain that the accident is the result of a social intéraction within the traffic conditions.This fact is quite apparent in conflict studies.The idea of conflict includes an evident social dimension and the study of conflicts in general is an important heading in social psychology (Festinger,1957,Zajonc,1966,etc...).A traffic conflict may be conceived as a simple social conflict between two or more people fighting for driving space(Boltanski,1976).Also,it can be considered as the outcome of a communication process disturbed by differing norms of reference.In France,Monseur and Malaterre(1969)have shown the ambivalence of the priority rules as soon as different and diverging assumptions accur concerning the purpose of the other driver.

People's daily life is full of conflicts connected with power,authority and prestige.There is no special reason for the driving social relationships to be any different.Wilde(1976) emphasizes the interest of research on social interaction patterns.He has shown the feasibility of applying some social psychology theories to traffic research, espacially the study of the influence of informal norms on driving and the estimation of danger.The relationship between legal norms and social norms has been fully studied in France by Moget-Monseur(1984) then by Biechler-Fretel(1986).

Researches on the "social factors" of accident have of course a threshold.Some leads followed a few years ago (Haddon,Suchman and

Klein,1964) have been dropped : they took up again the idea of accident proneness no longer on the basis of psychological criteria or personality but on the basis of social features. Considering the driver 'responsible" of the accident to be a "deviant" is more a distinction relating to criminology and normative issues than to a research attitude.

DRIVERS : PSYCHOLOGICAL SUBJECTS OR SOCIAL ACTORS ?

Social differences in drivers are not easily accepted in road safety research.In many cases of experimental studies the driver is put up in an abstract way, as the universal subject of psychology,as the medium of a psychological function (as motor skills or cognitive activities).

In other researches,this time clinically based,the driver is presented as a single element.Each driver is specified according to his background or personnal experience.

In a position between the general and the specific social sciences offer a half way solution by considering groups of drivers socially classed according to income,occupation,lifestyles...

Such a perspective is based on the idea that society is an organic unity of classes,groups,institutions.If we accept the fact that society is divided into social classes which differ on numbers of features:income,lifestyle,consumption,power...then we may suppose that these social classes differ also in driving and safety.

This is not a wishful thinking.If we relate occupation(which is a good index of social status)to risk exposure(accident/km) we obtain results which have both sociological sense and a meaning for road safety(Table 1,AGSAA,1980).

Profession of the driver	accident rate per year	accident rate per km
Non working population		
mother's help	90	95
pensioners	66	100
students	139	145
others	106	121
total	82	110
unemployed	128	134
working population		
farmers	67	78
industrialists and tradesmen	132	132
artisans	101	91
liberal professions,segnor executives,engineers	121	86
university and school teachers	108	96
technicians	111	91
employees and social services	113	105
foremen and workers	102	104
others	N.S	N.S
total	105	99
total	100	100

Table I Car accidents related to the drivers 'occupation.

Such a study implies of course the use of wide-spread surveys rather than direct observations on small samples.But surveys can reflect behavior precisely.This is the case for insurance or police files or ad hoc sociological questionnaires.Interviews methods and data analyses are now accurate enough to allow the validation of relevant assumptions to establish behavior patterns which then can be specified in a sociological way.Especially,we have tried to clarify behavioural patterns concerning risk taking and obedience to countermeasures(Barjonet,Cauzard,1987).These large surveys allow us to relate safety behaviour any factor juged wothwhile :mobility,attitudes towards health ...Thus,the explanations have greater scope.Moreover,theses methods are commonly used for travel studies, in transport economy and sociology.(ICTB,1987).

A small importance is usually granted to these foundings because we often believe that we cannot influence deeply large social groups.This idea is reinforced by the conviction that the most efficient way to influence people's behaviour is to operate directly on traffic layout or vehicle engineering.This viewpoint was rightly criticized(Wilde,1982) and we know that indirect levels can be put into use.In France,the almost simultaneous laws concerning speed limit,the wearing of safety belts and legal alcohol rate have significantly changed behaviours and the curve of fatalities has been reversed.(Table 2,3.)

Table 2.

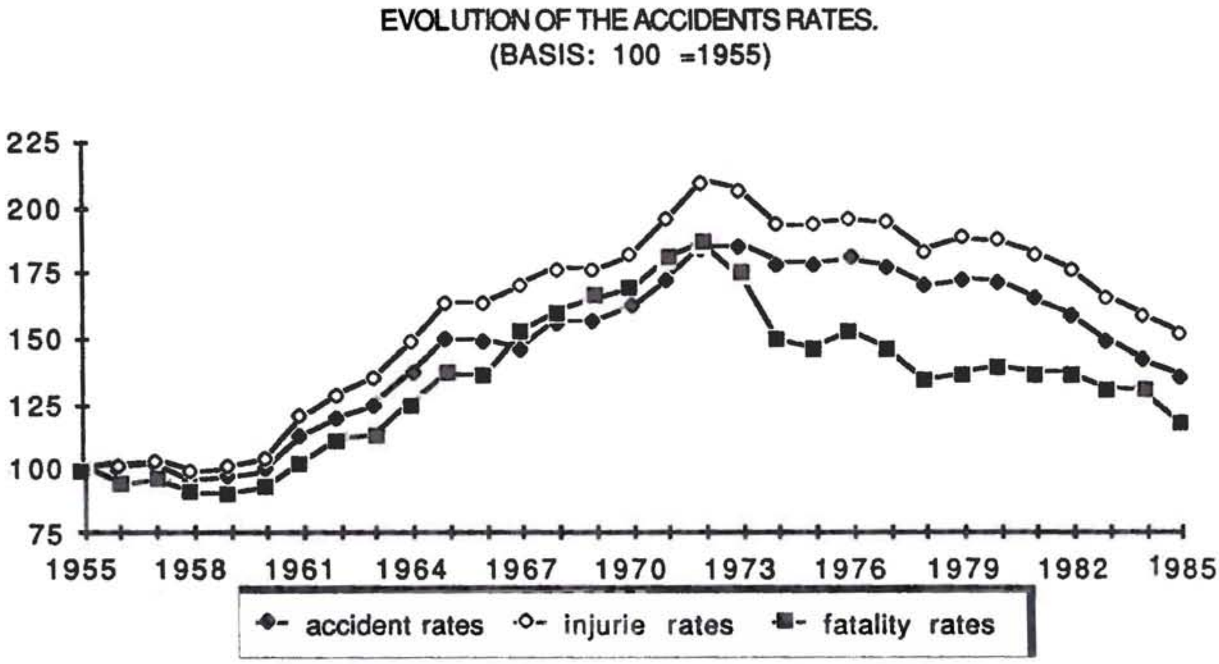


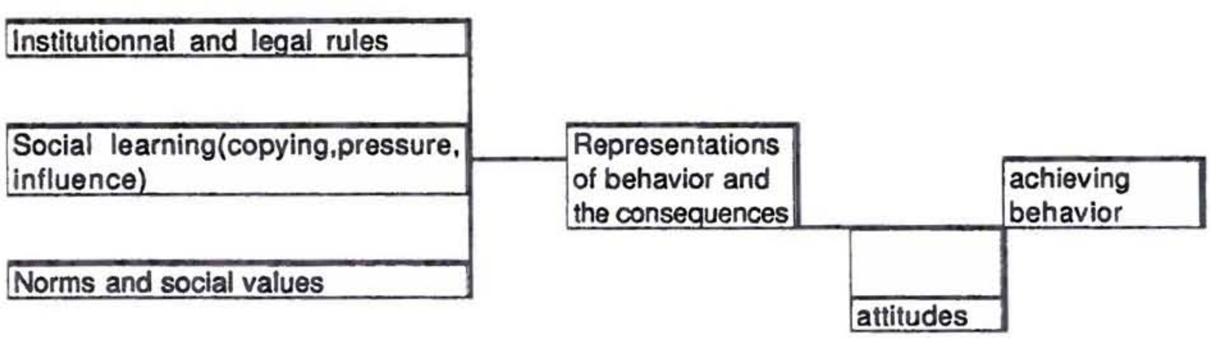
Table 2 :Evolution of accidents number. (Setra,1986)

year	number of accidents	number of injuries	number of fatalities
1955	140232	184387	8858
1956	141737	188897	8283
1957	143796	192267	8517
1958	134713	184156	8126
1959	137273	187202	8049
1960	141309	193326	8295
1961	159535	222744	9140
1962	169204	239255	9928
1963	176275	250981	10027
1964	192999	275180	11105
1965	210754	302406	12150
1966	209906	302267	12158
1967	205472	314941	13585
1968	220201	326587	14274
1969	220618	325937	14664
1970	228050	336590	15034
1971	242464	361524	16061
1972	**259954**	**388363**	**16545**
1973	261212	381779	15469
1974	251378	357647	13327
1975	251192	358622	12996
1976	253318	361322	13577
1977	250158	359061	12961
1978	238815	339697	11957
1979	242975	348101	12197
1980	241049	345977	12384
1981	232269	338041	12190
1982	223800	325760	12160
1983	209715	306040	11677
1984	199454	294010	11525
1985	191096	281192	10447

Another example this time concerning speed.It has been shown that drivers change their behaviour through fear of punishment but also because they think that sped limit could protect them from accidents and make accidents less serious(Barjonet,1983,Chich,1981).Drivers react to safety measures not only to conform to the code but also to convert to safety rules through belief of their efficiency and legitimacy. Both these cases are the result of influence and social pressure.When drivers do not obey the safety rules it is also the result of social presssure but a reversed one,centered, for example,on risk.

The truth of the matter is that I really wish to insist on the fact that changing behaviour,conversion into safety norms can be done in an indirect way.And this is necessary.So that behavioural structures last and have some consistancy and regularity we have to accept the assumption of an organizing mental structure and admit that behaviour is not only ruled by physical stimuli .Behaviour is not only a reaction to external surrounding.The social learning theory (Bandura,1976) claims that if a behaviour changes according to the consequences of the responses this does not imply that theses consequences have to be tested: it is enough to have representations of these consequences.This means that people learn rules indirectly through symbolic process and behave through mental control.

This implies that more importance is attached to intermediate variables such as representations or attitudes.We cannot within this short paper insist enough on attitudes properties such as readiness for action and instrumental pattern.(Fishbein and Ajzen,1975).And yet,the ability to act on attitudes and especially social ones is a main level to create safety behavior.When legal rules become social rules they gain all the strength of the custom and its legitimacy too.
As the following diagram shows,an attitude can be conceived as a system which regulates social pressure and mental control and plays a strategic role in the accomplishment of behaviour.



Traditionnally,in the field of road safety, advertising campaigns are conceived as useful ways of influencing attitudes.Contrary to legal regulations which are adressed to all drivers here we can adapt the message to each target groups.The impact of a campaign can vary.We know that reactions to campaigns vary according to the topics,the styles of communication,the social belongings(Barjonet,Cauzard,1980).Their impact can be measured before and after with attitude scales.Unfortunately, researchers rarely control campaigns from the beginning to the end.The administration tends to trust rather the avertising agency than the advice of researchers.This is why campaigns have often little scientific support.They are based more on administrative ritual than on scientific principles.It is this fact that increases the belief that campagns are not serious tools.

The political use of campaigns does not imply that such an action is unefficient in principle.If we accept the fact that exposure to risk and attitudes towards safety vary according to social belongings,ages and sexes, then we must go on thinking about persuasive communication as an useful means of reaching selected social groups.

SAFETY BEHAVIOURS WITHIN SOCIAL DYNAMICS.

Driving and attitudes towards safety are not only built by individual norms or collective customs but also by the overal sate of society.The american psychologist A.Rappoport wrote in 1964:'I a formly convinced that our cultural climate, our inspirations and miths find definite reflection in the prevaling attitude towards the automobile and that this contribute in no small degree to a basic accident rate."(in Suchman,Haddon and Klein).Safety is a matter of cultural value and one can suggest that each society gives special attention to some types of dangers.

Chesnais(1980) has measured the rate of criminal violence for several western societies(the average rate for murders,rapes,hold-ups and muggings per 1000.000 inhabitants):

USA	18,8	Sweden	2,8
Finland	8	Italy	2,7
Great-Britain	4,8	Japan	1,9
West-Germany	4,4	Spain	1,4
France	3		

According to these numbers we notice that the rate of violence in America is 4 times higher than in Great-Britain or West-Germany and 6 times higer than in France or Italy.
In the other hand,Lamm,Choueiri & Kloechner(1985) have shown that "the fatality rate in the United States is still about 35% lower than that of Western Europe and this indicates clearly that it is still much safer to drive on US roads."
If we believe these data we have to agree that societies accept or are more tolerant than others of certain types of violence.It seems that in America,car drivers are more protected than other citizens...

We can ask questions about the social mechanism which is at the origin of these differences.The theory of risk homeostasis (Wulde,1986) explains these kinds of contradictions.But if the state of society is the result of internal balance it is also the result of a historical process.Thus,safety cannot have the same status nor the same shape in France which has had a centralised administration for 4 centuries or in Germany or Switzerland which are federal states(Barjonet,Cauzard,L'Hoste,Perrin-Jacquet,1981).In many cases safety objectives are reinforced by social pressure groups,the action of active minorities like ecological movements,district committees and users associations.

The level of acceptable risk is perhaps a cultural or anthropological dimension but it also depends on a certain balance of social forces(Douglas,1985).In France, the administration had to impose speed limit and legal alcohol rate on the car industry and the wine lobby.It is the administration which gave a great part of legitimacy of safety action and we know that without legitimacy action loses its efficiency(Chich,1988).In our societies,the level of acceptable risk depends on the impact of the demand of social movements and on administrative action,even in its normative aspect.

But there is,of course,a limit to the use of will power and activism.We have noticed that people's awakening to traffic danger was limited by the presence of competitive dangers.Research has shown(Slovic,1981) a relative position of traffic danger among other perceived dangers.The surveys that we have undertaken have given road accidents a middle place on a scale about perceived fears and threat.Within the social representation of risk,traffic danger appears as a "middle risk"(Barjonet,Cauzard,1987).

I have tried to show in this paper that the driving of a car was an integral part of constraining social and cultural systems.The study of these systems is,in our belief,an important field of road safety research in so for as we consider that safety measure not only consists on technical improvments of traffic network or on vehicle engineering.Safety measures are integrated into different social classes and differing cultural contexts.Knowing this context will help us to understand and perhaps to anticipate individual and group reactions to risk, accident and safety measures.Social sciences do not lack eitheir theories, concept or methodes to deal with these questions.I hope I have shown how they play their part in the research effort.

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AMBIGUITIES IN THE DEFINITION AND IDENTIFICATION OF ACCIDENT BLACKSPOTS

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ABSTRACT

A successful policy of blackspot treatment must rely on an adequate blackspot concept. It is proposed that the only adequate concept consists of three defining criteria: (1) A blackspot has a higher expected number of accidents than (2) Other similar places (3) Due to specifically local deficiences. Identification of blackspots is essentially a two stage process. First, a number of "statistical" blackspots are identified. Second, accident analyses are performed in order to point out local deficiencies which characterise the "true" blackspots, but are absent at the false ones. This process involves a number of ambiguities: (1) Identification of statistical blackspots must always rely on the recorded, rather than the expected, number of accidents. (2) For a specific site, the expected number of accidents is never known. (3) It is possible to estimate the number of "statistical" blackspots in a population, but not by means of statistical techniques alone, identify which of these "statistical" blackspots that are true and which ones that are false. (4) No sieve for identifying statistical blackspots works perfectly. All sieves will let through a number of false positives and leave undetected a number of correct positives. (5) The explanatory and predictive value of accident analyses conducted at each statistical blackspot is at present completely undetermined. If a large number of accidents has occurred, it is nearly always possible to point out some defect, no matter how trivial it may be, which may explain this.

An experiment in accident analysis is proposed in order to enhance the explanatory and predictive value of such analyses.

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1. INTRODUCTION

A successful policy of blackspot treatment is frequently thought of as one of the most efficient ways of reducing the number of accidents in road traffic.

Recent research (Hauer & Persaud, 1983; Hauer, 1986) has shown that the benefits of blackspot treatment may be overestimated unless proper account is taken of random fluctuations in the number of accidents. The traditional concept of an accident blackspot, a site where more than the "normal" number of accidents has been recorded during a specific period, does not take account of the fact that the number of accidents will often be reduced even if no countermeasures are introduced, due to the regression-to-the-mean effect.

In this paper, some proposed definitions of an accident blackspot are reviewed. The argument is made, that a theoretically satisfactory definition must take account of both systematic and random variation in accident risk.

The argument leading to this conclusion may be outlined as follows: In deciding whether a road element (intersection, road section, curve, etc) is a blackspot, we must compare its expected number of accidents to the expected number of accidents at otherwise apparently similar sites. To compare the recorded number of accidents would be inadequate, as this would not take account of the regression-to-the-mean effect. It would also be inappropriate to compare the expected number of accidents for two groups of sites which were different with respect to variables which might explain differences in the expected number of accidents. It is, for instance, not unusual that intersections with 25,000 entering vehicles per day have a higher expected number of accidents than intersections with 650 entering vehicles per day. Blackspot identification is aimed at establising deviancy, not merely identify normal variation in the expected number of accidents.

Ideally, if all risk factors were known, we would obtain a perfect explanation of variation in the expected number of accidents. This would reduce all remaining variation in the number of accidents to random variation. In practice, however, it is impossible to obtain this. The theory of blackspot identification therefore seems to rest on the assumption, that by means of statistical techniques one may identify and assess the separate contributions of three sources of variation in accident numbers: general risk factors, specifically local risk factors and random variation. The idea is that general risk factors explain variation in the normal expected number of accidents within a population

of sites, whereas specifically local risk factors explain why a specific site has experienced a worse safety record than the combined contributions of general risk factors and random variation would explain.
It follows that a true blackspot is a site where the expected number of accidents is higher than what systematic (general risk factors) and random variation would explain. The argument that an adequate blackspot concept must take account of this is developed in more detail below. Section 2 of the paper contains a problem statement. In section 3 a set of necessary and sufficient criteria for true blackspots are proposed. In section 4, a number of definitions of accident black- spots are reviewed. Their adequacy for identifying "true" blackspots is discussed. In section 5 the discussion is summarized and some of its implications are discussed.

2. PROBLEM STATEMENT

The general problem underlying the discussion in this paper is the following:

Which are the defining criteria a true blackspot should fulfill in a successful policy of blackspot treatment?

By a "successful policy of blackspot treatment' is meant: the systematic application of treatment to blackspots, leading to a reduction of the expected number of accidents at these blackspots and in the system to which the blackspots belong.

There are three criteria of successful blackspot treatment. First, treatment should be applied exclusively at the blackspots. Sites not considered as blackspots should not be treated.

Second, the expected number of accidents at the blackspots should be reduced. A reduction in the recorded number of accidents, should not count as a safety improvement, unless it reflects a corresponding reduction in the expected number of accidents. Due to random variation in the recorded number of accidents this will not always be the case. On the contrary, the bias by selection implied by the blackspot concept means that a number of sites where the recorded number of accidents is higher than the expected number will be identified as blackspots. At these sites, the recorded number of accidents will be reduced even if the expected number of accidents remains unchanged.

Finally, the third criterion of successful blackspot treatment is that the overall accident rate should be reduced. Applying treatment to blackspots should not lead to a corresponding increase in the number of accidents elsewhere - leaving the overall accident rate for the system unchanged.

To summarize, the three criteria of successful blackspot treatment are:

1) A reduction in the expected number of accidents,
2) For the entire system,

3) Obtained by applying treatment to a subset of elements in the system, termed "accident blackspots".

3. ELEMENTS OF A BLACKSPOT CONCEPT REQUIRED FOR SUCCESSFUL BLACKSPOT TREATMENT

Several definitions of blackspots have been put forward, by scientists as well as road authorities.
In this section, it is argued that a successful policy of blackspot treatment as described in section 2, must rely on an adequate blackspot concept. It is argued that the following concept is the only adequate one:

An accident blackspot (in this paper, the term applies to road elements) is a road element where due to specifically local causes, the expected number of accidents is higher than at otherwise similar road elements to which it is compared.

The term "road element" is intended to cover all classes of sites to which the blackspot concept is commonly applied, like road sections, intersections, highway ramps, curves, bridges and so on.

The key terms of the blackspot-definition are:

1) Expected number of accidents

2) Otherwise similar sites

3) Specifically local causes

The expected number of accidents is the true, long term accident rate per unit of time (e.g. per year) of an element under conditions of unchanged exposure (traffic volume) and general risk factors.

The need to estimate the expected number of accidents arises from random variation in the recorded number of accidents. Because of this, the recorded number of accidents is not always a good predictor of the true, long term accident rate. More specifically, if an abnormally high number of accidents has been recorded at a site, we would expect a reduction in the recorded number of accidents in a subsequent period of unchanged exposure. This has been shown in a number of recent studies (see for instance Brüde & Larsson, 1982A; Hauer & Persaud, 1983).

In ascertaining deviancy, a road element should be compared to a set of similar road elements. This "similarity" condition should apply to all known general risk factors which may explain variation in the expected number of accidents. Comparisons of accident records should be made within a group of sites where these factors are "kept constant", or at least do not vary significantly.

The reasons for this should be obvious. For instance, we do not want to identfy an element as a blackspot, simply because it has more traffic than another element. It is quite normal that sites with heavy traffic have more accidents than sites where there is less traffic.

For a specific site, the expected number of accidents is never known. What is known is the recorded number of accidents, and perhaps a number of factors influencing the expected number of accidents like traffic volume, road width, number of approaches (intersections), posted speed limit, etc. In addition to such factors, random variation will influence the recorded number of accidents. From knowledge of the recorded number of accidents ands factors influencing the expected number of accidents, "statistical" blackspots may be identified. These are sites where the expected number of accidents exceeds some critical value.

Accident analyses of the "statistical" blackspots are designed to identifying specific, local accident causes, which for various reasons are not included among the general risk factors explaining the expected number of accidents. The task is to disentangle the contribution of these factors from the contribution of random variation for each site, thus pointing out a set of specific local circumstances which may explain why a high recorded number of accidents is not entirely due to chance or general risk factors.

In the next section, several definitions of an accident blackspot are reviewed in light of the criteria discussed above.

4. A REVIEW OF SOME DEFINITIONS OF AN ACCIDENT BLACKS POT AND THE ARGUMENTS UNDERLYING THEM

The survey conducted in this section is not intended to be exhaustive. It covers only a few of the proposed definitions of an accident blackspot. The selection of definitions is intended to highlight the problems involved in empirically fulfilling the criteria of a theoretically satisfactory definition of the concept.

4.1 An official definition

We shall start with an official definition.

In Norway, road authorities have adopted the following official definition of an accident blackspot (Statens Vegvesen, 1983):

"An accident blackspot is any road section of length no more than 100 metres, where during a period of four years, at least four personal injury accidents have been reported by the police".

This definition will cover any concentration of accidents within a 100 metre space, irrespective of whether the concentration occurs in an intersection, road section, curve, bridge, or at other places. All these sets of different road elements are lumped together in the blackspot definition.

This means that, at least for some road elements, it may be difficult to define a population of sites, of which the blackspots are a sample. In fact, the blackspot definition will allow several such populations to be defined.

Another deficiency of the definition is that no account is taken of exposure or other general explanatory variables. Clearly, four accidents will not represent a deviation from the safety norm everywhere.

Finally, no account is taken of random fluctuations. It is the recorded, rather than the expected, number of accidents which constitutes the blackspot criterion.

Taken together, these deficiencies greatly reduce the usefulness of the blackspot concept. Road authorities are probably aware of this, but stick to the simple definition partly because it requires no sophisticated analysis of the accident data file.

4.2 Common scientific formulations

Thorson (1967) was one of the first scientists in Scandinavia to define a blackspot in statistical terms. He proposed this definition (1967, p 83):

"A blackspot is a road element where the number of accidents as related to a theoretical distribution for consecutive years is placed in the upper end of the distribution, for instance over the 80% or 90% significance level".

Variants of this definition have been endorsed by Jørgensen (1971) and Ahlquist (1970, 1973). Ahlquist proposes the following definition of a blackspot:

"A road section where the difference between the recorded and expected number of accidents exceeds some critical value (1973, p 2)".

These definitions make an abnormally high recorded number of accidents the criterion of a blackspot.

This concept is not satisfactory. If the recorded number of accidents exceeds the expected number, this may be partly due to chance, and we would expect a return to the expected value in a subsequent period. The concept takes no account of this.

The concept is an improvement from the official concept presented in section 4.1, in that an attempt is made to estimate the expected number of accidents. In particular J¢rgensen (1971) dwells on this:

"A ... detailed analysis of the Black Spot concept shows that it is only meaningful if it is associated with local permanent circumstances. ... Furthermore, if a place is a Black Spot, it must produce accidents at a higher rate than other places of apparently similar quality (1971, p 1)".

"Comparisons are only carried out within each category (of the variables explaining the average expected number of accidents within that category). The reason is, that if - say - rural areas were compared to urban areas, then all urban areas would turn out as black since the accident density is higher in urban areas. This result would obviously be of little use in the search for Black spots (1971, p 1)".

Ahlquist, on the other hand, states that (1973, p 2) "in determining the expected number of accidents a prediction model is applied". By a prediction model is meant a statistical model relating the expected number of accidents to a set of general risk factors.

A large number of such models have been developed. Some of them perform extremely well in predicting the average number of accidents per element for a group of road elements which have some important characteristics in common, like for instance ADT (traffic volume), number of lanes, width of pavement, curvature, etc.

The following model is an example:

$$Y = a\ I_p^b I_s^c$$

Where:

Y = the expected number of accidents per intersection per year

Ip = average daily number of vehicles entering from the primary road

Is = average daily number of vehicles entering from the secondary road

a,b,c = coefficients determined empirically by least squares regression on accident data

b,c = powers to which Ip and Is are raised

In fitting this model to accident data for three years for more than 14,000 intersections in Sweden, Brüde & Larsson (1978) obtained an explained variance of 93%. The model was applied to three way intersections outside urban areas, with primary road speed limit of 70, 90, 110 or 130 kms/hour.

4.3 Concepts taking account of random fluctuation in the recorded number of accidents

Brüde & Larsson (1982B) have utilized prediction models in developing a blackspot concept for intersections which tries to take account of random variation in the recorded number of accidents.

Briefly stated, identification of a statistical blackspot by means of a prediction model is a stepwise procedure, consisting of these steps:

1) Select a critical value for the recorded number of accidents warranting inspection of an intersection.

2) Determine the expected number of accidents in each intersection by means of a suitable prediction model (several models have been developed, e.g. for three way and four way intersections, for different speed limits etc).

3) Determine a critical value for the expected number of accidents, in order to take account of random variations.

4) Compare the recorded number of accidents to this critical value. If the recorded number of accidents does not exceed the critical value, it is concluded that the intersection is probably not a blackspot, since the

recorded number of accidents lies within the limits of "normal" random variation.

5) If the recorded number of accidents exceeds the critical value, estimate an adjusted, expected number of accidents in order to remove the effects of chance variations.

6) Conduct an accident analysis for intersections whose adjusted, expected number of accidents lies above the critical value in order to find deficiencies in design or regulation that might account for the high expected number of accidents.

The procedure may be illustrated by an example:

1) The critical recorded number of accidents is set at three accidents during five years. This corresponds to the official Swedish definition of an intersection which needs to be examined in order to determine if it is a blackspot.

2) Intersection A 72 has recorded 5 accidents during the five-year period 1974-78. The expected number of accidents for an intersection with normal safety is estimated according to the prediction model:

$$\text{Accident rate} = 0.18966\ (I_p + I_s)^{0.0957} \left(\frac{I_s}{I_p+I_s}\right)^{0.3052}$$

This model gives an expected accident rate per million entering vehicles of:

$$0.2615 = 0.18966\ (5719)^{0.0957}(0.19)^{0.3052}$$

The expected number of accidents during five years is 2.72.

3) The critical value for the expected number of accidents at the 97.5 per cent level of confidence is:

$$2.72 + 1.96\sqrt{2.72} = 2.72 + 3.23 = 5.95 = 6 \text{ accidents}$$

4) The recorded number of accidents is 5. The critical value is 6. The recorded number of accidents is not exceptionally high. The same conclusion applies to the accident rate.

5) The recorded number of accidents lies above the expected number of accidents for an intersection with normal safety, but below the critical value. It is therefore concluded that this intersection probably has a somewhat poorer safety than the norm. The run of accident counts from 1974 to 1978 is:

1974	1975	1976	1977	1978
0	0	0	2	3

The expected number of accidents can be estimated by "deleting" one half of the worst year:

$$[(0+0+0+2+3) + \frac{0+0+0+2}{4} \times 5]/2 = \frac{5+2.5}{2} = 3.75 \text{ accidents}$$

6) The accident analysis consists in studying the distribution of the recorded accidents by several variables and comparing this distribution to the typical distribution in intersections. In this analysis, the following variables were included:

Month

Weekday

Hour of the day
Light conditions (darkness, dusk, daylight)
Road surface conditions (dry, wet, slippery)
Injury severity (killed, severely injured, slightly injured)

Accident type (right-angle, left-turn, right-turn, head-on, rear-end, etc)

The analysis showed that three of the five accidents occured on a slippery, partly ice-covered surface. This is atypical for accidents in inter sections. Closer scrutiny revealed that vehicles from the minor approach often had difficulties stopping in time. This was attributed to a speed limit of 90 kms/hour on the minor approach, combined with a very long descending gradient. It was recommended that the speed limit be lowered to 70 kms/hour, and resurfacing with coarse pavement be undertaken on the minor approach.

This case study shows that deficiencies can be pointed out even in an intersection not considered to be a statistical blackspot. In conclusion, Brüde & Larsson state that "one might hope that the accident analysis together with on-site inspection should enable us to decide whether the high recorded number of accidents is due to chance or to deficiencies in design or traffic control. In practice this may not be possible. It is nearly always possible to point out some deficiency -in particular this is so when we know that a large number of accidents has occurred".

We are thus often limited to proposing our hypotheses after first looking at the data thereby depriving ourselves the opportunity of real tests of these hypotheses.

In determining the critical value for the expected number of accidents (step 3 of the stepwise procedure), Brüde & Larsson employ a formula which implies that the number of accidents is Poisson-distributed. This assumption may underestimate the true variance of the probability distribution. The recorded number of accidents is influenced by a number of temporary and highly fluctuating factors like a sudden snowstorm or short-term variations in traffic volume. This will cause the parameter λ in the Poisson-distribution to fluctuate. These factors are not included among the predictor variables in the models for predicting the expected number of accidents in intersections with normal safety. The temporary factors will not influence the number of blackspots, as these are related to more permanent factors, which affect the long term accident rate. The temporary factors will appear as unexplained variance in the prediction models.

The test for statistical deviancy employed by Brüde & Larsson is therefore not strictly correct from a theoretical viewpoint. It will tend to underestimate the true standard deviation.

Another weakness of their concept is that the method of estimating the adjusted expected number of accidents lacks a theoretical foundation.

Brüde & Larsson have subsequently (1987) rejected this method in favor of a modified version of the method proposed by Hauer (1986). A description of the modified method for estimating the conditional, expected number of accidents is found in VTI-meddelande no 511 (Brüde & Larsson, 1987) as well as in an article soon to appear in the journal Accident Analysis & Prevention.

The modified method combines the advantages of using prediction models to determine the normal number of accidents with the theoretical appeal of Hauer's Empirical Bayes method for estimating the expected number of accidents.

4.4 A method for estimating the number of true and false blackspots among the statistical blackspots

Hauer & Persaud (1984) have developed a technique which permits the number of false and correct statistical blackspots in a population of sites to be estimated. Such an estimation can be used in assessing the performance of different statistical blackspot criteria.

Hauer & Persaud assume that accident occurence at each site obeys the Poisson probability law. Each site has its own, unknown expected number of accidents, λ. This number varies from site to site. If the distribution of μs between the sites forms a Gamma-function, then the distribution of the recorded number of accidents in the population of sites is given by the negative binomial probability law.

Hauer & Persaud describe a technique for identifying the number of sites for which λ is larger than some critical value λ^*. This is done by selecting for inspection sites for which x is equal to or greater than some limiting value x*.

For a detailed, technical description, see Hauer & Persaud, 1984. In this paper, the technique will be illustrated by an example which perhaps will highlight the strengths and weaknesses of the technique.

The example draws on data for 885 1-kilometer road sections in Aust-Agder county in Norway. All personal injury accidents reported by the police are included in the data set (including accidents at intersections). The data cover the four-year periods 1977-80 and 1981-84.

Table 1 shows the distribution of the 885 sections by recorded number of accidents during the period 1977-80 and the distribution expected by a negative binomial distribution.

Table 1. Comparison of observed distribution of 885 1-kilometer road sections by number of accidents with a negative binomial distribution. Personal injury accidents reported by the police 1977-80.

Number of accidents	Observed number of sections	Expected by negative binomial distribution
0	590	605
1	158	136
2	61	62
3	34	33
4	11	19
5	12	11
6	6	7
7	5	4
8	1	3
9	2	2
10	1	1
11	2	1
12	1	-
13	1	-

Parameter values: $x_2 = 0.7231$ $\quad x^2 = 7.94$
$s = 2,3312$ $\quad df = 5$
$a = 0.4497$ $\quad p = 0.22$
$b = 0.3252$

The assumption of a negative binomial distribution is well supported. The difference between the actual distribution and that expected by the negative binomial assumption is not significant at the 20% level of confidence.

With x* as the selection criterion and λ* as the criterion of deviancy, we may now define three measures describing the performance of this selection criterion in identifying the statistical blackspots:

1) The number of false positives.

This is the number of sites with recorded number of accidents x* or more for which the expected number of accidents is below the critical value λ*.

2) The number of correct positives.

This is the number of sites with x* or more recorded accidents where the expected number of accidents is equal to or above the critical value λ*.

3) The number of false negatives.

This is the number of sites with an expected number of accidents equal to or above the critical value λ^* not identified by selecting for inspection sites with a recorded number of accidents x* or more.

Methods for calculating these numbers are given by Hauer & Persaud (1984).

For the 885 road sections presented in table 1, the mean number of accidents is 0.7231. Let sections with an expected number of accidents of twice this value, i.e. at least 1.4462 accidents be the statistical blackspots. Table 2 gives the number of false positives, correct positives and false negatives for the 885 1-kilometer sections using this criterion.

The set of road sections will contain altogether 161 statistical blackspots. If, in order to identify these sections, it is decided to inspect sections where two or more accidents have been recorded, 137 sections will have to be examined. 38 of these will have an expected number of accidents below the critical value. These are the false positives. 99 of the 137 sections will be correct positives. Thus 62 of the 161 correct positives, those found among sections which recorded 1 accident, will go undetected. These are the false negatives.

If it is decided to inspect sections with three or more accidents, a smaller number of false positives will be included. But then 94 of the correct positives will go undetected.

By setting the critical value at 5 or more accidents, we would altogether avoid examining false positives. But the price of this would be that at least 130 of the correct positives went undetected.

We are thus facing a difficult trade-off. By setting the "trigger" recorded number of accidents markedly above the critical value for the expected number of accidents, we will reduce the number of sites that need to be inspected, as well as the probability of including a large number of false positives in the sample. But a large number of the correct positives will then go undetected. From table 2 it can be seen that at no recorded number of accidents is a perfect identification of all the correct positives, but none of the false ones, possible.

Setting the critical value for inspection at five recorded accidents and the critical value for a correct positive at an expected number of accidents of 1.4462 is clearly not a very strict blackspot criterion. As table 2 indicates, less than 4% of the sections where five accidents were recorded will have an expected number of accidents below 1.4462. Of the remaining 96%, many will have an expected number of accidents far higher than 1.4462.

Furthermore, the criterion will not identify the number of sections that have a higher expected number of accidents than other, similar sections. It will only identify the number of sections that have an expected number of accidents above the critical value.

A third deficiency is that the method takes no account of traffic volumes or other variables that might explain variation in the expected number of accidents. It does therefore not necessarily identify sections where the risk of accident is higher than at other sections.

Recorded number of accidents	Number of sections	Number of sections with x or more accidents	Proportion of sections with λ> 1.4462	Expected number of false positives	Cumulative expected number of false positives	Expected number of correct positives	Expected number of false negatives
0	590	885	0.960	566	724	161	0
1	158	295	0.759	120	158	137	24
2	61	137	0.479	29	38	99	62
3	34	76	0.244	8	9	67	94
4	11	42	0.102	1	1	41	120
5	12	31	0.036	-	-	31	130
6	6	19	0.011	-	-	19	142
7	5	13	0.003	-	-	13	148
8	1	8	0.001	-	-	8	153
9	2	7	-	-	-	7	154
10	1	5	-	-	-	5	156
11	2	4	-	-	-	4	157
12	1	2	-	-	-	2	159
13	1	1	-	-	-	1	160

Table 2. Performance of a sieve for detecting statistical blackspots on 1-kilometer road sections in Aust-Agder, Norway. Based on the recorded number of accidents 1977-80.

Table 3 shows that traffic volume (ADT) for the sections examined in table 3.

Table 3. The relation between traffic volumes and accident risk for 885 1-kilometer sections in Aust-Agder.

Number of accidents per section 1977-80	Number of sections	Traffic volume (ADT) Average 1981-84	Total number of accidents 1981-84	Accident rate per million vehicle kms (1981-84)
0	590	952	209	0.26
1	158	1859	120	0.28
2	61	3054	97	0.36
3	34	4410	64	0.29
4	11	5134	27	0.33
5	12	5283	47	0.51
6	6	7013	25	0.41
7	5	8165	29	0.49
8	1	7916	5	0.43
9	2	7560	15	0.68
10	5	9431	34	0.49

It is seen that traffic volumes increase in proportion to the recorded number of accidents. There is, however, no corresponding increase in the accident rate per million vehicle kilometers. Sections which during 1977-80 recorded 10 or more accidents have 10 times the traffic volume of sections which recorded 0 accidents. The accident rate, however, is only twice as high.

Hauer& Persaud recognize this weakness of their method. They state: "The screening process used in practice is more complex than what has been analyzed. In particular, the accident rate (accidents per vehicle kilometer), which is the most important selection criterion, is not used here. Thus the theory and computational process need to be extended so as to be applicable to the realistic blackspot identification procedures. This extension appears to be straightforward. The corresponding research work is under way".

5. CONCLUSIONS

A successful policy of blackspot treatment is a policy which results in:

1) A reduction in the expected number of accidents at the blackspots.

2) Without "migration" or transfer of accidents to other places.

3) By means of treating a selection of sites where the risk of accident, due to permanent local circumstances is higher than at other apparently similar sites.

A policy of blackspot treatment cannot be successful unless it is based on an adequate blackspot concept. It was argued that an adequate definition of an accident blackspot must include the following criteria:

1) A blackspot has a higher expected number of accidents than

2) Other sites with similar traffic volume, design and traffic control, due to

3) Specific, permanent local properties.

Unless a blackspot has a higher expected number of accidents than other similar places, there is no point in selecting it for treatment. In a population of sites, all of which have an identical expected number of accidents, selection for treatment can be done by the toss of a coin.

In comparing the expected number of accidents at different sites, statistical control must be exercised over at least the most important factors that explain variations in normal safety. For instance, it is normal for four way intersections to have more accidents than three way intersections of similar design, control and exposure.

Identification of blackspots can be thought of as a stepwise process. The first step consists in identifying a number of statistical blackspots. Such identification is normally done by selecting for inspection sites where the recorded number of accidents exceeds a critical value. The second step in blackspot identification consists in performing accident analyses for the each of the statistical blackspots. The purpose of these analyses is to point out deficiences in design or traffic control at the statistical blackspots in order to explain why the risk of accidents is abnormally high and invent possible treatments.

This stepwise procedure introduces several ambiguities.

1) There are no general rules for setting the critical value for recorded number of accidents. This value is therefore arbitrarily chosen.

2) In identifying statistical blackspots, random fluctuation in accident counts must be taken into account. This requires estimation of the expected number of accidents. Such estimation can be done in a number of different ways, not always giving identical results.

3) In estimating the expected number of accidents so called "accident prediction models" may be used. It is essential to remember that these models can only predict the expected number of accidents for an entity with normal safety.

4) In identifying statistical blackspots, it is impossible to estimate the true expected number of accidents for each site where the recorded number of accidents exceeds the critical value. The best that can be achieved is (a) an estimate (by means of prediction models) of the expected number of accidents for each site provided it has normal safety, (b) an estimate of the number of sites where the expected number of accidents is likely to exceed some critical value.

5) No sieve for identifying statistical blackspots will be perfect. As Hauer & Persaud have demonstrated, any sieve is likely to let through a number of false positives. Most sieves will leave some of the correct positives undetected. The only way of avoiding this is by examining the entire population - which is precisely what we want to avoid by examining only the potential blackspots.

6) By means of accident analysis, it is hoped that the true blackspots in the sample of statistical blackspots will be correctly identified, and the false ones sorted out. However, no great confidence can be placed in the ability of current methods of analysis in achieving this. It is nearly always possible to point out some deficiency at any site - however trifling it may be. In particular this is the case when the number of accidents is known. Surely, it is very hard to resist the idea that a high number of accidents must be caused by some site-specific deficiency.

To summarize: no current method can achieve a perfect identification of true blackspots. Any criterion of a statistical blackspot will let through some false positives, and leave behind some correct positives. Any method of accident analysis will leave somewhat undetermined the status of each statistical blackspot - whether it is a true or false blackspot.

By means of experimental studies, some of these ambiguities could be reduced, if not entirely removed. In particular, an experiment in accident analysis might enhance the credibility of methods for discriminating between true and false blackspots.

Such an experiment might be designed as follows: A group of statistical blackspots is subjected to accident analysis. The analyses should be performed by a group of trained accident analysts. During the experiment, this group could be devided into three subgroups:

Subgroup 1: This group is given the task of pointing out deficiencies at a number of sites, <u>without</u> knowing the type or number of accidents which had occurred at these sites. Also, this group should try to predict which types of accident the deficiencies they had found might produce. This group should have full access to information concerning the sites.

Subgroup 2: This group of analysts should conduct an ordinary accident analysis, <u>with</u> full knowledge of the number of accidents, and full access to information concerning properties of the sites.

Subgroup 3: This group should have access to full information on accidents, but <u>only general</u> information concerning the sites. Their task would be to predict in detail which properties a site producing the given pattern of accidents might have.

Subgroup 1 is "blinded" from accident information. Subgroup 3 is "blinded" from information concerning the sites. Subgroup 2 should have full information.

During the experiment each analyst should have at least one run in each subgroup (though each time with a different set of sites). This way, the influence of personal factors might be reduced.

Agreement in the description of deficiences between the three groups would imply that properly conducted accident analyses might have an explanatory and predictive value (predictive in the sense of correctly classifying sites as true or false).

Whether the analyses did in fact have this predictive value, could only be tested by subsequent accident experience. Ideally, part of the experiment would be to let the analysed blackspots remain untreated, in order to see whether the blackspots at which agreed deficiencies had been pointed out recorded more accidents than blackspots where the analysts were unable to agree on a common description of deficiencies.

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ANALYSIS OF ACCIDENT DATA: TWO EXPERT SYSTEM APPROACHES

Margaret Theobald and Benjamin Heydecker

1. INTRODUCTION

Accident researchers and safety engineers use historical accident records in a number of different ways. Firstly, these data are used to identify sites for investigation with a view to implementing remedial measures. Secondly, they are used to identify and investigate the kinds of accident that have occurred frequently at any particular type of site. Thirdly, they are used on a site-specific basis to suggest appropriate remedial measures.

The advent of expert systems has provided new tools which offer the prospect of assisting in these analyses. These new tools offer the potential to extract information automatically from accident records, thus relieving the safety engineer or researcher from many of the repetitious and mundane tasks that this involves. This relief will allow a more effective allocation to be made of time and other resources in accident investigation and prevention work.

In this paper we discuss two approaches to the analysis of road accident data which use techniques of expert systems. The first technique is that of inductive inference. This technique takes a set of examples and from them induces a general rule that relates the recorded outcomes to the observed attributes and relationships between them. In particular, when applied to accident records it should generate rules that describe the features which best distinguish between different kinds of accidents.

The second technique is that of deductive inference. The aim of this is to identify the most appropriate remedial measures from a range which are available and in common use. This requires a specification for each of the remedial measures and in particular, typical characteristics of accidents that are made less probable by each of them. An heuristic decision tree is constructed from these specifications and is applied in turn to each site in the area under consideration. This will then suggest a ranked list of remedial measures for each site for the further consideration of the investigating engineer. This technique is suitable for the identification of sites for inclusion in 'mass action' programmes.

The two techniques are therefore complementary. The first takes the accident data base and searches for relationships within it which can then be used to suggest appropriate remedial measures. On the other hand, the second technique takes known relationships between available remedial measures and accident characteristics, and uses these together with historical accident records to suggest suitable remedial measures.

2. THE INDUCTIVE APPROACH

In accident investigation and prevention work, there are a number of tasks that are suitable for the application of rule induction techniques. These techniques could be used to identify the special characteristics that distinguish between accidents occurring at, for example, a particular type of site, or to a particular road user group. This information could be used by a safety engineer to identify groups of accidents that might be susceptible to remedial treatment. This technique could also be used to monitor sites that have been treated with a particular engineering remedy. It would highlight any changes that might have occurred to the accident patterns at these sites as a result of their treatment. This would help the engineer to assess the effect of the remedial action, not only on the type of accident which was targeted for treatment, but also to give some indication of any other changes in the kinds of accidents that have occurred at the site since treatment took place.

In applying these techniques, a choice of induction tools has to be made. In our experiments, we used two software packages, each of which has a different objective. The objective of the first package, Beagle (Forsyth and Rada, 1986), is to induce a simple rule with a good, but inexact, fit to the observations. To this end, the package uses an heuristic search strategy which is modelled upon evolutionary principles. Rules are generated either at random or by the user and are then tested for their success at classifying data. A rule that is good at this will be retained whilst less successful ones are discarded. The retained rules are then used as the basis for the next generation. They are manipulated by 'genetic' operators in an attempt to improve their success in classifying the data. Eventually, stable, successful rules will evolve.

On the other hand, the second package, SD-RULES (Systems Designers, 1987) has a different objective and therefore a different induction strategy. The objective of this package is to induce rules that fit the input data exactly. This package employs the CLS algorithm (Hunt, Marin and Stone, 1966) which successively selects the remaining attribute within the data that best discriminates between the observed outcomes, until every example in the data has been classified correctly by the induced rule.

In order to be able to use the rules induced by either of these methods with confidence on data other than the learning set, it is necessary to test the rules using a control data set. The rules induced are likely to be successful at discriminating between the examples in the learning data set, but their generality can only be evaluated by applying them to an unseen test set of data similar in form to those in the learning set. In accordance with this principle, each data set used in the induction experiments was divided at random into two - a learning set and a test set.

In these experiments, the objectives were to assess the usefulness of the induction techniques and to investigate whether effective and useful rules for distinguishing between junction control types could be established. The accident records used had 46 variables taken from police data (Department of Transport, 1978). When using Beagle, the number of examples used was restricted by the size of the machine to about one hundred. However, with this package relatively few variables appear in each rule, so the ratio of examples to variables is greater than would appear at first sight. There are no such constraints on SD-RULES and it was possible to use all the available data.

These experiments resulted in the generation of lengthy rules corresponding to bushy decision trees. With each package, the rules classified the examples in the learning data successfully. However, they did not classify examples in the test data with any great success: this indicates a good fit of the rules to the learning data but a lack of explanatory power. Beagle aims to generate a logical expression that will classify the data and because of this, spurious relationships can be incorporated in the induced rules. Thus for example, in single vehicle accidents, no valid data will be available for the second or subsequent vehicles, but the resulting blank or default values could still be used within a rule.

The outcome of this early work has been inconclusive. The results obtained so far are lacking in generality and thus are not reliable indicators of operational difficulties at the junctions. However, the classification scheme used - junction control - is somewhat arbitrary. This variable was chosen as the classifier on the basis that the strategies and skills required for negotiating junctions operating under each kind of control were thought to be different. The induction technique could equally be applied to data classified according to any other highway element or road user group: the results should indicate particular features of each class of accident and differences between them.

Further experiments are underway using cluster analysis (Kendall, 1975) to identify other classification schemes. Induction will then be used to identify important differences and relationships between clusters. This is expected to provide a method of directing the induction process towards well supported relationships without biasing the outcome towards any preconceived ideas as to the nature of accidents.

3. THE DEDUCTIVE APPROACH

In this approach, physical site characteristics and records of accidents occurring there are used with predetermined rules to deduce which of a range of remedial measures appears to be appropriate for that site. This deduction is based upon previous experience - in this case a preliminary system was based upon the experience of Strathclyde Regional Council (Robertson, 1986).

This process works by accumulating evidence both for and against the hypotheses that each of a range of treatments is appropriate. A system of Bayesian inferencing is used to estimate the likelihood that each measure is appropriate using evidence available from the accident records. This process assumes that each treatment that is available can be described in terms of typical accidents which it makes less probable. In this system, knowledge of the relationships between the treatments and the site and accident characteristics is represented by Bayesian rules of inference. Although this explicit knowledge is difficult to obtain, the technique has been found to work well for established remedial measures. Thus it is suitable for identifying sites to be included in a mass action scheme in which the same treatment is applied to a number of sites.

The system takes the number of accidents recorded in particular circumstances at a site and performs a statistical test using control ratios derived from the population of similar sites within the same country. This is used to calculate the likelihood that the characteristics of accidents occurring at this site differ from the norm. This likelihood is then used to update the likelihoods that each of the remedial measures under consideration is appropriate for that site.

4. SUMMARY

Two expert systems approaches are described here which are complementary to each other. The first one, which uses inductive inference, searches for relationships and recurrent characteristics within historical accident data. It is hoped that in the future rules thus induced will give an insight to the mechanisms involved in the occurrence of accidents.

The second approach, which uses deductive inference, seeks to establish which of a range of remedial measures is appropriate for use at a site. The deductive process is based upon empirically derived relationships between each of the remedial measures, and site and accident characteristics. This results in the suggestion of suitable remedial measures for each site or of sets of sites which are suitable for inclusion in a mass action plan.

These tools provide safety engineers with a powerful means of extracting information from historical accident records. The inductive method offers a means of identifying previously undiscovered relationships while the deductive method offers the means of embodying past experience and expertise within a computer program. These techniques can relieve the qualified engineer from some of the routine tasks that require expertise but little innovation and thus allow more time to be spent on complex, intuitive tasks.

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THE APPLICATION OF COST DATA IN TRAFFIC SAFETY

D.C. Andreassen

ABSTRACT

Traffic accidents result in damage and a variety of casualty classes to the persons involved and all of these classes have to be accounted for when costing an accident. This aspect has been ignored in major valuation studies. Accidents vary in severity, the number of persons involved and the number of vehicles involved according to the 'accident-type'. The effects of traffic safety measures vary with respect to frequency and severity according to accident type, a fact long known to Traffic Engineers through the use of the Collision Diagram in before and after studies.

This paper demonstrates the correct structuring of data to derive the costs of accidents for various severity levels and/or accident types. The typical casualty outcomes of a number of accident types are explored and the types producing the most severe results per accident are identified as are the types that produce the greatest contribution to the annual cost of accidents. This illustrates the range of costs by accident types and how the use of overall average accident cost is of no value in evaluation of countermeasures. The paper further demonstrates the stability of the casualty outcomes of particular accident types across an eight year period and how these can be used as reference distributions for the application of unit costs, making it relatively simple to update accident costs.

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1. INTRODUCTION

The fact that traffic accidents result in death, injury, and damage and are regarded as a general loss to the community is widely accepted. There is a small counter effect in that a reduction in accidents means a loss in business to tow truck operators, crash repairers, medicoes, etc., however that is usually not considered in valuation and will not be discussed in this report.

The reason for having an estimate of accident costs may seem obvious but it is seldom expressed explicitly. Costs are sometimes used for general statements such as 'accidents in Australia are worth more than $6000 million per year', or 'accidents are three per cent of GDP'. For such uses, 'ball-park' figures are sufficient as long as they are of the right magnitude and not wrong by, say, a factor of two. Costs are also required for assessing the value of duplicating a highway, installing traffic signals, enforcing specific traffic laws, putting reflective plates on trucks, various safety countermeasures, etc. When these are to be considered a very specific cost is required to determine the benefit.

Safety countermeasures can be placed into two categories, those that seek to reduce accident frequency and those that seek to alter the injury consequences to the persons involved. Some measures might exist that seek to do both.

For benefit/cost studies involving safety measures, the basis of the analysis must be sensitive to the variables that will significantly change accident costs. To illustrate this consider the seat belt. Use of seat belts does not reduce accident frequency, rather it alters the distribution of injury outcomes of the occupants involved in an accident, i.e. it reduces the degree of the injury sustained by the individual. For an evaluation, the cost of a 'fatal accident' or an 'injury accident' would be inappropriate; what must be used is the cost of a 'death' or the cost of an 'injury'. The proportional reduction in each injury class would be multiplied by the cost of each class to obtain an average cost reduction.

So before the cost-effectiveness of a countermeasure can be calculated the factors that need to be considered include:

(a) an understanding of the likely effects of the countermeasure; that is, frequency reduction, injury reduction, what 'accident types' will be affected and to what extent and the reliability of the estimates.

(b) knowing the typical costs for each casualty class and 'accident type'. The latter are determined by the porportions of persons of varying casualty class in the relevant accident type, and the average number of vehicles and their damage level for that accident type.

Countermeasures vary in their effect on specific accident types, a fact long known to Traffic Engineers through the use of the Collision Diagram in before and after studies. Accident types, in turn, vary in their proportions of casualty classes; that is, some types result in more severe casualty classes to the persons involved than do other types (e.g. a head-on accident compared with a parking manoeuvre accident).

Thus if accident costs are to be used in benefit/cost assessments the costs associated with the change in accident frequency or casualty classes within accident types has to be weighed against the cost of the countermeasure.

2. CASUALTY CLASS AND ACCIDENT SEVERITY LEVEL

One of the continuing confusions in the literature is between 'accidents' and the 'persons' involved in them. When discussing safety there needs to be clarity between 'accidents' and 'casualties'. To distinguish the two, 'casualty class' is used here to refer to a person, while 'severity level' is used to refer to an accident. Accident severity is classified by the most severe casualty class sustained by one of the persons involved. The 'severity' is of limited information content, it says nothing about the number and severity of injury of the others involved in the accident nor the number of vehicles involved. A bus accident in which one person was killed and 30 admitted to hospital would be classified by severity as a fatal accident. A pedestrian accident where one person is killed and no one else injured is also classified as fatal accident severity. There is nothing in the 'severity' definition to accentuate the difference between these two accidents.

The solution to this problem lies in not only making use of specific accident types but in also using the average number of persons of each casualty class for each accident type. And this, as it happens, is the structure needed for the correct application of unit costs.

3. A FRAMEWORK

Depending on the amount of information available in the accident reporting system the casualty class of each person involved should be determined for each accident. The number of persons killed, injured and not injured, would be the most basic type of break-up. Usually the distribution of costs is highly skewed so it is very desireable to subdivide the 'injured' category in a manner related to cost. Injuries with high medical costs, long hospital stays, etc. should be distinguished from minor injuries. The number of days in hospital and/or the injury compensation paid are possible ways of subdividing the casualty classes. To illustrate the technique the following subdivisions, for which the data was available in the 'reported' accidents in Victoria, Australia, are used:

(i) death,

(ii) admission to hospital,

(iii) injured - required treatment by a doctor,

(iv) injured - did not require treatment by doctor, and

(v) not injured.

It is then possible to cross classify 'accident severity' by 'casualty class' of persons involved, using these five levels, highlighting the mistake made by a number of other researchers in ignoring the other persons involved in accidents of a stated severity level (see Table I).

TABLE I

REPORTED ACCIDENTS, WHOLE OF VICTORIA, 1981

Accident Severity Level	Casualty class (persons/acc) 1	2	3	4	5	Total (pers/acc)	Acc.	Vehs	Veh/Acc
1. Fatal	1.13	0.50	0.27	0.07	0.88	2.86	677	996	1.47
2. Hospital		1.23	0.21	0.09	1.04	2.57	6,450	10,319	1.60
3. Med. Treat.			1.27	0.09	1.33	2.69	8,490	15,090	1.78
4. No Medical				1.23	1.52	2.75	1,872	3,400	1.82
5. No Injury					2.14	2.14	10,060	18,011	1.79
All levels	0.03	0.30	0.45	0.13	1.56	2.47	27,549	47,816	1.74
Persons	766	8,305	12,374	3,693	42,983	68,121			

Note: In Victoria accidents are required to be reported when someone is injured or if it is an event where the owner of the property damaged was not present. Thus the 10,060 level 5 accidents are those, in theory, involving an alleged breach of traffic regulations or where the owner of the damaged property was absent at the time of the accident.

The number of persons injured per accident varies with the severity level and the number of vehicles involved per accident also varies with accident severity. Hence the use of average factors for all severity levels can produce gross errors. For example, NHTSA (1983) used an average factor of 1.7 vehicles per accident for all severity levels (except fatal, 1.02) and 2.21 injured persons per accident (except fatal, 1.13). Atkins (1981) likewise used an average factor for all severity levels of 1.56 vehicles per accident (except damage-only 1.90) and approximately 1.44 injured persons per accident (except fatal, 1.13).

The overall average number of vehicles per reported accident of 1.74, or 1.7 per level (1-4) accident is comparable with the USA figure of 1.746 (Smith et al. 1981) or 1.70 (NHTSA 1983) but the variation of the figure for each severity level should be noted. If it is assumed that damage costs increase with accident severity (as in the NHTSA Report), then the damage costs will be over-estimated for the severe accidents and under-estimated for the lesser injury accidents.

From a table such as Table I, the total cost of accidents in an area can be readily determined by applying the 'unit costs' associated with each casualty class and the average cost of repair to vehicle damage. Namely; the number of persons killed x the unit cost of a death, plus the number of persons admitted to hospital x the unit cost of hospital admission and so on, plus the number of vehicles involved x the average repair cost.

Further, Table I, permits the determination of the cost of accidents of each of the specified severity levels, and the cost of an average accident of each severity level. For example, the cost of an 'average' fatal accident is made up of:

1.13 x the unit cost of death
0.50 x the unit cost of a person admitted to hospital
0.27 x the unit cost of an injured person of casualty class 3
0.07 x the unit cost for an injured person of casualty class 4
1.47 x the unit cost of damage to vehicles in fatal accidents.

This method takes all the casualties within accidents into account, not just the number of the highest casualty class in a level. To get the correct result, it is necessary to structure the data in the form of Table I, rather than taking, say, published data of the number of accidents of various severity levels and number of persons of various casualty classes. To illustrate the difference, the margin totals from Table I are used for levels 1 to 4:

Accident Severity	Casualties/Acc.		Vehs/Acc.
	Incorrect	Correct	
Level 1	1.13	1.97	1.47
Level 2	1.29	1.53	1.60
Level 3	1.46	1.36	1.78
Level 4	1.97	1.23	1.82
Average (1-4)	1.44	1.44	1.70

The incorrect values are produced by dividing the total number of persons of a particular casualty class (e.g. 8305 persons of class 2) by the total number of accidents of the corresponding severity (e.g. 6450 accidents of level 2). (8305 ÷ 6450 = 1.29 casualties per accident.) The correct values are produced by summing the number of persons per accident for each casualty class within a particular accident severity level (e.g. for severity level 2, the total number of casualties is 1.23 + .21 + .09 = 1.53 casualties per accident).

The use of a single factor, such as 1.44, to multiply the number of accidents in each severity level to derive the number of casualties and hence the cost is incorrect on two accounts. Firstly it would underestimate the number of casualties in the high severity accidents (and overestimate the ones in the lower severity) and, secondly, the unit cost of just a single casualty class cannot logically be applied to a number that represents a mixture of casualty classes. All the casualty classes within an accident severity level must be accounted for.

4. COSTS OF ACCIDENT TYPES

While the above is a refinement over earlier procedures, it still gives only coarse measures. It should be obvious that, for example, all fatal severity accidents are not of the same type nor circumstances. When accident types are introduced into the analysis they provide a further disaggregation which can be employed to advantage for both accident frequency reduction and the modification of casualty classes within accidents. Thus for countermeasure work the data must be oriented to accident type and we then deal with the 'typical outcome' of each accident type (viz the average number of persons in each casualty class per accident).

To demonstrate the variation by accident types, eight groups of accident types have been selected and the numbers of persons per accident in each casualty class and the number of vehicles per accident are listed in Table II. These eight accident types account for 61 per cent of the reported accidents in Victoria.

The data shows that 'head-on' accidents produce the greatest number of deaths per accident and the greatest number of hospital admissions per accident and indeed the greatest number of 'casualties' per accident. Hence the relatively high value on a per accident basis of any countermeasures that would reduce the number of head-on accidents or reduce their casualty level. The next worst accident type for total casualties per accident is 'running off the road at a bend' (also second for deaths and admissions to hospital).

If the average values for accident severity levels are wanted, each of the accident types can be further disaggregated in a table of the same format as Table I.

TABLE II

CASUALTY CLASSES WITHIN ACCIDENT TYPE
REPORTED ACCIDENTS VIC. 1981

Acc Types	casualty class 1	2	3	4	5	Total	Veh/acc	No. Accs
	persons per accident							
Pedestrian	.08	.46	.41	.08	1.23	2.26	1.02	1959
Vehs. adjacent streets	.02	.32	.59	.19	1.97	3.09	2.08	4769
Right-thru	.01	.33	.60	.19	1.94	3.08	2.08	1821
Rear end	.002	.13	.59	.19	2.35	3.27	2.37	2221
Head on	.09	.61	.58	.22	1.86	3.35	2.13	1076
RoR, bend	.07	.54	.51	.10	.55	1.78	1.03	1518
RoR, straight	.04	.42	.38	.10	.69	1.63	1.03	2575
Lane	.006	.10	.17	.08	2.48	2.83	2.08	968
All types	.03	.30	.45	.13	1.56	2.47	1.74	27,549

Consistent outcomes

Having sorted out that accident types should be used the question that then arises is, are the outcomes of accident types consistent across a number of years? That is, does a 'vehicles adjacent streets' accident on average, produce the same split up in the five casualty classes irrespective of whether it occurred last week or five years ago. It would seem a reasonable hypothesis that the one accident type would consistently produce the same average outcome (i.e. the split into five casualty classes). This would be expected to change if some countermeasure was introduced that modified the severity outcome of that accident type. For example the wearing of seat belts would alter the distribution of casualty classes for "head-on" accidents. A reduction in classes 1, 2 and 3 of 49 percent (Andreassend, 1972) might be expected, without a change in accident number.

To test this hypothesis, the six accident types/groups in 1981 with the highest annual total costs were selected (from Table II).

Data were available for the eight year period 1974 - 81 for the six accident types/groups and so the information for each accident type for the reported accidents for each year was put into the table format as illustrated by Table I, where it might be recalled that 'Casualty Class' is the degree of injury sustained by a person involved in an accident while 'Accident Severity Level' is based on the most severe casualty class recorded for any of the persons involved in that accident.

In Victoria, some 40 per cent of the recorded accidents are 'property damage' accidents despite the reporting criterion being basically one of accidents involving injury, and there is debate about not using the 'property damage' accident information because of some imagined unreliability. To examine what accident severities might provide the greatest consistency across years, the accident type 'vehicles adjacent streets' was chosen and progressively accident severity levels 1, 1 to 2, 1 to 3, 1 to 4, and 1 to 5 were tested for significant differences in persons per accident in the five casualty classes across the eight years (with a k sample test). None of the tests showed any significant differences between years and as the levels 1 to 5 gave the smallest chi-square value it was considered that there was no evidence to suggest that including level 5 accidents introduced any unreliability and indeed the converse might be true. Thence a decision was made to make all the comparisons for the six accident types using all the recorded accident information that is levels 1 to 5.

For each of the six accident types a matrix of persons per accident in the five casualty classes for each of the eight years 1974 - 1981 was produced as illustrated by the accident type 'vehicles from adjacent streets' in Table III. The Friedman Test was then applied to ascertain if there were any differences between years in the number of persons per accident in the five casualty classes. None of the six accident types tested showed any significant differences across the years. Thus there is no evidence to reject the hypothesis that a particular accident type consistently produces the same average outcome in terms of persons per accident in the five casualty classes.

TABLE III

OUTCOME OF 'VEHICLES FROM ADJACENT STREETS' ACCIDENTS
VICTORIA 1974-1981

Year	1	2	3	4	5	TOTAL
			Casualty Class (persons per accident)			
1974	.023	.352	.661	.207	2.10	3.34
1975	.023	.382	.616	.204	2.13	3.35
1976	.032	.393	.584	.201	2.17	3.38
1977	.020	.376	.608	.207	2.04	3.31
1978	.030	.378	.655	.207	2.04	3.31
1979	.026	.374	.621	.189	2.06	3.27
1980	.017	.391	.637	.207	2.02	3.27
1981	.026	.366	.642	.206	1.95	3.11
Mean rate						
Mean	.0246	.376	.628	.204	2.07	3.29
S.D.	.0046	.012	.024	.006	.062	.073
Coeff. of Variation						
(S.D./Mean)	18.7%	3.2%	3.8%	2.9%	3.0%	2.2%

As there was no significant difference between years it is legitimate to produce an average rate for the eight years and use it as a reference distribution. Table IV lists the mean rates within each casualty class for the six accident types.

The mean rates in Table IV can be used to represent the average outcome of each of the accident types illustrated and unit costs per person for death and injury can be applied to the casualty classes and damage repair costs per vehicle for that type of accident can be applied to the average number of vehicles per accident thus giving a cost for each accident type. The only thing varying with time that one need consider is the unit costs and they can be revalued in line with changes in the Consumer Price Index and average weekly wages.

Within each accident type the variations (Table V) are small for classes 2 - 5, and are generally larger for class 1 (deaths). The range of the values is reasonably controlled, with the standard deviation being less than the mean for all cases.

TABLE IV

CONSTANT OUTCOMES (EIGHT YEAR AVERAGE)

Accident Type	Casualty Class 1 (fatal)	2 (hosp.)	3 (IMT)	4 (INT)	5 (NI)	Total	Veh/Acc
	(person per accident)						
Vehicles from adjacent streets	.0246	.376	.628	.203	2.069	3.289	2.086
Run off carriageway, on straight	.0525	.491	.381	.093	.631	1.650	1.039
Run off carriageway, on bend	.0927	.618	.461	.103	.567	1.843	1.034
Head-on	.0968	.606	.555	.176	1.982	3.416	2.097
Right turn/opposing	.0187	.352	.550	.179	2.076	3.175	2.077
Pedestrian accidents	.0845	.471	.378	.103	1.252	2.290	1.013

TABLE V

COEFFICIENT OF VARIATION, PER CENT

Accident Type	Casualty Class 1 (fatal)	2 (hosp.)	3 (IMT)	4 (INT)	5 (NI)	Total	Veh/Acc
Vehicles from adjacent streets	18.7	3.2	3.8	2.9	3.0	2.2	.50
Run off carriageway, on straight	20.6	8.8	5.2	7.5	5.7	1.7	.67
Run off carriageway, on bend	21.9	9.6	5.6	13.6	5.1	2.1	2.1
Head-on	19.0	4.4	5.4	15.9	4.4	1.9	1.0
Right turn/opposing	39.6	8.5	5.8	8.9	3.9	2.3	.34
Pedestrian accidents	7.2	4.7	6.3	10.7	2.9	2.9	.39

(Coefficient of variation = Std Dev./Mean)

Per accident and annual costs

Table IV can give an idea of the relativity on a 'per accident' basis of the various accident types when just the persons are considered. The damage repair cost has to be taken into account for each accident type to finalise this comparison. A study of repair costs (James 1983) showed a definite variation of cost with accident type, the rank order of costs per vehicle of these considered types were: RoR, bend; RoR, straight; Head-on; Adjacent app; Right-thru; Rear end; Lane; and below these Pedestrian (at about one-third of repair cost of Rear end). A more recent study (RACV 1987) that was limited to the Melbourne area gave similar results. On a per accident basis: 'head-on' accidents were the most costly.

The aspect to be considered apart from the 'per accident' cost is the contribution to the total cost in, say, a year. For this the cost (injury plus damage) for each accident type needs to be multiplied by the number of each accident type and, for the data analysed, the greatest contribution was by the 'vehicles adjacent streets' accidents by a big margin followed by the two 'run off road' accident types.

The high casualty outcome for 'head-on' and 'run off road' accidents shows the value of any measures that can either prevent such accidents or reduce the casualty outcome. The seat belt is a prime device for the reduction of casualty and thus the value in requiring seat belt wearing and the enforcement of wearing. The improvement of road side environments and the removal of obstacles is of importance for the 'run off road' accidents.

From total annual cost contribution the 'vehicles adjacent streets' accident and the 'run off road' accidents (again) warrant expenditures (on countermeasures) to curb the frequency of such accidents.

Here the mechanism of costing is of importance rather than the answers for this particular data set.

Updating should be applied to the unit costs per person and per vehicle, and these costs then applied to the distribution of casualty classes for the particular year or accident-type concerned. It is inappropriate to update the total annual costs directly (or for that matter the average fatal accident or average injury accident) because the composition of accident types making up the total varies from year to year and accident types vary in their costs. Also the relative increases in casualty costs and damage costs can be different.

5. OTHER ISSUES

Any major change in the future to the severity outcome of accidents, such as that brought about by the introduction of seat belt wearing in the past, would require a reassessment of the relevant accident types; otherwise the issues that remain are those that pertain to the unit costs and some of these are listed below.

Within the components of the unit costs, the loss of time, frustration, etc. of uninjured persons in either casualty or damaged accidents should be costed.

Questions arise as to whether a single value of a life (or an injured person) is sufficient. When the value of a life is based on the age/sex distribution of those killed, the value obtained depends on whether the distribution used is that for all road users or whether selected road users are used e.g. the pedestrian age distribution differs from that for drivers, and that for bicycle riders, etc. A costing for the whole population alters with time as the population as a whole becomes older. Is there a case to sometimes use an age distribution more relevant to the situation being studied than the average for all road users?

The question of whether the unit costs are determined by ex post or ex ante techniques needs to be resolved.

Should pain and suffering be included in the costs?, some of the costings have included it and some have excluded it.

Should different costs be used for different regions e.g. metropolitan, country towns, and rural roads? The variation for accident types is readily determined. For Victoria the increase in severe casualties between Metro and Rural is in the range of three to seven per cent except for Head On (14 per cent) and ROR straight (12 per cent) (Andreassen 1984).

For costs of medical and hospital bills, motorcyclists and pedestrians were above the average amount paid. Should accidents involving these road users have unit costs that differ from the average for all road users?

6. CONCLUSIONS

A knowledge of the effect on specific accident types by particular countermeasures is an integral part of any proper safety program. To justify the expenditures on countermeasures, and this comment applies to all forms of countermeasures not just site treatments, the cost of the accidents saved (or increased) has to be weighed against the cost of the countermeasure. Averaged average costs are no value for such work because of the skewed nature of the distributions involved. The costs of the specific accident types must be used. This is readily done, as described herein, by using the casualty classes of the persons involved in accident types and the application of unit costs per person and per vehicle.

The 'unit cost' approach (i.e. per person by casualty class and per vehicle) has been advocated in the past and appears to be the most useful technique provided all the involved persons and vehicles are accounted for. The unit cost figures can be applied to National or State totals and to individual accident types, the latter being essential for a proper cost-benefit assessment of safety measures. The unit costs can be further tailored to reflect different road users and different environments. None of the past studies reviewed have been sufficiently detailed to produce a sensitive tool/method for analysis and further work should be done to establish the needed details on vehicle damage, different road users and environments. The unit cost approach is applicable irrespective of whether the costs have been derived by ex post or ex ante considerations.

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EVALUATION OF ROAD ACCIDENT COSTS IN YUGOSLAVIA - - METHODOLOGY, RESULTS AND APPLICATION

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The unavoidable by-products of the motor vehicles traffic increase are road accidents, causing pain and suffering of individuals as well as serious losses for the society. Due to its complexity, this problem provoked a lot of the research work and also controversies concerning the approach, the methodology, the results and their application. In Yugoslavia, beside partial investigations until the middle of seventies this problem has not been studied enough, but in 1977 a study concerning these problems[1.] was elaborated for the National Highway Authorities and its methodology, results and application are presented below.

1.A METHODOLOGY FOR EVALUATION OF ROAD ACCIDENT COSTS IN YUGOSLAVIA

Taking into account numerous studies in various countries (main bibliography inclosed here) the methodology adopted is in accordance with the existing social values and economic theory and practice, but the approach was rather pragmatic. The evaluation of road accident consequences was based on the assessment of each disaggregated element thus enabling partial quantification for each type of accident or for any group of accidents or one accident.

1.1. General Approach

Adopting internationally accepted definitions the basic assumptions were the following:

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1. MOGUĆNOSTI I PRIMENA KVANTIFIKACIJE POSLEDICA SAOBRAĆAJNIH NEZGODA NA PUTEVIMA SA GLEDIŠTA NARODNE PRIVREDE (POSSIBILITIES AND APPLICATION OF ROAD ACCIDENT COSTS EVALUATION - SOCIO-ECONOMIC ASPECT) - Institut "Kirilo Savić" - Institut za ekonomiku saobraćaja, Beograd 1977-79.

1. Two main types of accidents were observed: accidents with injuries (including three sub-types: accidents with fatal injuries, with serious and with slight injuries) and accidents with damage only (including registerd and non-registered accidents).

2. Taking into account two categories of accident consequences: subjective, related to pain, fear and suffering of individuals and relatively objective and broder one from the social point of view, this analyses related only to the latter supposing that it represents the only adequate way and possibility of evaluation.

3. Due to great differences of the level of economic growth in various regions in Yugoslavia (republics and provinces) assessment of each element was performed by regions, and the values for the country as a whole represent the sum of them or the weighted averages. Taking into account the decentralisation of investments, safety programs and economic instruments, it was necessary, but it also demanded great attention in relation to the level of programs.

4. The data sources were relatively good official data on the structure of road accidents and their consequences and on relevant economic parameters. For the purpose of this study 14 surveys and interviews comprising 296 organizations and institutions were performed in order to obtain good assessment of the elements not included in the official statistic data.

5. The basic formula for the determination of the total sum of road accident consequences in monetary terms for each region vas the following:

$$C = \sum_{i=1}^{3} \bar{A}_i m_i + \sum_{j=1}^{2} \bar{V}_j n_j + \sum_{j=1}^{2} \bar{R}_j n_j , \qquad (1)$$

C - total sum of costs and losses caused by road accidents
$\bar{A}_i$ - average costs per injured group i
i - group of injuries (fatal, serious, light)

m_i - number of injured by i-type of injury
$\overline{V}_j$ - average damage per group of accidents
j - group of accidents (with injuries, with damage only)
$\overline{R}$ - average other costs per group of accidents

Registered number of casualties with damage only was increased by 20% in order to include non-registered casualties.

6. The following elements of costs and losses related to particular consequences were included into the analyses:
   a. Loss of output for killed[1] and injured persons,
   b. Medical and rehabilitation costs of the injured,
   c. Damage to motor vehicles,
   d. Other costs - insurance administration costs and loss off output of transport operators due to vehicles immobility.

1.2. Evaluation of costs components

The evaluation was rather difficult, because the loss of output imposed methodological problems, and the other components asked for separate analyses and assessments due to the lack of precise data relating to road accidents only.

a. Loss of output. After long dilemmas it was assumed that the loss of output should be measured as the social loss of the community caused by the absence of injured persons from the production, but it should not be identified with the value which the community assigns to human lives. The basic input ellement for the killed persons was net national product reduced for the consumption per active person, and for the injured persons it was the same element per active person, consumption included. The loss of output was calculated according to the following formula:

$$\overline{D}_1 = \frac{\overline{D}_{o1}}{2} + \sum_{n=a}^{b} D_{o1} \cdot \frac{(1+i)^n}{(1+r)^n} \qquad (2)$$

1. According to the international standards it was assumed that all the persons who have died wtihin 30 days since the occurrence of the accident are killed in road accidents.

for each region and for 5 age classes.[1.] It was assumed that the average working period starts in 22 years and ends in 55 years regardless sexes. Relevant symbols were the following:

$\bar{D}_1$ - present value of lost output for 1 killed person

$\bar{D}_{o_1}$ - average lost output of 1 killed person in the starting year (1975)

n - limits of the working period for each age class

i - expected growth rate of productivity (3 to 5% by periods and regions)

r - discount rate (12%)

a,b - starting and ending year of the working period

As the number of foreign citizens killed was not negligeable, lost labour output for the total number of persons killed by each region was reduced for the corresponding amount.

Assuming that the accident injuries are close to work injuries, i.e. that their feature is politraumatic, statistics of social insurance and medical institutions were used for the assessment of the average absence from work:

Type of injury	Average naumber of days - in hospitals	- sick leave	total leave
Seriously injured (disabled)	21	150	171
Other seriously injured	21	21	42
All seriously injured	21	27	48
Lightly injured hospitalised	4	7	11
Other lightly injured	-	2	2
All lightly injured	2	4	6
All injured	9	13	22

The lost output for injured people was evaluated by the following formula:

1. 5 age classes: 0-19, 20-24, 25-34, 35-44, 45-54.

$$D_2 = m_{2A} \cdot \overline{D}_2 \, n, \tag{3}$$

D_2 - total loss of output for seriously injured people

m_{2A} - number of active injured persons

$\overline{D}_2$ - average daily output per active person

n - average work leave for seriously injured persons (48 days)

About 4,9% of seriously injured persons remain disabled. Out of that figure 25% remain totally disabled, 3,5% need professional rehabilitation and 71,5% can continue to work after about 18 months. The lost output for all these three groups of disabled persons was assessed analogously to previous cases. For the first group the observed period was the remaining working life and for the second 39 months.

The lost output for slightly injured persons was calculated as above.

b. Medical and rehabilitation costs. The main sources for this part of evaluation were statistics and surveys in relevant institutions. Medical emergency costs comprise all the costs realated to this kind of medical services (fuel and depreciation of vehicles, salaries etc) related to work hours and performed trip distances. Total costs by regions were calculated according to the following formula:

$$C_{HPi} = \sum_{i=1}^{2} a_i m_i \cdot \overline{C}_{HPi} \tag{4}$$

C_{PHi} - total medical emergency service costs

a_i - percentage of the injured of i-type who needed the service

$\overline{C}_{PHi}$ - average costs by intervention by injured of i-type

Available sources showed that about 70% of killed and 15% of seriously injured persons used the ambulance car transport.

Hospitalisation costs asked also for special investigations, because they are not directly related to road accidents consequences. Numerous sources and differences in methodology gave partially controversial results, but they helped the assessment of crucial elements:

- all killed persons who did not die on the spot were transported to a hospital, where they remained about 5 days,
- all seriously injured persons were transported into a hospital, where they remained about 21 days,
- about 44% of lightly injured persons were also transported to a hospital, where they remained about 4 days,
- average daily hospital costs for slightly injured are equal to average hospital costs, for seriously injured, they are increased by 47% due to politrumatic feature of injuries and for killed persons they were increased by 92%.

Total hospital costs were the result of the following formula:

$$C_{Hi} = \sum_{i=1}^{3} b_i m_i \bar{C}_i d_i \qquad (5)$$

C_{Hi} - total hospital costs

b_i - percentage of hospitalized persons of i-type injury

$\bar{C}_i$ - average hospital costs per i-type injury

d_i - average length of hospital treatment per i-type injury

Costs of ambulant examinations were assessed analogously to previous elements assuming, according to the available sources, that a serious injury requires 2,5 and slight injury 0,8 ambulant visits.

The basis for medical rehabilitation costs assessment was the fact that 5,9% of hospitalized persons, i.e. 10% of seriously injured need medical rehabilitation with the average duration of 58 days, with corresponding average costs.

Professional rehabilitation costs for 0,17% of seriously injured persons (or 3,5% of disabled by road accidents) were determined similarly on the basis of the respective average costs and average length of rehabilitation (11 months).

c. Damage on vehicles. Due to the lack of informations on road and load damage, only damage on vehicles was observed in this investigation. Insurance statistical data enabled the assessment of total vehicle damage taking into account types of insurance, damage causes, reimbursement etc. According to foreign experiences too, very small damages were excluded and the number of accidents with only damage was increased by 20% for non-registered accidents. The formula was:

$$V = V_{zo} + O\,(N_2 d)\,(1-c) + k\,(N_1 d) \qquad (6)$$

V - total amount of vehicle damage costs in road accidents

V_{zo} - total amount of payed and reserved demands in insurance organizations for compulsory insurance

o - average amount of payed and reserved demands for compulsory insurance

k - average amount of payed and reserved demands for total insurance

N_1 - number of accidents related to running into road facilities, to running out of the road and to vehicle overturning

N_2 - number of collisions and strokes against other vehicles (minimum two participants)

d - coefficient of uncomprised events (d = 1,2, i.e. 20%)

c - corrective coefficient due to excluded damages caused by collisions and strokes (c = k/o = 0,15, i.e. number of totally insured vehicles to number of vehicles compulsory insured).

Insurance statistical data showed also that differences in costs between accidents with and without injuries are from 3,8:1 to 2,4:1 by regions or 3:1 in the average.

The administration costs of insurance companies amount about 9% of motor vehicle insurance and half of that sum can be related to road accidents. Administration costs for injury accidents are about 4 times higher than for accidents with damage only.

The evaluation of transport output loss in goods transport was also based on available data and additional surveys. The average exclusion of goods vehicles from the transport process was from 4.8 to 21 days, or on the average 9.3 days per vehicle. Total loss by regions was obtained by multiplication of the number of excluded vehicles, average costs per vehicle and percentage of the added value in company receipts.

2. QUANTITATIVE RESULTS AND ANALYSIS

This analysis was mainly based on official statistical data on number, structure and consequences of road accidents which are rather reliable particularly concerning accidents with injuries. In the observed 1975. 207,781 accidents occured, of which 40,467 were accidents with injuries and 166,814 were accidents with damage only. Their structure was the following (in %):

Accidents structure

Type of accident	Total		- in urban areas		- in rural areas	
All accidents	100.0	100.0	65.3	100.0	34.7	100.0
Accidents with injuries	100.0	19.7	64.7	18.5	35.3	20.1
Accidents with damage only	100.0	80.3	65.5	80.4	34.5	79.9

In that year, 4,366 persons were killed, 21,759 were seriously and 34,723 lightly injured and their distribution was the following:

Structure of the injured persons

Type of fatality	Total		- in urban areas		- in rural areas	
All injured	100.0	100.0	61.8	100.0	38.2	100.0
Fatally injured	100.0	7.2	48.1	5.6	51.9	9.7
Seriously injured	100.0	35.8	60.9	35.2	39.1	36.6
Lightly injured	100.0	57.1	64.1	59.2	35.9	53.6

It is obvious that in urban areas the number of accidents is greater, but their nature is less dangerous, because accidents with damage only prevail and injuries are lighter.

Total amount of social losses caused by road accidents, with minimal assumptions, was about 214 millions of US dollars, representing 50% of investments in construction, modernisation and maintenance of national, regional and part of local roads in Yugoslavia; or representing approximately construction of 125 km of modern highway with 4 lanes in plane highly urbanised area. At the same time mortality caused by road accidents took 5 th place among other causes and the first place among accident deaths. Injured persons occupy 7.3% of beds in surgical, traumatic, orthopaedic and similar hospitals yearly. Damage costs were by 7% higher than total road motor vehicles import.

Total social loss caused by road accidents varies according to the type of accidents and road environment (in %):

Structure of the total social loss caused by road accidents

Type of accident	Total		- in urban areas		- in rural areas	
All accidents	100	100	57.5	100	42.5	100
Accidents with injuries	100	65.3	57.1	64.9	42.9	66.0
Accidents with damage only	100	34.7	58.3	35.1	41.7	34.0

It is also interesting to analize the structure of the average costs by type of accident and consequences, showing that accidents with damage only have 7.6 times lower costs due to different consequences structure (in % and US dollars):

Structure of average costs by accident and consequences types

Type of accident	Output loss	Medical costs	Damage	Insur. adminis.	Transp. output	Total doll.	= 100
All accidents	26.6	6.4	57.0	3.5	6.5	1029	100
Accidents with injuries	40.7	9.8	36.8	2.7	10.0	3410	331
Accidents with damage only	-	-	94.9	5.1	-	444	43

Obviously, 1/5 of the total number of accidents, with injuries, caused 2/3 of the total losses. Therefore in this study as well as in road safety programs particular attention was payed to that type of accidents. The distribution of loss components for accidents with injuries for the country as whole, with variations by regions, was the following (in %):

Structure of total losses caused by accidents with injuries

Type of losses	Total	- in urban areas	- in rural areas
Output loss	40.7	38.5	43.6
Medical and rehabilitation costs	9.8	10.5	8.9
Damage	36.8	36.6	37.0
Insurance admin.costs	2.7	3.1	2.2
Transport output loss	10.0	11.3	8.2
Total	100.0	100.0	100.0

In spite of relatively moderate assumptions for output loss and real assessment of damage loss, these two categories represent 2/3 of total costs of accidents with injuries.

The most important figures in medical costs are the costs of seriously injured persons, particularly hospital costs (in %):

Structure of medical and rehabilitation costs

Type of injury	Emergency	Hospital	Ambul.	Medical rehabil.	Profes. rehabil.	Total
Killed	47.9	1.4	-	-	-	1.6
Seriously injured	52.1	89.8	62.6	100.0	100.0	89.6
Lightly injured	-	8.8	37.4	-	-	8,8
Total	100.0	100.0	100.0	100.0	100.0	100,0
	1.0	81.3	4.2	12.7	0.8	100,0

Average costs per injury accidents, causing 0.11 killed persons, 0.53 seriously injured persons and 0.85 lightly injured persons, were the following (in US dollars):

Average costs per injury accident by injury type

Cost element	per 1 accident	per 1 injured	per 1 killed	per 1 ser. injured	per 1 lig. injured
Output loss	1388	939	10320	612	42
Medical and reh. costs	334	225	52	563	34
Damage	1255	-	-	-	-
Insur.admin.	93	-	-	-	-
Transp.output	340	-	-	-	-
Total	3410	1164	10372	1175	76

Average costs per accident with damage only amounted to 444 US dollars in 1975, namely 394 US dollars in urban areas und 537 US dollars in rural areas.

3. APPLICATION OF THE OBTAINED RESULTS IN ROAD SAFETY PROGRAMS

Road safety programs vary by nature, extent and other features from country to country. In this case, methodological problems related to the application of road accident costs evaluation will be stressed, and an example of their application in programs for elimination of black spots on national and regional roads will be presented.

3.1. General possibilities for application and problems

Application possibilities for this kind of investigation are very well known and broad. But, tha application arises several problems:

- actuality of the results,
- liability of the application,
- regional and other differences.

The evaluation of social costs and losses regardless the methodology is rather complex and requires relatively long period for obtaining results. This investigation showed also that it would be irrational to perform it freqently. The introduction of shadow prices would make the problem more complex. Road safety programs are predominantly multi-year programs. All these facts lead to the adoption of the average values for basic elements of consequences which should be multiplied by the structure of time series of occured or expected accident consequences. In spite of the numerous changes of input elements for the observed model, related to the level of motorisation, types and structure of accidents, road quality in broade sense, and the structure of injured persons at one side and the level and structure of national product and economy, cost categories, and structure of population on the other side, it is obvious that the most important variables had similar trends causing minimum changes of road accident costs structure. Multiplication of two sets - the set of average consequences costs and the set of real or expected consequences - can give satisfactory result for determination of road safety programs requiring primarily determination of priorities. Comparison of different road investment programs requires as well revalorization and the unique prices and time period. Therefore, beside revalorisation, it may prove to be more useful to investigate in details the structure of the input elements each 15-20 years in order to check the structure relations and in the meantime to use the available revalorised values. This has been done in Yugoslavia since 1977.

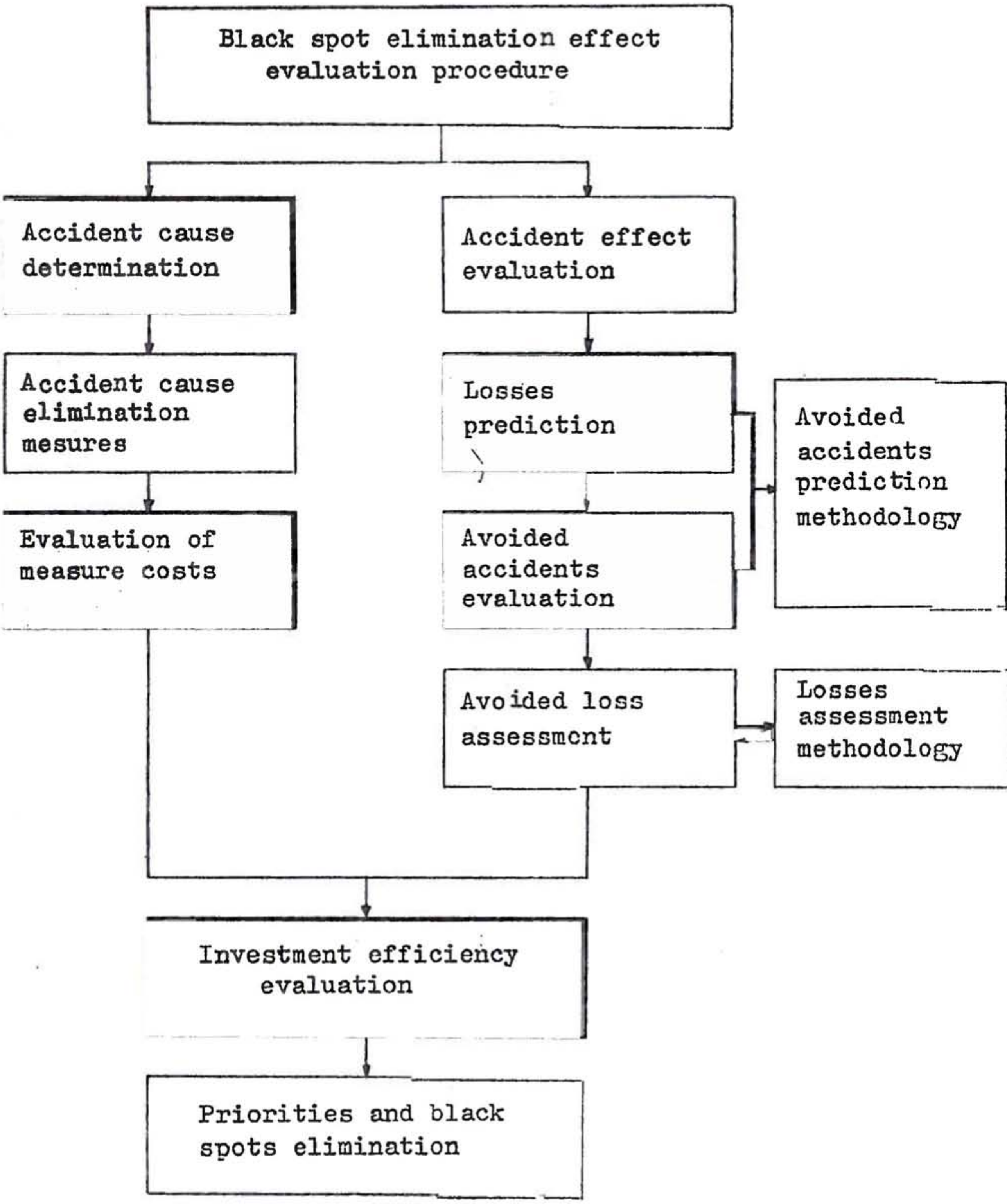
Liability problem rises in some countries such as ours, but the new methodology for feasibility studies will inculude this element. If not so or if the input elements differ, the comparison between the programs is hardly possible.

Differences in the level of economic development among Yugoslav regions are still significant. This fact made the whole investigation more complex because it was done by regions. Experiences in some other countries and this one, too, showed that differences in the average costs approximately correspond to differences in the level of economic development, but differences in number and structure of accidents vary significantly. Since 1975 until nowadays the level of safety relatively improved - the number of passanger cars increased by 85%, number of injury accidents increased by 6%, number of injured persons increased by only 2% and number of killed persons even diminished by 2%. It is also an argument in favor of use of average costs values in long term and real or expected values for accidents and consequences. The assumption for correct application of the obtained results is also the use of Yugoslav (weighted) average values for national projects irrespectively of the facility phisical location. Regional average values may be used only for regional or local programs and projects.

3.2. Application of the results in programs for elimination of black spots

The results of this investigation were also used for evaluating some separate projects. Those were mainly programs to eliminate the most dangerous spots on main and regional roads in Vojvodina, Serbia, Macedonia, and Monte Negro. The general methodology applied was the same and based on impartial recognition of black spots, analysis of accident causes, elimination programe, and on efficiency evaluation for each measure on every single spot, according to the cheme on the following page.

a) Black spots recognition. Assuming that traffic accidents are stochastic events the adopted methodology for reliable recognition of black spots on non-urban links was statistical method based on comparisons between accident rate by unit length as well as safety rate (coefficient expressed as the number of accidents by unit of transport output) and the limit values of these indicators, which with certain variation (0,5% variation at 99.5% reliability) may be considered random. The real data on accidents which exceed statisticaly obtained critical values indicate that the accidents are not only random events but the consequences of


Black spot elimination effect evaluation procedure
Accident cause determination
Accident effect evaluation
Accident cause elimination mesures
Losses prediction
Avoided accidents prediction methodology
Evaluation of measure costs
Avoided accidents evaluation
Avoided loss assessment
Losses assessment methodology
Investment efficiency evaluation
Priorities and black spots elimination

some external influences which implies that the corresponding road network should be examined. Statistical calculations and identification of the most dangerous spots on the main and regional network was performed by a computer.

Recognition of black spots for urban portions of the main and regional network was, due to previously mentioned restrictions, based on comparisons between actual and calculated-unique critical (limit) number of accidents with killed persons and no further statistical analysis was done.

b) Analysis of causes for creating the black spots. Detailed examination of causes for the occurence of each black spot was performed by analizing the following:

- causes defined on the basis of statistical forms on accidents estabilished by the Road Police Department, and
- data collected on spot by detailed observations of each single black spot.

Comparative analysis of these data indicated that causes for creating dangerous spots differ significantly depending on whether these were determined by police investigation or by on spot observations. The conclusion is that in actual practice the road network and its environment as the component of traffic safety is completly neglected or classified as a minor cause of traffic accidents.

According to official statistics the predominant cause of accidents in 90% of cases was drivers fault (violation of speed limit, violation of priorities, psycho-physical state of driver, etc.). But, the recognition of road elements on the black spots indicated other types of causes:

- in urban areas: undevided flows of pedestrians and motor vehicles, inadequate traffic flow regulation, unsatisfactory sight distance, inadequate road width, bad signalisation, unsatisfactorly designed service area, etc.,

- in rural areas: bad road elements, worsened by bad signalisation, bad vertical alignement, inadequate skid resistance, holes in pavement, short sight distance, inadequate horizontal alignement demanding sudden changes of drivers behaviour, badly designed cross-section grade in circle, unseparated busstops, road narrowness at bridges, etc.

The causes of these differences are probably the consequence of the fact that it is always easy to blame the driver "who did not adjust the driving to the road and traffic condidions". Investigations at each black spot showed that several negative causes coincided often and that they were related to the road elements and traffic flows as well as to the drivers behaviour.

c) The proposal for black spots eliminiation. On the básis of the determined causes on the spot a program of improvement measures was elaborated comprising three main measure groups:

1. regulation measures
2. streets lighting
3. improvements of road elements.

In accordance with combined accident causes the measures werw often complex. Measures relating to signalisation and lights dominated in urban areas and measures relating to the improvement of road elements dominated in rural areas.

d) Forecast of measures expected effects and determination of priorities. A particular analysis was made in order to determine reduction coefficient expressing the decrease of accidents due to the proposed measures. Taking into account the correlation between accident density and traffic flows density, a prognosis of the expected accidents on each spot was made for 20 years and afterwards it was decreased by reduction coefficient. The obtained number of injury accidents on each spot was the input for the calculation of the relevant benefits resulting from the proposed measures.

As it is normal that the accident consequences at the black spots are more severe than the average consequences for a region, the average accident costs were calculated separately for black spots in urban and in rural areas. The two average values were obtained by multiplying three types of average costs by injury type with the real number of injuries on the observed black spots for urban and rural areas separately. The same was done for damage costs according to the following formula:

$$\bar{C} = \frac{\sum_{i=1}^{3} \bar{A}_i \, m_i + \sum_{j=1}^{4} \bar{V}_j \, P_j}{n} \qquad (8)$$

$\bar{C}$ - average accident costs

$\bar{A}_i$ - average injury costs for injured persons of i-type

m_i - real number of the injured persons of i-type

$\bar{V}_j$ - average damage costs (in injury accidents) by vehicle type

P_j - real number of damaged vehicles of j-type (bycicle, passanger car, goods vehicle, bus)

Total benefits for each spot were obtained by multiplication of the number of the avoided accidents and the average accident costs for 20 years discounted to the present value by the formula:

$$B = \sum_{n=1}^{20} \frac{B_n}{(1+i)^n} = \sum_{n=1}^{20} \frac{\bar{C} . n_n}{(1+i)^n} \qquad (9)$$

B - total benefits at the particular spot

B_n - benefits in n-year

$\bar{C}$ - average costs for the observed spots in rural, i.e. urban areas

n - years in the observed period

i - discount rate

n_n - number of the avoided accidents in the year n

Priorities were determined according to the ratio of total benefits and measure costs for each spot for three categories of global priorities:

a) First priority - measures which can be realized within road maintenance causing minimum investments (horizontal and vertical signalisation, semaphore synchronization, etc). Investments in these measures pay back several times in the first year, and benefits are some time 50 times greater than investments. It was not necessary to calculate the ratio of benefits and costs.

b) Second priority - measures which ask for more serious actions and for greater investments (guard rails, installation of semaphores, road enlargement, bus stop construction, improvement of sight distance, improvement of cross-section grade). The benefit cost ratio was in the average 1.5 in urban areas and 4.5 in rural areas already in the first year.

c) Third priority - measures demanding great investments and construction works (at grade intersection, radii increase in vertical and horizontal alignement, bridge enlargement, etc.). The pay back period for these investments is longer (6-7 years). The benefit cost ratio was from 2.45 to 6.50 in urban areas and from 0.81 to 15.50 in rural areas and the investment priorities were easily determined according to this ratio.

. . .

The presentation of these theoretical and practical investigations was rather short in comparison with the performed studies as a whole and therefore numerous arguments and assumptions were omitted, but it can give general impression on the problem methodology and results.

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COMPLEMENTARITY AS AN AXIOMATIC FRAMEWORK FOR BEHAVIORAL RESEARCH IN TRAFFIC SAFETY: A YOUNG DRIVER CASE

By

J. Peter Rothe

INTRODUCTION

Young drivers are high profile subjects of much speculation, hypothesis and empirical study. Laymen and traffic safety researchers ask questions such as: "Why do young drivers drive the dangerous way they do?" and "How may we account for their risky driving behavior?" By attempting to answer these questions, researchers have become sensitized to the pathological premise that there is something inherently wrong or deviant about young drivers. For example, over the years researchers have assessed different factors related to young drivers.

Statisticians such as Lawson and Stewart (1981), Stewart and Sanderson (1984), and Fell (1984) compared young driver accident rates with a population of older drivers. The difference between the groups defined the degree to which young drivers were a problem. It should be noted that such statistical analyses define problems at arms length. They are far removed from everyday driving behavior.

The psychologists, Loitzl (1965), Schuster (1966), Levonian (1969), Mayer and Treat (1977), and Waller and Hall (1984), employed abstract concepts such as personality (e.g., maladjustment, extroversion), diagnostic cognitive abilities (e.g., information processing deficiency) and driver aptitude (e.g., intelligence, literacy) to measure young drivers' behaviors. Their concepts are incorporated in such theoretical designs as "personal maladjustment theory" (Selzer, Rogers and Kern, 1968), "information processing defect theory" (Klein, 1974) and "compensatory theory" (McBride and Stroad, 1975). The concepts reflect stereotype behavior based on empirical studies and theoretical constructs involving a variety of groups. When applied to young driver behavior, any discrepancy between young drivers and normative expectations then becomes the object of compensation.

Epidemiologists such as Tillman and Hobbs (1949), Thorson (1968), Carlson (1972), and Tonkin (1985), among others, considered young drivers as social health problems because of their increased exposure to external factors as the roadway, traffic, environmental conditions and times of day. The Organization for Economic Co-operation and Development (OECD) footnoted the exposure thesis by writing:

> . . . some kind of "natural selection operates and that the drivers who use the roadway at night differ significantly in certain personal characteristics from those who use the highways in the day. If so, part of this increased exposure may be related to personal characteristics, rather than being entirely a function of factors outside the driver (OECD, 1975; p. 39).

An often mentioned personal characteristic responsible for "induced exposure" is risk-taking (Cerrelli, 1972). As part of their age, young drivers engage in problematic behavior. One such behavior is risky driving (Jessor, 1985).

Much of the epidemiological research defines young driver risk-taking behavior as pathological, revealing the presence of physiological deviation from an assumed normal state. To illustrate, the extent to which young people engaged in violent, problematic or self-destructive behaviors represents a disease for which cause, origin and nature must be discerned. Yet, according to Mills (1963), the application of medical categories to a social phenomenon as young driver behavior constitutes a too ready acceptance of the prevailing norms as being "healthy." A follow up question is, "What constitutes healthy normative behavior?" The answer to this question has not been forthcoming.

Throughout the literature, young drivers were consistently defined as a specious singularity, encompassing a "whole" of integrated activities (Allport, 1961). Cameron remarked:

> If nothing else, this controversy in the literature over the particular ages at which traffic problems are vast should make us realize the problems inherent in treating young drivers, aged 16 to 25, as one homogeneous group about which generalizations can be made. In terms of driving experience, drinking experience, and various other social, psychological and behavioral factors, persons aged 16 or 17 are very different from those aged 21 to 25 (in OECD, 1982).

The statistical data used to define young driver behavior are based on the possibility of understanding everyday life conditions according to parsimonious definitions of concepts, objects and subjects. To transfer an objectivist abstraction like risk-taking into life situations is a fait accompli. Lifestyle issues are either devalued or considered non-problematic. For definition purposes the young drivers are considered static, verifiable entities.

Each research perspective mentioned entails a singular approach. No attempt has been made to combine the approaches to develop a holistic understanding of young drivers. Benner (1978), Woods (1981), and Jessor (1985) proposed that a master model for young driver research orientations is the single greatest need in accident studies. Hence, the next step is to further the research paradigm whereby singular research perspectives are avoided, data are integrated and everyday lifestyle features are addressed.

This article proposes a step, albeit a small one, towards developing a conceptual framework to interrelate data into a protracted behavioral image of young drivers. The following description of the framework entitled complementarity draws on the conceptual configuration and research data extracted from a year long study of British Columbia young drivers.

COMPLEMENTARITY: BACKGROUND

Complementarity is based on the assumption that objectively defined characteristics established through hypothetico-deductive reasoning are appropriate for descriptions of statistical trends but they say little of everyday social behavior. They do not refer to the expectations young drivers have of their relationships with people, to the meanings which they assign to their own and other people's conduct, to their self images, to the norms governing their behavior and to their ideas, attitudes, sentiments and motives. Relevant to the apparent shortcoming, Weber wrote:

> All interpretation of meaning like all scientific observation, strives for clarity and verifiable accuracy of insight and comprehension (Evidenz). The basis for certainty in understanding can be either rational, which can be further subdivided into logical and mathematical, or it can be of an emotional empathic or artistically appreciative quality . . . . Emphatic or appreciative accuracy is attained when through sympathetic participation, we can adequately grasp the emotional context in which the action took place (1949, p. 88).

For Weber, meaning has an objective or rational component and a subjective or empathetic dimension. Similarly, Cooley's (1926) definition of statistical and empathetic knowledge, Znaniecki's (1934) description of "vicarious experience" as a valuable source of sociological data, Sorokin's (1937) conception of "logico-meaningful" methods to explain 'casual-functional unities" and McIver's (1942) affirmation of "imaginative reconstruction" to validate causes, support Weber's thesis.

Gurvitch (1942), Merton (1949) and Polanyi (1966), among others, suggested that people's actions can be interpreted in terms of causes (normative ideals or facts) which determined them, or the reasons people have for them (actuality or values). If researchers concentrate only on responses to a given set of stimuli without alternative interpretations of human affairs, they obliterate any grounds on which justifications for the action can be given or disputed. Of themselves normative heuristic structures are empty. They anticipate a form that needs to be filled (Lonergan, 1958).

Complementarity's academic base also includes psychology, where Maslow (1954), Allport (1961), van Kaam (1969), and Giorgi (1971), specified that psychologists require background understandings to achieve appropriate interpretations of behaviors. To attain these understandings, qualitative data are needed. Behavior becomes datum only when its "relevant" aspects are measured, and experience becomes datum only when subjects meaningfully describe "relevant" aspects of their situations (Giorgi, 1971).

Although complementarity has achieved academic rigor and credibility in the social sciences, its most substantial grounding is in metaphysics, defined as the drive for knowledge. From that drive proceed all questions, insights, formulations, and judgments (Lonergan, 1958). The research method corresponds to that drive to know. It is a set of directives which guides a process towards a result (Lonergan, 1958: 396).

Correspondingly, Bergson (1949), specified there are "two profoundly different ways of knowing a thing." The first implies moving around the object; the second, entry into it. The first kind of knowledge stops at the relative; the second, whenever it is possible, to attain the absolute. If a social phenomenon is envisioned as a box the existence of an inside and an outside comes to mind. The inside and outside are mutually dependent, for the existence of the inside pre-supposes the existence of an outside, vice versa. The inside consists of individuals' "Lebenswelt" (life world) whereas the outside consists of generalized understanding of human actions herein referred to as "Umwelt" (external world). According to Schutz:

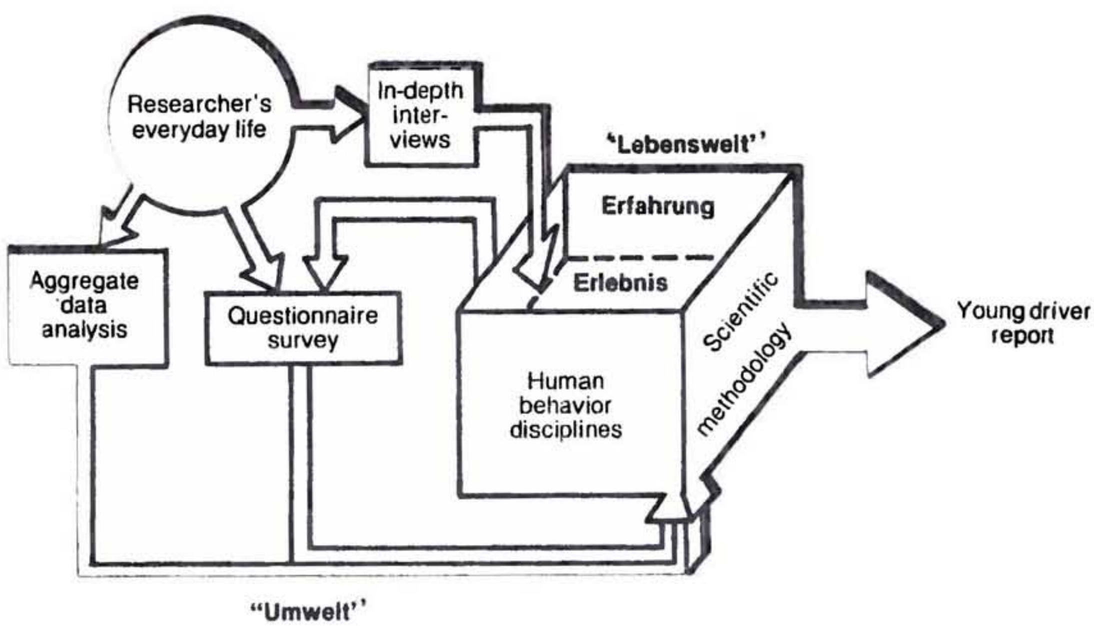
If the social sciences' aim is to explain social reality, then the scientific constructs on the second level, [Umwelt] too, must include a reference to the subjective meaning an action has for the act . . . . All scientific explanations of the social world can and for certain purposes, must refer to the subjective meaning of the actions of human beings from which social reality originates (1973, p. 62).

Researchers study young drivers. When they do so, they should not only analyze the complexity of the young driver phenomenon by topographically charting the variables and empirical structures -- laws, patterns or principles, but also they should mine the depth of human meaning.

COMPLEMENTARITY: THE CONCEPTUAL FRAMEWORK

To clarify complementarity, Bergson's Box has been modified according to the following illustration:

Complementarity design of young driver study



In the following description of complementarity, givens are considered as generalizations. They are the pillars of rationality supporting the complementarity framework.

Generalization 1: Young drivers' everyday lives or Lebenswelts are composed of behavioral events which follow contextual rules governing the describable properties of human action.

Young drivers' Lebenswelt includes their thinking and acting within given contexts (Dewey and Bentley, 1949). What young people do, know, and believe is a function of the groups to which they belong, their background experiences, their thought models, their intents and their particular interpretations of experiences (Geertz, 1972; Lazlo, 1973).

In the Lebenswelt, young drivers' knowledge about driving is cyclical and cumulative. It is cyclic in that their cognitional processes advance from everyday experience through inquiry and reflection to judgment, and revert back to experience (Lonergan, 1958). It is impossible for young drivers to define their driving behavior in terms of anything but their "Lebenswelt" as it is experienced by them, and as it is interpreted by them to be real (Combs and Snygg, 1959).

Corollary 1: A primary goal of young driver research is to obtain organized knowledge of the young drivers' Lebenswelt.

Social theorists such as Weber (1944), Bruyn (1966), and Gurvitch (1971) theorized that peoples' nature cannot be comprehended fully by those methodologies which rely solely upon sense data, logic and ontologies of mechanism (Bruyn, 1966). Researchers, therefore, should concentrate on discovering and verifying the existence of young drivers' realities through their own meanings -- to gather data "that which is given" as feelings, influences, fears, yearnings, disillusionments, relations, perspectives, and experiences (MacLeod, 1964).

Generalization 2: Young drivers' Lebenswelt as a unity of everyday driving behavior is held together by emphatic encounters (Erlebnis) and routine events of practical activities (Erfahrung).

The sum total of young drivers' experiences forms a frame of reference for everyday behaviors. Although the frame of reference is sufficiently integrated it becomes a focus of question whenever a highly dramatic event is experienced. The taken-for-granted becomes problematic as the typical becomes atypical. For the purpose of this paper the atypical is signified as "Erlebnis" and the typical is represented as "Erfahrung."

Corollary 1: "Erlebnis" or dramatic encounters bring together the young drivers' natures, meanings of the episodes, conducts, structures of reasoning and perceptual apparatus.

Erlebnis is a dramatic experience lifted out of the young drivers' stream of life (Palmer, 1969). It corresponds to Frankl's (1963) concept of "neo-dynamics," Michiavelli's (1963) "man-in-episodes," and Lofland and Lofland's (1980) "episodes."

Much like Cressey (1971), who investigated the impact that embezzlement has on the embezzler and the victim, traffic safety researchers should study the impact which injury-producing or fatal crashes have on the young drivers. They can then formulate general sequences as to how disparate traffic experiences are traversed by young drivers.

Corollary 2: Young driver behavior is associated with social patterns, routine activities defined by group norms, practical accomplishments and taken-for-granted reasons hereby labelled "Erfahrung."

Young drivers live with people in a taken-for-granted world. Fundamental structures as cultural, social or peer factors which influence experiences are not questioned but are lived through as seemingly natural and self evident conditions of life (Berger and Berger, 1972). They comprise "Ehrfahrung" (Znaniecki, 1934; Schutz, 1962; Belshaw, 1969). Lonergan (1958) describes Erfahrung as an imaginable domain comprised of normal codes of actions. Unless something happens to interrupt a young drivers' "Erfahrung," the everyday conditions are seldom questioned. They represent Heidegger's "domain of every man."

Generalization 3: Questionnaire items define young drivers' social scenes in hypothetical terms which assume that both the meaning of the propositions and differential responses are invariant to situational interpretations of "reality" and the young drivers' knowledge at hand.

Young drivers' background information is the basis for survey data. Contained therein are the commonsense meanings the researcher employed to construct questions (Cicourel, 1964). Although items are designed to reflect the kinds of typicality that young drivers use to manage their daily world, nevertheless the "forced" character of responses restricts the possibility that young drivers' perceptions and interpretations of the items will be problematic (Hyman, 1955). Social behavior is reduced to hypothetical norms and attitudes. Surveys reflect an "Umwelt" perspective because the items seek to measure young drivers' values, attitudes, opinions, norms and the like through fixed choice structures, ignoring the emergent, innovational and problematic character of everyday life.

The fixed-choice questionnaire features standardized propositions from the researchers' perspectives (Green, 1954). It provides a determination of frequency and distribution of pre-defined young driver characteristics, and an outline of relationships between various young driver aspects (Sanders, 1976).

<u>Generalization 4</u>: Young driver behavior has some sense of order and uniformity from which plausible generalization can be made and trends defined.

From an Umwelt perspective, young drivers as a group are defined by specific external characteristics gathered from controlled statistical research (Durkheim, 1951). The boundaries of definition and the potential of the characteristics for explaining the nature of young drivers are predetermined according to a rationalization of society and behavior (Bruyn, 1966). Statistical and mathematical techniques are used to express uniformities of the young driver phenomenon as they illustrate some consistency of character in the behavior of aggregates (Skinner, 1953). Other things being equal, the consistency of character is refined into trends which provide researchers with some predictive insight into future course of events. Projection of young driver behavior is achieved according to a pre-determined classification of analytic characters, as for example, in psychology (stimulus-response or aggression theory), sociology (alienation, socialization, institutionalization), education (cognition and pedagogical models), epidemiology (risk-taking) and engineering (perspicuity). Although these disciplines reflect a useful reconstruction of events they omit commonsense reasoning.

<u>Generalization 5</u>: The degree to which young drivers associate themselves with researchers on discussion of their Lebenswelt depends on the degree to which the interviewer approaches or avoids a topic.

<u>Corollary 1</u>: The researcher does not depict young drivers in terms of structural or statistical deviations from central tendencies as society, social order, social organization and institutional behavior.

Often traffic safety researchers begin and conclude their studies from a social pathological perspective whereby young drivers are considered to be a problem. Such a perspective starts with researchers having unreflective conceptions of values, unrealized standards and unique patterns of behavior. Data are ordered to better group the label, scope and character of deviation from the original conceptions.

Klein's (1972) label of adolescents as deviants, Shuster (1966) and Goldstein's (1973) conception of young peoples' driving behavior as symptoms of human problems, Levonian (1969), Fielding (1972) and Jessor's (1984) discussion of young driver behavior as antisocial and Carlson and Klein's (1970) conclusion of young drivers as delinquent exemplify the social pathological orientation which is so typical of traffic research.

An alternative perspective on young drivers is that what may be humanly experienced and cognitively understood, should be sought. Researchers should envision young drivers as individuals who do not behave idiosyncratically, but rather act according to the canons of the context. Since behavior is the result of meaningful experiences, interpretations of reality and understandings of conduct, it is necessary to establish the latter without pre-ordained judgments. Rather than ask the question, "How are young drivers different from other groups?" the questions should be, "How do young drivers use commonsense reasoning similar to other people? How do they structure their reality, and how does this structuring lead to driving behaviors? What motivates young drivers to do what they believe is proper to do? How do young drivers' commonsense actions and motives lead to a statistical, demographic trend?"

Corollary 2: The interviewer shares in the life activities and sentiments of young drivers in face-to-face disclosures.

In social psychology, early theoretical work suggests that self-disclosures are positive. Jourard (1964) wrote that the opportunity for people to reveal personal information to interviewers is a sign of psychological health, a state which should be judged favorably. Further, Cazby (1972) believed that personal revelations often reduce uncertainty about disclosures and that uncertainty reduction is pleasurable.

To support the process of face-to-face interviews for understanding young drivers "Erlebnis," Worthy, Gray and Kahn (1969) concluded that persons respond favorably to disclosure about dramatic life situations. Jourard and Friedman (1970) supported Worthy, Gray and Kahn's views on disclosure by quoting from their empirical research. They suggested that personal disclosure about relevant life events is psychologically healthy and socially beneficial. Therefore, properly trained interviewers are able to extract personal accounts about injury-producing crashes in ways that are beneficial to the researchers and respondents alike.

<u>Corollary 3</u>: Small group interviews provide interviewees opportunities to speak in colleagual group situatedness and they provide the interviewers opportunities for gaining a variety of shared and variable singular and group perspectives.

Imaginative participation in small interview groups comprised of young drivers provides the interviewers with opportunities to gather group relevant data (Schwartz and Jacobs, 1979). Verification between and amongst group participants' statements provides a clearer picture as to what is considered normative behavior of a cohort. Interviewers are both detached and active participating members, depending on the topic and flow of conversation (Gumperz, 1970; Eastman, 1970). They negotiate the interviews to unearth maximum data about young drivers everyday lives and boundary conditions which influence them.

<u>Generalization 6</u>: A complementarity approach towards young drivers is structured upon the hermeneutic principle, continuity of analysis.

Philosphers as different as James, Bergson, Dewey and Whitehead agree that commonsense knowledge of everyday life is the background upon which inquiry is built. As Schutz wrote:

> It is this Lebenswelt, as Husserl calls it, within which, according to him, all scientific and even logical concepts originate; it is the social matrix within which, according to Dewey, unclarified situations emerge, which have to be transformed by the process of inquiry into warranted assertibility; and Whitehead has pointed out that it is the aim of science to produce a theory which agrees with experience by explaining the thought-objects constructed by common sense through the mental constructs or thought objects of science. For all these thinkers agree that any knowledge of the world, in commonsense thinking as well as in science, involves mental constructs, syntheses, generalizations, formalizations, idealizations specific to the respective level of thought organization. (1973, pp. 57-58).

Attentive to Schutz's quote, a key concept of complementarity is the principle of continuity between the young drivers' Lebenswelt and Umwelt.

If understanding is taken as the conceptual leitmotif, it is possible to trace the continuity of understanding between Lebenswelt and Umwelt. In the Lebenswelt, understanding is primordial, meaning that the young drivers' chaotic order is overcome and they may move about their business with little difficulty. For example, teenagers' understanding of a car is such that it enables understanding of all cars. There is a natural attunement to the surrounding world so that items such as cars are not enigmas.

A higher level of understanding is empathy (Weber, 1949; Bruyn, 1966; Abel, 1974). For example, interviewers need to understand young peoples' anxieties before adequately analyzing the data (Strasser, 1963).

When engaged in survey and aggregate data analysis (Umwelt), understanding is achieved when a causal explanation or empirical correlation is achieved, (Rudner, 1966). When researchers compute a coefficient of correlation between, for example, young drivers with traffic violations and literacy they almost immediately infer the existence of a relation and they draw out its significance for the research problem as they order, break down and manipulate the data. This constitutes understanding within the "Umwelt" perspective (Ogden, 1923).

One cannot forget that the thought objects within the "Umwelt" are founded upon the thought objects constructed by commonsense thinking of young drivers in their Lebenswelt. Their understanding of the world and behavior within it leads them to become statistics for empirical understanding. For as Schutz wrote:

> Constructs of the second degree, constructs of the constructs are made by the young drivers included in their Lebenswelt, whose behavior the empiricist has to observe and to explain with the procedural rules of his science (1973, p. 57).

IMPLEMENTATION OF COMPLEMENTARITY

The complementarity framework led to the development of a methodology faithful to Lundberg's (1939) assertion that "understanding is the end to which all methods aim, rather than the method itself.' A methodology comprised of "open-ended and small-group interviews," "questionnaire survey" and "aggregate data analysis" was used for a year-long study in British Columbia, Canada.

To gain insight into the "Erlebnis" of young drivers involved in injury-producing crashes, open-ended interviews were activated with 130 drivers ranging from 16 to 18 years of age. Through logistical support from the British Columbia Motor Vehicle Department, the University of British Columbia Multidisciplinary Accident Investigation Team, and local police detachments, 130 young drivers were interviewed. Questions were negotiated around such central themes as, immediate and distant events which led to the accidents, interpretations of fault and blame, purposes for the trips, parental awareness of trips, post-accident reactions, driving biographies, views of self and driving, relationships with relevant others (as girl/ boyfriends, parents, friends, teachers and employers), judgments on life features (as school, home and work), lifestyles, drinking and driving experiences, meanings of the car, (as displayed in usage, upkeep and selection) and treatments received by authorities after the accident.

The taped interviews were edited, coded and transcribed. They were then analyzed according to characteristics found within the content of the transcripts, attitudinal, motivational and behavioral reasons for producing the content, and their relations to group norms and social structures. The categories for analysis, establishment of trends, and construction of relationships resulted from careful analysis by two independent researchers.

The small-group interviews, which were held to describe teenagers' "Erfahrung," consisted of 300 contacts with students, parents and driver examiners from three separate school districts representing urban, rural and suburban demographics.

In small groups of six and in a school setting -- usually a nursing or counselling office or an empty classroom -- 200 students enrolled in grades 10 to 12 met with interviewers to discuss a variety of lifestyle and driving-related issues such as expectations of licensure, driving patterns, common violations, the law, leisure activities, alcohol consumption, social/ community influences, parents and peer pressures.

School district approval to conduct the interviews was obtained through the superintendents of schools. Once permission was granted, further approval to do in-school research was given by school principals. Interview arrangements were handled by each school's counselling staff.

Also, 90 parents with children aged 14 to 18 were contacted. Some of the parents had their children interviewed in group discussions while others did not. Ten Motor Vehicle Department driver examiners were interviewed between examination appointments. After a promise of complete anonymity the examiners discussed teenagers' behavior, performance and training in an examination environment.

A sociologist interpreted the audio-taped data and field notes according to the properties of expression which are contingent on young drivers accomplishments of organized everyday life (Garfinkel, 1967). More precisely, categories of interpretation sought by the analyst consisted of, "taken-for-granted features of driving," "of-course assumptions influencing driving," and "views of student life that serve as practical reasons for driving behavior."

The first component of Unwelt was a questionnaire survey. In all, 1,368 of full-time students enrolled proportionally in grades 10, 11 and 12 were sampled. The student sample represented British Columbia geographic and demographic variables. The questionnaires probed students on a variety of driving-related issues; requested students for information on lifestyles, licensure and established driving behaviors; instructed students to rate safety of driving practices and conditions; and asked students to indicate their relationships to cars.

The final set of "Unwelt" research was comprised of in-depth aggregate data analysis. An accident database was constructed using statistics from police-reported injury-producing accidents occurring in 1984, matched with related information on claims and driver records. A sample size of 21,000 young drivers in accidents was found.

A separate file on information gleaned from coroners' reports by the Ottawa-based Traffic Injury Research Foundation was also employed, although the small sample size of 89 fatally-injured young drivers (matched with claim and accident files, etc.) severely restricted its potential. Results (comparisons) based on numerical differences which were significant at the 5% level or better in chi square analysis were noted.

The described research methodology provided a broad range of findings. Due to limited space only those findings related to "caution," "drinking and driving" and "risk" are reported.

FINDINGS

Caution

A prominent theme in psychology is that individual perception of experience demonstrates behavior (Thomas, 1979; Cohen and Lazarus, 1981). Concerning the young driver research, a theme of note was the extent to which young drivers perceived themselves as cautious drivers.

Seventy-five percent of the teenagers involved in injury-producing crashes considered themselves as cautious drivers. Without coaxing from the interviewers, caution was defined by specific behavior, by specific situation or by degree:

(1) I'm always shoulder checking . . . .
(2) Very cautious, cause I'm always looking around like even on a straight stretch . . . make sure where the positions of the other cars are . . . .
(3) In the morning I'm cautious but when I'm on errands I'm aggressive . . . .
(4) Yeah, I am, but when I don't foresee danger I'm not cautious, and some young drivers defined caution . . . .
(5) I don't drive that cautiously . . . just enough.

When asked about the responsibility of the accident, a predominant line of reasoning used by 66% of the interviewees was that the accidents resulted because of the other driver. The teenagers were, "going forward with caution," "passing with care," "just making a normal turn," or "looking ahead," when the other drivers made "sudden," "unexpected," "unsafe" or "illegal" driving maneuvers like "slamming their brakes," "weaving on the road," "speeding," "passing illegally," "suddenly turning," "running a stop sign or red light," or "non-signalling." However, 30% of young drivers said that they were explicitly engaged in suspect behaviors such as "speeding," "playing games on the road," "operating faulty equipment," "misjudging distance between cars," and "giving insufficient attention to driving." Some blame was transferred to conditions young drivers perceived to be outside of their realm of control. They "just did not see" the other car.

Further querying by the interviewers resulted in additional data. For example, immediately before the crash 50% of the interviewees were listening to the radio or cassette player. Of these, 12% of the young drivers said that their driving was seriously influenced by music. They were "singing along," "listening to real loud music" or "changing radio stations." As a result they "were just not paying attention to driving."

A second predominant line of reasoning arising from the discussions was that 30% of the young drivers were talking to their passengers immediately before the crash. Of this group, 18% linked talking with the accident. These responses came later in the interviews. They were not direct responses to the question on caution.

Further, a majority of young drivers expressed that they feel comfortable driving. However, when discussion continued, young drivers explained that they feel comfortable driving, except . . . . The exceptions were weather, other drivers, traffic, left turns and intersections. Uncomfortable weather conditions were snow, wind and rain in combination with wind, darkness and rush hour traffic. Heavy traffic got some teenagers "worked up," "excited" or "frustrated."

During the "Erfahrung" interviews, teenagers expressed that they exceed the speed limit and drive unsafely. However, they reasoned their present driving style as representative of behavior "for now," or applicable only while they are young. As they settle into "more mature" styles of adulthood their driving practices will change. Overall, the respondents considered themselves to be good drivers and "cautious enough."

As in the Erlebnis data, once interviewees were questioned about uncomfortable driving conditions normative descriptions arose. Although good drivers have no fears and are fully confident of all driving conditions, a follow-up line was the admission that some driving scenarios are scary.

To avoid being teased, scorned or labelled a coward, teenage boys admitted to being "scared stiff" while driving during poor weather conditions and through risky intersections. Nevertheless, they acknowledged to taking chances so as not to stray from what is expected by others and thought to be normal.

The most common strategy for concealing inappropriately-experienced fears and anxieties about particular motoring circumstances is to act in ways that suggest their non-existence. In other words, one merely enters the circumstances as if nothing was wrong. The initial anxiety about the circumstances is compounded by having to actually be in them. It is further compounded by having to be in them under extreme conditions of expressive control, i.e., without revealing that there is anxiety in the first place. Consider the following:

> This boy received his licence during the skiing season. Within weeks, it was his turn to drive his friends to Whistler for a day of skiing. "I was a wreck when we got there," he said. "I'd never driven on the

> highway before and I'd never driven in snow. And all the while I had to be cool."

It should be noted that concealing fears and anxieties by acting in ways that suggest their non-existence is not only the most common strategy, it is also potentially the most dangerous: it guarantees that teenagers will enter motoring circumstances that they perceive as demanding beyond their competence.

That they enter these situations in the first place is not wholly attributable to peer expectations. As the following example indicates, parents play a role as well:

> As soon as he got his licence, this boy's parents demanded that he help out with the family driving chores by transporting his younger sister to her twice-weekly music and theory lesson in West Vancouver. This was not something he wanted to do, as it involved "driving over the bridge" during the evening rush hour -- these "bothered" him. For two reasons, though, he felt he "had to." Firstly, this helping out was a condition of further use of the car to pursue his own interests and business. Secondly, if he expressed any lack of confidence about driving he felt that his parents might only allow him to drive "under supervision."

Being seen as a good driver involves more than keeping fears, anxieties, and perceived incompetence invisible; there is a display component to it as well. Time and time again teenagers, especially boys, told of how being in control was central to driving comfortably. Furthermore, they indicated it was how you could tell a driver was in control. Being comfortable driving denotes being a good driver. And being a good driver means being able to turn corners without having to visibly slow down, driving with one hand and being able to perform certain stunts like 180-degree turns.

When teenagers' views of themselves as drivers were placed within an Umwelt perspective, it was noted that 61% of the licensed students agreed with the statement, "compared to most people I know, I am a cautious driver." A chi square analysis between males and females showed no significant difference between group responses (p less than .05).

The survey also supplied statistical support for the teenagers' normative desire to associate with friends. Of the <u>licensed</u> respondents, 58% marked that they usually drive with their friends while cruising the streets. Thirty-one percent of <u>all</u> students answered that they often cruise with friends, one of whom drives. Furthermore, 65% of <u>all</u> respondents believed that driving with friends is safe. The relationship between passengers and increased risks of crashes was not recognized by the majority of students.

An analysis of the British Columbia accident data base provided a statistical perspective on the contributing factors related to young driver accidents. As outlined in the Lebenswelt descriptions, although young drivers consider themselves to be cautious and good drivers, nevertheless they are uncomfortable in certain driving scenarios. According to survey results, they recognize the potential danger, but as discussed in the group interviews, for group behavior reasons they tackle the dangers without visible signs of fright or hesitation.

A major police-reported contributing factor in young driver accidents was "weather," both as a singular and as a related factor. Only 30.8% of the survey respondents answered it was "safe" to drive in the rain, while only 9.6% felt it was safe to drive in the snow. The province-wide data analysis revealed that 24.4% of young driver accidents occurred during poor weather conditions such as rain and snow.

Female young drivers had slightly more problems with weather than males, with 25.9% of their accidents occurring during bad weather conditions (rain, snow, hail, fog, etc.) as compared to 23.9% of the males. An examination of "weather" as a police-reported factor, which contributed to accidents, produced a more significant differential: 8.3% of factors assigned to female young drivers were "weather" as opposed to 6.2% for males. No significant differences in involvement were found between the 16-18 and 19-21 age groups. When driving experience was carefully examined it was noted that young drivers with less than 12 months' driving experience had 28.4% of their accidents under adverse weather conditions -- a level somewhat greater than the average of 23.7% for those with more than two years' experience.

While, on the whole, 24.4% of young driver accidents happened under poor weather conditions, 37.8% of those young drivers who were charged following the accident with speed-related offences were involved in accidents in bad weather (of the 37.8% of young drivers, 45.1% of those were charged with "speeding too fast for conditions"). For young drivers judged to be at fault in an accident which occurred in poor weather, unsafe speed was cited as a contributing factor in accident causation 14.4% of the time but, for those not considered to have caused the accident, unsafe speed was only cited 13.1% of the time.

Based on the survey findings, students generally believed that passengers were safe. This belief was not consistent with the aggregate data. An analysis of coroner files showed that for 89 fatal accident-involved young drivers, the average number of passengers per vehicle was 1.06. Comprehensive review of the British Columbia Accident Data Base provided a further elucidating view. Younger drivers (16 to 18 years old) had an average of .94 passengers per vehicle and 22.1% of the vehicles carried two or more passengers. For the older drivers (19 to 21 years old) the figures were .69 and 15.3% respectively. Female young drivers in the 16 to 18 age bracket had a slightly higher average number of passengers per vehicle (.96) than males (.93). Younger teens carried more passengers per vehicle in a crash than older ones. Further, driving experience affected the number of passengers in cars. The average number of passengers carried in vehicles driven by young drivers in accidents generally decreased with increased driving experience, from 1.00 for those with 0-1 years of experience, to .75 for those with more than two years' driving experience.

Based on "Lebenswelt" findings, young people drive with friends to "cruise at nights," and visit or attend social events/parties on weekends. Provincial statistics generalize these themes. In daylight conditions there were .68 passengers per accident-involved vehicles. This rose to .76 under dawn/dusk conditions and to .97 at night (darkness) when cruising and parties predominate. Also, weekend accident-involved young drivers carried more passengers (.95 per vehicle) than those involved on weekdays (.71 per vehicle).

Drinking and Driving

Because a prominent theme in traffic safety literature is that young drivers are over-represented by population in alcohol-related accidents, the complementarity research addressed this matter.

The "Erlebnis" interviews revealed that of the young drivers involved in injury-producing crashes, about one-quarter of them characterized party attendance as "sometimes." No regular attendance routine was established. Rather, the interviewees characterized their partying as "on occasion," "once in a while," "the odd time," "sometimes," "once a month or so," "for special occasions." Events such as sports, movies, family events, get-togethers, and visits with friends were deemed more important than partying.

Young people do drink alcohol at parties but there appear to be common-sense control mechanisms. Many of the teenagers involved in injury-producing crashes indicated that they monitor their alcohol consumption. They keep within self-defined limits or restrict themselves to certain liquor classifications such as beer and wine. For example, they don't drink enough to "screw them up," "make themselves sick," or "wipe out their bodies." Others "just" drink wine or beer. They assumed that beer and wine consumption is less dangerous than hard liquor. By prefacing their choice of liquor with the word "just" (e.g., just drink wine and/or beer), the young drivers attempted to devalue the significance of drinking a specific generic liquor.

Similar monitoring themes were found when small groups of students discussed their general behavior at parties. Some students in grade eleven and twelve watched their drinking because of past experiences when they became "sick," "passed out," or "couldn't stand up." Like the "Erlebnis" interviewees, drinking "only" wine and beer was considered to be less severe than other drinks, regardless of volume.

Further, it was found that partying was related to age. Grade ten students (15 to 16-years old) who partied regularly did so because there "was little else to do." According to them, one could attend a party "whenever one wants." "News spread around the school" when someone was having a party, so sometimes more people turned up than were invited - and sometimes spontaneously. The major reason for partying was the lack of facilities or meaningful events planned for them in their communities.

Once students entered grade ten, previous activities were now interpreted as "boring" or "not with it." Grade ten appeared to be the pivotal point for "getting into the party scene" because they were "too young" to party in grade nine. Now in grade ten, they were more "mature," and more accepted by older classmates.

Grade eleven is a mediating year. Although consuming alcohol at parties was still prevalent, more students had boyfriends or girlfriends, resulting in less emphasis on partying. Other forms of recreation such as movie attendance, eating out, and sports participation became more important.

Metaphorically, grade twelve is the last way-station before students enter adulthood. For some, partying was "once a big deal." Now, they were more concerned about studying, working part-time, finding a job or going steady. Although they fondly remembered when they attended "raunchy" drinking parties, they now viewed themselves as having "settled down."

In the survey it was found that 40% of the survey respondents answered "always" or "often" when asked whether they attend parties on weekends. However, when students prioritized weekend activities, visiting friends, dating, and playing sports, they were rated as more important than partying.

The analysis of the British Columbia accident data base showed that drinking and driving amongst teenagers is not as frequent as with drivers over twenty-one years old. For the 11.1% of young drivers (16-21 years) charged with alcohol-related offences as a result of accidents, 79.1% of the crashes occurred at night and 16.9% occurred during daylight conditions; overall, 54.1% of all charges laid were in daylight, and darkness rated next with 41.5%. Fifty-eight percent of all drinking-related charges to young drivers arose out of weekend (as opposed to weekday) accidents even though only 32.9% of all young driver accident-involvements occurred on weekends. This indicates that drinking-driving is predominantly a weekend, nighttime phenomenon.

For drivers over the age of twenty-one, 15.3% of those drivers involved in an injury-producing accident were charged with drinking and driving-related offences. As noted, drivers 16 to 21 years old have a lower alcohol-related offence record (11.1%) than drivers older than 21 years (15.3%).

Risk and Drinking Driving

Better understanding of risk and drinking and driving is possible through the "Erfahrung" and "Erlebnis" interviews and the survey.

When students in small groups (Erfahrung) discussed their general behavior, they pointed out that parents were the primary source of their exposure to impaired driving. For example:

- After a dinner with some relatives (much alcohol was consumed) my family and I were driven home by my father, who was impaired. When he's this way he usually lets my mother drive, but she was pretty impaired too, probably worse than him.

- The family was out to visit friends. Dad had quite a bit to drink and mom can't drive. We had no other way of getting home so dad drove.

- One time I went to dinner with my aunt, uncle, and cousins, to a restaurant about an hour's drive from home. My uncle, the driver, had way too much to drink -- a few Scotches before dinner, lots of wine with, and a Spanish Coffee after. He drove us home, even though he was in no condition to, and we're lucky we didn't have an accident.

The choice to expose oneself to the risks of travelling with an impaired parent was made because to choose otherwise would be disruptive of normal relationships. If they declined, students would "never hear the end of it," "be in big trouble," or, worse yet, they would "get killed" or "grounded."

Few students said they would phone home for a ride after drinking. For them, it was a case of a risk preferred to a certainty. If discovered, parents would certainly punish a teenager for either drinking or being with the wrong crowd. The result may be degradations, curfews, groundings, restrictions of association with friends, long lasting suspicions, removals of privilege to use the family vehicle, or even banishment from the home (religious families). For some students, phoning home would not enhance a student's reputation with friends. Several students spoke about phoning home for rides after parties. They characterized this as a mistake because their parents no longer trusted them. All had their activities restricted considerably. Instead of phoning home for a ride, calling for a taxi or walking home, the preferable alternative was riding with a drinking driver. While impaired, some students drove through circuitous back alleys or seldom-used streets in order to get home "safely" (Rothe and Cooper, 1987).

The students indicated that parents, although "out of touch," set down rules to protect them. Because few teenagers considered the rules reasonable, skirting them required strategy. For example, to avoid detection, some students ensured they brought the car home after drinking liquor. Coming home without the car would prove to parents they had been drinking; a realization they wanted to avoid. So they return by the designated hour, often in an intoxicated heightened emotional state rather than "sleep it off," "have a cup of coffee," or "walk it off." Students assessed that parents would already be asleep or they would not get out of bed to greet them late at night. Thus, the next morning their parents would not suspect they had been drinking and driving.

The majority of young drivers who were involved in crashes ("Erlebnis") suggested that parents knew only generally of their whereabouts. They knew their children were "at work," "out," "around" or "at the game," but they did not know "exactly what they were doing" or who they were with. Consequently, parents did not know if their children were drinking alcohol.

When interviewed, parents enunciated a code of rules based on the ubiquitous effects of proper conduct. One such rule was that parents want their children to know they are being cared for. So, they expect their children to call home rather than drink and drive. Parents expect their children to realize that even though they may not be happy about them drinking, parental care and trust overrides this unhappiness.

A group of parents explained that during family discussions children were instructed not to drink and drive. Instead teenagers were advised to phone a taxi or ask parents for a ride. The consequences of following this advice, however, differed amongst the parents. For example, some parents did or would punish:

1. If he were to call home because he were drunk and couldn't drive I would pick him up. I would be glad although I would have to have a serious talk about his behavior and I think I would have to take the car away for a while because he showed irresponsible behavior. He must learn the seriousness of doing something like that;

2. I've never seen her drunk. If she did call me she knows I won't be happy about it but I would rather she called me than drove home. I would punish her if it happened a lot but probably would not on the first time. Everyone can make mistakes;

3. He only called once because he was too drunk to drive home. I was really furious with him and grounded him and he was not allowed to use the car for a month.

Some were, or would be, mad without punishing:

1. She has called because she has been too drunk to drive home. I was angry about it in one way but really glad she called. I was mad but didn't punish her. She knew it was wrong because she had responsibility when she took the car.

2. I would pick her up or at least have her take a cab and I would pay for it. I would be glad she phoned.

Some would be unhappy:

1. If she phoned in that situation I would be relieved that she called instead of trying to get home. If that happened she knows I would not be very happy about it.

Some would be instructive:

1. She has never phoned because she has been too drunk to drive home. I would be surprised if she did. I would either pick her up or instruct her to take a cab if that situation ever came up again.

Some would be reflective:

1. If he ever found himself in a spot like that I would certainly hope he'd phone or take a taxi. I guess we're not that good an example because we've both driven after drinking a bit.

A count of responses indicated that the majority of parents would punish. Teenagers calling parents for rides home lived with the guarantee of unfavorable outcomes. Yet, by calling home, young people adhere to the law and socially responsible behavior. Rather than appraising a request for a ride home as responsible action, parents usually interpreted it as proof of bad behavior such as drinking, partying, or hanging around with a bad crowd. As a result, punishment! Hence, the teenager's rule of taking risks to avoid certain punishment was based on reasonable commonsense assumptions.

Nearly all students interviewed in small groups related that they had been intoxicated, some to the point of "falling down" without their parents knowing about it. Further, nearly all teenagers had been exposed to impaired driving as passengers, generally in the process of getting a ride home after a party. This was not something they wanted parents to discover. Students defended these actions as, "I'm an experienced drinker and know my limits," "If I didn't get my parents' car home I'd be in deep trouble," "I'd better get home on time or else I'd be in real trouble," "There is no other way to get home (parties in distant municipalities)," and "Many of my friends have driven home with no problem."

From a provincial perspective, questionnaire findings showed that 70% of the young respondents agreed that parents "should accept the fact that young people drink alcohol before they are legally allowed." Further chi square analysis by gender illustrated that more boys (75%) than girls (65%) agreed.

The obtained chi square = 28.77, degrees of freedom, 4, was significant at better than the .001 level (p = .000). By grade, more grade eleven respondents (77%) agreed than did grade twelve (68%) or grade ten students (67%). The obtained chi square was significant at better than the .01 level (p = .0059).

DISCUSSION

While the data gathered in the Umwelt perspective provided a topographical description of relevant themes, the Lebenswelt descriptions resulted in everyday accounts of behavior much of which led to involvement in accident statistics. Of interest is that: (1) young drivers portrayed themselves as cautious, (2) their definition of caution was not related to their definition of the accidents, (3) in-car actions such as talking to passengers and listening to music just before the crash were not originally considered as factors for the accidents (4) responsibility for the accidents was assigned to the other drivers and (5) good driving meant tackling fearful driving situations and making it appear as competence.

Partying, after which much driving is done, particularly in grade ten, is influenced by social acceptance, site, and age. Needing to be accepted by older students, growing out of grade nine activities, and experiencing a lack of community organized events for teenagers, contributes to increased partying and alcohol consumption. In grade twelve, partying, drinking, and drinking and driving tends to decrease, because older students (17 to 18 years old) are more inclined to "monitor" their drinking, study for examinations, work part-time, or go steady with a partner.

Deciding to expose themselves to impaired driving may be seen as a strategy young people employ to accomplish the concealment of information that might erode parents' view of them as good children. As a routine of social order, young people suspend the knowledge of the dangers of drinking and driving, and prefer to take the <u>risk</u> of an unfavorable outcome. Not doing so <u>guarantees</u> parental punishment.

"Getting home" after a party was a prominent document of students' conformity. Getting home without the car attenuates the likelihood that parents will discover young people's deviant engagements. Asking for parental assistance to get home introduces certain consequences such as future restriction on associates, denial of access to car, or the levy of curfews.

Parental responses verify students' claims. Most parents will punish their children when or if they ask for help to get home after consuming alcohol. Although students could make appropriate legal and social decisions about drinking and driving, they will still be punished for drinking liquor. On a rational basis students make the wrong decisions for what they perceive to be the right reasons.

CONCLUSION

Young driver research left entirely to statistical analysis within the hypothetico-deductive domain brings with it dangers of telelogical definitions whereby young driver behavior is characterized as a phenomenon comprised of natural processes inherent in age, psychological characterization or epidemiological design. This leaves little interest for discovering young drivers' perceptions of realities and how these perceptions relate to behavior.

It should be stressed that young drivers' interpretations of the "Lebenswelt" are social constructs and are not merely idiosyncratic beliefs. The validity of their orientations is not of primary concern. Rather, attention should be paid on how their views influence behaviors that may result in traffic misfortune.

The complementarity approach to young drivers is intended to give credence to the inside (Lebenswelt) as it relates to the outside (Umwelt). The combined information provides a holistic portrayal of the group. A football coach is quick to point out that many elements are necessary for the team to be successful. To arrive at better statistical achievements (win and loss records) the coach must understand, motivate, direct and quantify. However, before he can successfully direct new strategies and quantify statistical improvements he wants to know players' commitments to the game, their willingness to work with other players, their lifestyles, expectations, feelings of confidence, levels of skill and natural game intelligence. So it is with young drivers. Before intervention strategies are produced to decrease the number of accidents, the researchers and educators need to understand young drivers' perceptions, normative actions, relationships, interpretations, beliefs, social influences and biographies. Complementarity was developed to enhance this goal.

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RISK EVALUATION

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The research for risk factors and quantitative evaluation of their significance is the basis of road safety action. It calls for the identification of factors that typify vehicle-driver-environment groups presenting abnormally high risks. These may be evaluated in different ways, each one having features that must be identified. The present study concentrates on the etiological concept of risk, i.e. that which expresses a causal relationship; the risk will be evaluated by means of two different measures of risk exposure: distance travelled and driving-time in order to highlight the consequences of choosing a particular measurement, and the effect of the driving speed. We will show, through the analysis of the speed of young drivers and male drivers that different interpretations appear, according to how deeply we go into the detail of the data used.

1- MEASURES OF ETIOLOGICAL RISK

Risk can be expressed in a probabilistic or etiological form. The probabilistic risk is an accident rate. It is an individual average risk defined for a vehicle-driver group as the number of involvements in accidents of that group, divided by the corresponding exposure value for the same group. Involvement in an accident and exposure to risk can be considered in terms of the various "driver-vehicle-environment" combinations which exist whatever the whereabouts of the network or period considered. This accident rate varies according to the definitions selected for exposure to risk. In studies of road safety, exposure to the risk of a road traffic accident is usually defined in terms of the number of vehicle-kilometres travelled.

Observation of a high average accident rate requires special studies for closer evaluation of the part played by certain factors presumed to be contributory. These are risk studies. Having established statistically that the relationship between accident occurrence and the presence of one or more variables cannot be attributed to chance, the logic of that relationship may then be analysed ; this brings causal reasoning into play - as a complement to statistical analysis - thereby indicating as a cause, or rather probable contributory factor, such and such a variable or combination of variables. Then we consider the growth of average individual risk, more or less attributable to a particular factor that is supposed to be the cause of the growth, thereby accounting for the etiological concept of risk which may be expressed in terms of the relative risk or fraction of attributable risk.

1.1 Relative risk

This is the ratio of average accident rate in a population concerned by the contributory factor under study to the average accident rate in a population not concerned by that factor.

In other words :

P_1 : total number of drivers concerned by the factor being studied,

P_2 : total number of drivers not concerned by this factor,

A_1 and A_2 : number involved in accidents respectively in populations P_1 and P_2,

A : total number of involved in accidents,

a_1 and a_2 : the corresponding percentages, calculated in proportion to the total number of accident involved, A

E_1 and E_2 : measure of exposure to risk of the two populations,

E : global measurement of exposure to risk of the two populations as a whole,

e_1 and e_2 : corresponding percentages in proportion to E,

A and E should correspond to the same period and network.

The average accident rate among drivers featuring the factor under study is : $\frac{A_1}{E_1} = \frac{a_1}{e_1} * \frac{A}{E}$

The average accident rate among other drivers is $\frac{A_2}{E_2} = \frac{a_2}{e_2} * \frac{A}{E}$

The total number of involved in accidents, A, is generally well known, but the total measure of risk exposure, E, is more difficult to estimate. The relative risk, r, eliminates these terms:

$$r = \frac{\frac{A_1}{E_1}}{\frac{A_2}{E_2}} = \frac{a_1}{e_1} * \frac{e_2}{a_2}$$

This relative risk uses population P_2 as a reference population. If the total number of vehicles-drivers on the road is used as a reference population, the relative risk for population P_1 would be : $\frac{a_1}{e_1}$.

1.2 Attributable risk fraction

The attributable risk, AR, is the part of the global risk that can be linked solely to the factor under study and not to the others. It is defined as the difference between the accident rate in populations P_1 and P_2 :

$$AR = \frac{A_1}{E_1} - \frac{A_2}{E_2} = \frac{A}{E} * \left(\frac{a_1}{e_1} - \frac{a_2}{e_2}\right)$$

This indicator is difficult to obtain insofar as it includes total values of involved in accidents and exposure, A and E, in the population as a whole. It means that vehicles-drivers are characterized by a whole variety of factors other than the one under study. Thus if the average accident rate in population P_2 is $\frac{A_2}{E_2}$, we regard this part of the accident rate in population P_1 as being due to the other factors. Only the difference can be attributed to the factor under study. Accordingly, the result of the calculation is a real rate.

In most cases the attributable risk can only be calculated by means of rough estimates of the total values of accidents and exposure, A and E. It is preferable therefore to use the concept of attributable risk fraction, f, which is the ratio of the attributable risk to the average individual risk in the population featuring that factor.

This gives a part of the global risk of the considered group, that can be attributed to the factor under study :

$$f = \frac{\frac{A_1}{E_1} - \frac{A_2}{E_2}}{\frac{A_1}{E_1}} = 1 - \frac{a_2}{e_2} * \frac{e_1}{a_1} \quad \text{or} \quad f = 1 - \frac{1}{r}$$

The same result can be obtained by using another approach : if the effect of the factor under study could be controlled, the average accident rate of drivers in population P_1 would become the same as the rate of drivers in population P_2.

$$\frac{A_1}{E_1} \text{ would become } \frac{A'_1}{E_1} = \frac{A_2}{E_2} \quad \text{i.e.} \quad \frac{a'_1}{e_1} = \frac{a_2}{e_2}$$

A'_1 being the number of accidents in population P_1 when the factor has been controlled.

The relative reduction in accidents would become :

$$\frac{A_1 - A'_1}{A_1} \quad \text{i.e.} \quad 1 - (\frac{A_2}{A_1} * \frac{E_1}{E_2})$$

which may be written : $1 - (\frac{a_2}{a_1} * \frac{e_1}{e_2}) = 1 - \frac{1}{r}$

giving once again the attributable risk fraction, f.

The etiological concept of risk therefore provides far more information than simply calculating an average accident rate. It makes it possible to quantify the effect of a cause and to draw conclusions from it.

There follows an illustration of these risk evaluations by means of an example taking account of the various age groups and sex of drivers of light vehicles. Two different measurements of exposure to risk of a road traffic accident are used in making these estimates : distance travelled and duration of driving-time.

2. DATA UTILIZED

Data utilized in evaluating risks are drawn from two sources :

- For accidents, the results of data records of overall accident figures at national level have been used. These records have been built up from 1/25th of all reports of accidents involving casualties in France en 1982. Approximately 9000 accidents were processed.

- For risk exposure, use has been made of the findings of the travel diaries transport survey carried out by the National Institute of Statistics and Economic Studies (INSEE) in 1981-82. Travel diaries were distributed to a sample of 3000 vehicles representative of the total number of private vehicles. The driver was asked to fill them in, noting every trip made by the car in 7 days (with details such as motivation for trip, time of departure and arrival, distance, number of persons carried, identity of driver, etc.). The survey was done in four stages in order to avoid seasonal repercussions. However, the long holiday period, i.e. July and August, was not represented ; data collected in the course of the survey were compared with those of accidents occuring in 1982 outside the long holiday period. The sample consists of 51 188 trips averaging 9.9 km in length and 16.5 min. in duration, i.e. approximately 500 000 km in 14 000 hours of driving. The average driving speed is about 36.1 km/h

3. ASSESSMENT OF ETIOLOGICAL RISK ACCORDING TO AGE AND SEX OF DRIVERS

Prior to making an assessment of risk exposure, it is important to indicate the measurement selected to calculate risk exposure. In road safety studies, risk exposure is generally defined in terms of the number of vehicle-kilometres travelled; however, other measures may be used : duration of driving-time, traffic density, number of vehicles registered, number of driving licences issued, petrol consumption, etc. Risk is calculated here by measuring exposure by means of kilometres travelled, on the one hand, and length of driving time on the other. This highlights the effect of the type of measurement employed.

3.1 Accident risk per kilometre travelled

Thus data relating to accidents and kilometres travelled represent the total number of drivers of light vehicles in 1982, excluding July and August.

Table 1 indicates the population involved in accidents:

	men	women	total
18 to 19 yrs	4,1%	1,0 %	5,1 %
20 to 24 yrs	16,5 %	5,0 %	21,5 %
25 to 29 yrs	12,1 %	3,9 %	16,0 %
30 to 39 yrs	17,8 %	7,0 %	24,8 %
40 to 49 yrs	10,7 %	3,5 %	14,2 %
50 to 59 yrs	8,6 %	2,3 %	10,9 %
60 to 69 yrs	3,6 %	0,8 %	4,4 %
70 yrs and over	2,6 %	0,5 %	3,1 %
total	76 %	24 %	100 %

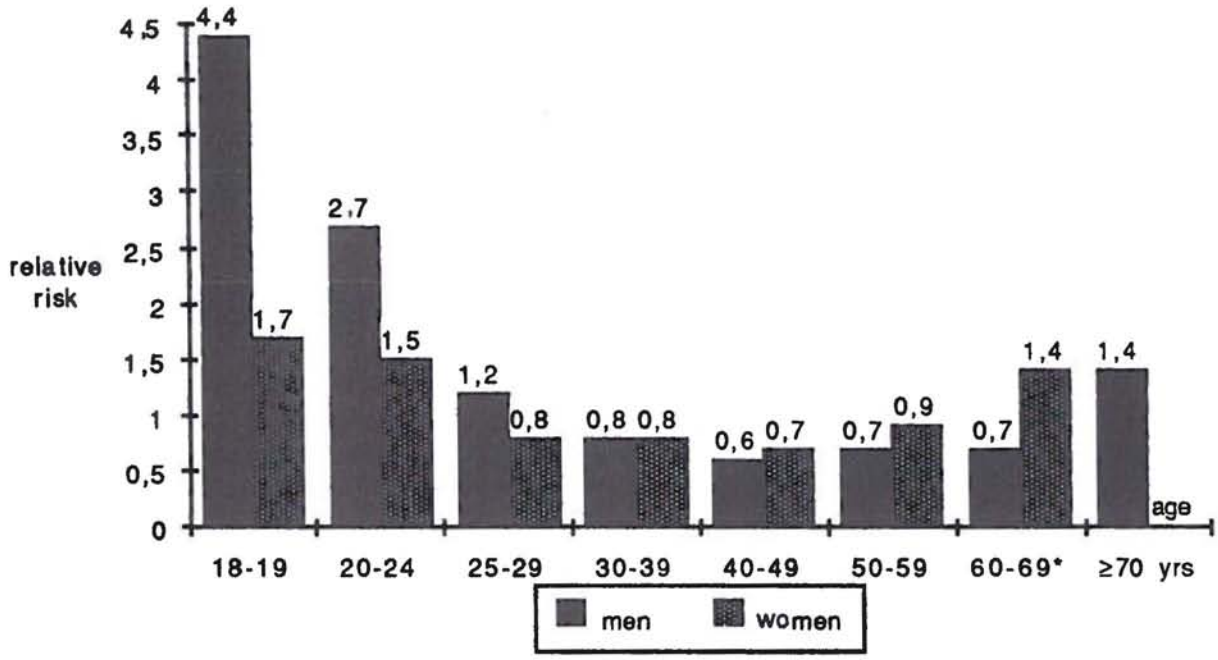
Table 1 : Distribution of involved in accidents by age and sex

Table 2 indicates the population of road-users, according to distance covered:

	men	women	total
18 to 19 yrs	1,0 %	0,6 %	1,6 %
20 to 24 yrs	6,8 %	3,4 %	10,2 %
25 to 29 yrs	10,2 %	5,0 %	15,2 %
30 to 39 yrs	21,5 %	8,3 %	29,8 %
40 to 49 yrs	15,8 %	5,1 %	20,9 %
50 to 59 yrs	11,9 %	2,6 %	14,5 %
60 to 69 yrs	5,1 %	0,4 %	5,5 %
70 yrs and over	1,9 %	0,4 %	2,3 %
total	74,2 %	25,8 %	100 %

Table 2 : Distribution of kilometres travelled according to age and sex of drivers of light vehicles

With these data, it is possible to calculate the relative risk of an age and sex group using as reference either other drivers, i.e. those not belonging to that group, or the total number of drivers. In the former case, the risks are more clearly differentiated. The results obtained are given in the following histogram :



* In view of the insufficient number of women-drivers over 70 years of age, the two final categories have been grouped in their favour.

Figure 1 : Relative risk of accident per kilometre covered as compared to drivers not in the group.

If we now consider the attributable risk, i.e. the risk linked specifically to a particular factor, the attributable risk fraction in the considered group can be calculated :

$$f = 1 - \frac{1}{r}$$

This enables us to grade high-risk groups taking account of the factors under consideration. Attributable risk fraction for age and sex in each group:

men aged 18 to 19 yrs:	f = 78 %
men aged 20 to 24 yrs:	f = 63 %
women aged 18 to 19 yrs:	f = 41 %
women aged 20 to 24 yrs:	f = 34 %
women over 60 yrs of age:	f = 31 %
men over 70 yrs of age:	f = 30 %
men aged 25 to 29 yrs:	f = 17 %

In the group of men aged 18 to 19 years, age and sex have high effects on the risk of accident per distance travelled. The attributable fraction of 78 % means that if this group of drivers had the same behaviour on the road as the other drivers not belonging to the group, their rate of involvement in accidents per kilometre would decrease by 78 %.

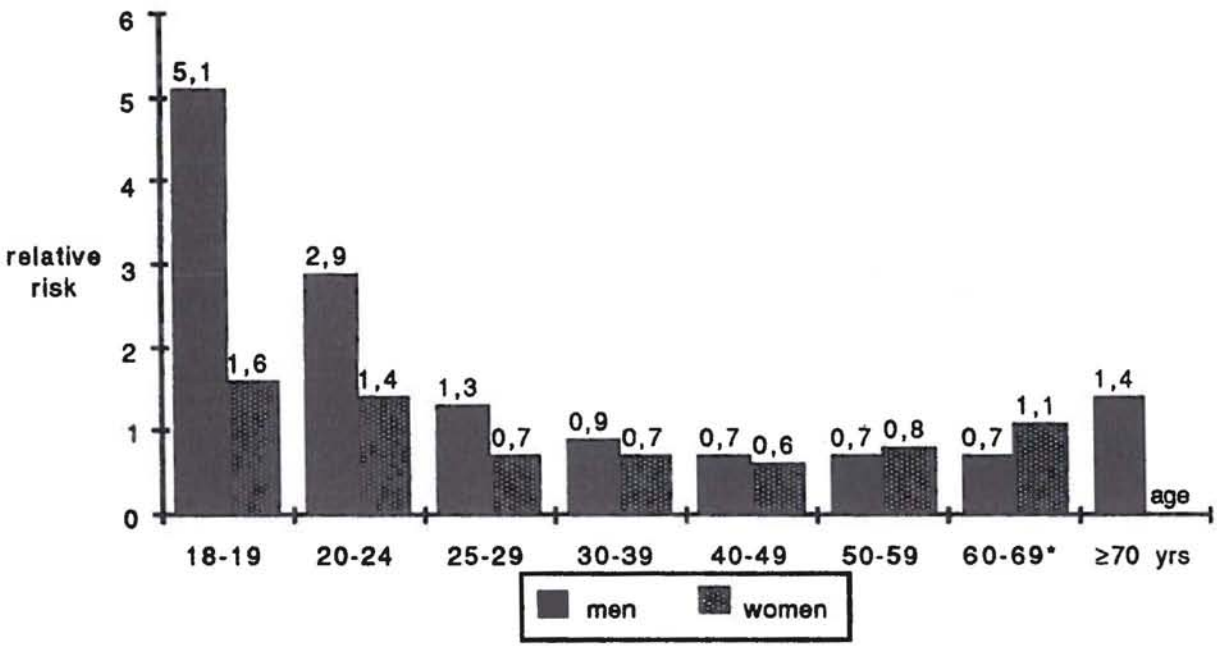
3.2 Risk of accident per unit of driving-time

The same calculations can be made using duration of exposure on the road, taking account of any stops at traffic lights, pedestrian crossings, etc. that may intervene.

	men	women	total
18 to 19 yrs	0,8 %	0,7 %	1,5 %
20 to 24 yrs	6,5 %	3,6 %	10,1 %
25 to 29 yrs	9,6 %	5,3 %	14,9 %
30 to 39 yrs	20,0 %	10,1 %	30,1 %
40 to 49 yrs	14,9 %	5,9 %	20,8 %
50 to 59 yrs	11,7 %	3,0 %	14,7 %
60 to 69 yrs	5,0 %	0,6 %	5,6 %
70 yrs and over	1,8 %	0,5 %	2,3 %
total	70,3 %	29,7 %	100 %

Table 3 : Distribution of driving hours by age and sex of drivers of light vehicles

The relative risk in each age and sex group has been calculated using as reference other drivers not belonging to the group, as illustrated in the histogram in Figure 2 :



* The two final categories are grouped in favour of women drivers

Figure 2 : Relative risk of accident per unit of driving time

Young men represent the highest risk group according to both exposure measures, and the shape of both histograms are fairly similar. Attributable risk fraction for age and sex in each group is as follows :

men aged 18 to 19 yrs:	f = 80 %
men aged 20 to 24 yrs:	f = 65 %
women aged 18 to 19 yrs:	f = 36 %
women aged 20 to 24 yrs:	f = 30 %
men over 70 yrs of age:	f = 30 %
men aged 25 to 29 yrs:	f = 24 %
women over 60 yrs of age:	f = 10 %

The groups with the highest attributable risk fraction are the same according to both measures. If men aged 18 to 19 years behaved like other drivers on the road, their accident rate per unit of driving time would fall by 80 %. For the group of male drivers aged 25 to 29 years, or the one of female driver over 60 years of age, the attributable risk percent is modify according to the measure of risk exposure.

3.3 Comparison of the two risk-exposure estimates and analysis of the speed as an underlying contributory factor

These two risk-exposure estimates are linked by the average driving time, i.e. r_k, the relative risk per kilometre in population P_1 compared to population P_2, and i.e. r_t, the relative risk per unit of time in population P_1 compared to population P_2

Thus: $r_k = \frac{a1}{k1} * \frac{k2}{a2}$ and $r_t = \frac{a1}{t1} * \frac{t2}{a2}$

where:

k1 and k2 indicate the distances in kilometres travelled respectively by populations P_1 and P_2,

t_1 and t_2 indicate the parts of driving time in those populations

v_1 and v_2 indicate the average driving speeds of the two populations

The two risk indicators are linked by the relationship :

$$r_k = r_t * \frac{v2}{v1}$$

If v_2 is less than v_1, the relative risk per kilometre in P_1 as compared to P_2 is less than that calculated per unit of time. If the two populations have the same average driving speed, the two risk indicators are equal. The attributable risk fractions progress in the same way as the relative risk. For example the attributable fraction for age and sex in the group of female drivers over 60 years of age decrease of one third and the fraction in the group of male drivers aged 25 to 29 years increase according to the measure of risk exposure; because the average driving speed of female drivers over 60 years of age is 28 km/h and the speed of male drivers aged 25 to 29 years is 39 km/h (average speed for the total population is 36,1 km/h).

We must go further in the analysis of driving speed, if we want to highlight possible contributory factor. We shall compare in our example, on the one hand, the situation of male and female drivers and, on the other, that of drivers under and over 25 years of age.

Calculations made from our data give the following results :

-Male drivers have a risk of accident per distance travelled 1,10 higher than risk of female drivers. They have a risk of accident per driving time 1,34 higher than the risk of female drivers, that is 22 % up.And men have a higher average driving speed than women (38 km/h for men as against 31 km/h for women).

-Drivers under 25 years have a risk of accident per distance travelled 2,6 higher than the risk of drivers over 25 years. The risk of accident per driving time is 2,76 higher than the risk of the drivers over 25 years. The results in this case are relatively close (6 % up) because the average driving speeds are fairly similar (37 km/h in those under, and 36 km/h in those over, 25 years of age).

A superficial conclusion could be drawn to the effect that speed is not a contributory factor in risk among young drivers. The reality, however, is rather more complex. If we analyse speed in terms of journeys of equal length rather than globally, the results are quite different.

Taken all in all, average driving speed is faster for male than for female drivers, although differences in speed are far less marked in journeys of equal length, as can be seen in Figure 3 :

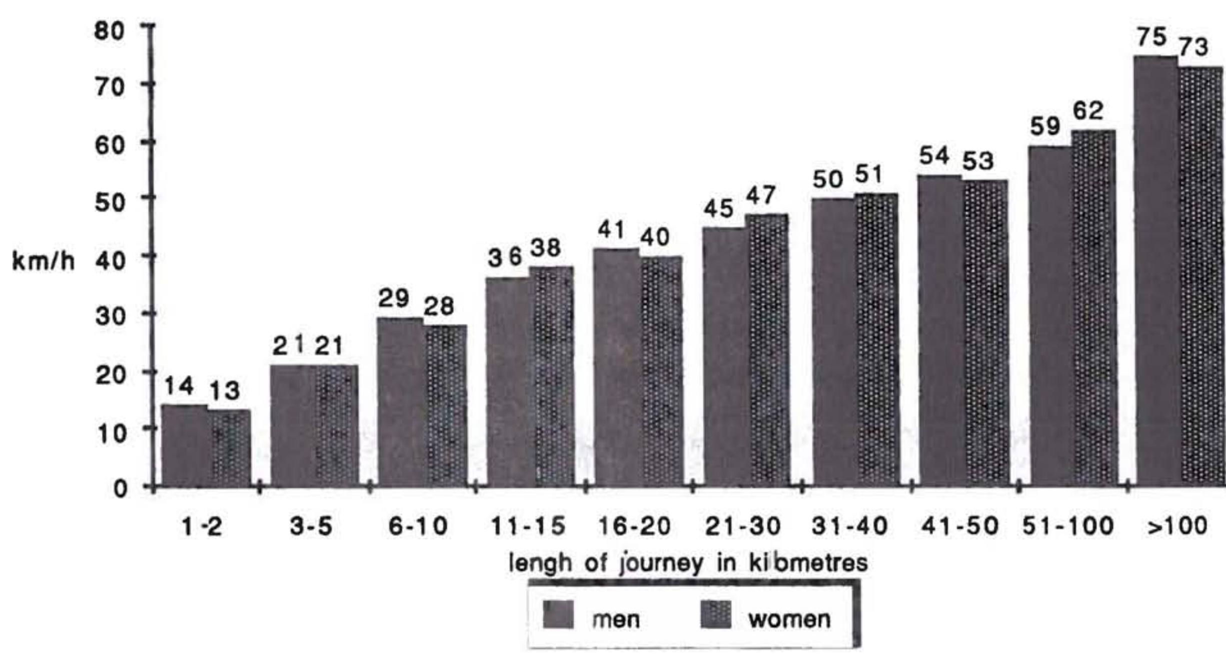


Figure 3 : Average driving speed according to length of journey in kilometres.

The overall result is due to the fact that women drivers make considerably more short journeys : 65 % of all their journeys are less than 6 km in length, representing 21,9 % of the total distance they cover. And only 1,3 % of all their journeys are more than 50 km in length. On the other hand, 53,6 % of journeys made by male drivers are less than 6 km in length, amounting to 12,8% of their driving. And 3,3 % of their journeys are more of 50 km in length.

The average driving speed of drivers under 25 years, taken as a whole, is nearly the same as that of older drivers. However, for journeys of equal length, there is greater differentiation of speed:

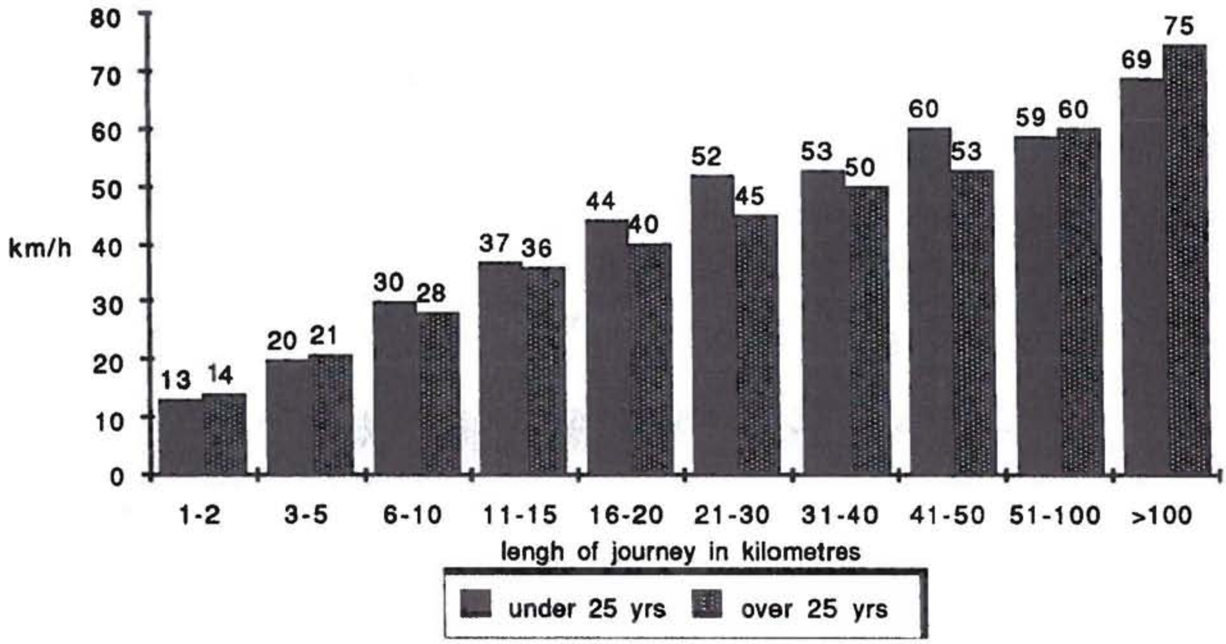


Figure 4 : Average driving speed according to length of journey :

Average driving speed is greater among young drivers for distances under 50 km, representing 76 % of their total distance. It is less for longer journeys. The vehicle power has greater impact than the age for long journeys. With our data we cannot know the actual horsepower, but we can approach it with the treasury rating. The average engine rating of vehicles used by drivers over 25 years is greater (6,3 horsepower) than that of cars used by drivers below that age (5,6 horsepower). Young drivers use all the power of their vehicle.

It is clear therefore that the study should be carried further, to include in particular analysis per journey of similar type. Unfortunately, the corresponding data on accidents are not available.

4. CONCLUSION

Quantitative risk estimates are essential if safety measures are to be evaluated or high-risk groups identified. Such evaluations should be used with caution, however:

-We saw that speed seemed, in a first step, not being a possible contributory factor of risk: young drivers have a high risk and their average driving speed is nearly the same as that of older drivers (37 km/h and 36 km/h). Male drivers have a risk lightly above than that of female drivers and their speed is greater (38 km/h for male drivers and 31 km/h for female). But the analysis of the driving speed according to the distance travelled, shows different behaviour: young drivers drive at speed as much as their car can do it; male and female drive at the same speed as journeys have the same length. These different behaviours have to be taken into account in risk analysis.

- Grading of high-risk groups depends on the measurement used to denote risk exposure. In the example used in the present document, the hierarchy of groups of risk-prone drivers changes little between distance covered and driving-time, since average speeds are fairly similar. The result could, however, be quite different if risk were compared according to type (e.g. two-wheel and light vehicles).

- The attributable risk fraction makes it possible to quantify the effect of a factor and gives an estimate of the reduction in accident rate in populations concerned by that factor, whenever it is possible to control this (this may be the case if a dangerous type of infrastructure is modified, for instance). However, any such change in a factor disrupts the 'system' to which it belongs as well as any interactions between it and other factors. The assumption that everything else remains the same is not generally confirmed.

- A link between a factor and a high accident rate is not sufficient to affirm a definite causal relationship. The factor under study may simply be developing in the same way as another contributory factor.

Quantitative risk evaluation is essential although it has a number of shortcomings. Accordingly, it should be possible to compare various approaches to the matter of risk in order to confirm the relevance of relationships that are identified.

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