MACRO-LEVEL EVALUATION OF ROAD SAFETY IMPROVEMENT INTERVENTIONS: AN EVALUATION OF THE ARRIVE ALIVE 1 (1997/98) ROAD SAFETY CAMPAIGN

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MAKRO-VLAK EVALUERING VAN VERKEERSVEILIGHEIDSVERBETERINGS-PROGRAMME: 'n EVALUERING VAN DIE ARRIVE ALIVE 1 (1997/98) VERKEERSVEILIGHEIDSVELDTOG

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DISSERTATION SUMMARY

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700 000 people die annually in road traffic accidents around the world and road traffic safety interventions are implemented annually across the world. Macro-level evaluation is necessary to ensure financial accountability and clarification that the intervention improved road safety. The study identified two categories of indicators that can be utilised, namely quantitative (evaluating accident data using, for example, statistical analysis and also other methods) and qualitative indicators like the human factor (this includes aspects such as behaviour, attitudes, perception, etc.). The study found that the statistical analysis and trend analysis of macro-level accident data is problematic as changes and predictability is statistically non-significant. The evaluation of human factors was identified as a possible alternative and complementary indicator of the effectiveness of road traffic safety improvement interventions. The aspects relevant to road safety improvements with regard to behavioural changes were investigated. The study found that there is a number of criteria that can be used to measure the input (e.g. communication, publications, the media etc.) and output-related aspects of the human factor (e.g. changes in behaviour, attitudes, motivation, risk, skills etc.). A list of these indicators were generated based on the study of aspects related to behavioural change and a preliminary evaluation of the Arrive Alive 1 was made. The study recommends that a measure of exposure be developed that will allow for the utilisation of macro-level accident data in the evaluation process and that the human factor also be included in the macro-level evaluation of road safety improvement interventions.

SAMEVATTING VAN VERHANDELING

MAKROVLAK DIE EVALUERING VAN VERKEERSVEILIGHEIDSVERBETERINGSPROGRAMME: 'n EVALUERING VAN DIE ARRIVE ALIVE I (1997/98) PADVEILIGHEIDSVELDTOG

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Jaarliks sterf 700 000 mense in padverkeersongelukke in die wêreld. Verkeersveiligheidsverbeteringsprogramme word jaarliks regoor die wêreld geimplementeer. Makrovlak evaluering van verkeersveiligheidsverbeteringsprogramme is noodsaaklik vir finansiële toerekenbaarheid en om te verseker dat die program wel verkeersveiligheid verbeter het. Die studie het twee kategorieë aanwysers geïdentifiseer wat gebruik kan word in die evalueringsproses, naamlik: kwalitatiewe en kwantitatiewe aanwysers. Kwantitatiewe aanwysers verwys na byvoorbeeld die analise van ongeluksdata met statistiese analise metodes en kwalitatiewe aanwysers verwys na die menslike faktor wat aspekte soos gedrag, houding, persepsies ens. insluit. Die studie het gevind dat statistiese en tendens-analise van makrovlak ongeluksdata problematies is aangesien die veranderinge en voorspelbaarheid daarvan nie statisties betekenisvol is nie. Die evaluering van die menslike faktor is geïdentifiseer as 'n alternatiewe en komplimentêre maatstaf vir die evaluering van verkeersveiligheidsverbeteringsprogramme. Die aspekte wat met gedragsveranderinge tydens en na verkeersveiligheidsverbeteringsprogramme verband hou, is bestudeer. Die studie het gevind dat 'n aantal kriteria gebruik kan word om die in-en uitset van die menslike faktor te meet. Die inset kriteria verwys na byvoorbeeld kommunikasie, publikasies, die media ens en uitset kriteria verwys na veranderinge in gedrag, houding, motivering, risko, vaardighede ens. 'n Lys van hierdie kriteria is ontwikkel gebaseer op die studie oor faktore wat gedragsveranderinge beinvloed en daarmee verband hou. 'n Voorlopige evaluering van die Arrive Alive 1 veldtog is ook gedoen. Die studie beveel aan dat 'n maatstaf vir blootstelling ontwikkel word wat die gebruik van makro-vlak ongeluksdata in die evaluering van verkeersveiligheidsprogramme sal moontlik maak. Die studie beveel ook aan dat die menslike faktor ingesluit word in die makrovlak evaluering van verkeersveiligheidsverbeteringsprogramme.

ABSTRACT

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Road traffic safety improvement interventions[1] are planned and executed with two basic objectives in mind, namely reducing the number and severity of road traffic accidents. Road traffic safety improvement interventions normally include three elements: engineering, education and enforcement. Large amounts of money are used for these interventions. The evaluation thereof is essential to ensure that the public receives the full benefit of the limited available budget. Evaluation of improvement interventions are normally done through an objective analysis of one or more of the dimensions of the road safety problem. This involves statistical analysis of accidents or critical offence monitoring.

Behavioural science offers a wide range of opportunities to increase an understanding in the field of road safety. Among others, Glendon (1987) lists three main areas:

- mental processes/ cognition – e.g. risk perception, learning and development, hazard perception and labelling, attributing responsibility, cause and blame;
- behaviour – e.g. accident causation, responding to hazards, making and correcting errors;
- environment – e.g. valid indicators of risk exposure, training, education, communication, responding to hazards.

1.2 OBJECTIVES OF THE STUDY

The study was aimed at providing a framework for the evaluation of road safety improvement interventions. It investigated the various elements that should be included in the evaluation of a road safety improvement intervention. The framework provides a discussion of the various elements and methodologies that can be followed in the evaluation of a road safety improvement intervention.

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[1] A road safety improvement intervention includes road safety campaigns, changes in legislation, or for example, the AARTO Bill.

The study also includes an evaluation of aspects of the Arrive Alive 1 to illustrate the different elements in the evaluation of a road safety improvement intervention.

The objectives of the study are:

- a literature study on the evaluation of elements of road safety improvement interventions;
- a contextualisation of the road safety status of South Africa in the international scene;
- a framework for the evaluation of road safety improvement interventions;
- an evaluation of certain elements of the Arrive Alive 1 road safety improvement intervention to illustrate the proposed framework.

1.3 SCOPE OF THE STUDY

The study is limited to the preparation of a framework for the macro-level evaluation of road safety interventions and a preliminary evaluation of some of the elements of the ARRIVE ALIVE 1 campaign (1 October 1997 to 31 January 1998), by taking accident history (where available) from as early as 1994 into consideration. Macro-level evaluation refers to the evaluation of an intervention in an area, i.e. not at a location or on a specific route. Road safety improvement intervention refers to any action (campaign, legislation, programs etc) that is aimed at improving road traffic safety in an area. The area can, for example, be a country, a province or a metropolitan area.

On a national level, the accident history from as early as 1938 is utilised. Monthly data for 1999 is not included in the study as the delay period for obtaining reasonable accident data is at least one year, measured from January of the following year.

Data from Statistics SA (formerly the Central Statistical Service) is utilised for the evaluation on national and provincial levels. An evaluation on metropolitan level including a selection of worst routes and worst locations is based on data from the Durban Metro. The Durban Metro expends significant amounts of manpower and resources on checking the accuracy of accident reports and provides more accurate data than normal accident databases that only capture data as provided on the SAPS 352 accident reports.

Law enforcement data for the ARRIVE ALIVE 1 period was found not appropriate to evaluate offence levels. The extent of law enforcement actions during the Arrive Alive 1 campaign was obtained from an official report on the Arrive Alive 1 road safety campaign included in the literature study on the campaign.

1.4 METHODOLOGY

A literature study was done on the development of road safety approaches, road safety improvement interventions and the evaluation of elements of road safety improvement interventions.

A framework was then developed for the evaluation of road safety improvement interventions.

Monthly and annual accident data were analysed at national level, for Gauteng, Western Cape, KwaZulu-Natal, for the Durban Metro area, for a selection of intersections in Durban and for a number of major routes in the Durban Metro area. Certain elements of the ARRIVE ALIVE 1 campaign were evaluated to illustrate outcomes of the campaign and the result of different evaluation methodologies.

1.5 PROBLEM STATEMENT

Road traffic safety is an important health and society issue. The costs of road traffic accidents are high and the public demands improvement. The evaluation of the efficiency of road safety improvement interventions are difficult due to a number of factors like poor data and complex techniques – some questionable. A framework for the evaluation of road safety improvement interventions is required to enable the evaluation of the different dimensions. The framework for such an evaluation process includes the evaluation of existing methods and perceptions. Such a framework will enable the monitoring of interventions for improvement in the design of the intervention and also the data requirements for the evaluation process.

1.6 ORGANISATION OF THE REPORT

Chapter 1 is an introduction to the study.

Chapter 2 discusses the road safety problem and illustrates the need for road traffic safety improvement interventions.

Chapter 3 describes the principles of road safety improvement interventions.

Chapter 4 discusses the international approaches to road safety.

Chapter 5 discusses the ARRIVE ALIVE 1 campaign.

Chapter 6 introduces the evaluation of road traffic safety improvement interventions.

Chapter 7 introduces accident analysis as a measure in the evaluation of road traffic safety improvement interventions.

Chapter 8 describes the statistical analysis of road traffic accident data.

Chapter 9 illustrates the use of accident data analysis with annual data using the annual accident statistics of South Africa.

Chapter 10 illustrates the use of monthly accident data series to evaluate the Arrive Alive 1 road safety campaign.

Chapter 11 introduces and discusses the evaluation of other factors, like human responses, in road traffic safety improvement interventions.

Chapter 12 provides the framework for the evaluation of the human factor in road safety interventions and also illustrates the use of the framework by providing a preliminary evaluation of Arrive Alive 1.

Chapter 13 describes the conclusions and recommendations of the study.

The references and a bibliography are included at the end of the report.

Appendix A: The regression analysis of number of accidents and fuel sales.

Appendix B: The regression analysis of number of accidents and number of registered vehicles.

Appendix C: The graphic representation of monthly accident data series for South Africa, Gauteng, KwaZulu-Natal, Western Cape, the Durban Metro, a selection of worst locations in Durban Metro and a selection of major routes in the Durban Metro area.

Appendix D: The graphical representation of the distribution of driver and passenger ages involved in accidents in the Durban Metro area.

CHAPTER 2: THE ROAD SAFETY PROBLEM

2.1 INTRODUCTION

700 000 people die annually in road traffic accidents around the world (World Highways, January/February 1999). In the USA road traffic accidents is the fifth top leading cause of death (NCHS website 2000).

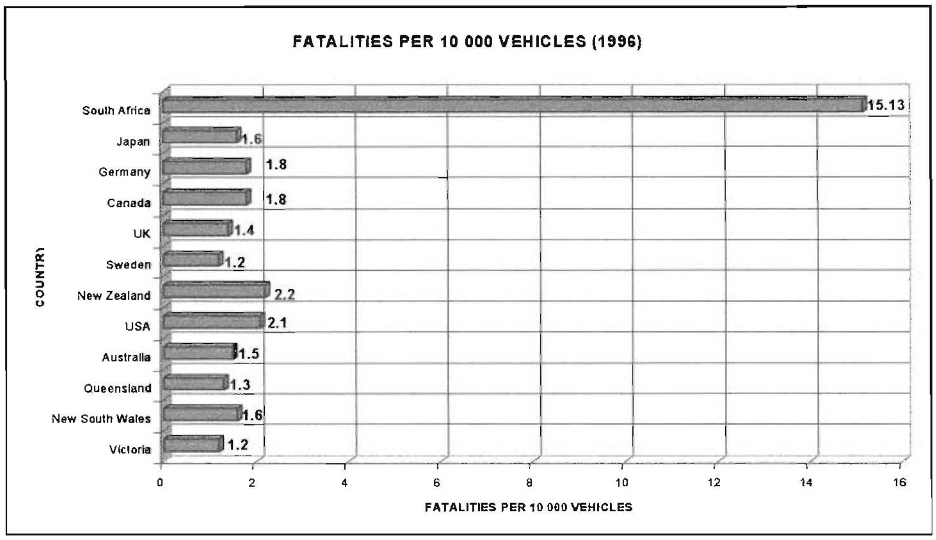
This chapter will highlight the road traffic safety problem in South Africa. Road safety improvement interventions that contribute to the reduction of accidents and/or the severity of accidents can be justified in terms of both human suffering and economic benefits. The chapter shows some of the gains for South Africa to be derived from a reduction in the accident rate and severity.

2.2 THE ROAD SAFETY PROBLEM IN CONTEXT

During 1998, 512 605 accidents were reported on South African roads, resulting in 129 672 people being injured and a further 9 068 dying. Apart from the traumatic social cost of these accidents, the burden on the economy amounted to R 13,5 billion (1998 Rand) (CSS 1999).

2.3 SOUTH AFRICA'S ROAD SAFETY RECORD COMPARED TO OTHER COUNTRIES

Graph 2.1 shows the fatality rates per 10 000 registered vehicles for South Africa compared to other countries in the world. Note that the definitions of fatalities differ from country to country and that this can influence the results. Unfortunately statistics from other African countries or transitional countries in the world are not readily available and are therefore not included in this report.



Graph 2.1: Comparative fatality rate per 10 000 registered vehicles in 1996 (after CSS 1999)

2.4 The Cost of Road Accidents and Potential Savings

The total cost of road traffic accidents in South Africa amounted to R 13,5 billion in 1998 (1998 Rand) (CSS 1999). This cost is based on the severity of accidents:

- fatal degree of injury accident = R 340 337
- serious degree of injury accident = R 89 332
- slight degree of injury accident = R 25 434
- damage only degree of injury accident = R 17 983.

The saving will be proportional to the percentage reduction in accident severity or fatalities (the sum of the individual savings per injury category).

2.5 Attitude towards Road Safety

The attitudes towards road safety can be divided into three main categories, namely:

- the public: the level of road safety on the roads is not acceptable and it is dangerous to travel;
- technical - special task teams are set up after bombing attacks while road traffic deaths generally only receives attention during peak holiday periods or after a series of fatal accidents. Although the associated costs and number of

accidents are high, the probability of death or injury during a trip is as small as 1 in one million per trip (Lay, 1986). It is, however, twenty times less than the chance of death caused by an act of terrorism (Shubik, 1991). The reason for the unwillingness of society to appreciate this is not clear. Wilson (1975) suggested in a study that the number of individuals involved in a single incident is used by society to quantify the risk of an event.

- the public sector

  - national level – Minister Mac Maharaj stated that *we are aware of the critical situation on our roads in which more than 10 000 people are currently killed per annum and close to 50 000 seriously injured of which 40% are pedestrians* (RTMS 1997)

  - the main purpose of the Road Traffic Management Strategy that was accepted by all levels of government *was to reduce road traffic accident fatalities by 10 percent by the year 2000*

  - in the preparation of Moving South Africa (a vision for 2020) the effect of road traffic accidents were seen as a threat to the sustainability of transport: *road safety (is rated) at or near the top of customer needs... road safety imposes enormous costs on society, making the transport system inherently unsustainable... This destabilises the long-term sustainability of transport and depresses usage levels through fear of road safety* (Moving South Africa 1998).

2.6 CONCLUSIONS

The road safety problem in South Africa is serious in terms of cost and suffering. Public sentiment demands attention to the problem and government accepted a Road Traffic Management Strategy geared towards improving road traffic safety in South Africa.

CHAPTER 3: APPROACHES TOWARDS IMPROVING THE ROAD SAFETY PROBLEM

3.1 INTRODUCTION

The purpose of this chapter will describe the views on, approaches to and stages of developments to improve road safety.

3.2 VIEWS ON ROAD TRAFFIC SAFETY IMPROVEMENTS

During the past century, views on addressing the road safety problem have changed significantly. Eight basic views were identified by Haight (1983). In addressing the problem it is important that these views be taken into consideration:

- The Road Safety problem is not curable. A road traffic accident is a consequence of mobility. It is therefore important to keep in mind that accidents cannot be eliminated. We can, however, reduce the consequences thereof. It affects the approach to road safety because it changes the focus: from a problem to be eliminated to a problem that should be managed. This in turn places a responsibility on professionals to develop scientifically sound techniques to ensure that resources spent on safety are effectively and well-spent. The target for road safety problems should therefore be a reduction to acceptable and manageable levels (Evans, 1994).

- The *Blame* or *Causal* approach should be abandoned. It is generally agreed that there are contributing factors in any accident. It is important to realise that the human factor should be closely studied, observing that a human being has limited capabilities, needs information to make decisions, requires time to receive and act upon the information/ make the necessary decision and can make incorrect decisions. In the causal approach the road safety specialist fails to recognise the responsibility of designing the road system for the human being. Provision should be made by designing for the human being and not forcing the human being to fit into the design.

- A road traffic accident is a consequence, not an accident. The concept of blaming an accident on human error gives rise to the thought that a road safety specialist should change the human to prevent the accident. A road safety specialist should rather focus on controlling the consequences of the three phases of an accident: pre-crash (e.g. accident prevention), during-crash (e.g. seatbelts) and post-crash phases (e.g. emergency services). It is also important to realise that a countermeasure normally either reduces the number of accidents or the severity thereof (Ogden, 1996).

- Exposure reduction. By managing the mobility, i.e. the exposure of high risk groups, accident losses can be reduced. This approach is specifically successful with novice drivers.

- Statistical analysis. Scientifically sound analysis - using a sound database and skill in the analysis and interpretation thereof - is required to evaluate whether a program or system is rendering the required benefit or has the necessary effect. The road safety specialist should therefore be aware of the following when attempting statistical analysis:

  - accident databases have limits and shortcomings (e.g. different definitions of fatalities, inaccurate reporting, missing data);

  - the isolation of a single factor from others is problematic as the other factors may also affect the safety;

  - the danger of *regression to the mean.*

- The probability of counter-intuitive outcomes. A road safety improvement intervention based on logical and sensible ideas may not have the effect it was designed to have.

- Evaluation of proposals. Proposals for the improvement of road safety should be evaluated to ensure the selection of only the proposals most likely to be effective.

- Setting intelligent priorities. Road safety projects compete with other programs for already limited budgets. Evaluations should therefore enable authorities to set priorities to select only projects that will reduce the number and severity of accidents and be the most cost-effective (Ogden, 1996).

3.3 Stages in the Historical Development of Road Safety Improvement Interventions

Over the past years, various approaches to road safety were taken. Six basic stages in the historical development of road safety improvement interventions can be identified (Organisation for Economic Cooperation and Development, 1984), namely:

- the Mono-Causal Casuistic Approach;
- the Mono-Causal Accident Proneness Approach;
- the Mono-Causal Chance Phenomenon Approach;
- the Multi-Causal Chance Phenomena Approach;
- the Multi-Causal Static Systems Approach;
- the Multi-Causal Dynamic Systems Approach.

3.4 The Mono-Causal Casuistic Approach

In the mono-causal casuistic approach, every accident is seen as unique and one too many. It is believed that by taking away the cause of the accident, the problem can be solved. This approach does not consider the following:

- by taking away one problem, one may create another;
- there may be more than one solution, i.e. there is not a unique and separate solution to every single accident;
- this approach leads to the attitude of *blaming the victim*.

The main reason for the failure of this approach is the fact that it ignores the interaction between the components of the road system.

3.5 THE MONO-CAUSAL ACCIDENT PRONENESS APPROACH

The mono-causal accident proneness approach refers to the approach where accident-prone drivers are identified and then either kept away from traffic or forced to improve themselves by training and punishment. All previous attempts to identify these accident-prone drivers have failed. A US Department of Transport report (Hulbert 1982) states that *the negligence law usually treats driver error as both avoidable and unreasonable, and imposes liability pursuant to an objective standard to which all drivers are held ... but .. a significant gap exists between the standard of behaviour required by the negligence law and the average behaviour normally exhibited by most drivers*. Hulbert (1982) therefore concludes: *the old concept of the accident prone driver is not supported by the facts.*

3.6 THE MONO-CAUSAL CHANCE PHENOMENON APPROACH

This approach regards accidents as being purely a matter of chance. Accidents can therefore not be prevented, as fate cannot be changed. This approach leads to the development of mechanisms to reduce the severity of accidents, e.g. crashworthy vehicles, break-away supports etc.

3.7 THE MULTI-CAUSAL CHANCE PHENOMENA APPROACH

The multi-causal chance phenomena approach started in the early 1970's. The approach assumes that accidents are the result of a combination of factors or the outcome of a chain of events. The interactions of these factors (human-vehicle-road) are partly random and partly deterministic (i.e. controllable). This gives rise to the development of extensive database systems and statistical techniques to identify the interaction among the portion of factors that are deterministic. This is in essence the current approach followed in road safety.

The biggest drawback of this approach is the fact that the amount of accident related information that can be collected is limited and that the ability to evaluate and model the interaction of all the relevant factors is limited.

The multi-causal static and dynamic systems approaches are refinements of this approach.

3.8 THE MULTI-CAUSAL STATIC SYSTEMS APPROACH

The multi-causal static systems approach is a problem-oriented strategy that focuses on the nature of the problem. It singles out the specific part of the problem and attempts to examine it more closely. The approach led to a number of *in-depth studies* where as much data as possible is collected at the site, about the circumstances of the accident, as well as information from the early stages of the chain of events that led to the accident itself.

This approach fails as it does not take cognisance of the fact that transport and accident processes are dynamic. The data collected is purely *snapshots* and not a *movie*. In every accident, the probability of failure is partly the result of circumstances or actions that preceded it.

3.9 THE MULTI-CAUSAL DYNAMIC SYSTEMS APPROACH

The multi-causal dynamic systems approach attempts to search for *critical lines or sequences through all the processes leading to road trauma* (OECD 1984). It is the most appropriate approach as it is not only problem-oriented and directed at effectiveness like the other multi-causal approaches, but it is also aimed at optimisation, i.e. achieving specific goals and integration, while considering all phases and countermeasures.

The OECD (1984) identified a number of key links that require investigation to operationalise this approach. They are:

- travel needs that create the demand for mobility;
- predisposition, i.e. the factors that increase the risk of travel;
- road user factors such as urgency, fatigue, use of alcohol and/or drugs etc.;
- modal factors such as comfort and access;
- environmental factors such as traffic volumes, characteristics of the road, traffic and weather;
- encounters, i.e. the potentially risky traffic situations of travellers - the outcome of these encounters is determined by:

- road user characteristics such as experience, skills, motivation, risk-taking, etc;

- vehicle characteristics such as manoeuvrability, braking, stability, etc.;

- traffic factors such as volume, stability of flow, intersecting traffic, conflicting manoeuvres, etc.

- incidents, i.e. encounters that require extreme responses by road users (heavy braking, swerving etc.) or those that result in undesirable vehicle behaviour (jack-knifing, skidding, etc.);

- accidents, i.e. incidents that involve a collision. In this case, little discretion is left to the road user at this stage and the outcome of this incident is the result of already established conditions and actions (during the preceeding phases);

- injury and damage, i.e. the consequences of the energy exchange in the accident;

- recuperation, i.e. the attempts to save the life of the accident victim, the physiological and physical recuperation of survivors and the disposal or repair of damaged property.

The systems-oriented approaches lead to significant progress in road safety as they incorporate the essential interactions between the road user, the vehicle and the road system.

3.10 CONCLUSIONS

The views on road safety improvement interventions and the historical development of these interventions form an essential part of the strategic planning of road safety improvement interventions. The multi-causal dynamic systems approach provides opportunity to address the contribution of the road environment, the vehicle and the road user to road traffic accidents in a holistic manner.

CHAPTER 4: INTERNATIONAL PROGRAMS TO IMPROVE ROAD SAFETY

4.1 INTRODUCTION

A number of comprehensive and co-ordinated national road safety strategies were developed by a number of countries; including the Netherlands, the United Kingdom, Australia and New Zealand.

The purpose of this chapter is to discuss the various road safety improvement interventions of different countries across the world and to summarise the similarities in the programs.

4.2 UNITED KINGDOM

In 1987, the Government of the United Kingdom set the target of a 33% reduction in road traffic accidents by the year 2000. In absolute terms, this referred to a reduction of accidents per annum from 320,000 to 220,000. The responsibility of delivering this road safety target mainly lies with local authorities. The Local Authorities Association (1989) published a *Road Safety Code of Good Practice* that outlines the structure of a road safety plan. The seven components of this proposed road safety plan are:

- planning;
- information;
- engineering;
- education and training;
- enforcement;
- encouragement;
- co-ordination of resources.

Road safety plans were implemented across the country and a key element of their success is the fact that they have the *legislative requirement*, i.e. the obligation and authority, to:

- perform a program of measures that is designed to promote road safety;
- perform studies into accidents;
- take the necessary measures to prevent accidents by using the results of the studies of accidents;
- take the necessary measures when constructing new roads, to reduce the possibility of accidents when these roads are opened for traffic;
- perform road safety audits on new road projects.

4.3 AUSTRALIA

The Federal Office of Road Safety (1992) prepared a national strategy with the aim of *reducing road crashes and their human and economic costs in real terms during the 1990's and into the next century*. This gave rise to a number of concerted and disparate road safety actions on federal, state and local government levels. The strategy developed specific goals, the reduction of road fatalities to 10 per 100,000 population by the year 2001 and a corresponding reduction in injury, and specific priorities. In the different States and Territories, a number of complementary road safety strategies were also developed. The national action plan for road safety was also prepared. This plan has 37 specific initiatives across the following eight strategic objectives:

- ownership and participation in road safety by major stakeholders;
- road safety as a major public health issue;
- road safety as a major economic strategy;
- road safety as a priority in land use and transportation management;
- safer vehicles, safer roads and safer road users;
- integrated framework for road safety planning and action;
- strategic research and development program;
- the rationalisation of Federal, State and Territory programs (Ogden 1996).

4.4 UNITED STATES

The 1991 Intermodal Surface Transportation Efficiency act (ISTEA) of the USA states that the States should develop management systems for seven areas related to highways – this includes a safety management system (SMS). ISTEA required the development thereof to be completed by the end of 1994 and fully operational by October 1996. The different areas of a SMS that were identified through various workshops of the FHWA (FHWA 1991b, Zogby 1994, Bray 1993) included:

- the co-ordination and integration of broad base road safety programs into an integrated approach of highway safety management;
- the identification and investigation of hazardous (or potentially hazardous) locations and features and the establishment of countermeasures and priorities to implement it;
- ensuring that safety is considered in all transportation projects and programs;
- the identification of safety needs of specific user groups in the design, planning, construction and operation of the roadway system;
- the routine maintenance and upgrading of safety hardware, roadway elements and operational features.

4.5 SIMILARITIES IN THE INTERNATIONAL APPROACHES

There are a number of similar elements in the safety strategies of the UK, Australia and the United States. They include (Ogden 1996):

- *a "champion" in the form of a specific governmental office or department that is also influential;*
- *establishment of short and long term safety goals;*
- *recognition of institutional and organisational initiatives, with commitment to co-operation at both policy and operational levels;*
- *collection, maintenance and dissemination of data;*

- *development of processes to assess needs, select countermeasures, and set priorities on a rational basis of cost-effectiveness;*
- *development and implementation of public information and education activities;*
- *identification of skills, resources and training needs;*
- *adequate guaranteed funding;*
- *monitoring the effects on safety of implementation;*
- *an on-going adequately-resourced research program.*

The setting of specific targets for accident reduction seems to have a significant effect on the safety gains of road safety projects (Ogden 1996).

These similarities can be used to define key performance indicators for road safety interventions.

4.6 THE SOUTH AFRICAN APPROACH

In July 1996 a Road Traffic Quality and Safety Symposium was held. During the symposium the Road Traffic Management Strategy (RTMS) was formulated based on the resolutions. During 1997 a formal Business Plan based on the RTMS was prepared.

Twenty key steps were identified to achieve a 10% accident reduction by the year 2000 (Business Plan 1997):

- *Provincial-Local Authority Consultation and Co-ordination;*
- *establishment of the Road Traffic Safety Board;*
- *responsibility for Traffic Control and Policing;*
- *professionalism in Traffic Control;*
- *traffic control management model (TRAFMAN);*
- *SOS Highway patrols;*
- *traffic operations monitoring and control centres;*

- *traffic control centres;*
- *incident management;*
- *adjudication of traffic offences;*
- *road traffic legislation;*
- *National Traffic Information System (NaTIS) and credit card size driving licence;*
- *vehicle testing stations;*
- *education and communication;*
- *driver education, training and testing;*
- *road traffic operations management systems;*
- *monitoring and reporting;*
- *research;*
- *financing;*
- *critical offence management programme.*

Short, medium and long term goals and programs were identified. The Arrive Alive 1 forms part of the STIP (Short Term Implementation Program). Refer to Chapter 5 for more information regarding the Arrive Alive 1 campaign.

On 17 March 1998 the Director General of Transport presented a proposal on the creation of a Road Traffic Management Corporation. The following ten areas of responsibility were identified:

- *vehicle registration and licensing;*
- *vehicle roadworthiness and testing stations;*
- *driver licensing;*
- *road safety education and communication;*
- *National Traffic Information System;*

- *traffic law enforcement;*
- *accident reporting;*
- *accident investigation and reconstruction;*
- *administrative adjudication of traffic offences;*
- *road safety audits.*

A study team was appointed by MINCOM (a committee consisting of the National Minister of Transport and the nine MEC's of Transport of the different provinces in South Africa). They had to *examine the status quo in South Africa, to investigate international best practice, to make recommendations for adapting the model based on these findings, to investigate the financial implications of the model and to draft legislation detailing the operation of the proposed Corporation* (Gray 1998).

The study team undertook a study tour to Victoria, Australia, the United States and the Netherlands. They found that those countries had achieved a reduction in fatalities despite a growth in vehicular traffic. This was the *result of dedicated activities over considerable periods of time, linked to a clear co-ordinating strategy.* A model was proposed by the study team and in 1999 the legislation for the Corporation was approved (Gray 1998).

The date of implementation of the Corporation is to be determined.

4.7 CONCLUSIONS

There are similarities among the approaches of the different countries discussed in this chapter. The establishment of the Road Traffic Management Corporation and progress in the 20 functional areas of the Business Plan of the RTMS are developments in South African development aimed at improving road traffic safety in South Africa.

CHAPTER 5: ARRIVE ALIVE 1

5.1 INTRODUCTION

This chapter discusses the Arrive Alive 1 in terms of approach, funding allocation, objectives etc.

5.2 BACKGROUND

The ARRIVE ALIVE 1 Road Safety Campaign forms part of the Road Traffic Management Strategy to reduce the high fatality rate (number of accidents and severity thereof) on South African Roads. The campaign took place from 1 October 1997 to 31 January 1998. Unfortunately, due to a lack of funds, the campaign is not continuous and was only continued in the form of ARRIVE ALIVE 2, 3 and 4 later in 1998 and 1999 (NDoT web-site, 1998, *What's it all about?*).

5.3 PROJECT FOCUS

The ARRIVE ALIVE 1 campaign targeted the main traffic offences that was thought to be contributory factors in accidents through intensive law-enforcement and awareness (communication) programmes (NDoT web-site, 1998, *Closer look*).

The ARRIVE ALIVE project identified four main traffic offences in South Africa that influence road safety (NDoT website, 1998, *Closer look*). They included speeding, drinking-and driving and a lack of vehicle and driver fitness (this includes driving without driving licences, worn tyres, no lights and no brakes).

5.4 OBJECTIVES

The campaign had the following main objectives (NDoT web-site, 1998, *What's it all about?*):

- a reduction in the number of road traffic accidents by 5% compared to the same period of the previous year;
- a reduction in the number of fatalities;

- a reduction in critical offence levels by 5% compared to the same period of the previous year;

- the improvement of the compliance of road users to traffic laws;

- the improvement of the co-operation and relationship between the various levels of government and traffic authorities;

- the targeting of law enforcement actions on speeding and drinking-and driving, with a focus on the wearing of seatbelts over the first campaign period (NDoT web-site, 1998, *Closer Look*).

5.5 FUNDING ALLOCATION

The personnel that participated in ARRIVE ALIVE 1 consisted of almost 7000 personnel from local and provincial traffic authorities. 98% of this personnel was trained traffic officers. 17% of the budget was allocated for overtime as research has shown that 65% of accidents occur outside the normal working hours of a traffic officer.

Table 5.1 summarises the budget for ARRIVE ALIVE 1.

Table 5.1: Funding of ARRIVE ALIVE 1 (NDoT web-site, 1998, *Closer Look*).

DESCRIPTION		AMOUNT (R million)
Equipment	Speed equipment	8,0
	Roadblock Trailers	3,5
	"Booze" Caravans	2,5
	Consumables (film, etc.)	4,0
	Breathalysers	7,2
Overtime		8,3
Communication		6,6
Training and information		9,9
Total		***50,0***

5.6 LAW ENFORCEMENT ACTIONS

A total number of 1,4 million notices were issued for road traffic offences during the ARRIVE ALIVE 1 campaign. Table 5.2 summarises the breakdown percentages of notices issued for the critical road traffic offences.

Table 5.2: Breakdown of notices issued during the ARRIVE ALIVE 1 campaign (NDoT web-site, 1998, *Closer Look*).

CRITICAL OFFENCES (%)	MONTH (1997)			MONTH (1998)
	OCT	NOV	DEC	JAN
Speeding	60,2	65,4	61,4	55,7
Not wearing a seatbelt	10,7	10,8	12,4	8,8
Ignoring road signs	8,4	5,5	5,6	7,2
Vehicles not roadworthy	3,9	5,9	5,5	9,4
Driving without a driving licence	2,8	3,4	3,0	5,3
Drinking-and-driving	0,6	0,5	0,5	0,0
All other	13,4	8,5	11,6	13,6
TOTAL	***100***	***100***	***100***	***100***

5.7 CONCLUSION

The Arrive Alive 1 campaign from 1 October 1997 to 31 January 1998 consisted of intensive law enforcement and publicity campaigns. During the Arrive Alive 1 campaign 3,7% of the total accident cost was used. 13% of the allocated funding were dedicated to communication. Expenditure for the evaluation of the campaign was not available. The provision for evaluation, both in terms of planning and data collection in a road safety improvement intervention is essential.

CHAPTER 6: EVALUATION OF ROAD SAFETY IMPROVEMENT INTERVENTIONS

6.1 INTRODUCTION

Road safety improvement interventions take place annually and the evaluation thereof is essential to determine whether the intervention had the desired result (*AUSTROADS* 1988).

The purpose of this chapter is to describe the need for evaluation and to identify the different elements of the evaluation of road safety improvement interventions.

6.2 THE NEED FOR EVALUATION

AUSTROADS (1988) provides reasons why the evaluation of a road safety improvement intervention is necessary. It is to ensure financial accountability and to clarify that the intervention actually resulted in a reduction of accidents.

Expenditure on road safety has been significantly reduced as a result of limited resources. Evaluation of interventions ensures that funding is directed towards projects that will have the most direct impact on road traffic accidents. The second reason for evaluation is the clarification of the accident reduction. Road traffic accident numbers and severity are influenced by numerous factors, e.g. traffic volume changes, changes in population, etc. There may also be other effects that can merely cause a shift in the presentation of accidents like the risk homeostasis process that is described in detail in Chapter 11.

6.3 EVALUATION METHODS

Evaluation of road safety improvement interventions includes qualitative and quantitative indicators. Quantitative indicators includes the analysis and evaluation of accident data and qualitative indicators includes the evaluation of the human factor in terms of behaviour, attitude etc.

Chapters 7 to 9 deal with the different types of accident data analysis and statistical analysis and also provide some examples in terms of Arrive Alive 1. The evaluation of the human factor is discussed in Chapters 11 and 12.

6.4 Conclusions

The evaluation of road safety improvement interventions is necessary and there are a number of measures that can be utilised in this process. A number of key performance indicators were identified.

CHAPTER 7: ANALYSIS OF ACCIDENT HISTORY

7.1 INTRODUCTION

Accident statistics are quantitative measures that can be utilised to measure the effect of road safety campaigns. The purpose of this chapter is to define, describe and discuss the various elements in the analysis of accident statistics in the assessment of a road safety campaign. Analysis of accident data for road safety campaigns takes place on the macroscale (ITE 1982) where an analysis is made based on summarised data that only allows for generalised conclusions. These conclusions may lead to legislation or regulatory measures to alleviate the problem. Microscale analysis is done in a localised manner with accident reconstruction.

The purpose of this chapter is to serve as an introduction to the analysis of accident data, explaining accident data characteristics, concepts of measures and pitfalls, where applicable.

7.2 PROBLEMS WITH STATISTICAL ANALYSIS OF ACCIDENT DATA

A number of factors will influence the quality and interpretation of accident data (*AUSTROADS* 1988):

- Accident reporting criteria – In certain countries, only injury accidents are reported, in other countries insurance is not required and this leads to an underreporting of accidents where there were no serious injuries. The definition of a fatality differs from a death within 7 days after the accident in South Africa to 30 days in other countries[1] (*ITE* 1992). In the latter case it is essential that a uniform means of updating accident fatalities be implemented throughout the particular area or country that is investigated (*ITE* 1992).

- Coding effects – Changes can occur in the coding or classification of accident data or the accident report form can change, as has recently happened in South Africa.

- Biased data – Reporting on alcohol involvement in accidents in South Africa is low as previous legislation required a blood sample and a district surgeon to enable a positive indication on the accident report form.

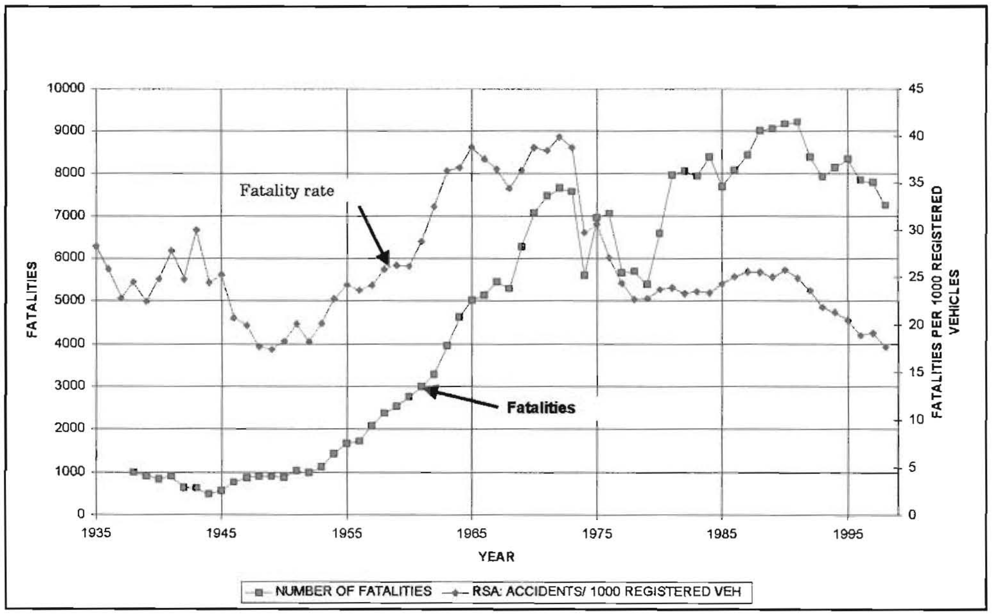
- Random fluctuations (refer to Chapter 8 and 9 for a detailed discussion).

7.3 MEASURES FOR ACCIDENT DATA ANALYSIS

Accident frequency, severity and rates are generally used to measure the safety performance of a country or area (*ITE* 1992).

7.4 ACCIDENT FREQUENCY

The number of accidents and/or fatalities can be used to measure the effectiveness of a campaign. However, it fails to take into account exposure that may change the result of the analysis significantly. Graph 7.1 shows the difference between the number of fatalities and the fatality rate per 1000 registered vehicles.



Graph 7-1: Number of fatalities and the fatality rate per 1000 registered vehicles for South Africa (after CSS 1999)

[1] A definition of the United Nations Organisation

7.5 ACCIDENT RATES

7.5.1 Population-based rates

Accident fatalities, injuries and numbers can be expressed in terms of the area population to provide a measure of public health to allow for the evaluation of target groups for public health funding. The values are static and do not take the amount of travel into account. Population-based rates can also be based on the number of licensed drivers, the number of registered vehicles or the length of road network (*ITE* 1990).

Typical population-based rates include:

- deaths or accident characteristic frequency per 100,000 area population;
- deaths or accident characteristic frequency per 10,000 registered vehicles;
- deaths or accident characteristic frequency per 10,000 licensed drivers;
- deaths or accident characteristic frequency per 1000 km of road network.

Note that the accident rate per registered vehicle population relates the accident experience to the number of vehicles that can be involved in accidents (Homburger, Kell and Perkins 1992).

7.5.2 Exposure-based accident rates

Exposure-based accident rates provide a measure of the extent of the risk exposure in the transportation system (ITE Homburger). Accident numbers or severity are typically expressed as rates to provide a measure in terms of unit of travel or per length of road in the road system (ITE 1992).

The standard equation for the calculation of accident rates is (ITE 1992):

$$Rate = \frac{Number}{Exposure}$$

where Number = fatalities, injuries, etc and

Exposure = the annual vehicle kilometres of travel, kilolitres fuel, etc.

7.5.3 Basic accident rates

Basic accident rates includes:

- degree of injury;
- number of fatalities per total number of accidents;
- number of fatalities and serious injuries per total number of accidents;
- involvement rates that describe the involvement of vehicle types, drivers, passengers, accident types, etc. in terms of the total number of accidents.

7.6 ACCIDENT SEVERITY AND COSTS

The accident rate can be adjusted to take into consideration the severity and related cost (*ITE* 1992). The Equivalent Accident Number (EAN) is a typical method used in South Africa. It gives weight to the different degree of injury accidents to express all the accidents in terms of no injury accidents. The emphasis on the fatal degree of accidents is, however, too large – in some cases the number of fatalities may be significantly lower than in the other types and degrees of injury accidents. This can result in a distorted representation of the accident data. ITE (1992) recommends that an average fatal-plus-injury average accident cost be used by combining the number of fatality and injury accidents.

The use of accident costs as a measure of effectiveness of road safety campaigns should be restricted to the analysis of alternative remedial measures, as the answers produced by these two methods will differ significantly (ITE 1992).

7.7 TRENDS

Accident data contains two components. The first is a portion that is related to external factors like the economy, vehicle population, population, etc. that show time related changes (i.e. trends). The second is the portion that describes the randomness of accident occurrence. The second is a random fluctuation around the first. It is difficult to identify the deterministic element of the accident data as a large number of variables can influence accidents. Frith and Toornath (1982), Pant *et al* (1992) and Hakim (1991) list a number of variables that can influence accidents and their outcomes:

- vehicle composition and traffic volumes;
- driving behaviour and changes in the driver population;
- population composition and the number of young drivers;
- violence and aggression;
- vehicle inspections;
- vehicle safety improvements;
- motorcycle crash helmets;
- improved roads;
- traffic management;
- vehicle occupancy;
- season (holiday), recreational and tourism travel;
- climate (especially wet weather);
- light conditions (number of daylight hours);
- socio-economic factors;
- economic factors and changes in fuel prices;
- legislation;
- driving under the influence of alcohol and drugs;
- use of seatbelts;
- traffic volumes.

AUSTROADS (1988) lists a number of reasons why, apart from road safety campaigns, changes in the accident rate can occur. It includes: changes in the safety of cars, changed legislation, improved driver education, improved health care systems, emergency services, etc.

The analysis of long-term trends of accident data from the National Safety Council in the USA proved that accident fatalities reflect economic, population and vehicle population growth. The trends can be explained by three theories. The first theory is that road users become more "roadwise" as motorization improves and therefore fatalities reduce. The second theory is that public demand for a safer road system increases as motorization improves. The road safety professionals then implement safety measures that reduce fatalities. The third theory is that economic recessions, legislation based on safety, road building projects and other discrete events contribute to cause a long-term fatality reduction. Even in North America, where the deterioration of the road infrastructure continued and smaller passenger cars were introduced to the road system, this downward fatality trend continued (*ITE* 1992).

Carter and Homburger (*ITE* 1982) note that seasonal effects are also typical of accident data and that the summer travel peak is associated with an increase in accidents. They also proved that the age distribution of those injured or killed in road traffic accidents reflect the variations in exposure rates, the unsafe driving strategies of young drivers, etc. and is not representative of the age distribution of the population or driving population.

7.8 ACCIDENT TYPES

Accident data can be represented per accident type. It allows for a more detailed analysis of accident patterns. In the case of road safety campaigns, some of the accident types (e.g. head-on, etc.) can indicate whether changes in risk or shifts in risk took place. Refer to the case study of the drinking-and-driving campaign of British Columbia in 1977 as described in Chapter 11.

7.9 RISK INDICES

A risk index can be calculated for age or sex groups of those killed, injured or involved in road traffic accidents (*ITE* 1990). It can be computed using the following equation:

$$RI = \frac{\%\_Accident\_involvement\_in\_group}{\%\_Population\_in\_group}.$$

This method, however, does not take the exposure of the particular age group into account.

7.10 CONCLUSIONS

Accident data can be analysed by using accident frequencies and rates. Each of the different methods describes an area-specific characteristic, e.g. the accident rate per registered vehicle population that relates the accident experience to the number of vehicles that can be involved in accidents. In the evaluation process a description of the limitations of the particular methods should be included for the benefit of the reader. The methods described in this chapter have limitations as data between periods is compared but no indication is given of the significance of changes – there is therefore a need for statistical analysis.

CHAPTER 8: STATISTICAL ACCIDENT ANALYSIS

8.1 BACKGROUND

Accident data is often analysed in the evaluation of road safety improvement interventions. The portion of change in accident numbers or rates during the campaign is often the primary measure used to determine the short-term success of a road safety improvement intervention. This chapter describes the statistical analysis of accident data and the problems associated with the use of statistical analysis on accident data.

8.2 ACCIDENTS AS A RANDOM EVENT

A series of accident data consists of two elements, namely, the deterministic and the random elements. The random element of accident data follows a Poisson distribution. The Poisson distribution is described by a discrete random variable that takes on integer values like 1,2,3, etc.

The probability P(x) of exactly x occurrences in a Poisson distribution can be calculated as follows: $P(x) = \frac{\lambda^x e^{-\lambda}}{x!}$ where lambda is the mean number of occurrences per interval (Levin and Rubin, 1991).

If the sample size of a Poisson distribution is large enough (greater than 1000), then it can be approximated by the normal distribution. For a normal distribution, the standard deviation is the square root of the value. For a 95% confidence interval, changes within two standard deviations from the mean can be attributed to random fluctuations. For example, an analysis of the number of accidents per year in South Africa will be as follows: during 1998, 511 605 accidents were recorded in South Africa, then $x = 511605$

And then the Standard deviation = $\sqrt{x} = 715{,}3$. For a 95% confidence interval, the interval of $x \pm 2\times$ Standard deviation = 1431 accidents. This means that a change of 1431 accidents, 0,28% can be attributed to random fluctuations. In this regard, a change of, say 6%, in the accident data, does not necessarily mean that 5,72% of the change is significant in terms of its consequences (i.e. it is not necessarily because of the intervention but can be the result of another external factor).

8.3 ARIMA (*after* NETER, WASSERMAN AND WHITMORE, 1988)

More complex time series is characterised by *having memory*, i.e. it is influenced by other events in the series. The series is characterised by intercorrelation between events in the series. The autocorrelation coefficient is used to measure this correlation. Although accidents are random events, certain external factors that influence accident occurrence are not random and have a trend. More complex analysis can be used to identify the trend and quantify the random fluctuations around the trend line.

ARIMA refers to the autoregressive moving average model. This model is a combination of the autoregressive and moving average model. The autoregressive model expresses observations of a stationary time series as a function of earlier observations. The moving average model expresses observations of a stationary time series as a function of random disturbances in earlier periods and in the current time interval. The moving average, autoregressive model, and ARIMA model are shown in equations 8.2, 8.3 and 8.4 respectively.

Moving average model:

The moving average model for Y_t is $Y_t = \mu + \varepsilon_t$ (Equation 8.2)

where Y_t = Observations

t = Current time period

μ = Expected value of Y_t

u_t, u_{t-1}, ..., t-q = Independent random disturbances in the time periods t-1, ... , t-q.

q = The order of the average model

ε_t = Error term that is expressed as a weighted moving average of the current disturbance u_t and the earlier disturbances u_{t-} , , , u_{t-q} with the weights $\theta_1, \ldots, \theta_q$.

Autoregressive model:

The autoregressive model for Y_t is $Y_t = \phi_0 + \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} + \varepsilon_t$

(Equation 8.3)

where

Y_t = Observations

$\phi_1, \ldots, \phi_p$ = Autoregressive parameters (parameters determining the dependence of Y_t on each of the p earlier values in the series)

p = Lagged values of the stationary time series (independent values) indicating the order of the time series model

ε_t = Independent value.

Note that Y_t is regressed on $Y_{t-1}, \ldots, Y_{t-p}$, i.e. therefor autoregressive.

ARIMA model: The ARIMA model of Y_t is

$$Y_t = \phi + \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} + u_t - \theta_1 u_{t-1} - \ldots - \theta_q u_{t-q}$$ (Equation 8.4),

where u_t is independent. The model is of the order (p,q) because the autoregressive component is of the order p and the moving average is of the order q.

The ARIMA model is applied in five steps, namely:

- removing the non-stationary components in the data series;
- identifying the appropriate ARIMA model;
- estimating the parameters of the model;
- analysing the residuals;
- evaluating the forecasting performance of the model.

The non-stationary components such as trends or seasonal components have to be transformed to make the series stationary.

The identification of the appropriate ARIMA model is a complicated task as it not only involves the selection of an appropriate model but also the suitable order (p,q) of the model. Computerised analytical techniques can be used to assist the statistician.

The parameters of the ARIMA model are estimated from the available data for the stationary time series. It is normally done by using special routines in a computerised analysis (using for example a software package like SAS).

A residual analysis is necessary to check the aptness of the model. Should the residual analysis indicate that the model does not fit well, modification is necessary (Neter, Wasserman and Whitmore, 1988).

8.4 CONTRIBUTING VARIABLES

To prove that a road safety improvement intervention resulted in an accident reduction or severity reduction, it is necessary to evaluate the contributing variables (Godwin 1984).

8.5 CONCLUSION

The comparison of accident data through statistical analysis techniques to determine the amount of change brought about by the implementation of a road safety improvement intervention is problematic as random fluctuations and other variables can have an impact on the statistical significance of the change.

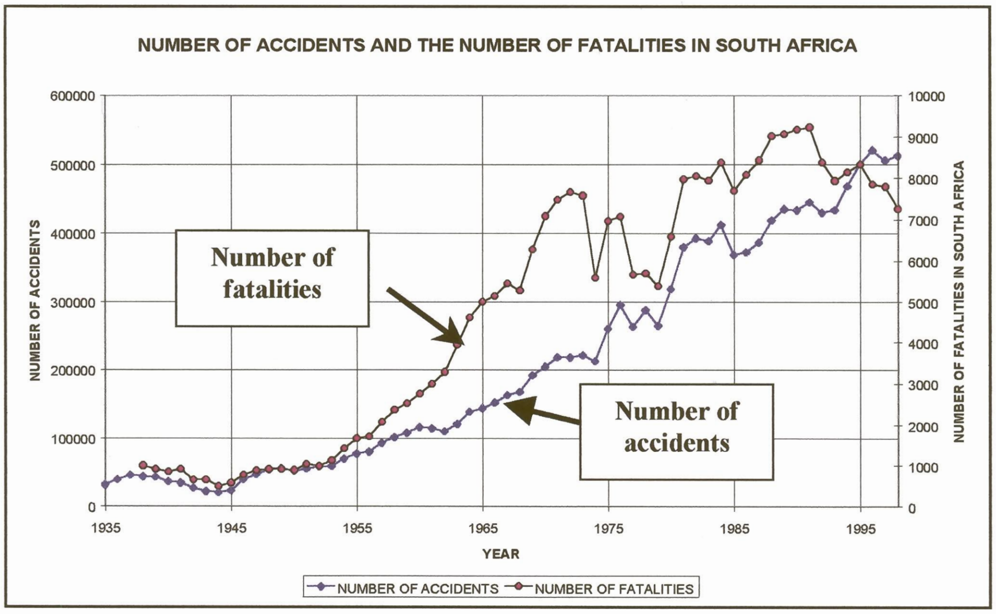
CHAPTER 9: ACCIDENT ANALYSIS USING YEARLY DATA

9.1 INTRODUCTION

The purpose of this chapter is to illustrate the different types of accident data analysis by utilising national annual data from as early as 1935. Difficulties with the different measures as well as relationships are highlighted. The chapter also provides details of attempts to predict the number of accidents by using long-term accident data. Predictions of the null alternative (no road safety improvement intervention) is essential to determine the effect of the road safety improvement.

9.2 ACCIDENT FREQUENCY

The total number of accidents in South Africa from 1935 to 1998 is shown in Graph 9-1.



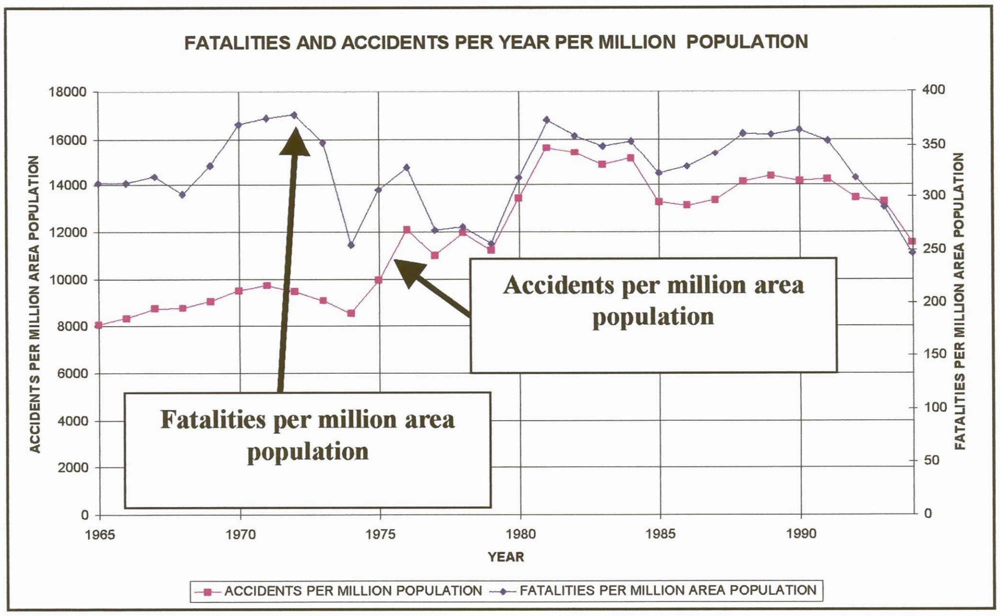
Graph 9-1: The number of accidents and fatalities in South Africa (after CSS 1999).

Accidents increased gradually until the 1970's. A decrease in the number of accidents and fatalities is noticeable in 1973 and 1979 that can be attributed to the energy crisis and the consequent reduction in mobility. Accidents increased by 4,1% from 1995 to 1996, decreased by 2,8% from 1996 to 1997 and increased again by 1,3% from 1997 to 1998. Fatalities increased slower than the total number of accidents from 1935 to 1973.

9.3 POPULATION-BASED ACCIDENT RATES

9.3.1 Death or accident characteristic frequency per million area population

Graph 9-2 shows the fatalities and accidents per million area population[1] for South Africa from 1955 to 1998.



Graph 9-2: Fatalities and accidents as a rate per million area population (South Africa) (after CSS 1999)

The increase and decrease of the fatality rate per million area population corresponded with increases and decreases in the number of accidents per million area population.

The accident or fatality rate per million area population does not provide a measure for effectiveness as it does not provide a measure for the exposure of the different age groups or for the greater exposure by the economically active portion of the population. It does however provide a measure in terms of public health when compared to deaths due to heart attacks, cancer etc.

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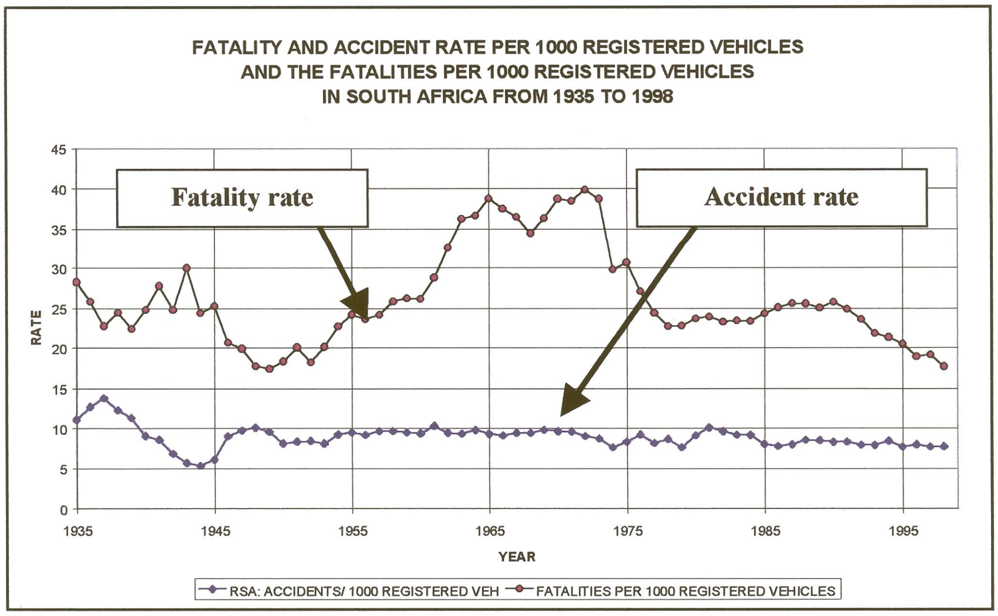
[1] The term *per million area population* refers to the number of people in a specific area.

9.3.2 Death or accident characteristic frequency per 1,000 registered vehicles

Graph 9-3 shows the fatalities and accidents per 1000 registered vehicle population. The fatality rate per 1000 registered vehicles reduced from 1996 to 1998.

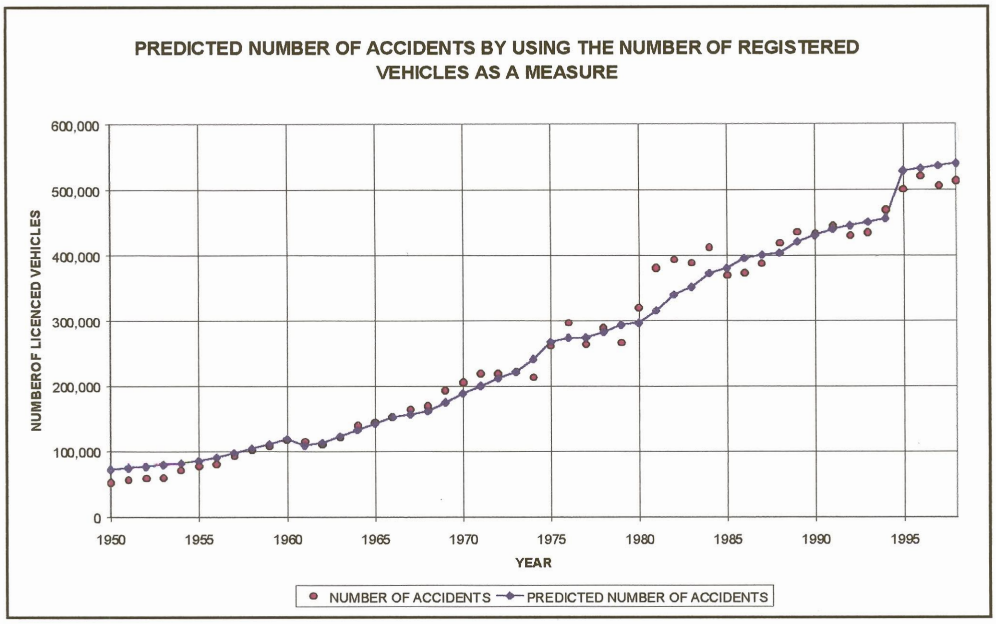


Graph 9-3 : The number of accidents and fatalities per 1000 registered vehicles (Data from CSS 2000).

The fatality rate per 1000 registered vehicle population remained relatively constant. From 1985 to 1998 the fatality rate remained lower than the rest of the curve – this can be attributed to an improvement to vehicle safety. The accident rate per 1000 registered vehicles decreased from the early 1990's.

A regression analysis was prepared for the number of accidents and the number of registered vehicles. The predicted number of accidents, based on the number of registered vehicles, is shown in Graph 9-4.

The regression analysis results are shown in Appendix A. The residuals represents residuals ranging from -5,7% to 20%. The residuals are however not acceptable if targets such as 5% accident reduction are set. This can be explained by the fact that the number of registered vehicles is not an indication of the exposure to accident risk.



Graph 9-4: The predicted number of accidents based on the number of registered vehicle population

9.4 EXPOSURE-BASED ACCIDENT RATES

9.4.1 Introduction

An accident is a direct result of mobility. Exposure-based accident rates take mobility into consideration. There are a number of exposure-based accident rates, namely:

- death or accident characteristic per 1000 000 vehicle kilometres;
- death or accident characteristic per 1000 litre fuel;
- death or accident characteristic per vehicle mode per 1000 000 vehicle kilometres.

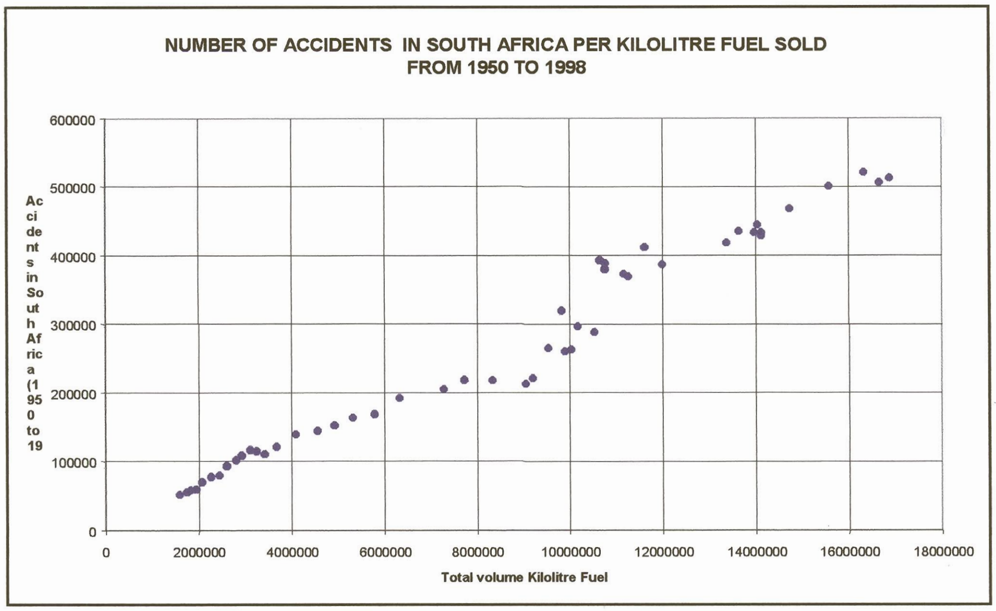
9.4.2 Available data

The amount of vehicle kilometres travelled in South Africa is estimated using certain categories of petrol and diesel sales as made available by the Department of Mineral and Energy Affairs. The categories of petrol and diesel sales are however only available for the period 1 January 1995 to date. Previous information is only grouped into total sales of petrol and diesel. Vehicle kilometres per mode are not available and can therefore not be utilised.

9.4.3 Fuel sales as a measure of exposure

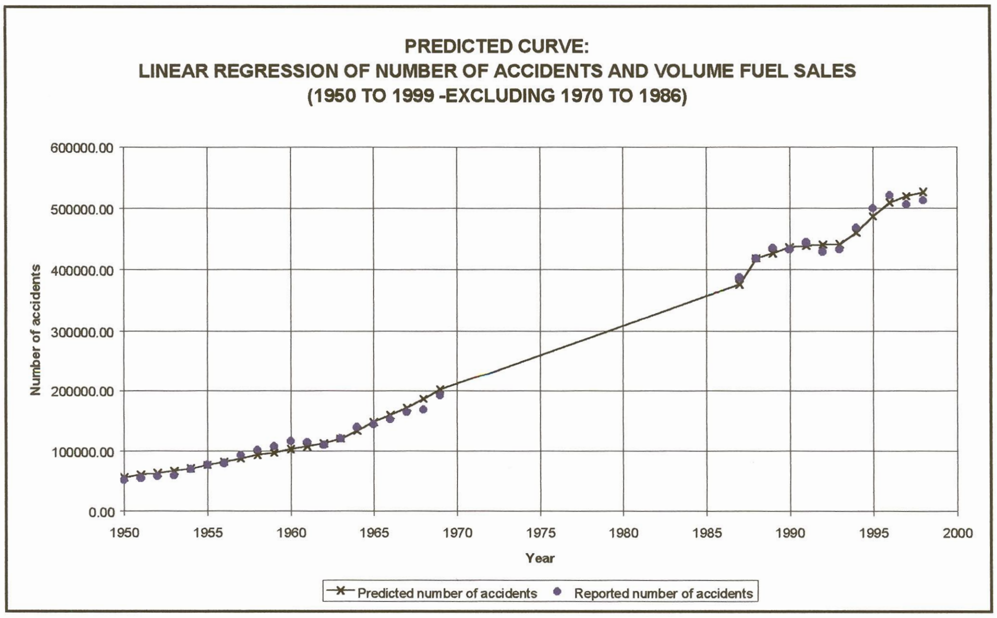
To determine long-term trends to enable the measurement of changes as a result of the Arrive Alive 1 campaign is not possible because the categories petrol and diesel sales prior to 1995 are not available.

Graph 9.5 shows the plot of number of accidents related to the total fuel (petrol and diesel) sales from 1950. Note that the data between 1970 and 1986 shows great variation.



Graph 9.5 : The number of accidents and the fuel (petrol and diesel) sales in South Africa from 1950 to 1998 (Department of Mineral and Energy Affairs, 2000 and data from CSS).

In the period 1970 to 1986, the data shows significant deviations. This can be explained by the fuel that the National Defence Force bought for the Angola war. If the data between 1970 and 1986 is disregarded, a regression line ($R^2 = 0{,}998$) can be fitted as shown in Graph 9.6. The regression analysis is shown in Appendix B.



Graph 9.6: Predicted and recorded number of accidents based on the petrol and diesel sales from 1950 to 1998 (excluding data from 1970 to 1986).

It should, however, be noted that the regression line does not intercept at the origin. This means that the estimation implies that accidents still occur even if fuel sales are zero. This can be explained by the fact that the petrol and diesel prices do not provide information or relationships that include the different transportation modes, their vehicle kilometres or fuel efficiency. The use of monthly data is even more problematic as fuel sales and usage do not necessarily take place during a calender month.

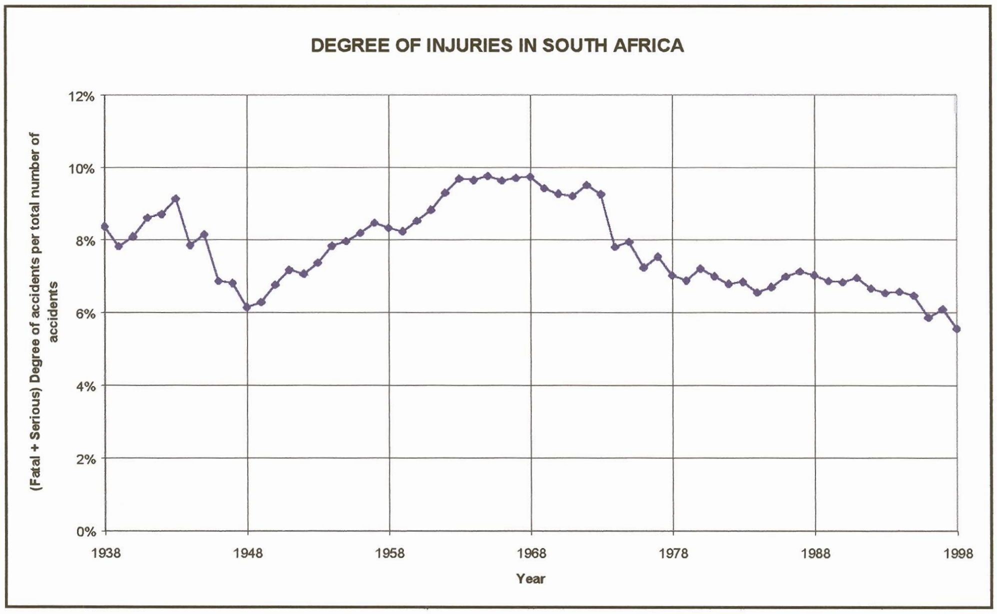
At particular sites or similar sites, vehicle-kilometres are easily estimated for microanalysis by using traffic counts for a particular intersection or route. Sample sizes can, however, reduce the significance of statistical findings. To solve this problem, a cross-sectional analysis can be carried out. Data from similar sites is added to increase the sample size. This is problematic as it increases the difficulty of the identification of all variables influencing the number of accidents at the particular sites.

9.6 CONCLUSIONS

The analysis of the annual accident data indicated that there are a number of factors that show similar trends to the number of accidents, e.g. volume of fuel sales and number of registered vehicles. The analysis shows too great a variation to be utilised as predictors of the number of accidents. The residuals in historic accident data prediction need to be much less than the target set for accident, injury or fatality reduction. There is a need for the development of a model that can predict the number of accidents, fatalities, etc. to evaluate the reduction in accidents and fatalities from the road traffic accident improvement interventions based on exposure.

9.4.4 DEGREE OF INJURY

The Degree of Injury can be defined as the percentage Fatal and Serious degree injury accidents per total number of accidents. Serious injury accidents are included as the difference between a fatality and a serious injury is merely a function of the health of the particular patient and the health or after-care system available. Graph 9.7 shows the degree of injuries in South Africa.



Graph 9.7: The degree of injuries in South Africa from 1938 to 1998 (after CSS).

The degree of injury of accidents reduced during the past few years. Degree of injuries is reduced by, for example, the use of seatbelts, safer car technologies etc.

9.5 TRENDS

The annual accident data and number of fatalities show large fluctuations. See Graphs 9-1, 9-2 and 9-3.

CHAPTER 10: ACCIDENT ANALYSIS FOR ARRIVE ALIVE 1 USING MONTHLY DATA

10.1 INTRODUCTION

The purpose of this chapter is to investigate the use of trends and characteristics of monthly accident data on a national, provincial, metropolitan, intersection and route level to evaluate a road safety improvement intervention. Arrive Alive 1 is utilised to serve as an example.

10.2 METHODOLOLGY

A number of population areas was selected for evaluation. Firstly the national level was selected as National government is setting goals for improving safety on an almost continuous basis. The provinces of Gauteng, KwaZulu-Natal and Western Cape were selected based on the fact that Arrive Alive 1 funding was concentrated in these areas and these areas should therefore show the most significant changes if any changes did occur as a result of the Arrive Alive 1 road safety campaign. The Durban Metropolitan area was selected based on the quality of the accident data. A selection was made of a number of intersections and a number of routes to assess whether changes occurred on elements in the network during the Arrive Alive 1 road safety campaign and to test whether changes (if statistically significant) on a metropolitan or provincial level correspond with the network level.

It should also be noted that the sample size of the selection of intersections and selection of major routes in the Durban Metro area is relatively small and therefore shows large variations in some cases.

The following data series were collected for each area and category:

- The various accident types, namely:
    - total accidents;
    - fixed object accidents;
    - head-on accidents;
    - left turn (same) accidents;

- overturning accidents;
- rear-end accidents;
- right angle (straight) accidents;
- right angle (turn) accidents;
- side-swipe (opp) accidents;
- side-swipe (same) accidents;
- right angled accidents;
- side-swipe accidents;
- right turn accidents
- pedestrian accidents,

- and for each accident type, the following series:
  - total number of accidents;
  - total number of fatalities;
  - total number of fatalities and severe injuries;
  - total number of accidents per kilolitre fuel (the fuel used for this measure is the accepted fuel for measure of mobility on the road network, i.e. the total petrol sales, for diesel: 10% of agriculture, none for sea-fisheries, none for mining industry and 10% of construction);
  - total number of fatalities and severe injuries per kilolitre fuel;
  - degree of injury;
  - percentage accidents on weekdays;
  - percentage accidents on Saturdays;
  - percentage accidents on Sundays;
  - percentage accidents during daylight-visibility conditions;

- percentage accidents during night-time-visibility conditions;
- percentage accidents during twilight visibility conditions;
- percentage accidents during AM peak time;
- percentage accidents during PM peak time;
- percentage accidents during the off-peak time.

In the analysis normalised data graphs were prepared for each of the different areas indicating data in terms of accidents, injuries, accident types, etc. A selection of the graphs are shown in Appendix C. The different graphs were prepared to establish whether statistically significant changes took place in terms of:

- number of accidents;
- severity of accidents (measured in number of fatalities, number of fatalities and severe injuries, degree of injury);
- travelling patterns – a road safety improvement intervention has the possibility of changing the day of travel, time of travel and also whether a driver is willing to drive in particular visibility conditions;
- shifts between accident types, i.e. whether the number of accident types that are associated with severe injuries reduced while other accident types increased.

Each data series was normalised by determining the average value of the data series from 1 January 1994 to the end of available data, the standard deviation of the series and then plotting the series using the following formula: $Plotted\_value = \frac{value - average\_value}{standard\_deviation}$. An example of such a graph is shown in Figure 10-1.

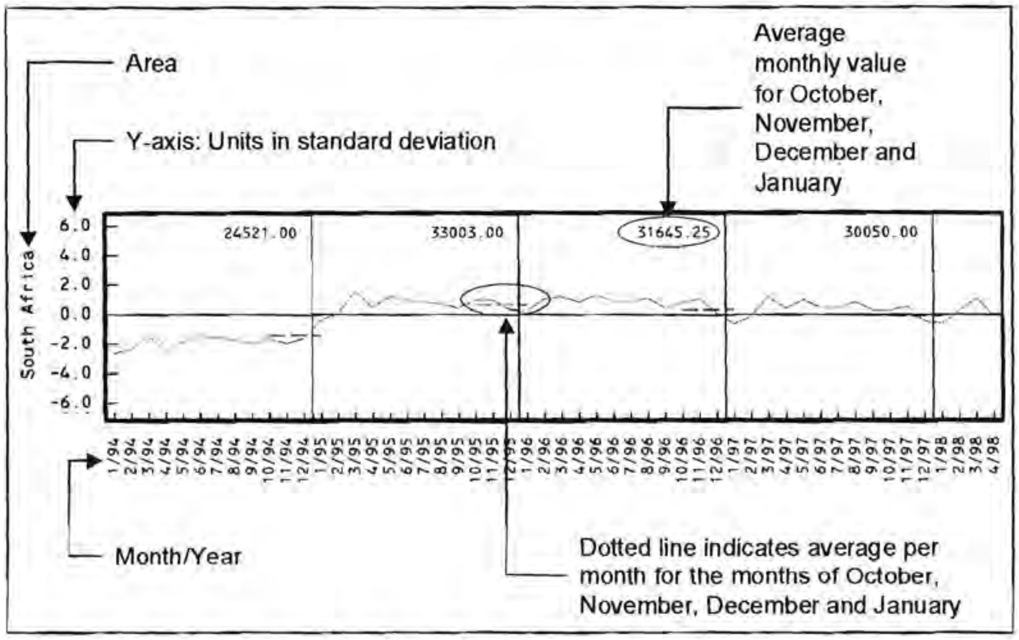


Figure 10-1: An example of the normalised accident data shown in Appendix C and D

The monthly average for the months October, November, December and January of each year in the series is also indicated on the graphs (Arrive Alive 1 took place from 1 October 1998 to 31 January 1999). The x-axis indicates the month and the y-axis shows units of standard deviation. Note that changes of two standard deviations can be attributed to random fluctuations alone. The graphs made a visual assessment possible as any changes greater than two standard deviation would have indicated that changes took place other than those that can be attributed to random fluctuations.

Data series for the involvement of the different age groups of drivers and passengers in the Durban Metropolitan area were also evaluated. The graphs are shown in Appendix D.

10.3 ACCIDENT FREQUENCY

The total number of accidents is shown in Graph C.1 (Appendix C), the number of fatalities in Graph C.2 and the total number of fatalities and serious injuries in Graph C.3. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. Assessment of the monthly average accident number over the comparative periods in 1994/95, 1995/96, 1996/97 also indicated fluctuation around the mean within two standard deviations. The same findings were made for the different accident types. Graphs C.4 to C.9 are included to illustrate typical graphs for the different accident types.

10.4 POPULATION-BASED ACCIDENT RATES

Variations in the population of areas are not recorded on a month to month basis and can therefore not be utilised as a measure for monthly accident data.

10.5 EXPOSURE-BASED ACCIDENT RATES

10.5.1 Introduction

In Chapter 9 the need to include a measure of exposure in the analysis of accident data was illustrated using national annual accident data.

10.5.2 Available data

Fuel sales (petrol and diesel) were obtained from the Department of Mineral and Energy Affairs for South Africa, Gauteng, KwaZulu-Natal and the Western Cape. Note that the data was categorised and it was possible to exclude fuel sales (e.g. to sea fisheries etc.) that were not utilised by transport using the road network.

10.5.3 The analysis

The total number of accidents per kilolitre fuel is shown in Graph C.10 (Appendix C) and the total number of fatalities and serious injuries per kilolitre fuel in Graph C.11. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. Assessment of the monthly average accident number over the comparative periods in 1994/95, 1995/96, 1996/97 also indicated fluctuation around the mean within two standard deviations. The same findings were made for the different accident types. The changes in the data set are therefore not statistically significant. Graphs C.12 to C.33 are included to illustrate the graphs for the different accident types.

10.6 DEGREE OF INJURY

The degree of injury of the total number of accidents is shown in Graph C.34. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. Assessment of the monthly average accident number over the comparative periods in 1994/95, 1995/96, 1996/97 also indicated fluctuation around the mean within two standard deviations. The same findings were made for the different accident types. The changes in the data sets are therefore not statistically significant. Graphs C.35 and C.36 are included to illustrate typical graphs for the different accident types.

10.7 INVOLVEMENT RATES AND ACCIDENT CHARACTERISTICS

10.7.1 Introduction

The data series were then evaluated to establish whether any conclusions could be drawn in terms of changes in driving behaviour. Graphs were prepared for the distribution of the different driver and passenger ages per vehicle type in the Durban Metropolitan area. Another set of graphs was prepared to establish whether the accident data showed any changes in terms of day of week travel, visibility conditions and time of day travel.

10.7.2 Driver ages per vehicle type

Graphs on pages D.1 to D.7 are shown in Appendix D. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. The changes in the data sets are therefore not statistically significant.

10.7.3 Passenger ages per vehicle type

Graphs on pages D.8 to D.14 are shown in Appendix D. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. The changes in the data set are therefore not statistically significant.

10.7.4 Day of week

The percentage weekday, Saturday and Sunday accidents for the total number of accidents are shown in Graphs C.37 to C.39. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. Assessment of the monthly average accident number over the comparative periods in 1994/95, 1995/96, 1996/97 also indicated fluctuation around the mean within two standard deviations. The same findings were made for the day of week characteristics of the different accident types. The changes in the data sets are therefore not statistically significant.

10.7.5 Visibility conditions

The percentage daylight visibility, night-time visibility and twilight visibilty accidents for the total number of accidents is shown in Graphs C.40 to C.42. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. Assessment of the monthly average accident number over the comparative periods in 1994/95, 1995/96, 1996/97 also indicated fluctuation around the mean within two standard deviations. The same findings were made for the visibility conditions for the different accident types. The changes in the data sets are therefore not statistically significant.

A pattern was observed on an annual basis that correlates with the length of days (hours sunlight) during the various seasons in the year. This is, however, also within two standard deviations. The changes in the data sets are therefore not statistically significant.

10.7.6 Time of day

The percentage daylight visibility, night-time visibility and twilight visibilty accidents for the total number of accidents are shown in Graphs C.40 to C.42. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. Assessment of the monthly average accident number over the comparative periods in 1994/95, 1995/96, 1996/97 also indicated fluctuation around the mean within two standard deviations. The changes in the data sets are therefore not statistically significant. The same findings were made for the visibility conditions for the different accident types. The data showed a visual trend on an annual basis that coincides with the holiday periods when morning peak and afternoon peak hour travel decreases.

10.8 Accident Types

Graphs C.46 to C.61 shows the different accident types as a percentage of the total number of accidents. This evaluation was done to establish whether changes between the distribution of the different accident types took place. The assumption was made that if, for example, drivers reduced their speed, the occurrence of, for instance, overturning accidents as the perception exists that a reduction in speed will prevent some of these types of accidents. The series in the different areas showed large fluctuation around the mean of the data series but still within two standard deviations from the mean. The changes in the data sets are therefore not statistically significant. Assessment of the monthly average percentage over the comparative periods in 1994/95, 1995/96, 1996/97 also indicated fluctuation around the mean within two standard deviations. The changes in the data sets are therefore not statistically significant.

10.9 TRENDS AND ARIMA ANALYSIS

ARIMA analyses were carried out for the total number of accidents in South Africa and the total number of accidents in the Durban Metro area. The analyses were performed using the SAS program and the data analyses was done by the University of Pretoria. Both data series showed a non-stationary character and AR(1) models were fitted to both series up to September 1997 (Arrive Alive 1 started on 1 October 1997). The models were able to make predictions but all the predictions were within the two standard deviations around the mean and longer term predictions tended to move to values closer to the mean, indicating the poor prediction value of the models.

10.10 SELECTION OF WORST LOCATIONS AND WORST ROUTES

In some cases the fluctuations of the graphs coincided with those observed in the metropolitan, provincial and national data. The small sample size in some categories of data series made the use of these results invalid.

10.11 CONCLUSIONS

Statistical analyses of macro-level accident data for South Africa, Gauteng, KwaZulu-Natal, Western Cape and the Durban Metropolitan area and selections of intersections and routes proved to be statistically non-significant. The use of alternative evaluation elements for road safety improvement interventions on a macro level is therefore necessary.

CHAPTER 11: HUMAN FACTORS RELATED TO ROAD SAFETY INTERVENTIONS - A LITERATURE SURVEY

11.1 INTRODUCTION

The purpose of this chapter is to provide background for the conceptual evaluation of the human factor in road traffic safety improvement interventions. It describes concepts to be tested and specific issues that should be considered when preparing survey questions or when evaluating media and communication-related issues. This chapter forms the theoretical basis of the qualitative indicators discussed in Chapter 12.

11.2 BACKGROUND

As a result of the limited use of statistical analysis of macro-level accident data as an indicator of the effectiveness of road traffic safety interventions and the statistical insignificance found in the data sets, the need developed to find alternative and complementary indicators to assess the interventions.

The use of law enforcement data as an indicator is not included as the relationship between traffic offences and accident data has not yet been established. It is however accepted that increased law enforcement may reduce speeds, etc. and some aspects of it are described in this chapter.

11.3 TESTING THE HUMAN FACTORS RELATED TO ROAD SAFETY INTERVENTIONS

In road traffic accidents, the human factor contributes on its own or in combination with the road user and vehicle to 95% of all accidents (AUSTROADS 1988). It is therefore essential that an evaluation of a road safety improvement intervention also includes the human factor. In the reduction of accidents, fatalities or severity, psychology offers, among others, five elements that can be related to the human factor in road traffic accidents, namely: behaviour, motivation, attitude, risk and skills.

All of these elements are interrelated and can have a significant impact on the methodology and outcome of assessment of the human factor and road safety improvement interventions.

Glendon and McKenna (1995) stress that road safety professionals need to win the hearts and minds of the road users to enable them to carry out their functions and tasks. This means that safety and risk professionals need to have a basic understanding of the *nature of attitudes, attitude change and how these concepts relate to and in some cases do not relate to behaviour* (Glendon and McKenna 1995). This includes an appreciation of the complexity of the attitude-behaviour relationship and the need to be equipped with the theories around this relationship that will be practical to use in their work.

In the following sections, these elements and their relationship to one another will be discussed.

11.4 BEHAVIOUR AND MOTIVATION

11.4.1 The relationship between behaviour and motivation

Motivation forms the basis of almost all behaviour. Motives strongly govern actions except where behaviour is the result of instinctive responses (e.g. when reacting to intense pain or avoiding imminent danger). The relationship between motives and behaviour in road safety should therefore be considered when evaluating a road safety campaign. The theory of the relationship between behaviour and motivation developed in four stages, namely: the mechanistic approach, the behaviourist approach, the cognitive approach and the applied approach (Glendon and McKenna 1995).

The mechanistic approach states that motivational states are inborn and that the individual is a victim of *uncontrollable inner forces and urges*.

The behaviourist approach states that behaviour is motivated by drive reduction and that individual motivation is fuelled by tension to reduce drives and hence to satisfy basic needs. The behaviourist approach includes concepts such as habit, reinforcement, punishment, need satisfaction and reward.

The cognitive approach states that human behaviour is a purpose and that the main human desire is to control the environment rather than be controlled by it. It is also concerned with predicting future actions and thereby confirming that the individual has some control over important events.

The applied approach focuses on specific cases of motivational behaviour, e.g. the work environment, consumer behaviour and some training applications. The applied approach also deals with risk-taking, change and influence.

The human being has, among others, one real basic instinct: to avoid those things that can harm him/her – fear is thus one of the most basic motivators. Fear can be induced by the media – written and/or visual and/or auditory. Fear motivates the individual to find a way of reducing the arousal, e.g. typical discomfort, dissonance or stress.

This can be achieved by any of the following:

- reduce the arousal by changing behaviour, i.e. act more safely;
- change attitude rather than changing behaviour, e.g. if the information is very threatening it can be rejected altogether because thinking about it makes one feel uncomfortable, alternatively the individual may decide that the information is not applicable on him/herself (rather for other people), or he/she may seek to justify or rationalise his/her behaviour in some or other way;
- to accept the fact that the behaviour is not in accordance with attitude, i.e that the behaviour is unsafe but that it is not changed;
- although road safety professionals strive for a change in behaviour as to improve road safety, it is of utmost importance that the alternative that exists for behaviour change, namely attitude change be considered and measures implemented with the aim of attitude change. This means that the aim of campaigns should be to keep the attitude and behaviour constant relative to each other, i.e. the safe behaviour should be reinforced with reminders that will direct attitudes in the same direction. An example would be reinforcing the idea that this is what intelligent people do, or that it was developed by experienced people, etc.

11.4.2 How fear influences motivation and behaviour

Glendon and McKenna (1995) warns that the use of fear is only effective as a motivator if the individual feels that he/she is in control of the behaviour change that is sought. Fear is thus effective to strengthen already held beliefs. Alternatively, the fear will induce rejection of the information. In some cases it will even strengthen the dangerous behaviour. Glendon and McKenna recommend that the information should give straightforward and simple information on what the individual should do (e.g. 'go for a health check'). Figure 11.1 shows the basic model that describes the role of fear in safety motivation.

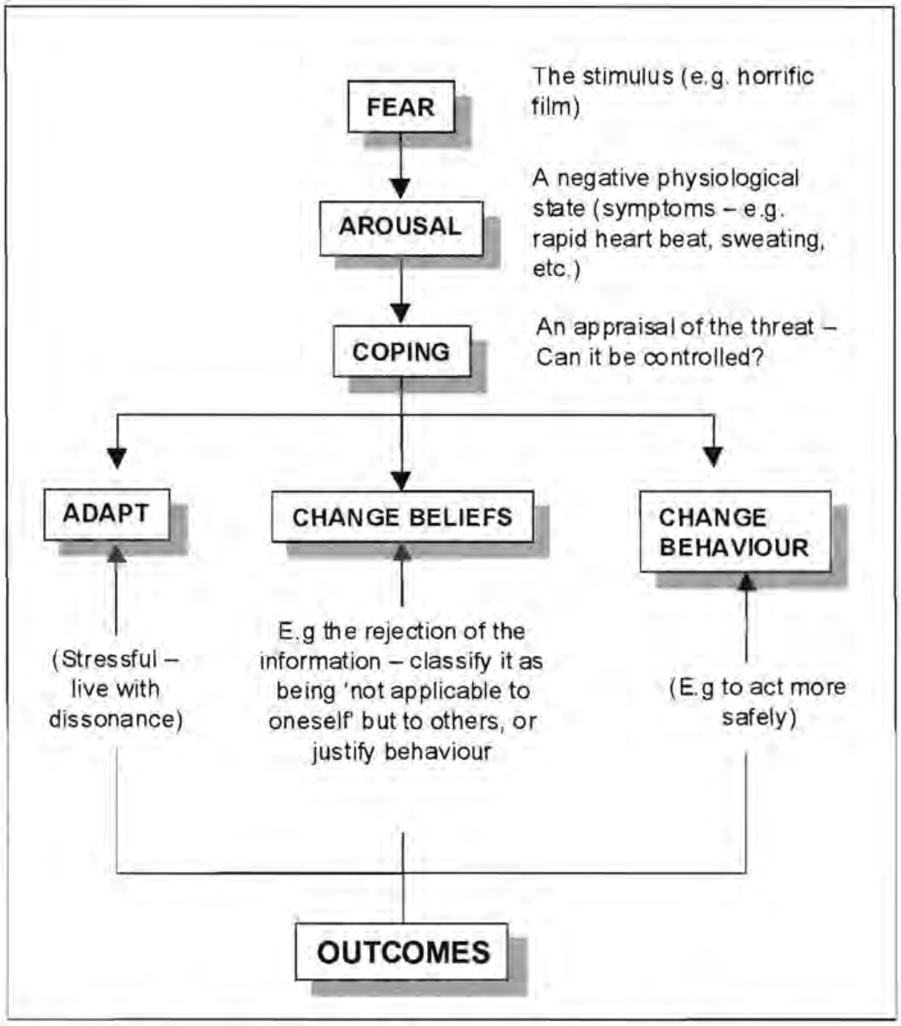


Figure 11.1: The relationship between fear, motivation and road safety (Glendon and McKenna 1995)

11.4.3 The character of motivation in road safety management

Motivation in road safety management is situation specific. If behaviour change is not supported (e.g. by continued extrinsic motivators like company standards or legislation) or sustained by intristic beliefs and as long as people perceive that they have some control over the risk, people will be motivated to take risks and to avoid risk (Glendon, in press).

In the assessment of the likely behaviour of people it is important to take the respective costs and benefits of both relatively safe and unsafe behaviour into account. The main issue when motivating for safety is the low probability of a negative outcome (e.g. being involved in an accident or being caught etc.) set against the very high probability of benefit (reaching your destination sooner etc.) (refer to the Risk Homeostasis Theory in Section 11.9).

11.5 ATTITUDE

11.5.1 Introduction

Attitude forms an integral part of any road traffic safety campaign. It not only influences behaviour but also has significant implications for behaviour modification.

11.5.2 Defining attitude

Attitude can be defined as "a learned tendency to act in a consistent way to a particular object or situation" (Fishbein and Ajzen, 1975). This definition implies that attitudes:

- are learned "through social interactions and other influences" (i.e. are not innate);
- are "tendencies to act" but it does not guarantee that a person with a particular attitude will actually act in a particular way;
- have elements of consistency as individuals tend to have clusters of attitudes that are generally consistent with one another;
- are situation or object specific, i.e. they are not generalizable to other situations or objects.

11.5.3 Attitudes and Behaviour Modification

If the assumption that some thought process always proceeds action is true, then attitudes have the potential to influence behaviour. Unfortunately the relationship between attitude and behaviour is much more complicated.

The position of attitudes within the framework of motivation, behaviour and psychological values is shown in Figure 11.2.

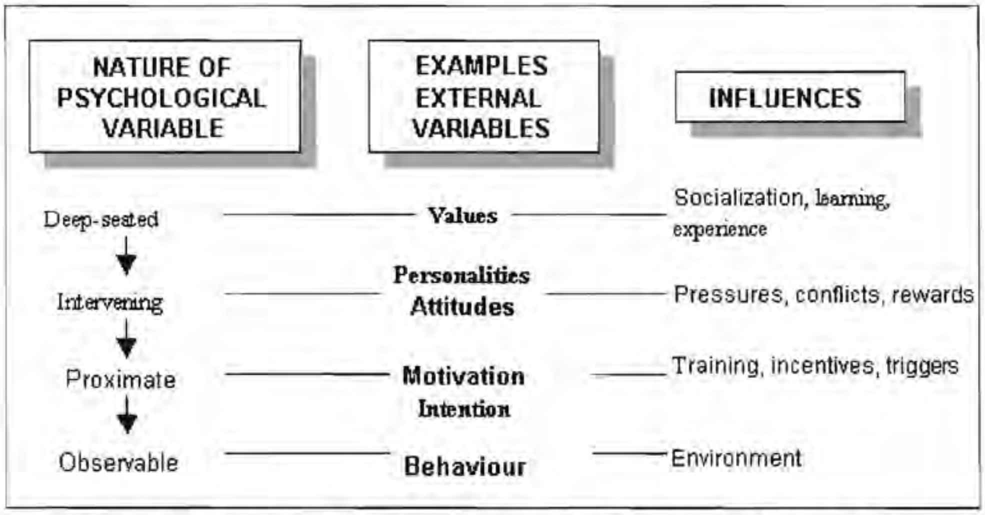


Figure 11.2: Psychological variables and in and influences (Glendon and McKenna 1995)

Attitudes can be considered as being located between deep-seated beliefs and values that can remain unchanged over a lifetime and relatively superficial opinions and views that can change frequently (they will depend mainly on the information an individual were exposed to most recently). This implies that attitude can change but that it cannot be done too readily. It would thus require more than a newspaper article or a poster.

11.5.4 The components of attitudes

It is generally accepted that attitudes typically consist of three components, namely:

- affective – the affective component of attitude refers to the attitude aspects related to the feelings and emotions; e.g. a person who witnessed a serious accident will feel more strongly about safety than a person who did not. This is the direct result of the powerful impact of the memory of the feelings when seeing the accident. It is this factor that is utilised in road safety advertising where a shocking accident scene is shown to the viewer. It is, however, important to note that emphasising the affective dimension is not desirable or practical when teaching people about safety;

- cognitive – the thinking aspect of an attitude; e.g. having the attitude of whether or not something is dangerous or not. It can be influenced in a wide variety of possible ways such as reading an article, seeing a TV documentary on risk-related topics and an anecdote related by a friend. The cognitive component also refers to risk cognition and risk perception. As the process of considering whether something is dangerous or not proceeds, so does the process of implicitly ranking different risks. The individual refers to that ranking when considering whether the perceived benefits of the activity more than compensate for the perceived risk that is involved (refer to section 11.8 dealing with the risk homeostasis theory);

- behavioural intention – the tendency to act; this is the one component on which the utility of the attitude concept succeeds or fails: *If attitudes can predict behaviour, then this behavioural intention has utility value* (Glendon 1995). It is an important component of some of the attitude-behavioural models. It refers to specific items, for example: if considering doing a job that is dangerous, then you will intend to acquire further training or intend not to engage in a dangerous activity at all.

The three components can thus be summarised with the following example: *if you imagine a snake in your presence and it is believed to be harmless (cognitive component), on the basis of verbal statements only, it might be presumed that you would not be afraid of it (fear being the relevant affective component in this case) and that you would be prepared to handle it (behavioural component). However, when actually confronted with a live snake, even a benign one, different reactions may be seen – i.e. heart rate increases, indicating increased arousal, probably fear or apprehension in this case and avoidance of the snake rather than handling it. Thus, it may be concluded that merely asking people to imagine what their reactions would be in a situation involving threat, is not a valid predictor of their actual behaviour or of their feelings in respect of the threat. Thus, the power of the actual situation in governing behaviour (and attitude) is paramount* (Rosenberg and Hovland 1960; Glendon 1995).

11.5.5 The Characteristics of Attitudes

The characteristics of attitudes (Glendon and McKenna 1995):

- Valence - The degree of positive or negative feeling, the way in which the object of an attitude is evaluated.
- Multiplexity – The degree to which an attitude can be differentiated from other attitudes (e.g. the difference between the attitudes about safety and attitudes about health).
- Breadth – The object of the attitude is characterised by a number of attitudes, varying from being very narrow (e.g. a particular brand of ear defender) to very broad (e.g. health and safety in the workplace).
- Intensity – The strength of the feelings about an object (e.g. an accident that was witnessed).
- Stability – The extent of the resistance to change.
- Centrality – The extent to which the person feels that the attitude reflects their identity or the extent of the attitude being part of an individual's self-concept (e.g. a safety professional feeling that holding safe attitudes is part of his/her self-concept).
- Salience – The degree to which the attitude occupies the awareness of an individual, e.g. a road safety professional might be considering safety issues all the time while driving, while other people would not be.
- Interrelatedness – The relation of the attitude with other attitudes (e.g. to form a consistent cluster of attitudes towards safety issues).
- Behavioural expression – The extent to which the attitude is acted upon.
- Verifiability – The degree to which an attitude can be tested against evidence (e.g. attitudes towards seatbelt use verified by observing actual use).

11.5.6 The Functions of Attitudes

Katz (1960) listed five functions of attitudes:

- instrumental function - it serves certain ends and it enables the individual to obtain reinforcement of his/her requirements and desires;
- ego defensive function - it permits the individual to express defence mechanisms (e.g. to protect him/herself from harsh realities such as that he/she is pursuing behaviour that presents a risk to him/her);
- value expressive function - it allows the individual to express the concept he/she has of him/herself;
- knowledge function - it serves as the prime means for an individual to order his/her environment and through which he/she can make sense of or react consistently and meaningfully to the world around him/her;
- instrumental function - by adopting a new attitude for an ulterior motive such as making a good impression on his/her boss/client or to develop a relationship with someone whom he/she values.

11.5.7 Attitude Change

There are certain circumstances under which attitudes are most likely to change They include:

- attitudes loosing function - attitudes can change when an individual finds that his/her attitude is no longer functional in dealing with the situation he/she find him/herself in. He/she will question existing attitudes and as a result bring his/her attitudes more in line with reality (Glendon and McKenna, 1995);
- the audience - to change attitudes, the message should be on the audience's "homeground": that they have an existing network of interconnected attitudes and that consideration be given to the self-esteem and ego involvement of the members of the audience. Attitude change can be promoted through addressing the motives and needs that are important to the individual's self-esteem and in which they are *highly involved*;
- the persuader: The persuader should have credibility in the eyes of the audience (i.e. be trustworthy and seen as an expert) and should be seen as

gaining little or no personal advantage from influencing others other than changing their attitudes. The characteristics of the persuader should preferably be similar to or at least be acceptable to the audience. He/she should further express views that are congruent with those of the audience. The message should aim to have an immediate impact to ensure that the audience remembers it. It has also been found that if the persuader asks for extreme change in an attitude, then it is likely that the audience will reciprocate by going some way in the direction of change;

- personality factors - individuals differ in liability to attitude change. Research seems to indicate that more intelligent people are more open to attitude change. Other factors include individual cognitive styles and needs. Individuals who are very self-defensive may hold attitudes that will be difficult to change. Group affiliations are also important, as people will discuss their views within peer groups before changing their own attitudes on a topic;

- presentation of issues - it is essential that both sides of an argument are presented unless positive attitudes exist on the issue already. There are two effects in communication that need attention: primacy and recency. The primacy effect refers to the first material that is more likely to be remembered – this effect is generally the stronger one and the recency effect refers to the last presented material that is likely to be remembered. It is also important to spell out the main findings and issues. The nature of the message and the desired change will determine whether the material should be presented in an emotional or a factual way. The use of threats or an appeal to fear is the most extreme form of emotional appeal in a safety message;

- persistence of change - active participation in the delivery of the message aids persistence of change. Repetition to reinforce the attitude change has also proven successful. A message can also have a "sleeper effect", i.e. the message is received and the processing takes somewhat longer, resulting in changes taking place later.

11.5.8 The Levels of Attitudes

Kelman (1958) identified three levels at which attitudes can be formed, namely: compliance, identification and internalisation.

At the level of compliance a person accepts the influence of another individual because he/she seeks favourable influence from them, e.g. avoiding punishment or to attaining certain rewards. An example of compliance in road safety would be the use of a seatbelt because of the presence of a traffic law enforcement vehicle alongside the freeway. The attitude-behavioural link is not strong because there is the possibility that once the reason for compliance is removed the behaviour will tend to lapse because of the weak link: the behaviour is the result of external pressures and not from internal beliefs.

The second level of attitude expression is identification. At the identification level the individual adopts a behaviour derived from another as a direct result of the relationship with that party. An example of identification is the operation of group norms where a person displays a behaviour because the other group members do and because the individual values his/her relationship with the group members. The behaviour is thus likely to continue as long as the individual stays part of the group. Should the individual join another group with different norms, then the behaviour is likely to change in response to the changed circumstances. The behavioural-attitude link is again dependant on external factors staying the same (in this case social in nature).

Internalisation is the third and final level of attitude expression. During internalisation, an individual adopts a particular behaviour because it corresponds to his/her existing belief system or because of its functional value. The behavioural-attitude link is the strongest at the internalisation level because, whatever the external factors, the individual will engage in the behaviour because he/she believes it is correct.

The different levels of attitude expression provide guidance to the road safety professional to address the behavioural-attitude challenge. It needs first be ensured that the individual believes that the desired behaviour is correct – the behavioural-attitude link is thus internalised and independent of external factors. If this individual is part of a group supporting the same norms and values, this will reinforce the individually held attitude. Regulations and laws will further serve to reinforce the correctness of the particular behaviour and attitude. The use of regulations and penalties without changing attitudes will thus be less successful.

11.6 BEHAVIOUR AND ATTITUDE

11.6.1 Introduction

Glendon and McKenna (1995) found that long-term positive changes in road traffic safety can only be secured by change in attitude and behaviour. Attitude change is a necessary but not a sufficient condition for behaviour change.

There are four general theories relating to the relationship between attitude and behaviour:

- attitudes influence behaviour – by knowing a person's attitude towards something, the behaviour towards it can be predicted;
- behaviour influences attitudes – if attitude change is needed, then it can be achieved by obliging a person to behave in a particular way (e.g. legislation or making a rule and enforcing the rule);
- attitudes and behaviour mutually reinforce each other – if either one is changed, it is likely to lead to a change in the other;
- attitudes and behaviour are likely to be mutually consistent but should both be addressed independently.

11.6.2 Attitudes influence behaviour

The first theory holds that attitudes predict or influence behaviour as shown in Figure 1-3a. This implies that if the attitude of an individual about something is known, then the behaviour of the individual about the same thing can be predicted with a reasonable degree of certainty. It also implies that changing a person's attitude about something can influence and change the relevant behaviour. It has been shown, however, that the mere expression of positive attitudes about safety practices is not sufficient to change the behaviour of individuals, i.e. to make them engage in safe behaviour. There are however, conditions under which attitudes are likely to change behaviour. Ajzen and Fishbein (1977) listed four factors that are particularly important: action, target, situation and time frame, i.e. the closer the relationship between the particular factor (object of the attitude) and the behaviour, the greater the likelihood that the behaviour will be influenced by the attitude.

They found that it is possible to predict behaviour if attitudes are known, provided that the attitude is highly specific to the particular behaviour. To achieve behavioural change, it is therefore necessary to address the attitudes that are directly and specifically related to that particular behaviour.

11.6.3 Behaviour influences attitudes

The second theory assumes that if behaviour can be changed by certain methods, then the attitudes will change to correspond to that behaviour as shown in Figure 11-3b.

This theory provides the basis for certain types of legislation relating to health and safety. In the case of legislation, an attempt to change behaviour directly is made, e.g. by providing an agency charged specifically with enforcement and a system of penalties for breaching the legislative requirements. Over time, behaviour may change – partially because of such legislation. According to the cognitive consistency theory, if an individual are obliged by legislation to behave in a certain way, whatever his/her initial attitude towards the particular behaviour, then to remain consistent, he/she changes his/her attitude to correspond with the newly required behaviour. It is difficult to prove that any given legislation will change or influence a person's attitude, but it is likely to be among the factors that form attitudes.

An alternative interpretation of this theory is that individuals often determine what their attitudes are by observing their own behaviour, i.e. self-perception. By repeatedly taking various safety precautions, an individual may conclude that he/she possesses positive safety attitudes. The self-perception theory holds that a person forms attitudes by observing his/her own behaviour. This also implies that attitude and behaviour is kept constant to each other - refer to the fourth option of handling fear as discussed in Section 11.4.2 (last paragraph on page 11-3).

Training is another example of methods aimed at behavioural change. The Commission of the European Communities (1990) emphasises the attitude-training link in safety by maintaining that *training is the bedrock of an active attitude to prevention*. They state three objectives for safety training. The strong attitudinal component of safety training is emphasised by the first and the last objective. The objectives are as follows: a) develop a sense of safety, b) learn to control the risks and c) promote awareness of the rules of safety.

11.6.4 Mutual influence

The third theory states that attitude and behaviour mutually influence each other. This is an improvement on the first two theories and is characterised by the notion of consistency between behaviour and attitudes. The basis of this theory is that people strive to have attitudes that are consistent with their behaviour and behaviour that is consistent with their attitudes, i.e. cognitive dissonance.

11.6.5 Influence by other factors

The fourth theory holds that, although there may be consistency between behaviours and attitudes, the possibility of additional factors that could influence both behaviours and attitudes is considered. It supports the fact that, to effect change in behaviour, it is necessary to address both cognitions (e.g. attitudes, perception, motivation) and behaviour directly in order to make progress.

11.6.6 Theory of Reasoned Action

Fishbein and Ajzen (1975) first described the theory of reasoned action. The theory states that more complex processes are involved in the route from attitudes to behaviour. This theory holds that behaviour can be predicted if the following is known:

- the person's attitude to the particular behaviour;
- the person's intention to perform that behaviour;
- the person's belief of the consequences of performing the behaviour;
- the social norms of the person or the phenomenon that socially acceptable behaviour governs that behaviour;

It is, however, not so easy to predict or change behaviour as a person may engage in safe practices in response to pressure from social norms, i.e. friends or colleagues expecting them to behave safely, rather than having a positive attitude towards safe practices or because they have an intention to engage in safe practices.

A study on attitudes towards seat belts (Knapper *et al*, 1976) showed that the use of seat belts was not about having a positive or a negative attitude towards it but it was governed by the habit of using a seat belt. Habits that are based upon previous behaviour seem to be more durable – a possible focus for future road safety campaigns. Health related behaviour like smoking is frequently at odds with attitudes: in spite of the fact that the activity is damaging to a person's health, he/she continue to engage in the behaviour. The reason for this can be the fact that the behaviour is physically determined (i.e. nicotine addiction) or that it is functional in releasing stress.

The theory of reasoned action does not make provision for the emotional factors that can influence the attitude-behavioural link. The Health Belief Model, however, takes account of this factor. The relationship between behaviour and attitude is shown in Figure 11.3.

11.6.7 Health Belief Model (HBM)

The fifth model, the HBM addresses human perception and experience as part of behaviour modification. The model states that two factors influence preventative behaviour to improve health: firstly, consideration of the perceived benefits and costs of taking the action and secondly, the view of the threat that is posed. The assessment of the perceived costs and benefits is influenced by the individual's personal experience and education, whereas the perceived threat is influenced by cues to action (e.g. posters, articles, comments by colleagues) and past experience

The HBM model states that, for any campaign to be successful, the following needs to be addressed:

- the perceived benefits of the action should be greater than the perceived costs (barriers), i.e. the positive aspects should be highlighted and the costs should be attended to (i.e. addressing uncomfortable safety devices, improving user-friendliness of safety devices etc.);
- the campaign should show that the target audience is susceptible and this should be demonstrated. The severity of the long-term condition (threat) should also be emphasised and the avoidance of the threat should also be covered;
- appropriate cues for action should be provided (e.g. posters, supervisors providing reminders) to demonstrate that the person has control over the situation and that he/she can take responsibility for his/her safety.

The HBM model includes a control component that is influenced by the person's evaluation of factors that is likely to inhibit or facilitate their performance of the behaviour – analogous to the costs and benefits in the HBM (Glendon and McKenna, 1995). Figure 11.4 shows the HBM model diagrammatically.

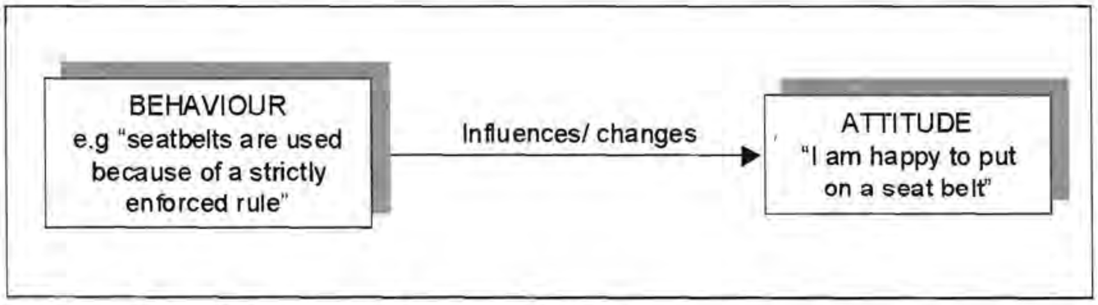


Figure 11.3a: Behaviour influencing Attitudes

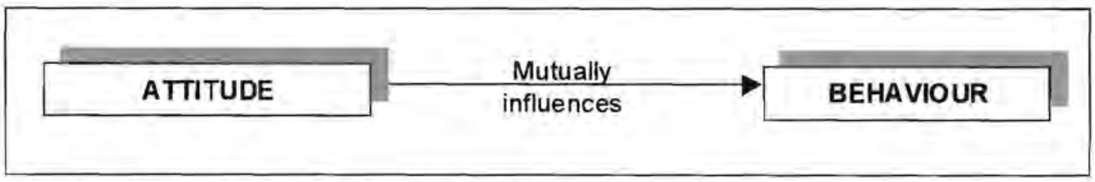


Figure 11.3b: Mutual influence model

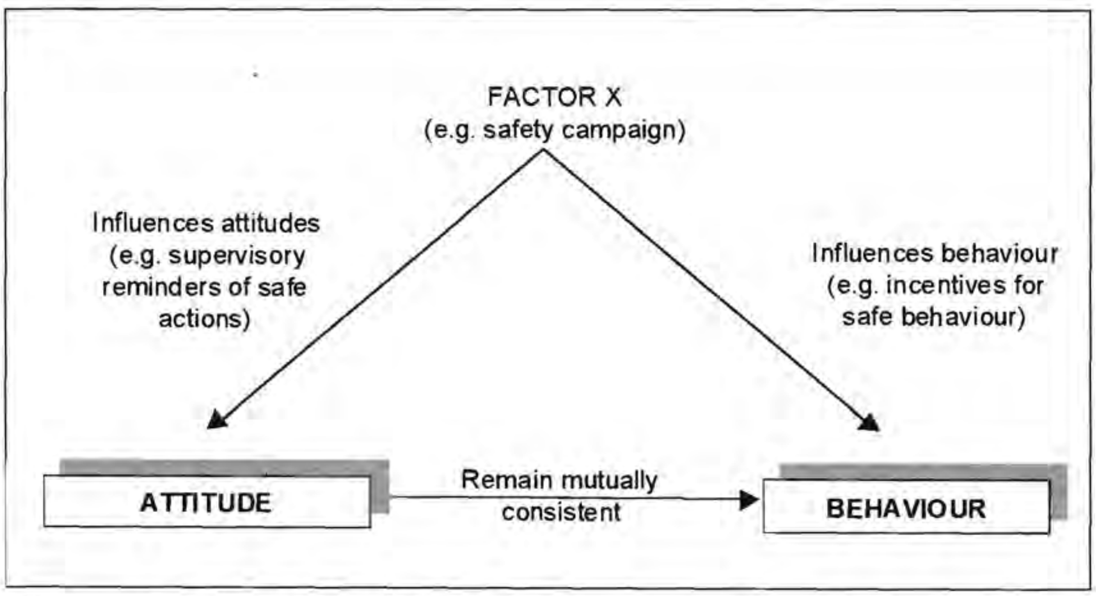


Figure 11.3c: Influence of other factors

Figure 11.3: The first three theories regarding attitudes and behaviour (Glendon and McKenna, 1995)

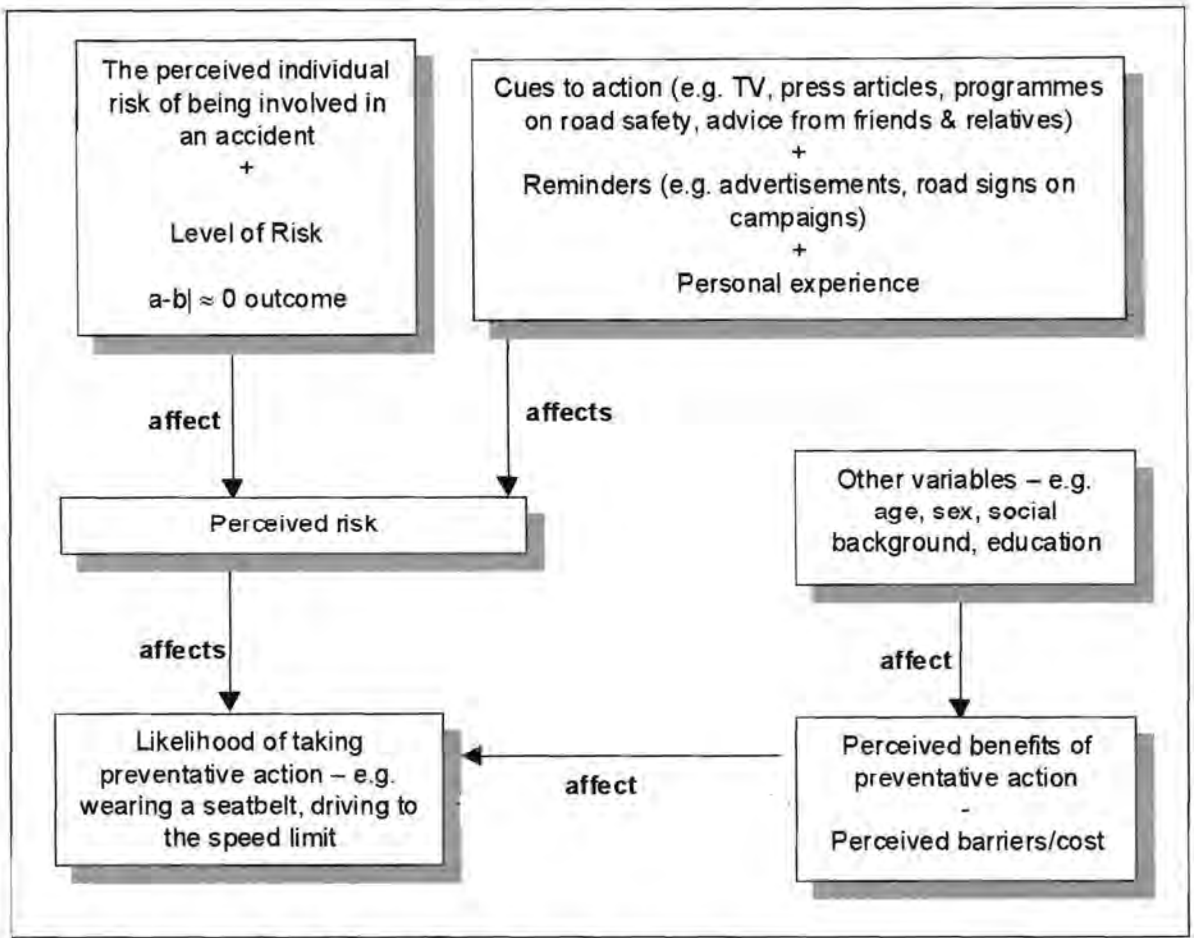


Figure 11-4: The Health Belief Model (Becker 1974)

11.6.8 The Protection Motivation Theory

The Protection Motivation Theory (PMT) (Beck, 1994; van der Velde and van der Plight, 1991) states that health related behaviours are affected by

- the perceived severity of the outcomes;
- the probability of the outcome;
- the effect of the behaviour;
- the expectation that the person will be able to carry out the behaviour.

The first two factors relate to the individual's perceived risk and the last two factors refer to the perceived control (i.e. the likely effectiveness of any individual intervention). The PMT introduces the concept that attitudes and perceptions are linked to behaviour through motivational processes.

Table 11.1 summarises the various concepts included in attitude-behavioural models as described by Glendon and McKenna (1995).

Table 11.1: Concepts in attitude-behavioural models (Glendon and McKenna, 1995)

CONCEPT	QUESTIONS
Behaviour only	• What is the social context (e.g. norms) for the behaviour? • What are the person's habits in respect of the behaviour? (past behaviour is a good guide to future behaviour)
Attitude and behaviour	• What is the nature of any social pressure in respect of the behaviour? • What factors are likely to inhibit or facilitate the behaviour?
Attitude only	• What is the person's attitude towards the behaviour?
Attitude and perception	What are the costs and benefits of taking a given set of actions? What do relevant others think about the behaviour?
Perception only	What are the various outcomes possible? How severe are the respective outcomes? How likely are various outcomes? How much control does the individual have? How effective is the individual's behaviour likely to be? What reminders are there?
Perception and motivation	Are there differences between long term vs short term benefits and costs?
Motivation only	What is the person's intention in respect of the behaviour? How important is this behaviour to the individual? What is the person's motivation to comply with social pressure? What are the emotional reactions to the decision and subsequent behaviour?
Behaviour, attitude, perception and motivation	• What are the individual's personal characteristics (e.g. age, gender, background and experience)?

11.7 RISK

11.7.1 Introduction

Behavioural modification is the ultimate goal of any road safety intervention (if the risky behaviour can be changed to safer behaviour then the resulting accidents will decrease). Risk, risk acceptance, risk perception, etc. have significant impacts on behaviour and the ease of behaviour modification.

Risk was defined by the British Royal Society in 1983 as *the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge* (British Royal Society 1983 in Adams 1995).

11.7.2 Risk and behaviour

Näätänen and Summala (1976) list a number of factors that reduce the subjective danger of road traffic for road users, i.e. increasing the level of risk that the individual is willing to take:

- misleading perceptual/cognitive processes: e.g. speed adaptation, the underestimation of speed or physical forces in an accident, failure to learn from others' accidents;
- *inappropriate*" learning from the consequences of *near misses*: e.g. the illusion that the individual is in control of those situations;
- subjective feelings with regard to driving: e.g. that it is an easy task;
- the feeling of control in driving situations;
- driver expectancy – i.e. the poor estimation of involvement in accidents;
- lack of traffic supervision – i.e. the poor likelihood of being caught and prosecuted for traffic violations;
- the belief that norms and rules are applying to others and not to oneself leads to a perception of low vulnerability.

11.7.3 The Ability of the Individual to Estimate Risk

Rothschild (1978) stated that the individual is poor at estimating objective risk. Subjective risk refers to the perceived risk.

The individual is faced with a number of biases when estimating risk:

- availability, i.e. the tendency to judge an event as likely or frequent if it is easy to recall or to imagine. There is a tendency to overestimate dramatic causes of death or those recently encountered e.g. among friends or family and to underestimate less dramatic events that involve only one person at a time e.g. bronchitis or diabetes;

- overconfidence, i.e. overconfidence often compounds the availability bias because people tend to overestimate how much they know about a risk. This is typical of lay people and experts;

- desire for certainty, i.e. certainty is desired because anxiousness makes people feel uncomfortable. This results in risks being played down because the frequency of occurrence is not known. Individuals differ in their willingness to accept certain levels of uncertainty;

- anchoring bias, i.e. people tend to, partly as a result of a general desire for certainty, anchor attitudes and beliefs on information that might be quite inaccurate. Anchoring bias presents particular problems to the road safety professional as it can be remarkably resistant to cease – even if new and more convincing evidence is found on the issue.

11.7.4 Other Factors Affecting the Acceptance of Risk

Risks are accepted for a number of different reasons. They can be accepted subconsciously or in full knowledge of the potential consequences. People are also more likely to accept risks that they regard as voluntary. It is quite interesting that people also tend to accept a risk that they feel that they can control, i.e. in the debate on nuclear power, the risk issues were not so much the objective risk of an accident but the lack of control individuals feel they have over it. The management of risks therefore need to include the management of the objective and subjective risks.

Cox and Tait (1991) list four factors that influence risk, namely: psychological aspects, economic and technical benefits, socio-political implications and environmental and physical risks.

Psychological aspects refer to threats to mankind and lead to accidents that affects a large number of people at the same time. It is generally a risk the individual is exposed to without his/her consent and a risk that the individual can not control.

The economic and technical benefits refer to:

- The increase in standard of living
- The increase in economic development
- The provision of good economic value
- The increase in a nation's prestige
- New forms of industrial development.

The socio-political implications include:

- The implementation of rigorous physical security measures
- The production of noxious waste products
- The diffusion of knowledge that facilitates the production of weapons by additional countries
- The dependency on highly specialised experts or on small groups
- The transportation of dangerous substances.

Environmental and physical risks include:

- Exhaustion of natural resources
- The increase in occupational accidents
- Water and air pollution
- Economical dependence on other countries
- Long term modification in the climate.

11.7.5 Risk and the Media

Glendon and McKenna (1995) recommend that the media be utilised to play an important role in risk perception, e.g. by:

- *providing information about consequences or risk (as in government or other health warnings which receive media coverage);*
- *translating expert views about the probability of risks (as in articles written by scientific correspondence;*
- *giving details of case histories of victims ('human interest' stories);*
- *informing the public of their own perceptions (as in opinion polls);*
- *acting as a medium of debate about risks (as in editorials and correspondence columns);*
- *giving warnings of impending disasters and what to do (e.g. of storms at sea or potential flooding);*
- *drawing differential attention to risks (e.g. in articles about safety).*

11.7.6 Risky behaviour

Glendon and McKenna (1995) found that the use of labels such as *motorway madness* or allegations that drivers are *careless* or *stupid* do not address risky behaviour because drivers don't think that these labels apply to them personally – although they may see them as applying to *other*. They recommend that the approach should rather be to understand the underlying motives of the *dangerous* driving and to focus on them.

11.8 RISKS, ATTITUDES AND BEHAVIOUR

Studies by Lowrence (1990) on industrial risks suggest that individual perceptions of industrial risks mirror a number of attitudes and beliefs. This can easily be utilised in the road safety industry. They include:

- *fundamentally, Western industrialised countries are conceived as risk-buffering societies, reflected in "compensation" schemes;*
- *individuals strongly prefer to choose their own risks. They resent involuntary and imposed risk and extend this voluntaries to others;*
- *individuals are willing to allow others to undertake risky actions if the consequences are internalised;*
- *individuals are willing to condone a risk-imposing activity if people are compensated;*
- *unspecified and undetermined consequences are not difficult to accept emotionally;*
- *catastrophic consequences are emotionally difficult to endure;*
- *individuals rate immediate consequences more highly than long-term ones;*
- *individuals have a need to delegate responsibility to both competent and trustworthy persons for assessing risks. If trust is lost it cannot easily be regained.*

11.9 THE RISK HOMEOSTASIS THEORY (BASED ON WILDE 1994)

11.9.1 Introduction

In 1977, in the British State of Columbia, a road safety program targeted at drinking and driving took place. 30% of the total number of registered vehicles in the country was tested by several Blood (breath) Alcohol Testing units (the *BATmobiles*) that were deployed along numerous high volume traffic sites. The enforcement action was supported by prominent attention in the mass media. Studies showed a 18% reduction in alcohol-related road traffic fatalities. Overall, however, the accident fatalities increased by 19%.

Gerald Wilde (1994) explains this phenomenon as follows: If it is assumed that the programme was effective in reducing the BAC of drivers, then those who used to drink-and drive previously, refrained from this behaviour more often but, as their target risk was not reduced, they adapted their behaviour by having more passengers in the vehicle, driving more, driving faster, driving less attentive etc. The other drivers who had not previously engaged in drinking-and driving, were under the impression that the campaign was very successful in removing the drunk drivers from the roads, i.e. they were feeling more relaxed about travelling during the more risky hours or about *watching out for the other guy*.

He formulated the risk homeostasis theory that describes the various aspects and mechanisms that can influence the outcomes of a road safety campaign.

11.9.2 The risk homeostasis theory

The risk homeostasis theory maintains that, in any activity, people accept a certain level of subjectively estimated risk to their health, safety, and other things they value, in exchange for the benefits they hope to receive from that activity (transportation, work, eating, drinking, drug use, recreation, romance, sports or whatever) (Wilde 1994)

11.9.3 The target level of risk

There are a number of factors (Box 1 in Figure 11.6) that determine the extent of accident risk that different people are willing to take during any given time period, and that the same people are willing to take during different time periods (Wilde, 1994). The target level of risk will be high if the expected costs are perceived to be relatively low and expected benefits of the risky behaviour are high. Note that the target level of risk refers to a value that varies like the set-point temperature on a thermostat varies.

There are four categories of motivation that determine the target level of accident risk:
the expected advantages of comparatively risky behaviour alternatives
the expected costs of comparatively risky behaviour alternatives
the expected benefits of comparatively safe behaviour alternatives
the expected costs of comparatively safe behaviour alternatives (Wilde, 1994).

The target level of risk will increase as the values of (a) and (b) increase while the level will reduce with an increase in the values of (c) and (d). Note that these values are selected intuitively rather than through a series of precise calculations of the expected benefits and costs.

The target level of risk of an individual can be defined as the level of subjective accident risk at which the difference between benefits and costs (including the perceived danger of accident) is believed to maximise (Wilde, 1994). A graphic representation of the optimisation process is shown in Figure 11.5.

Variations in the target level of risk can be long-lasting (e.g. as a result of cultural values, incentives for safe driving practice, level of education etc.) or shorter-term (e.g. specific trip purpose, the urgency of arriving on time, mood, etc.). Note that the target level of risk is not fixed and that the theory does not imply the conservation of accidents.

The selection of manner and amount of mobility will correspond to the level of associated subjective risk that will in turn correspond to the point at which the expected net benefit is maximised. Note that curve Y3 in Figure 11.5 is drawn in such a manner that each Y3 value will equal the corresponding Y1 value minus the corresponding Y2 value.

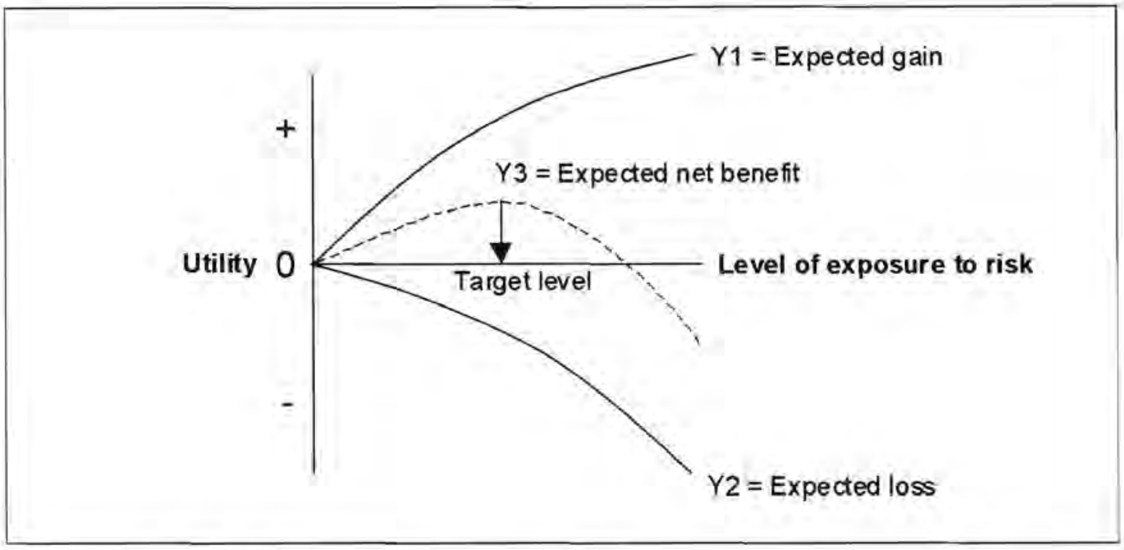


Figure 11.5: The theoretical representation of the road user as a net benefit maximiser. (Wilde, 1994).

11.9.4 Perceived level of risk

The perceived extent of accident risk of an individual at a given time (Box b in Figure 11.6) is derived from three sources, namely:

past experience in traffic (e.g. traffic conflicts, near-accidents, witnessing other people's accidents, conversations about accidents, occasional statistics in the mass media);
assessment of the immediate situation's accident potential (e.g. the speed and direction of travel, the paths and speeds of other road users and road environment features like weather, signals, signs and geometry);
the extent of confidence of the individual in possessing the required vehicle-handling and decision-making skill to cope with the situation (i.e. the risk will be relatively low if the person is confident about having the necessary skills to cope with the situation and high if the person doubts his/her abilities).

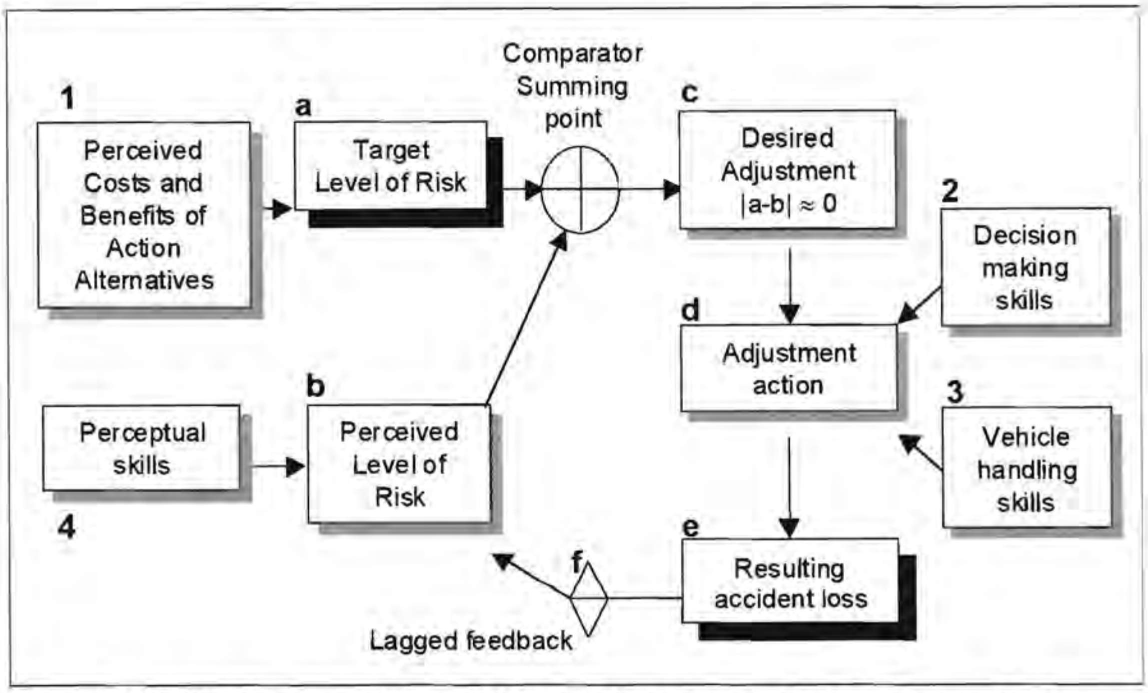


Figure 11.6: The homeostatic model that relates the level of caution in road-user behaviour to the accident rate per head of population and *vice versa*, with the controlling variable being the target level of risk.

11.9.5 Objective level of risk

The objective level of risk refers to *the amount of accident risk (probability times severity) that is associated with a particular behaviour by a particular driver on a particular road in the presence of other particular road users. It includes the risk implications of the driver's skill, his momentary perceptions, his mental alertness, the speed of the vehicle, the braking ability of the car, the likely actions of the other road users, and so forth.* (Wilde 1994).

11.9.6 Adjustment action

As shown by the comparator in Figure 11.6, the perceived amount of accident risk will be monitored continuously by road users, they will compare this with their target level and attempt to reduce any difference between the two (whether positive or negative). They will ultimately try to reduce the discrepancy to the just-noticeable-difference level. These comparisons are made at an intuitive and moderately conscious level. The road user will not alter his or her behaviour if the difference between the target level of risk and the perceived level of risk is below the just-noticeable-difference and corrective action will only be taken if it exceeds the just-noticeable-difference. Typical corrective actions can have immediate effects only, while others are longer term. The short term effects on road safety include change of following distance, speed, pathway, signalling to other road users, buckling or unbuckling the seatbelt, turning lights on or off or increasing or decreasing mental effort or concentration on the driving task. Longer-term decisions include the choice of transportation mode or deciding whether to make a particular trip or not. The choice will depend only on what the individual believes will best serve the maximisation of his/her overall benefit.

11.9.7 The effect on the accident toll

Box d in Figure 11.6 represents the action that is performed after the choice has been made. This action has an objective likelihood of accident risk. The traffic accident loss in that jurisdiction in that year can be determined by the sum total of all the performed actions (with the objective risk of each, across all road users and over an extended period of time like one year). As a result, this loss, combined with the everyday experiences of accident risk (e.g. conversations about accidents, near-accidents, exposure to mass-media accident reports) will influence the level of risk as perceived by the surviving road users in the jurisdiction (those that were not killed in the road accidents) – represented by Box b in Figure 11.6. This means that, as long as the target level of risk (Box a) remains unchanged, the accident loss at one point in time (Box e) and the subsequent degree of caution (Box c) displayed by road-user behaviour are interrelated in a mutually compensatory process that develops over time.

This then implies that, if the past accident rate is lower than the level of risk that people are willing to accept, road users will subsequently adopt a riskier manner and/or level of mobility. It also implies that they will do the opposite if the past rate and personal experience that they associate with it, exceeds the target (preferred) level of risk.

This implication can provide an explanation for the changes in accident rates during a changeover from left-hand to right-hand traffic in Sweden and Iceland during the 1960's. The day the change was made, accident rate per head of population dropped immediately and considerably after the change-over but it subsequently returned to pre-existing trends. In Sweden it returned to the pre-existing trends within two years and in Iceland after 10 weeks. The difference in time can be explained by the fact that the time lag (symbol f in Figure 11.6), if it can be assumed that all other influencing factors are equal, will be longer to the extent that the population size is larger. Sweden's population size was approximately forty times larger than that of Iceland.

It is important to note that homeostasis takes place on individual level and accident loss is thus the sum of the separate consequences of individual actions.

11.9.8 The influence of skills on behaviour

Three types of skills can effect the level of risk perceived and the action performed, namely, perceptual, decision-making and vehicle-handling skills.

- Perceptual skill (box 4 in Figure 11.6) determines the extent to which the subjectively perceived risk of the road user (box b in Figure 11.6) corresponds with the objective risk. Perceptual skill includes the ability to correctly assess one's level of vehicle-handling and decision-making skills. This implies that a person with limited vehicle-handling skills and decision-making skills is, if he/she realises his/her limitations and acts accordingly, at no greater accident risk. If the more skilful therefore overestimate their level of skill (to a greater extent than the less skilful) they may be at greater risk of being in an accident. If the more skilful have higher target levels of risk, they will also be more likely to be involved in accidents than individuals with lower skill levels.

- Decision-making skill (Box 2) refers to the ability of the road user to decide what action he/she should take to produce the desired adjustment (Box c) to minimise the difference between the target and perceived level of risk (i.e. [a-b] equals about zero). The vehicle-handling skill (Box 3) will then determine how effectively he/she can carry out the decision.

It is important to note that the task of the road users – as they see and perform it – is not to minimise accident risk but to maintain the accident risk at a level that corresponds to their target or optimal level of risk. This target level of risk will be the level at which the overall benefit from the mode and manner of mobility can be achieved. Improvement of one's skill will enable one to make better choices about the actions that will agree with one's target level of risk. Because skills do not minimise risk but optimise it, the three types of skill are shown outside the closed loop in Figure 11.6. It can thus be concluded that raising the skill levels of a population can not be expected to lower the accident loss per head of population, although it may influence the likelihood of the individual to survive.

Individuals differ not only in terms of the accident risk they are willing to accept but also in perceptual, vehicle-handling and decision-making skills. A risk-underestimator will typically be the individual that will risk more than corresponds to their target level of risk as a result of their incorrect perceptions of the objective accident risk. Risk-overestimators, on the other hand, would take fewer risks if they were better informed. It is important to note that training in terms of more correct risk perception will not improve the target level of risk of the population. It will merely mean the underestimators will have a better chance of surviving because of their improved estimation of objective risk, while others will be killed because they no longer overestimate objective risk.

Individuals agree reasonably well with one another in judging comparative accident risk when operating a vehicle on a number of different road sections. The collective perception of subjective risk also corresponds well with the objective accident risk per vehicle-km in each section (calculated from accident records).

If a group of drivers questioned on their rating as a driver, more than half will say that they are better than average at driving (Svenson O, 1981 and DeJoy DM, 1989). People tend to be more likely to be overconfident and unrealistically optimistic than unrealistically pessimistic. It is therefore possible to conclude that people will more often than not underestimate the road traffic accident risk they are exposing themselves to.

11.9.9 The risk homeostasis theory and individual accidents

The risk homeostasis theory attempts to explain the accident rate per head of population. It does not explain or try to explain specific individual accidents or the immediate causes like perception-, decision- or execution errors. If considering the accident rate per vehicle km travelled, it is interesting to note that an accident countermeasure[1] can reduce the accident rate per km travelled but increasing the mobility by providing a facility that is perceived as being safer. This implies that the accident rate per head of population increases as mobility increases.

11.9.10 Application of the risk homeostasis theory to influence the human factor in road traffic accidents

Wilde (1994) states that it is possible to motivate people to adopt safer behaviour in real-life conditions – resulting in a significant reduction in accident rates per person. He divides the tactics into four categories, aiming to:

- tactic A: increase the perceived benefit of cautious behaviour;
- tactic B: decrease the perceived cost of cautious behaviour;
- tactic C: increase the perceived cost of risky behaviour;

- tactic D: decrease the perceived benefit of risky behaviour.

Examples of tactic A would typically include:

- *instituting administrative awards for accident-free and violation-free driving through discounts in insurance premiums;*
- *free licence renewal;*
- *discounts in vehicle permits and medical insurance premiums;*
- *rewards for being healthy;*
- *discounts for people with appropriate health habits.*

Using Tactic B would include:

- *subsidies for public transportation;*
- *enhancing the efficiency and comfort of public transit;*
- *tax exemptions on safety equipment;*
- *making safety equipment easy to use.*

Examples of Tactic C would be:

- enhancing the *perceived cost of risky behaviours by actions like taxes on tobacco;*
- *increased penalties for traffic violations;*
- *building vehicles that become uncomfortable (noisy and vibrating) when driven at high speeds;*
- *manufacturing vehicles with frail exteriors and crashworthy interiors that would increase repair cost but reduce the severity of injury;*

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[1] The use of accident countermeasures is not criticised or challenged. The discussion is merely to create thought-provoking examples.

- *reduction of the right to restitution for damages incurred by individuals who don't wear a seatbelt.*

Finally, Tactic D might be the rationale to:

- *paying taxi drivers per time unit instead of per kilometre;*
- *making it mandatory that all employees involved in risky work be paid by the hour and not per unit of productivity.*

Note that he warns that the above are not necessarily recommendations, only examples meant to illustrate. The examples may fail as each is directed at particular behaviours like speeding, drinking and driving etc. If alcohol is for instance taxed beyond people's financial reach, it is likely that they will try to make it themselves – with the associated danger of poisoning.

11.9.11 Accident analysis and the Risk Homeostasis Theory

There are a number of basic characteristics that is associated with the Risk Homeostasis Theory:

- a successful road safety campaign will reduce the number of accidents during the campaign and the reduction effect will be maintained in the period after the campaign;
- a road safety campaign can fail to reduce the target risk by merely shifting risk, i.e. cause temporary changes in the distribution of accident types, degree of injuries, transportation modes, time of accidents, etc.;
- changes in the distribution of accident characteristics for a campaign will occur for the population but not for worst locations (intersections and routes).

A set of accident data can thus be evaluated for changes and if the changes are unsustainable or merely shifts that took place in the distribution, the risk homeostasis theory implies that, although significant changes took place during the campaign, the target level of risk of the population was not reduced and that the changes can be attributed to shifts in risk.

11.10 LAW ENFORCEMENT AND BEHAVIOUR

Shinar (1978) states that law enforcement is a negative reinforcer that produces avoidance behaviour, i.e. the threat of a negative reinforcer (a speeding ticket) should keep a person from committing certain behaviours (speeding). The law on the road is thus to prevent drivers from committing behaviours for which they know they will be punished. There is, however, a problem in the use of this method as the monitoring of the drivers by the police is not systematic and no feedback is provided. Feedback is required for learning to occur. Research by the Highway Safety Research Centre (Reinfurt, Levine, Johnson, 1973) indicated that the presence of this negative reinforcement can be effective. They observed that, when coupled with mass media campaigns and ticketing, the presence of the law enforcement vehicle led to the reduction in average speed from 38,7 mph to 35,5 mph, with an overall reduction of 21 percent in the number of speeding drivers. There was also an increase in driver detection of signage in the area of the parked vehicle. The effect of the speed reduction was much less in the absence of mass media campaigns. This confirms the importance of multiple approaches to safety. The effectiveness of law enforcement is also subject to the effectiveness of the court and legal system. This was confirmed by the lack of success of the implementation of automatic imprisonment and loss of driver license for a conviction for drunken driving in Scandinavian countries. Not even the rate of fatal accidents related to drunken driving showed any change (Shinar 1978).

11.11 CONCLUSIONS

The human factor forms an essential element of any road traffic safety improvement intervention. The mechanisms of attitude, behaviour, motivation, risk and skills should receive consideration in the evaluation of the human factor in the road traffic safety improvement interventions. The character of each, interaction with each other and the relation to the ultimate goal, behavioural change, play important roles in the evaluation of any road safety improvement intervention and will have a significant effect on the outcome of the intervention.

CHAPTER 12: HUMAN FACTORS RELATED TO ROAD SAFETY INTERVENTIONS - A LITERATURE SURVEY

12.1 INTRODUCTION

Chapter 11 described the five components of psychology, namely, behavioural change, attitude, risk, motivation and skills, that provide insight into the human factor in road traffic safety improvement interventions. Based on these sections, this chapter proposes a number of criteria to test the human factor in a road safety improvement intervention. Note that this evaluation should be carried out by human factor specialists. Only the concepts to be tested are stated and not, for example, the specific questions for a questionnaire.

This evaluation is tentative and preliminary. It is aimed at illustrating the urgent need for such an evaluation by specialists.

The purpose of this chapter is to discussed the proposed qualitative indicators for the human factor evaluation in road safety improvement interventions. A preliminary assessment of Arrive Alive 1 is also discussed.

12.2 CRITERIA AND EVALUATION ELEMENTS

The criteria and evaluation elements can be placed into two categories, namely: input related and outcome related issues. The input related category refers to the criteria and evaluation for the media, communication and other aspects that were presented to the public. The outcome related category refers to the criteria and evaluation of the public. Note that these elements are described as concepts only and that they can not be utilised directly as questions in a questionnaire or evaluation form.

12.3 INPUT-RELATED CRITERIA AND EVALUATION ELEMENTS

The concepts of the input-related criteria can be summarised in Table 12.1. The relevant references to Chapter 11 are also indicated. Note that these criteria are discussed in terms of concepts only and that human psychology specialists should prepare detailed questionnaires or evaluation forms based on these criteria to assess the human factor.

Table 12.1 Input-criteria for road safety improvement interventions.

INPUT-CRITERIA FOR ROAD SAFETY IMPROVEMENT INTERVENTIONS: Did communications (including media and press releases, speeches by political figures etc.)............		REFERENCE IN CHAPTER 11
1.	Provide reinforcement for the particular behaviour with reminders to change attitudes?	11.4.1
2.	Provide information on what the individual should do rather than what he/she should not do, i.e. provided cues to action?	11.4.2 and 11.6.7
3.	Use emotion to change attitudes and behaviour where a positive attitude did not already exist?	11.5.4
4.	Provide information with regard to the perceived benefits and costs of the unsafe behaviour and the perceived benefits and costs of safe behaviour?	11.5.4, 11.6.7, 11.9.4
5.	Make use of the instrumental function of attitudes?	11.5.6
6.	Make use of the value-expressive function of attitudes?	11.5.6
7.	Address the motives and needs important for the self-esteem of the individual and the things he/she is highly involved with?	11.5.7
8.	Use similar characteristics of the target group(s) – e.g. was the persuader acceptable to the group, did the persuader express views congruent with the target group?	11.5.7
9.	Use group affiliations to change attitudes and behaviour?	11.5.7
10.	Present both sides of the argument unless the target group already held positive attitudes on the issues?	11.5.7
11.	Present the desired behaviour in such a manner that the target group was able to believe that it is correct and that by engaging in the desired behaviour that he/she would remain part of the group that supports the same norms and values?	11.5.8

INPUT-CRITERIA FOR ROAD SAFETY IMPROVEMENT INTERVENTIONS: Did communications (including media and press releases, speeches by political figures etc.)............		**REFERENCE IN CHAPTER 11**
12.	Inform the target group of laws and regulations in place that will reinforce the desired behaviour?	11.6.7, 11.7.5 and 11.10
13.	Aim at changing the desired behaviour into a habit?	11.6.6
14.	Provide detailed information on the severity of the threat posed by the risky behaviour?	11.6.7
15.	Take the social context of the behaviour into consideration?	11.6.7
16.	Take the factors likely to inhibit or facilitate the behaviour into consideration?	11.6.7
17.	Take the target group individual's personal characteristic like age, gender, background, experience etc. into consideration?	11.6.7
18.	Provide the probability of the accident risk?	11.7.5
19.	Provide the consequences of the accident risk?	11.7.5
20.	Provide human interest stories around road traffic accidents?	11.7.5
21.	Inform the target group of their perceptions?	11.7.5
22.	Provide an opportunity for debate on the accident risk?	11.7.5
23.	Provide warnings on the accident risk?	11.7.5
24.	Provide occasional statistics?	11.7.5
25.	Inform the target group that the penalties for traffic violations increased?	11.9.10
26.	Label the individual or target groups with labels like *criminal* etc.?	11.7.6
27.	Provide feedback on law enforcement actions?	11.10

12.4 OUTPUT-RELATED CRITERIA AND EVALUATION ELEMENTS

The concepts of the output-related criteria can be summarised in Table 12.2. The relevant references to Chapter 11 are also indicted. Note that these criteria are discussed in terms of concepts only and that human psychology specialists should prepare detailed questionnaires or evaluation forms based on these criteria to assess the human factor.

Table 12.2 Output-criteria for road safety improvement interventions.

OUTPUT-CRITERIA FOR ROAD SAFETY IMPROVEMENT INTERVENTIONS: Check for changes in the following:		REFERENCE IN CHAPTER 11
1.	The use of fear: • Did it make the person act more safely? • Did he/she reject it altogether or • Did he/she believe it is unsafe but still did not change to the safe behaviour?	11.4.1
2.	How does the individual's attitude differ in terms of situation or object specifics?	11.5.3
3.	Is the attitude that the individual holds on the safe/unsafe behaviour deep-seated beliefs or superficial opinions?	11.5.3
4.	Is the individual aware of the benefits & costs of both the safe and unsafe behaviour?	11.5.4, 11.6.6, 11.6.7, 11.7.5, 11.9.3
5.	Is the individual aware of the risk of his/her unsafe behaviour?	11.5.4, 11.6.6, 11.6.7, 11.7.5, 11.9.3
6.	What is the individual's behavioural intention?	11.5.4
7.	How stable is the individual's attitude, i.e. what is the extent of resistance to change?	11.5.5
8.	Does the desired attitude allow the individual to express the concept that he/she has of him/herself?	11.5.6
9.	Will the individual be able to impress someone or develop a desired relationship by adopting the desired attitude?	11.5.6

OUTPUT-CRITERIA FOR ROAD SAFETY IMPROVEMENT INTERVENTIONS: Check for changes in the following:	REFERENCE IN CHAPTER 11
10. Will the attitude change address the individual's motives and needs important to the individual's self-esteem?	11.5.7
11. Media: Could the individual associate with the persuader, i.e.: • Being similar or acceptable to him/her? • Expressing views congruent with his/hers?	11.5.7
12. Media: Did the individual believe what was presented to him/her?	11.5.7
13. Does the individual have positive attitudes towards the desired behaviour and if not, what is his/her attitude?	11.5.7.11.5.8, 11.6.6,
14. Why would the individual engage in the safe behaviour: is it: • to avoid punishment; • to obtain certain rewards; • because he/she believes it is correct?	11.5.8
15. What is the individual's attitude towards the safe/ unsafe behaviour?	11.6.6
16. What is the intention of the individual in terms of performing the safe/unsafe behaviour?	11.6.6
17. What is the individual's belief of the consequences of performing the safe/unsafe behaviour?	11.5.4, 11.6.6, 11.6.7, 11.7.5, 11.9.3
18. Is the safe/unsafe behaviour a habit?	11.6.6
19. Does the individual know the costs and benefits of the safe and unsafe behaviours?	11.5.4, 11.6.6, 11.6.7, 11.7.5, 11.9.3
20. Does the individual experience any social pressure in terms of the safe and unsafe behaviours?	Table 11.1
21. What factors are likely (or did) inhibit or facilitate the safe and unsafe behaviour?	Table 11.1
22. What is the person's personal characteristics, e.g. age, gender, background, experience?	Table 11.1

OUTPUT-CRITERIA FOR ROAD SAFETY IMPROVEMENT INTERVENTIONS: Check for changes in the following:		REFERENCE IN CHAPTER 11
23.	Does the individual have an anchoring bias towards the risk perception?	11.7.3
24.	Media: Was the individual provided with feedback from law enforcement?	11.7.5 and 11.10
25.	Did the individual observe systematic monitoring of the behaviour by law enforcement?	11.5.8 and 11.10

Note that Criteria 5,6,7,8,9,17 and 21 cover the aspect of target group identification and focus.

12.5 PRELIMINARY EVALUATION OF THE INPUT-BASED ELEMENTS OF ARRIVE-ALIVE 1

Criterion 1: Attitude change – The campaign focused on providing information on law enforcement actions and traffic offences and reported on road traffic accidents. Attitude change was indirectly sought through press releases referring to the words of Minister Maharaj: *culture change* in a press release dated 4 November 1997 and, *Our aim in this short term campaign is not simply to punish people.... This is part of the wider aim of beginning to fundamentally change people's attitudes* (NDoT website, 1997).

Criterion 2: Cues for action – The media just stated *Speed kills*, other statements from Minister Maharaj included: *The carnage on our roads has to stop*. The Asiphephe project, however, installed a sign on the N3 border to KwaZulu-Natal that states: *Slow down, speed kills* that did provide a cue for action.

Criterion 3: Emotion was used to a large extent in press releases and in speeches by the Minister. It is not clear whether positive attitudes already exist on, for example, driving within the speed limit etc.

Criterion 4: Information on the costs & benefits of both safe & unsafe behaviour – The public was only informed on the costs of unsafe behaviour, e.g. *we are beginning with tough enforcement.*

Criteria 5,6,7,8,9,17 and 21: Focus on target group(s) - The Arrive Alive 1 campaign was targeted to the entire population of South Africa. The messages were therefore general (*Don't fool yourself, Speed kills*).

Criterion 10: Presenting both sides of the argument – Both sides of the argument of safe behaviour were not presented.

Criterion 11 – The desired behaviour was presented only in terms of the slogan *Don't fool yourself, Speed kills.* It is general and the issue of whether speed kills was debated among the public.

Criteria 12, 14, 25, 27: Law enforcement – The public was repeatedly informed on the extensive law enforcement actions that was planned, that took place and of the high penalties that would be paid for non-compliance with traffic laws.

Criterion 13: Habit – The communication effort did not urge the public to change the safe behaviour into habit, it merely stressed the fact that law enforcement would increase during the Arrive Alive 1 period.

Criterion 14: Severity of the threat – The severity of the threat, e.g. *Speed kills* was communicated to the public through the written media and with signs along the major routes.

Criterion 15: Social context of the behaviour – Attention was not focussed on the social context of the behaviour.

Criterion 16: Factors inhibiting or facilitating the behaviour – Attention was not focussed on the social context of the behaviour.

Criterion 18: Risk probability – Attention was not focussed on the risk probability, it was only stated that *The statistic will be you, your wife or husband, son or daughter – killed or maimed for life*, i.e. the possible threat

Criterion 19: Consequence of the accident risk – Press releases included statements like: *The statistic will be you, your wife or husband, son or daughter – killed or maimed for life.*

Criterion 20: Human interest stories were reported on a weekly basis in the written media and on TV.

Criterion 22: The media provided some opportunity for debate on the accident risk.

Criterion 23: Warnings were provided on the accident risk.

Criterion 24: Occasional statistics were provided.

Criterion 25: Use of labels – Unfortunately statements like: *If you commit road traffic offences you're a criminal* (NDoT website, press release 1 October 1997), *there is still a minority of drivers on the roads who behave like criminals, who have no regard for their lives, nor of lives for others* (NDoT website, press release 2 January 1998) were made.

12.6 PRELIMINARY EVALUATION OF THE OUTPUT-BASED ELEMENTS OF ARRIVE ALIVE 1

The output-based elements of Arrive Alive 1 can only be measured with questionaires and interviews. It is therefore not tested for the purpose of this study.

12.7 CONCLUSIONS

Input and output-based criteria for the human factor in road traffic safety improvement interventions provide a means for the evaluation of these interventions.

CHAPTER 13: CONCLUSIONS AND RECOMMENDATIONS

13.1 CONCLUSIONS

The following conclusions were made based on the study:

- road traffic accidents place a burden on South Africa in terms of cost and emotional hardship;
- South Africa is implementing various measures and programs aimed at improving road traffic safety (e.g. the Road Traffic Management Strategy, Arrive Alive 1, etc.);
- there is a need to identify qualitative and quantitative key performance indicators that can be used to evaluate road safety improvement interventions to ensure that the intervention is economically viable;
- the macro-level evaluation of accident data with statistical methods to determine the significance of change during and after an intervention is problematic as the data shows no particular trends, only random fluctuations around the mean – a lack of measure for exposure makes the use of trend analysis to predict the expected number of accidents without the intervention impossible as even the use of fuel sales as a measure of exposure is not accurate enough;
- there is a need for the development of an indicator of exposure with a higher degree of correlation than fuel sales that can be used to express accident data in terms of exposure;
- the human factor is an essential element of road safety improvement interventions. The mechanisms of attitude, behaviour, motivation, risk and skills should be incorporated in the planning and evaluation of road traffic safety improvement interventions;
- input-based and output-based criteria for the human factor in road traffic safety interventions provide qualitative key indicators for the evaluation of these interventions.

13.2 RECOMMENDATIONS

It is recommended that:

- road safety interventions be evaluated using both quantitative (accident data related) and qualitative indicators (human factor related);
- a model or measure be developed that can be utilised to predict accident trends and volumes – exposure need to be an essential part of this model - this can then be utilised as a quantitative measure;
- the human factor be considered in the development and evaluation of road traffic safety improvement interventions;
- independent experts with knowledge of human behaviour with independent funding be contracted to evaluate all steps and measures that were introduced to address road safety and to evaluate road safety interventions like Arrive Alive 1 using both qualitative and quantitative indicators.

CHAPTER 14: REFERENCES

Ajzen I and Fishbein M, 1977. *Attitude-behaviour relations: a theoretical analysis and review of empirical research.* Psychological bulletin, 84, pp. 888-918. in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

AUSTROADS, 1994. *Road safety audits*, Sydney, Australia.

AUSTROADS, 1988. *Guide to Traffic Engineering Practice: Part 4 – Road crashes*, Sydney, Australia.

Beck KH, 1984. *The effects of risk probability, outcome severity, efficacy of protection and access to protection on decision making: a further test of protection motivation theory*, Social Behaviour and Personality, vol 12. in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Bray JS, 1993. *A realistic safety management system,* Transportation Research Circular 416: Issues surrounding highway and roadside safety management, Transportation Research Board, Washington D.C.

British Royal Society 1983. *Risk assessment,* UK; in **Glendon AI and McKenna EF,** 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Bureau of Transport and Communications Economics, 1994. *Costs of Road Crashes in Australia,* 2p., BTCE, Canberra, Australia.

Business Plan 1997. *Business Plan towards implementation of the Road Traffic Management Strategy (RTMS) based on the resolutions taken at the Road Traffic Quality and Safety Symposium on 22 and 23 July 1996 in Pretoria,* 4th Draft, 3 January 1997, Office of the National Department of Transport, South Africa.

Central Statistical Service 1999. *Accident data from national database*, South Africa.

Commision of the European Communities, 1990. *Social Europe: Health and safety at work in the European community*, Office of Official Publications of the European Community, Luxemburg. in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Cox SJ and Tait NRS, 1991. *Reliability, safety and risk management: An integrated approach*, Butterworth-Heinemann Ltd, Oxford. in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Evans L, 1994. *Evaluating public transport and road safety measures.* Accident Analysis and Prevention 26(4), pp 411-428.

Federal Office of Road Safety, 1992. *The national road safety strategy,* FORS, Canberra, Australia.

Federal Highway Administration, 1991, Management approach to highway safety: A compilation of good practice, FHWA, Washington D.C.

Fieldwick R and Odendaal JR, 1981. *The relationship between rural speed limts and accident rate*, Technical Report, USA.

Fishbein M and Ajzen I, 1975. *Belief, Attitude, Intention and Behaviour: an Introduction to Theory and Research*, Addison-Wesley, Reading, UK. in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Frith WL and Toomath JB, 1982. *The New Zealand open road speed limit* , Accident Analysis and Prevention, Volume 14, Number 3, pp 209-218.

Glendon AI and McKenna EF, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Glendon AI, 1987. *Risk cognition,* in WT Singleton and J Hovden, Risks and Decisions, Wiley, Chichester. in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Glendon AI, in press. *Risks and values of the world of work*, in WT Singleton, *The spirit at work*, Blackwell, Oxford, UK; in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management*, Chapman and Hall, London, UK.

Godwin SR, 1984. *International experience with speed limits during and prior to the energy crisis of 1973-4*, Transportation Planning and Technology, Volume 9, pp 25-35.

Godwin SR, 1992. *Effect of the 65mph speed limit on highway safety in the USA (with comments and reply to comments)*, Transport Reviews, Volume 12, Number 1, pp. 1-14.

Gray J, 1998. *Road traffic management corporation: An overview*, South African Transportation Conference, September 1998, CSIR Conference centre, Pretoria, South Africa.

Haight FA. 1983. Some theoretical aspects of road safety, in Addreassend DC and Gipps PG (eds) *Traffic Accident Evaluation*, Monash University, Melbourne, Australia.

Hakim S, Shefer D, Hakkert AS and Hockerman I, 1991. *A critical review of macro models for road accidents*, Accident Analysis and Prevention, Volume 23, Number 5, pp. 379-400.

Hale AR and Glendon AI, 1987. *Individual behaviour in the control of danger*, Elsevier, Amsterdam.

Homburger WS, Kell JH and Perkins DD, 1992. *Fundamentals in traffic engineering*, Institute of Transportation Studies, University of California at Berkeley, Course Notes, January 1992, USA.

Hulbert S, 1982. *Human factors in transportation*, in Homburger WS, Keefer LE and McGrath WR (eds), Transportation and Traffic Engineering Handbook (2nd edition), Prentice Hall, Englewood Cliffs, NJ, for the Institute of Transportation Engineers, Washington D.C.

Institute of Transportation Engineers, 1978. *Introduction to Transportation Engineering*, by Carter EC and Homburger WS, Prentice-Hall, Virginia, USA.

ITE, 1982. *Transportation and Traffic Engineering Handbook*, 2nd Edition, by Homburger WS, Keefer LE and McGrath WR, Prentice-Hall, New Jersey, USA.

ITE, 1990. *Traffic Engineering*. By McShane WR and Roess RP, Prentice Hall Polytechnic Series in Traffic Engineering, Prentice Hall, New Jersey, USA.

ITE, 1992. *Traffic Engineering Handbook*, 4th Edition, by Pline JL, Prentice Hall, New Jersey, USA.

ITE, 1993. *The Traffic Safety Toolbox: A primer on traffic safety*, Washington DC, USA.

Katz 1960; in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Kelman HC, 1958. *Compliance, identification and internalisation: Three processes of attitude change*, Journal of conflict resolution, 2, 51-60; in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Knapper CK, Copley AJ and Moore RJ, 1976. *Attitudinal factors in the non-use of seat belts.* Accident Analysis and Prevention, volume 8; in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

KwaZulu-Natal Department of Transport, 1988. *Road Safety Strategy for KwaZulu-Natal*, A summary of the 1998/1999 to 2002/2003 five year plan, Office of the Minister, Province of KwaZulu-Natal.

Lay MG, 1986. *Handbook of Road Technology*, p.556, Gordon and Breach, London.

Levin RI and Rubin DS, 1991. *Statistics for Management*, Fifth Edition, Prentice-Hall International Editions, United States of America.

Local Authorities Association, 1989. *Road safety code of good practice*, Association of County Councils, London.

Lowrence WW, 1990. *Stewardship of chemical production risks,* paper presented at the First IUPAC Workshop on safety in chemical production, 9 – 13 September, Basel, Switzerland; in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Moving South Africa, 1998. *Towards a transport strategy for 2020: Report and strategic recommendations*, Draft for discussion, 7 September 1998, p 185.

Näätänen and Summala 1976; in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

National Department of Transport, 1998. *Setting of speed limits*, Research Report RR 96/006, May 1998, South Africa.

National Center for Health Statistics: US Department of Transport, 2000. *Fastats: Deaths/Mortality*, http://www.cdc.gov/nchs/fastats/deaths.htm, updated 1/5/2000.

National Department of Transport Website, 1987. *Press Release: Arrive Alive moves up a gear, ministers launch second phase of campaign on speeding,* http://www.transport.gov.za/projects/arrive/speed.html

NDoT Website, 1998. ARRIVE ALIVE - A closer look, http://www.transport.gov.za/projects/arrive/closer.html

NDoT Website, 1998. The ARRIVE ALIVE campaign: What is it all about? http://www.transport.gov.za/projects/arrive/pr/1998/pr0101.html

Neter J, Wasserman W and Whitmore GA, 1988. *Applied Statistics,* Third Edition, Allyn and Bacon, Inc, Boston, USA.

Ogden KW and Taylor SY. 1996. *Safer Roads: A Guide to Road Safety Engineering*. 516 p., Avebury, London, UK.

Ogden KW and Taylor SY. 1996. *Traffic Engineering and Management*. 680 p., Monash University, Melbourne.

Organisation for Economic Cooperation and Development 1984. *Integrated road safety programs*, OECD, Paris, France.

Pant PD, Adhami JA and Niehaus JC, 1992. *Effects of the 65mph speed limit on traffic accidents in Ohio,* Transportation Research Record 1375, Transportation Research Board, pp 53-60, USA.

Parker *et al*, 1992. Determinants of intention to commit driving violations, Accident analysis and prevention, Volume 24, No 2, pp. 117 - 131, Pergamon Pess Ltd. in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Reinfurt DW, Levine DN and Johnson WD, 1973. *Radar as a speed deterrent: an evaluation*, Highway Safety Research Center, UNC, February 1973.

Rosenberg and Hovland, 1960 ; in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Rothschild Lord, 1978. *Risk,* Listener, Volume 100, 30 November; in **Glendon AI and McKenna EF**, 1995. *Human safety and risk management,* Chapman and Hall, London, UK.

Road Traffic Management Strategy 1997. *Abridged Business Plan towards implementation of the Road Traffic Management Strategy (RTMS),* National Department of Transport, South Africa.

Shubik M, 1991. *Risk, Organisations and Society*, Kluwer Academic Publishers, Boston.

Stanton NA, 1992. *The human factor aspects of alarms in human supervisory control tasks,* PhD Thesis, Aston University, Birmingham.

Stanton NA, Booth RT and Stammers RB, 1992. *Alarms in human supervisory control: a human factors perspective*, International Journal of Computer Integrated Manufacturing, Volume 5.

US Department of Transport, 1981. *Deterrence of the Drinking Driver: An international survey*, Report no: DOT-HS-805-820.

US House of Representatives, 1985. *Status of the Nation's Highways: conditions and performance,* June 1985, USA.

Van As SC, 1999. *Applied statistics for civil engineers,* South Africa.

Van der Velde W and Van der Plight J, 1991. *AIDS-related behaviour: coping protection motivation, and previous behaviour*, Journal of Behavioural Medicine, Volume 14.

Van der Walt JJA, 1998. Arrive Alive report: Draft, Gauteng Provincial Government, January 1998.

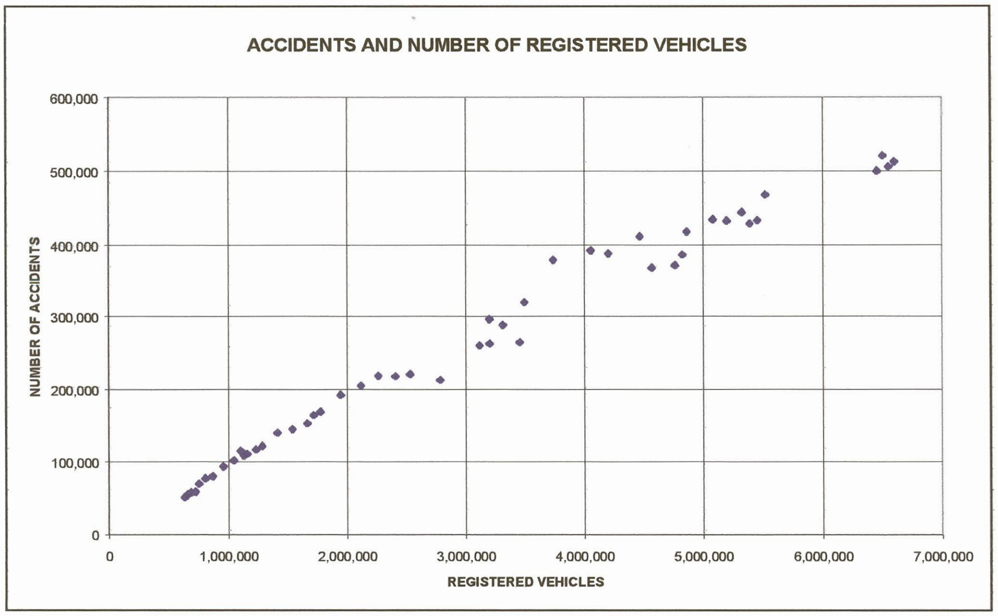
Wilde GS, 1994. *Target Risk: Dealing with the danger of death, disease and damage in everyday decisions*, PDE Publications, Ontario, Canada.

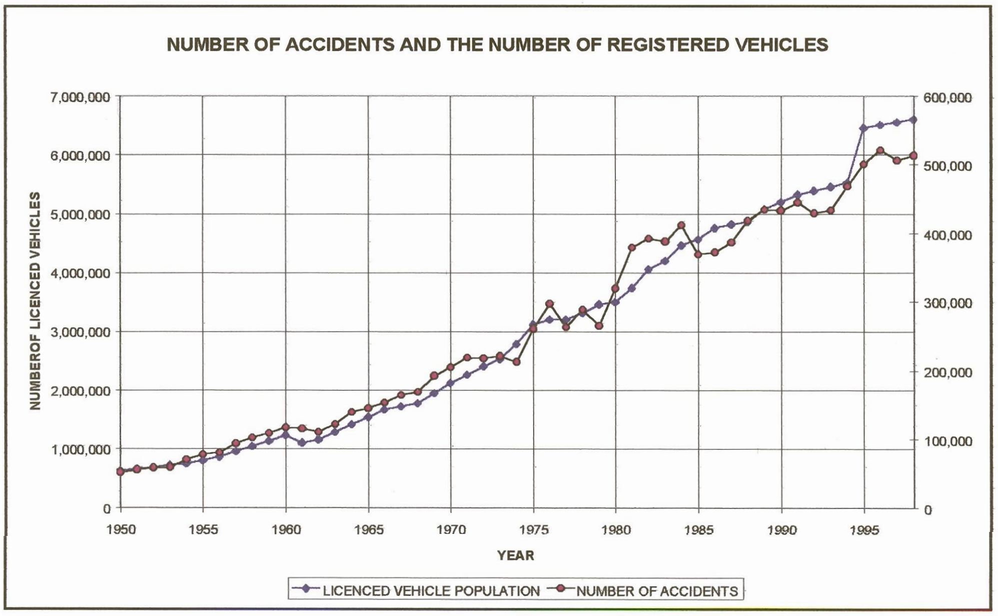
Zogby JJ, 1994. *Highway safety management: Past and current practice*, TR News 173, Transportation Research Board, Washington D.C.

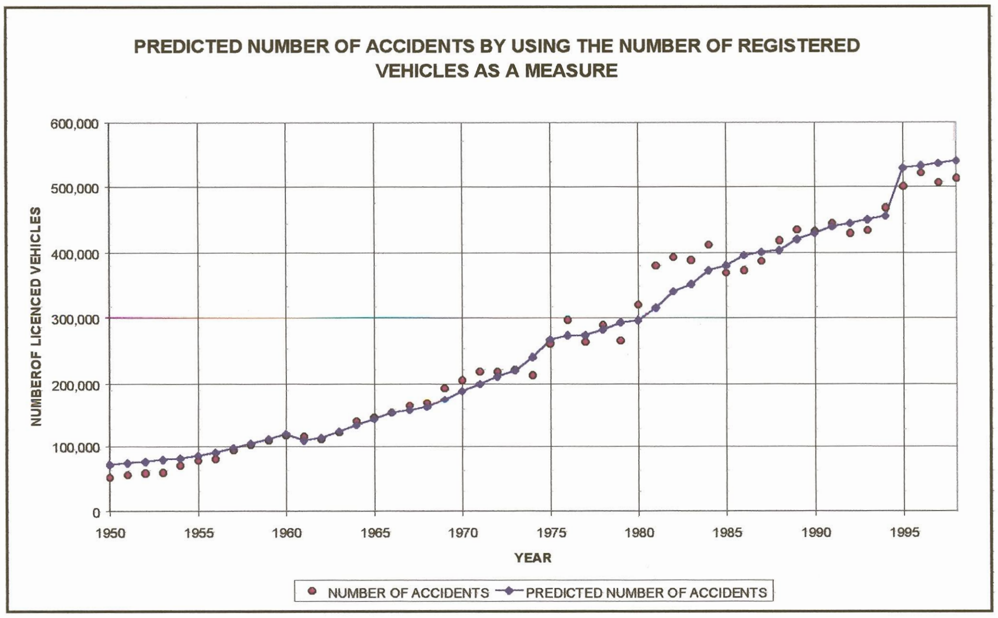
Appendix A:

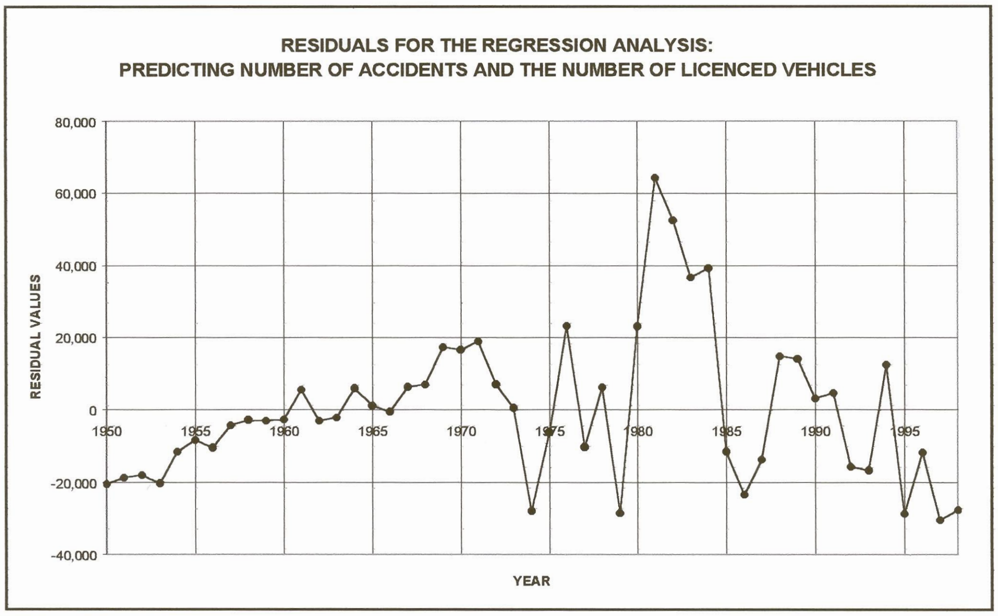
The regression analysis of number of accidents and fuel sales.

APPENDIX A: THE REGRESSION ANALYSIS FOR NUMBER OF ACCIDENTS AND NUMBER OF REGISTERED VEHICLES









SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.99
R Square	0.98
Adjusted R	0.98
Standard Error	20739.06
Observations	49.00

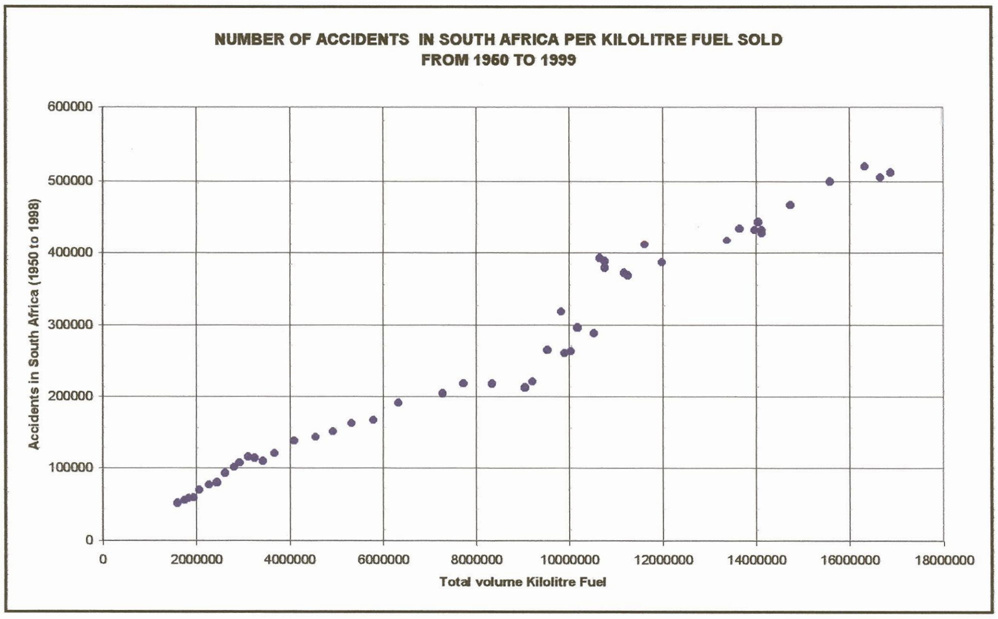
RESIDUAL OUTPUT

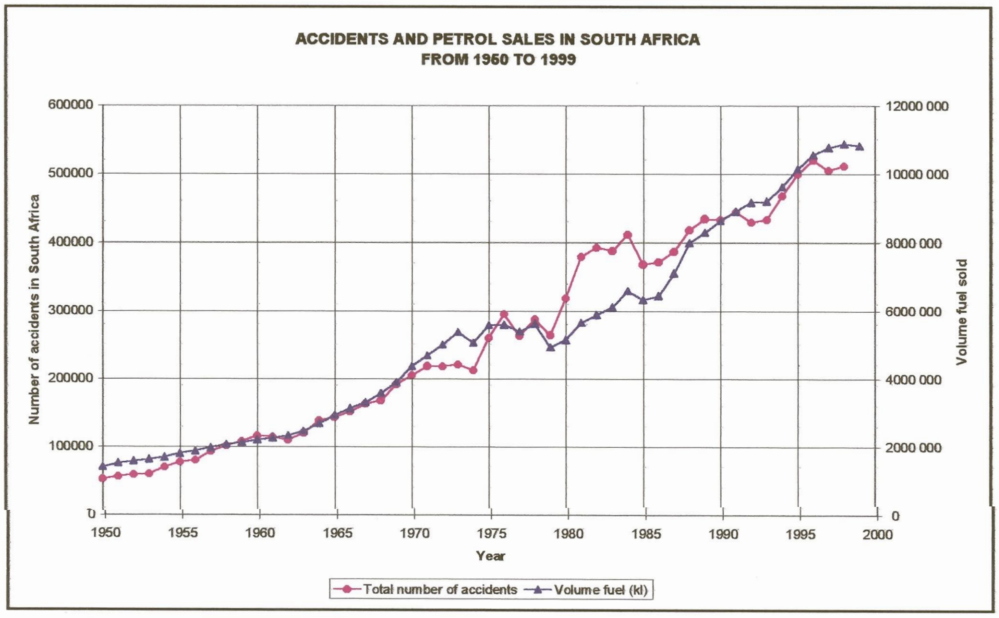
Observation	*Predicted Y*	*Residuals*
1.00	72390.99	-20424.99
2.00	74391.70	-18758.70
3.00	76503.11	-18060.11
4.00	79529.74	-20209.74
5.00	81756.94	-11575.94
6.00	85961.96	-8482.96
7.00	90732.77	-10469.77
8.00	97890.09	-4390.09
9.00	104763.70	-2868.70
10.00	111411.28	-3090.28
11.00	119451.43	-2763.43
12.00	109281.76	5507.24
13.00	113559.22	-3077.22
14.00	123488.72	-2192.72
15.00	133418.23	5982.77
16.00	143347.73	1149.27
17.00	153277.24	-594.24
18.00	157544.86	6330.14
19.00	161812.48	6903.52
20.00	175309.51	17205.49
21.00	188806.55	16460.45
22.00	200103.35	18822.65
23.00	211400.15	7035.85
24.00	221061.81	466.19
25.00	240952.65	-27849.65
26.00	267021.94	-6259.94
27.00	273514.60	23050.40
28.00	273680.18	-10315.18
29.00	282420.98	6217.02
30.00	293572.82	-28473.82
31.00	296487.49	23019.51
32.00	315652.53	64199.47
33.00	340477.41	52493.59
34.00	352086.94	36512.06
35.00	372946.70	39150.30
36.00	380747.19	-11562.19
37.00	395933.70	-23265.70
38.00	400950.68	-13802.68
39.00	403754.42	14728.58
40.00	420887.39	14047.61
41.00	430187.40	3099.60
42.00	439955.44	4585.56
43.00	445172.18	-15687.18
44.00	450388.93	-16677.93
45.00	455605.67	12391.33
46.00	528839.98	-28606.98
47.00	532630.90	-11856.90
48.00	536421.83	-30433.83
49.00	540212.75	-27607.75

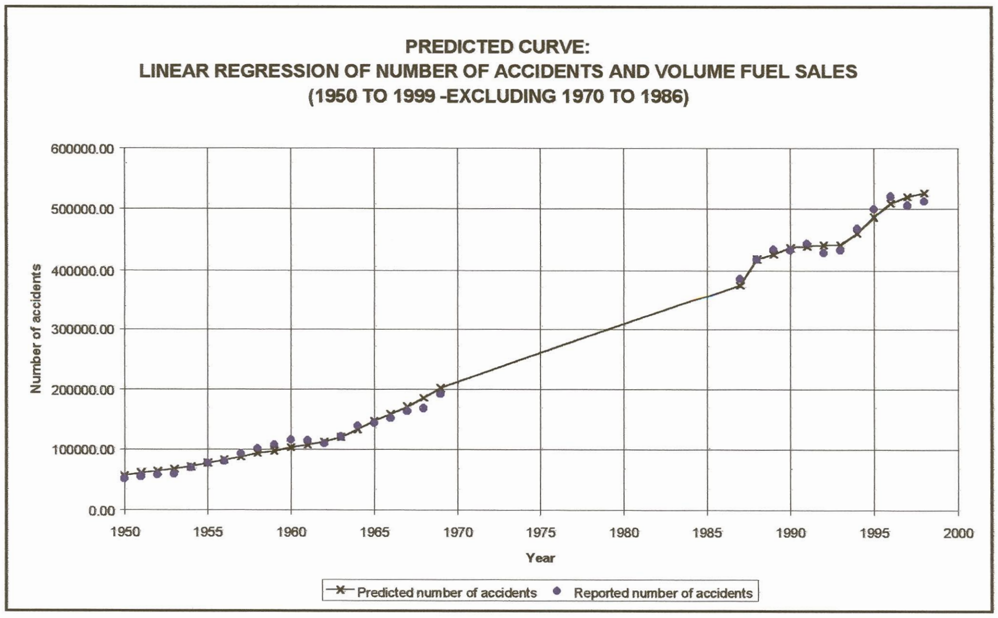
Appendix B:

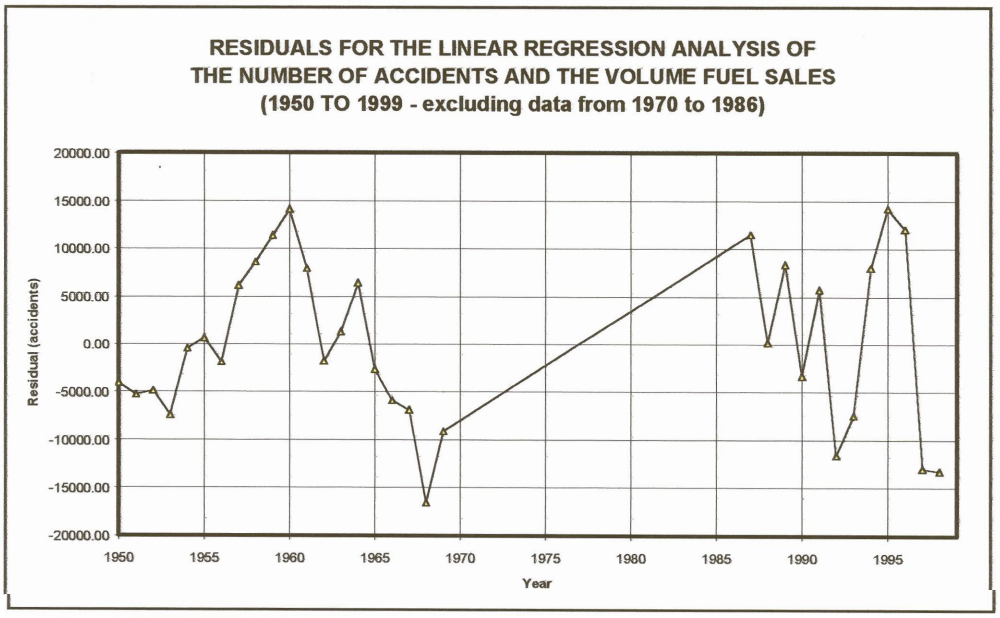
The regression analysis of number of accidents and number of registered vehicles.

APPENDIX B: THE REGRESSION ANALYSIS FOR NUMBER OF ACCIDENTS AND FUEL (PETROL AND DIESEL) SALES






PREDICTED CURVE:
LINEAR REGRESSION OF NUMBER OF ACCIDENTS AND VOLUME FUEL SALES
(1950 TO 1999 -EXCLUDING 1970 TO 1986)
Number of accidents
600000.00
500000.00
400000.00
300000.00
200000.00
100000.00
0.00
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year
Predicted number of accidents
Reported number of accidents


RESIDUALS FOR THE LINEAR REGRESSION ANALYSIS OF
THE NUMBER OF ACCIDENTS AND THE VOLUME FUEL SALES
(1950 TO 1999 - excluding data from 1970 to 1986)
Residual (accidents)
20000.00
15000.00
10000.00
5000.00
0.00
-5000.00
-10000.00
-15000.00
-20000.00
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Year

Output of the regression analysis of the number of accidents and the volume fuel sales from 1950 to 1999 with the exclusion of datapoints between 1970 and 1986.

Multiple R	1.00
R Square	0.99759397
Adjusted R Square	1.00
Standard Error	8788.61
Observations	32.00

RESIDUAL OUTPUT

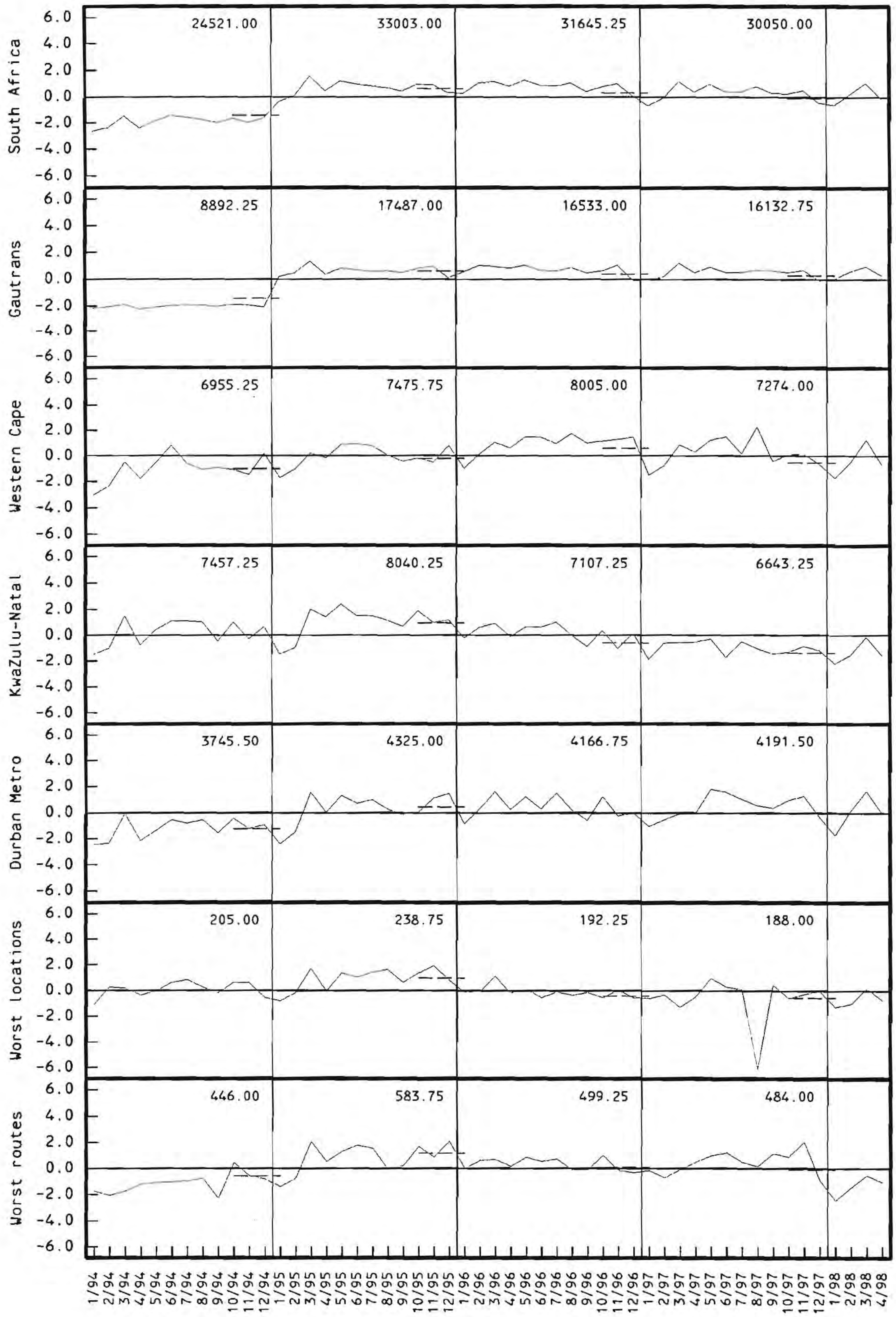
Observation	*Predicted Y*	*Residuals*	*Standard*
1.00	56067.52	-4101.52	-0.47
2.00	60954.75	-5321.75	-0.62
3.00	63352.25	-4909.25	-0.57
4.00	66733.36	-7413.36	-0.86
5.00	70698.47	-517.47	-0.06
6.00	76876.66	602.34	0.07
7.00	82194.21	-1931.21	-0.22
8.00	87358.08	6141.92	0.71
9.00	93321.11	8573.89	0.99
10.00	96978.85	11342.15	1.31
11.00	102603.77	14084.23	1.63
12.00	106876.25	7912.75	0.92
13.00	112347.49	-1865.49	-0.22
14.00	120031.81	1264.19	0.15
15.00	133002.95	6398.05	0.74
16.00	147172.84	-2675.84	-0.31
17.00	158607.11	-5924.11	-0.69
18.00	170779.08	-6904.08	-0.80
19.00	185317.81	-16601.81	-1.92
20.00	201639.31	-9124.31	-1.06
21.00	375704.57	11443.43	1.32
22.00	418337.19	145.81	0.02
23.00	426574.79	8360.21	0.97
24.00	436625.88	-3338.88	-0.39
25.00	438808.23	5732.77	0.66
26.00	441144.26	-11659.26	-1.35
27.00	441175.00	-7464.00	-0.86
28.00	460016.95	7980.05	0.92
29.00	486051.44	14181.56	1.64
30.00	508797.03	11976.97	1.39
31.00	519063.28	-13075.28	-1.51
32.00	525917.70	-13312.70	-1.54

Appendix C:

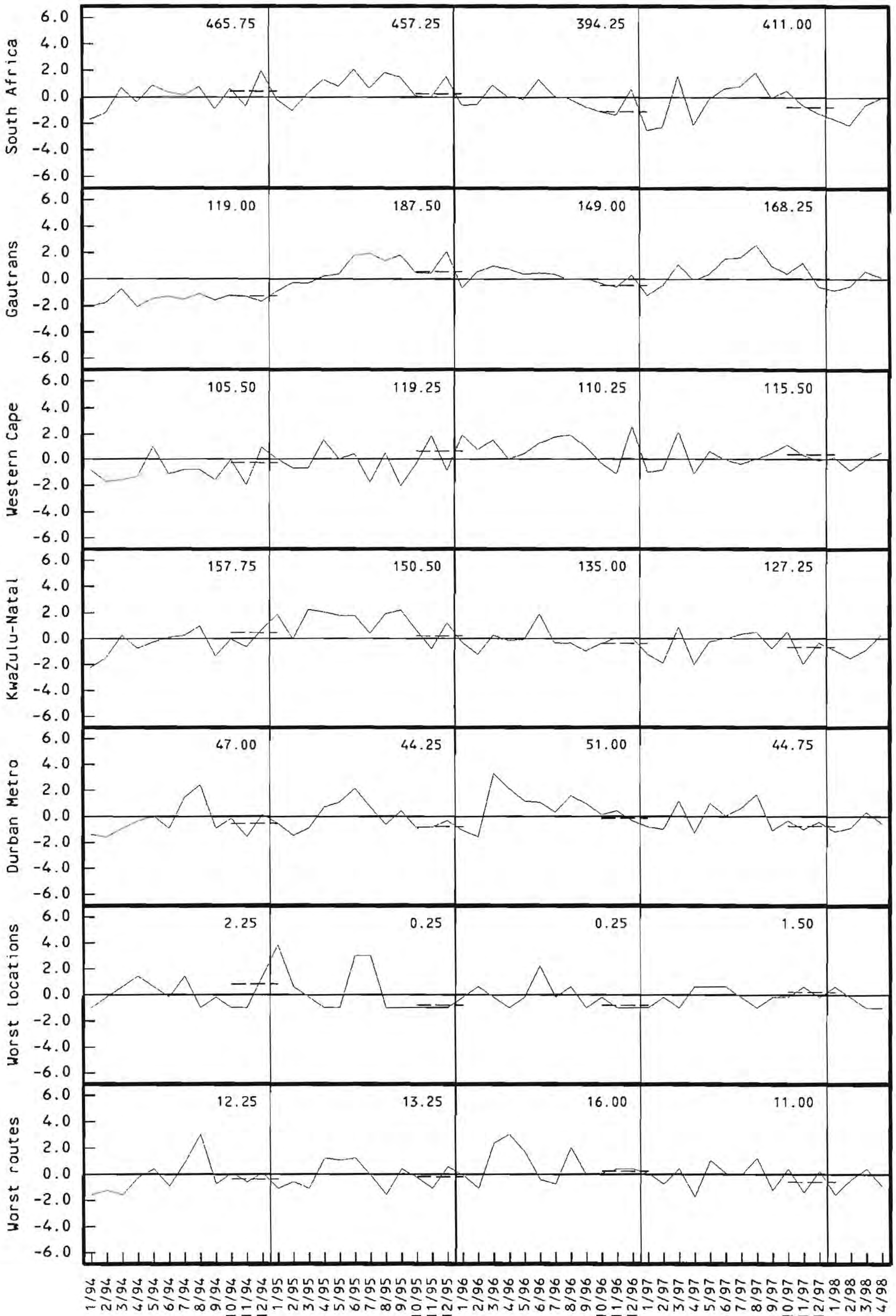
The graphic representation of monthly accident data series

for South Africa, Gauteng, KwaZulu-Natal, Western Cape, the Durban Metro, a selection of worst locations in Durban Metro and a selection of major routes in the Durban Metro area.

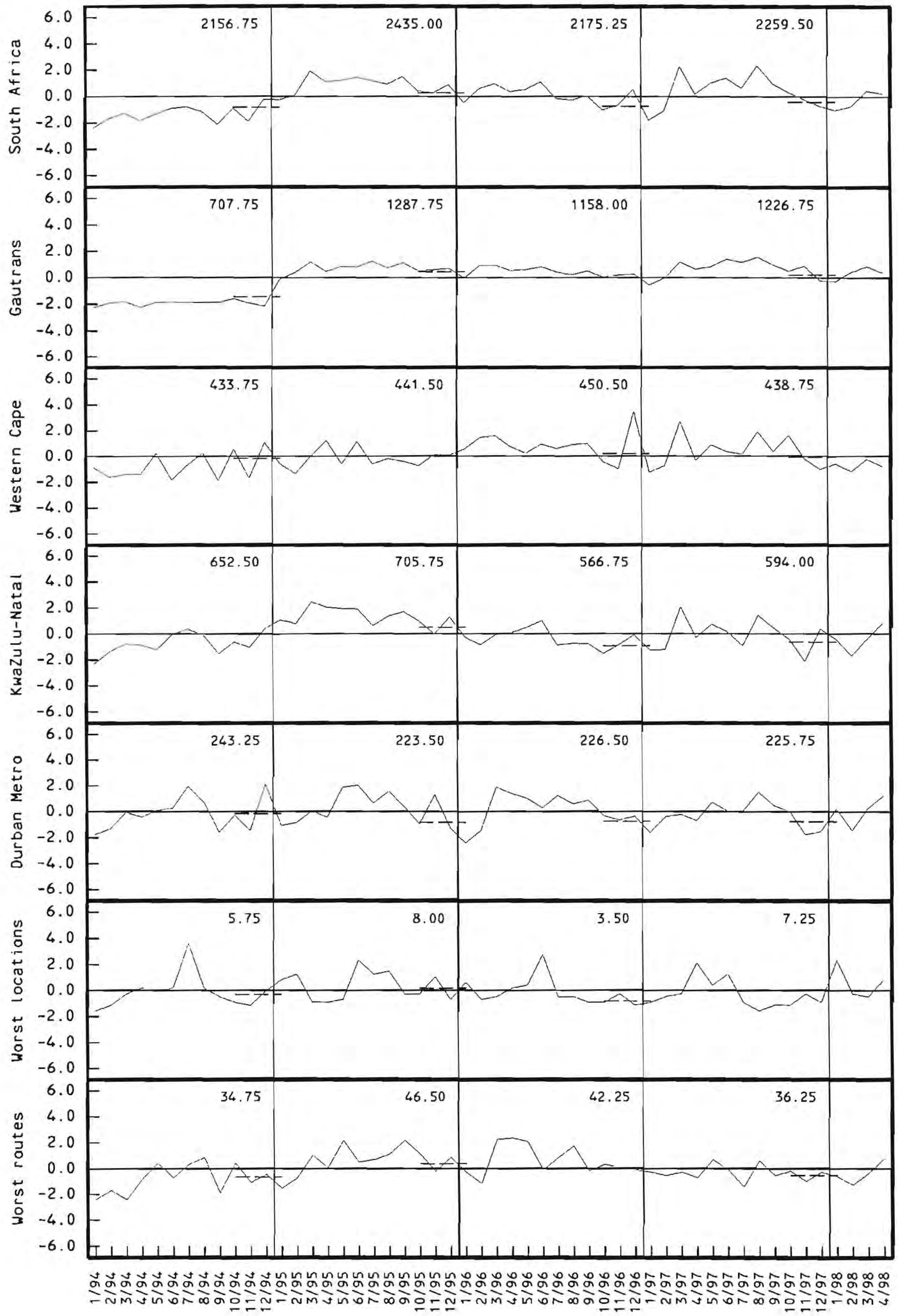
APPENDIX C: MONTHLY ACCIDENT DATA



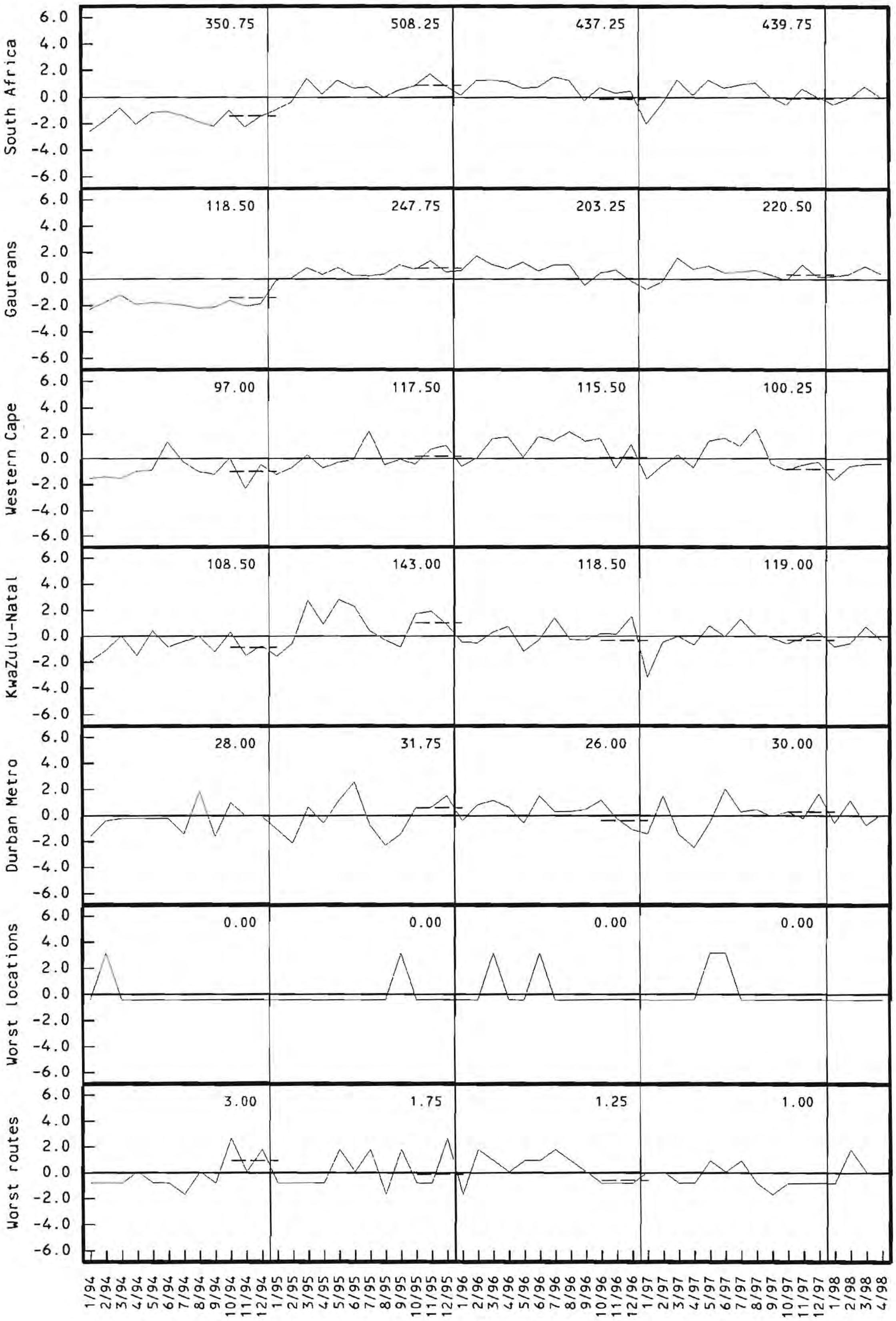
Grahp C.1: Total: Total number of acc



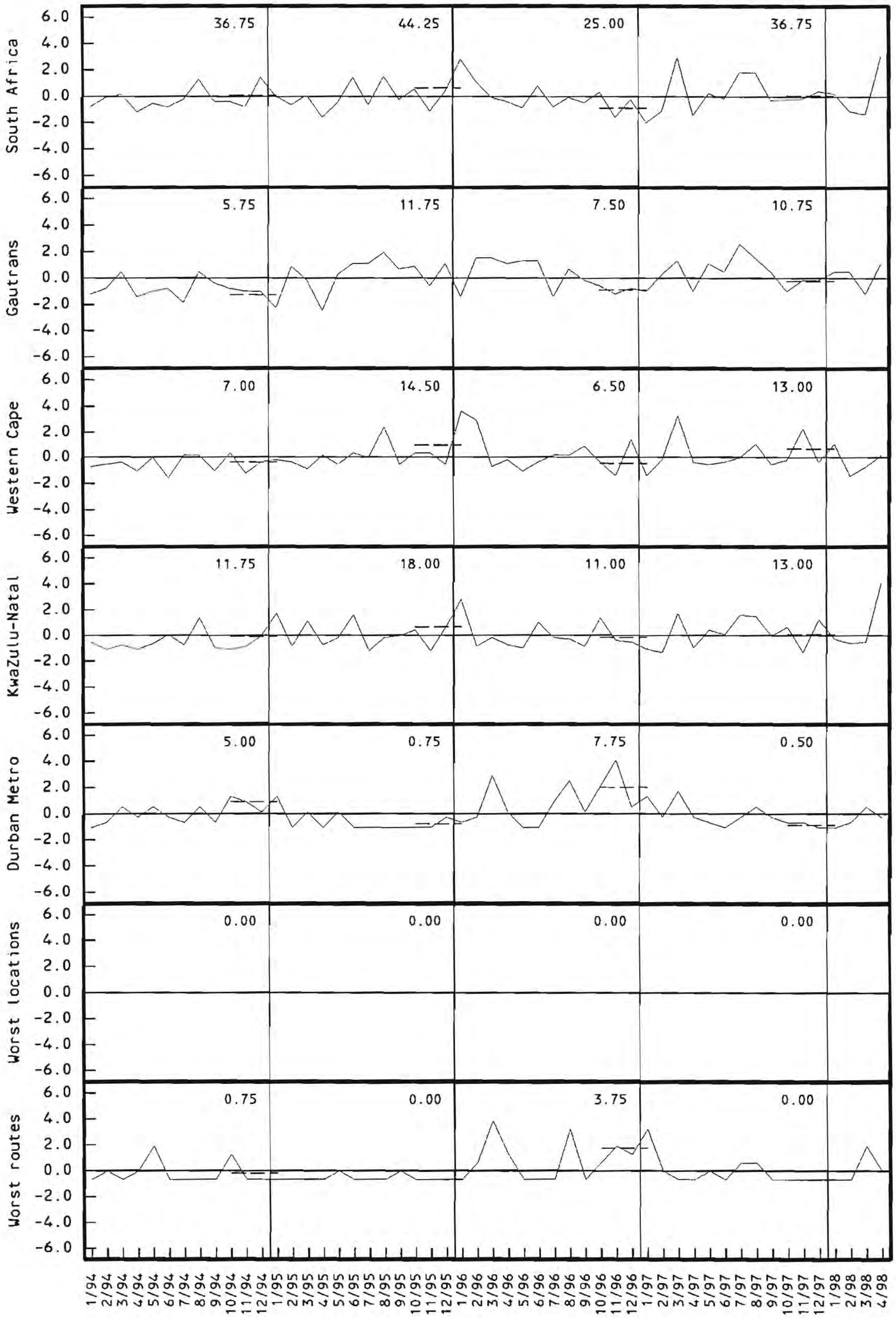
Graph C.2: Total: Total number of fatalities



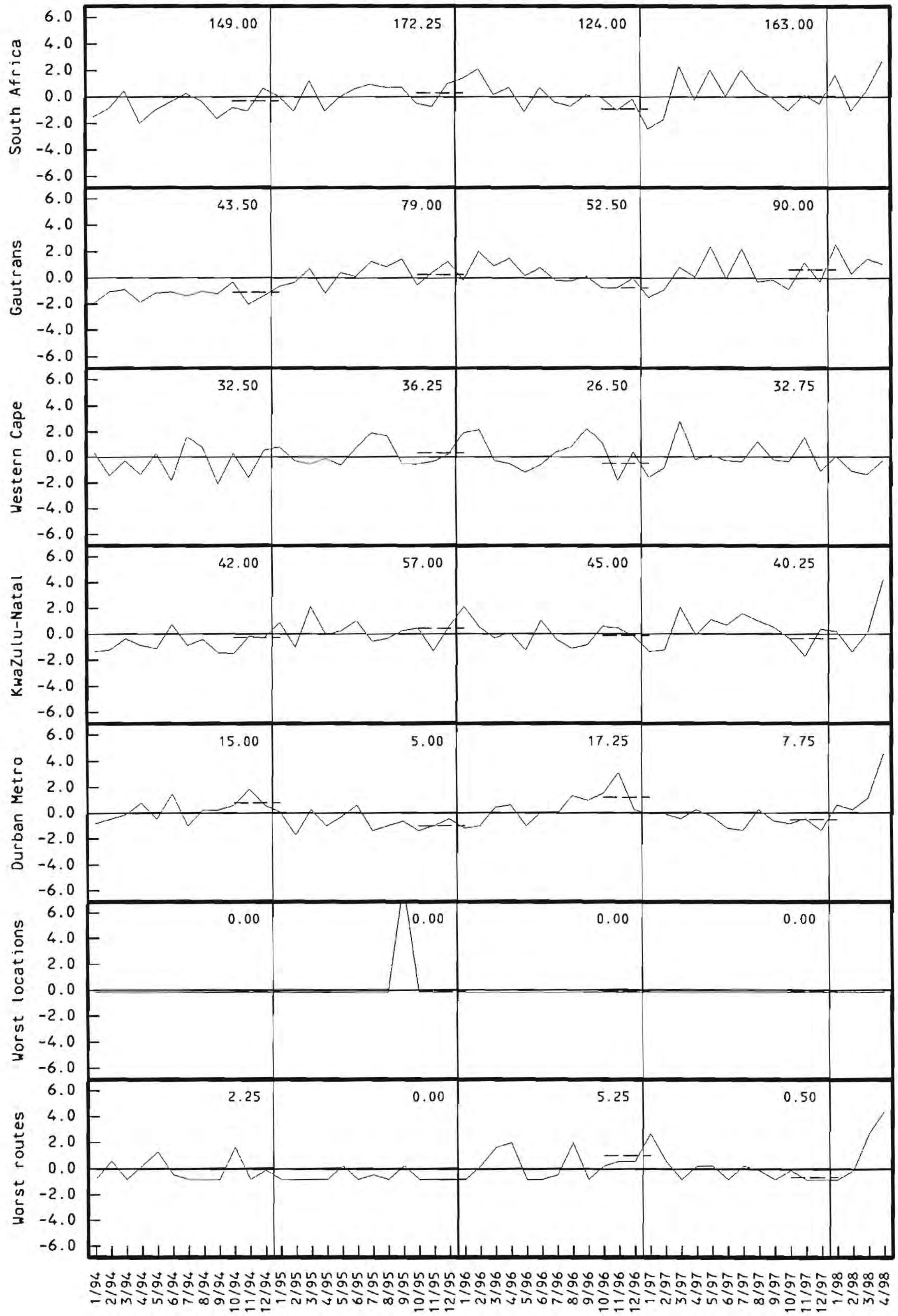
Graph C.3: Total: Total number of fatalities and severe injuries



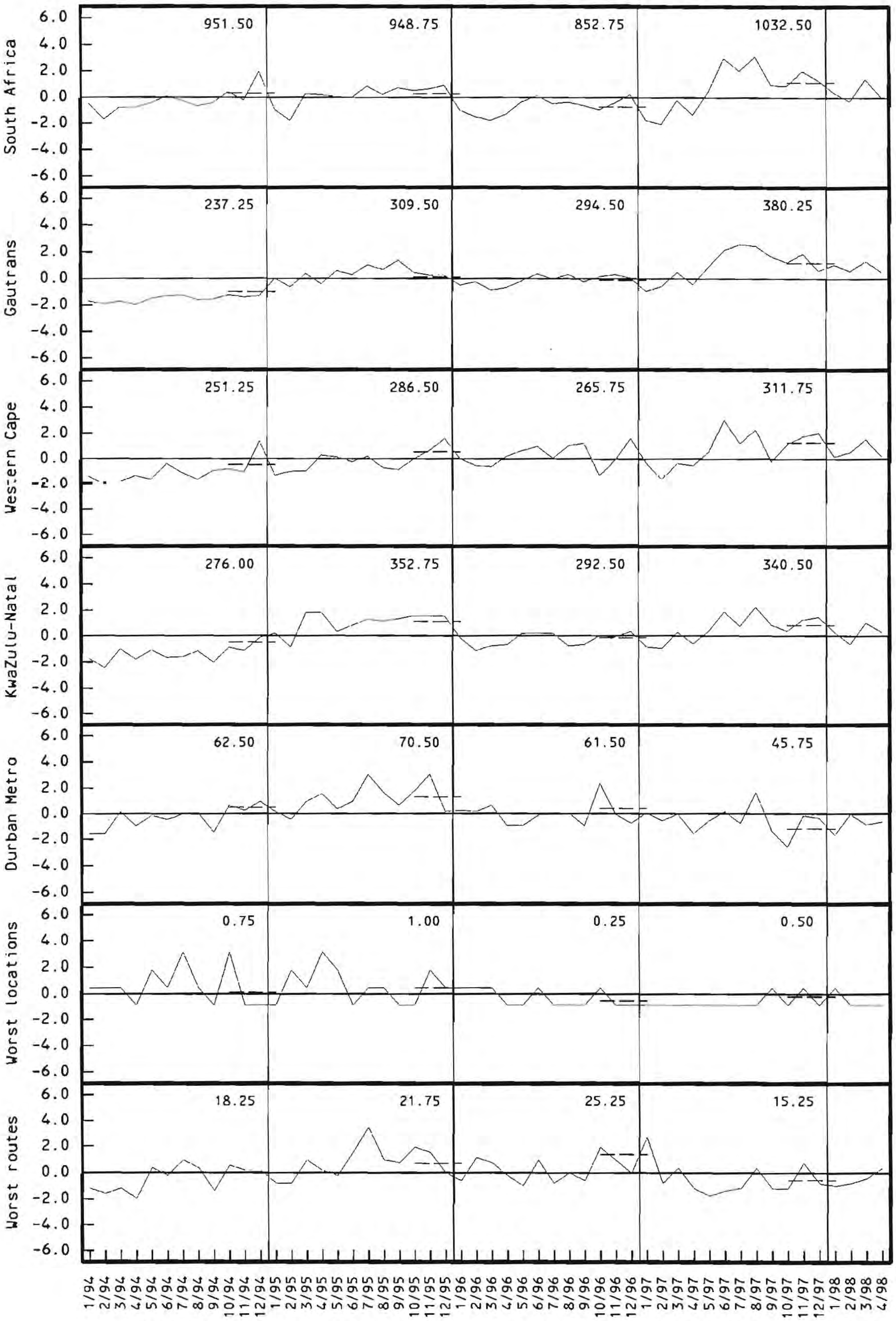
Graph C.4: Head on acc: Total number of acc



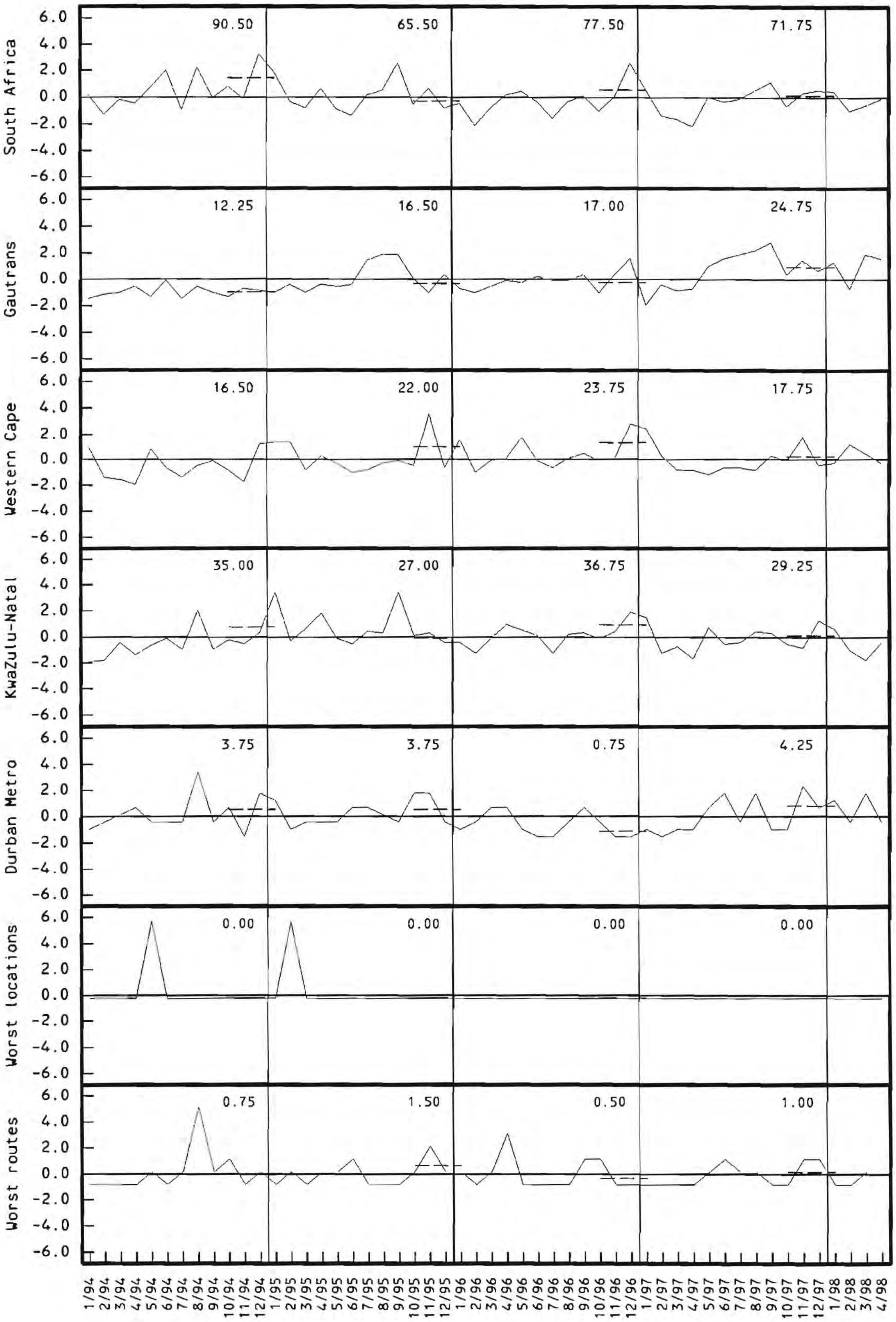
Graph C.5: Head on acc: Total number of fatalities



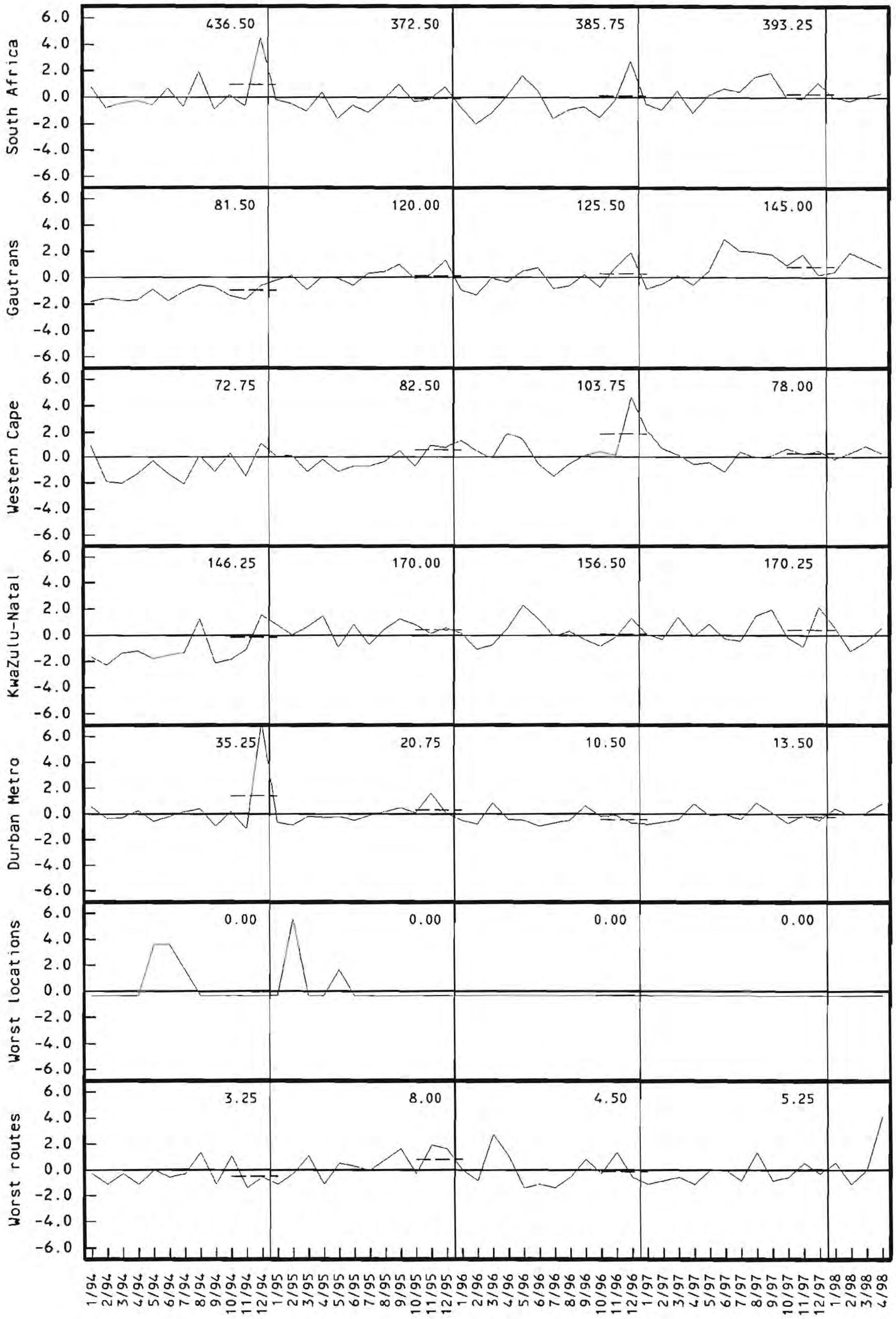
Graph C.6: Head on acc: Total number of fatalities and severe injuries



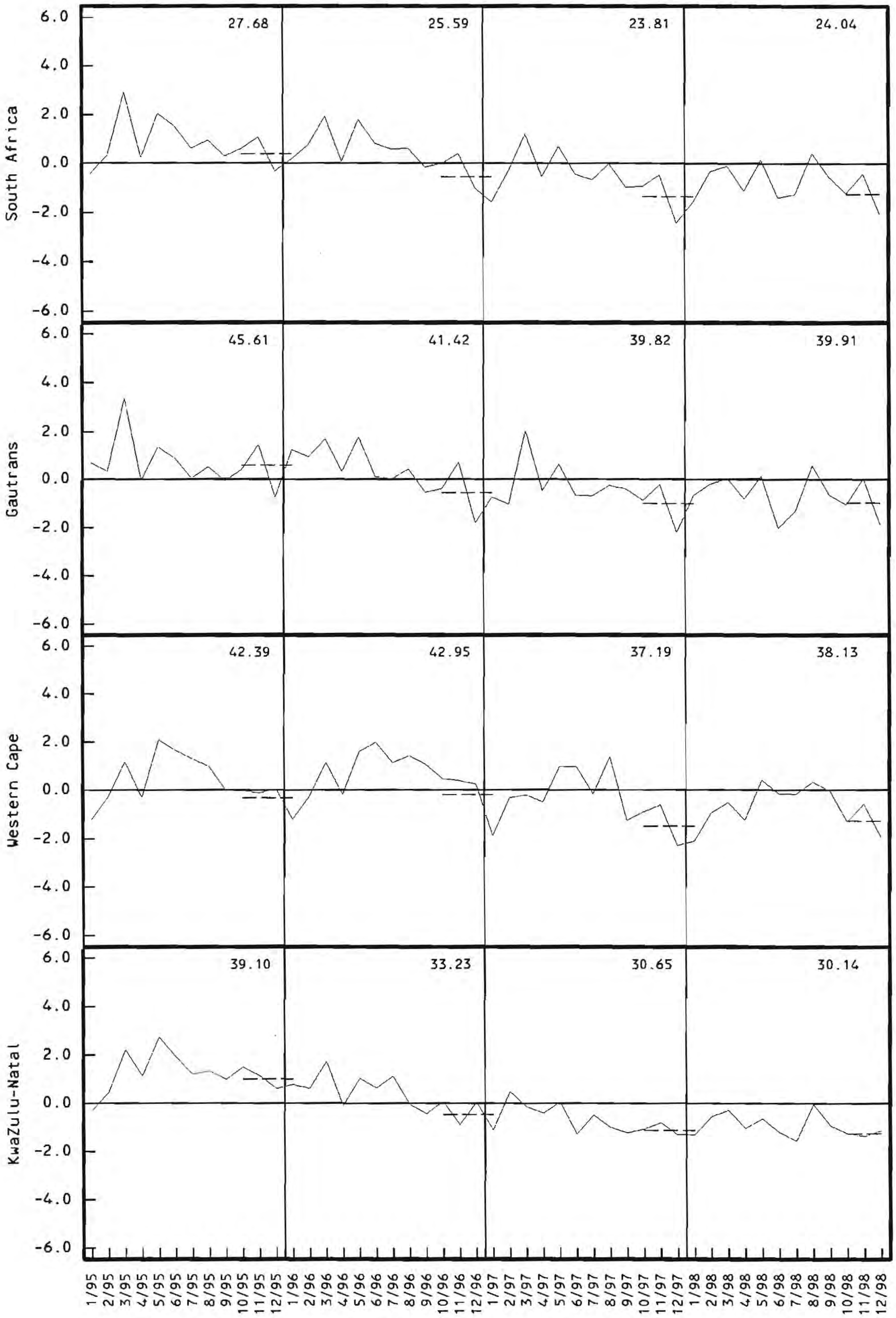
Graph C.7: Overturning acc: Total number of acc



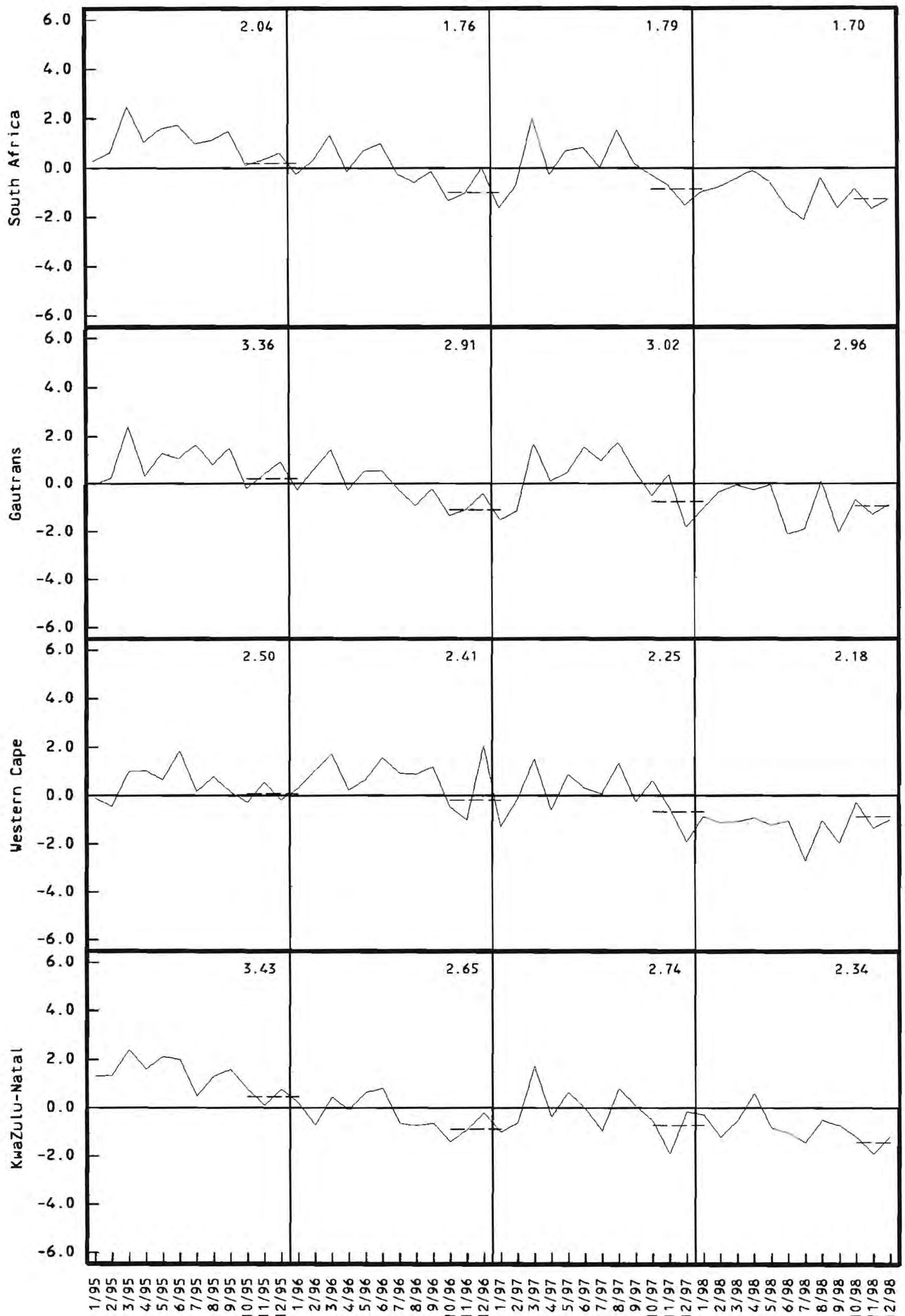
Graph C.8: Overturning acc: Total number of fatalities



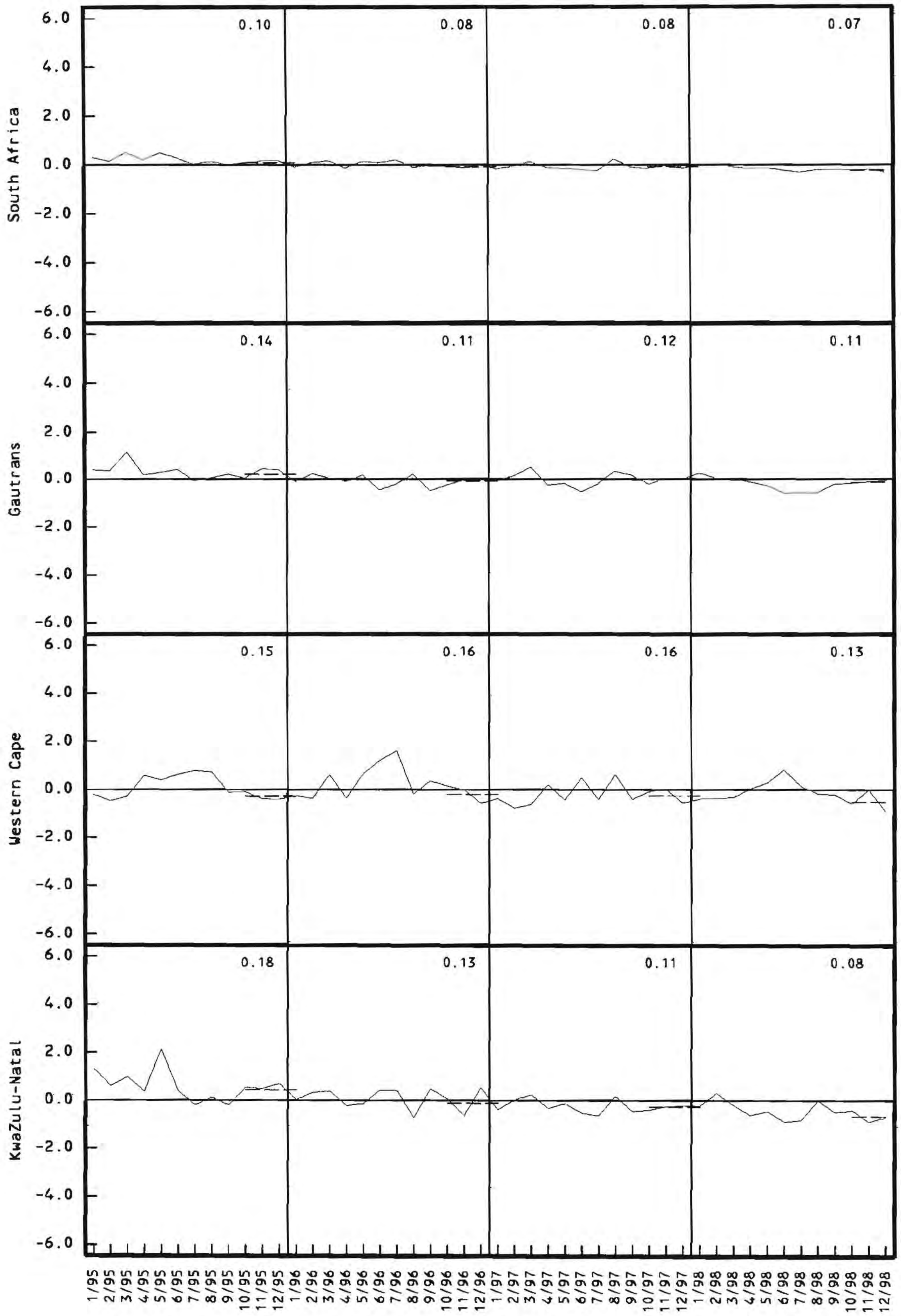
Graph C.9: Overturning acc: Total number of fatalities and severe injuries



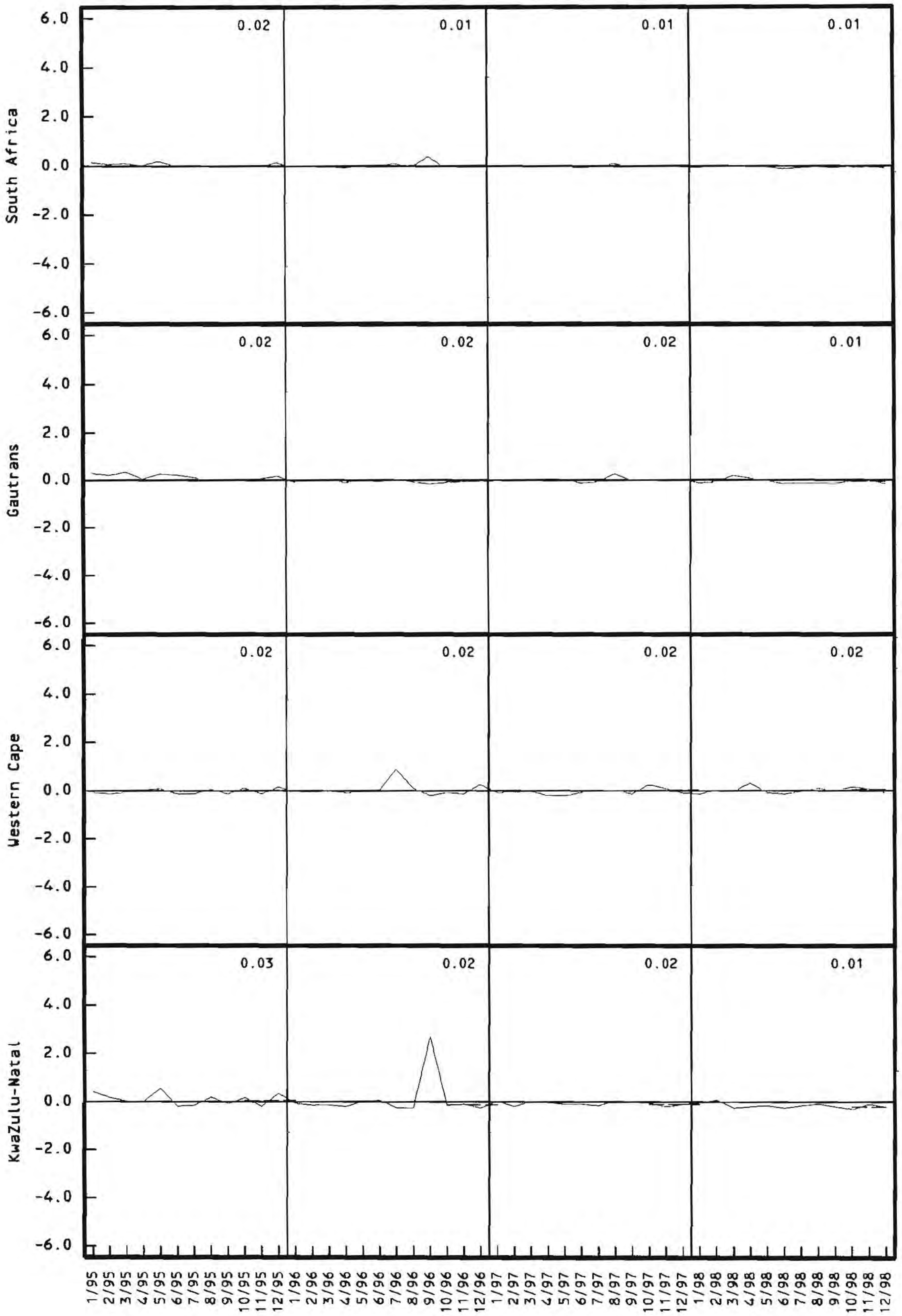
Graph C.10: Total no of accidents per Kilolitre fuel



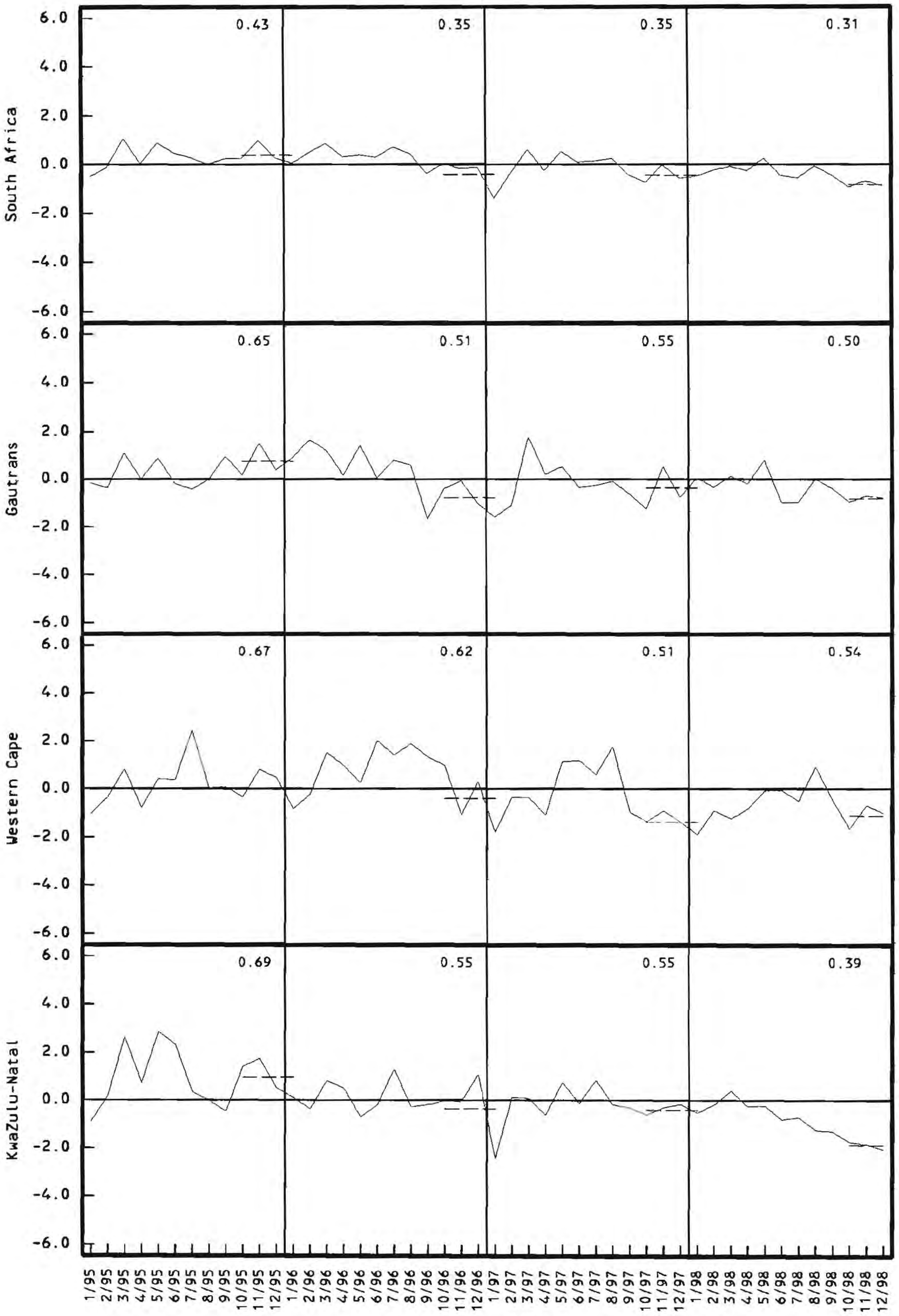
Graph C.11: Total no of fatalities and severe injuries per Kilolitre fuel



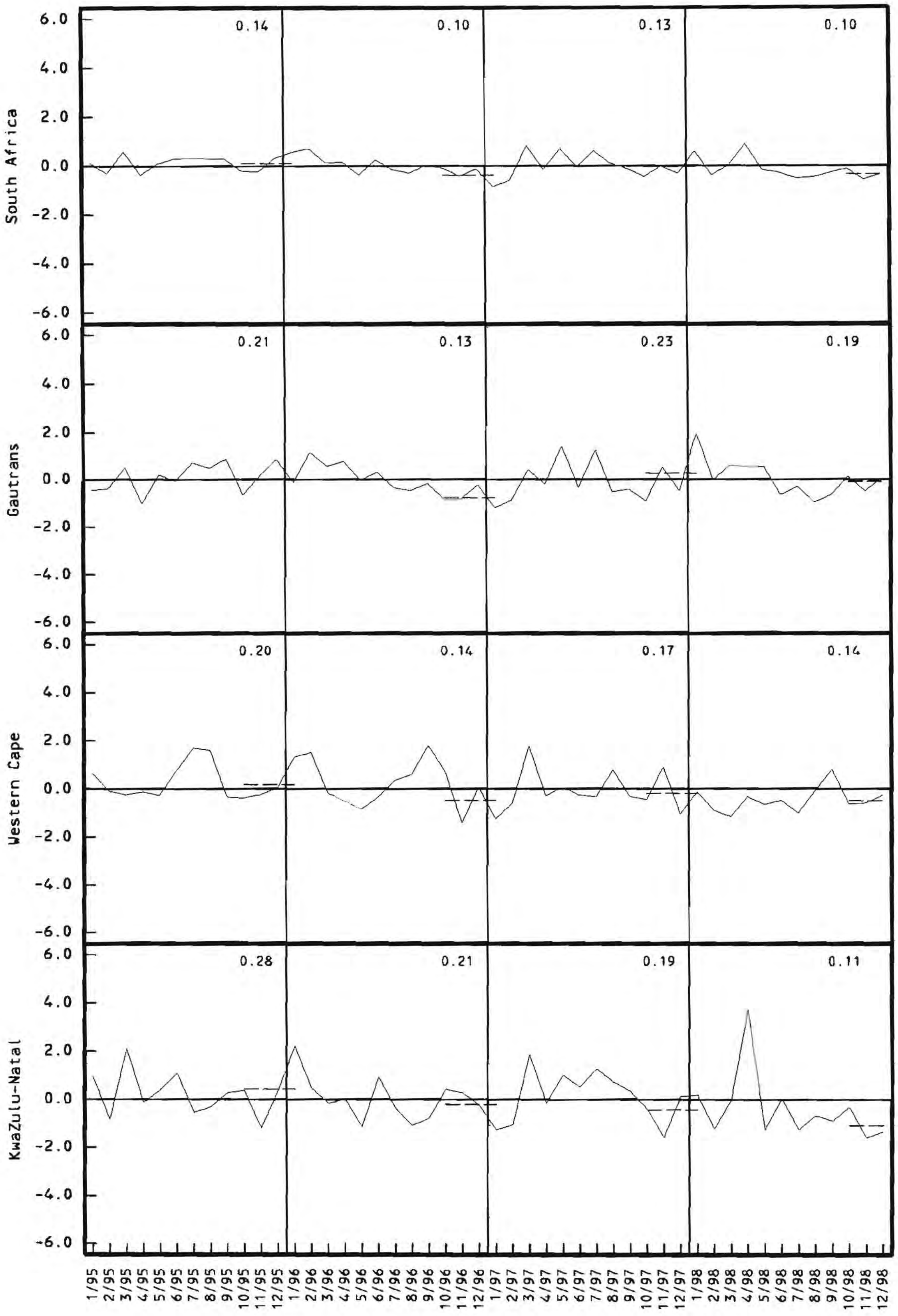
Graph C.12: Fixed object accidents per Kilolitre fuel



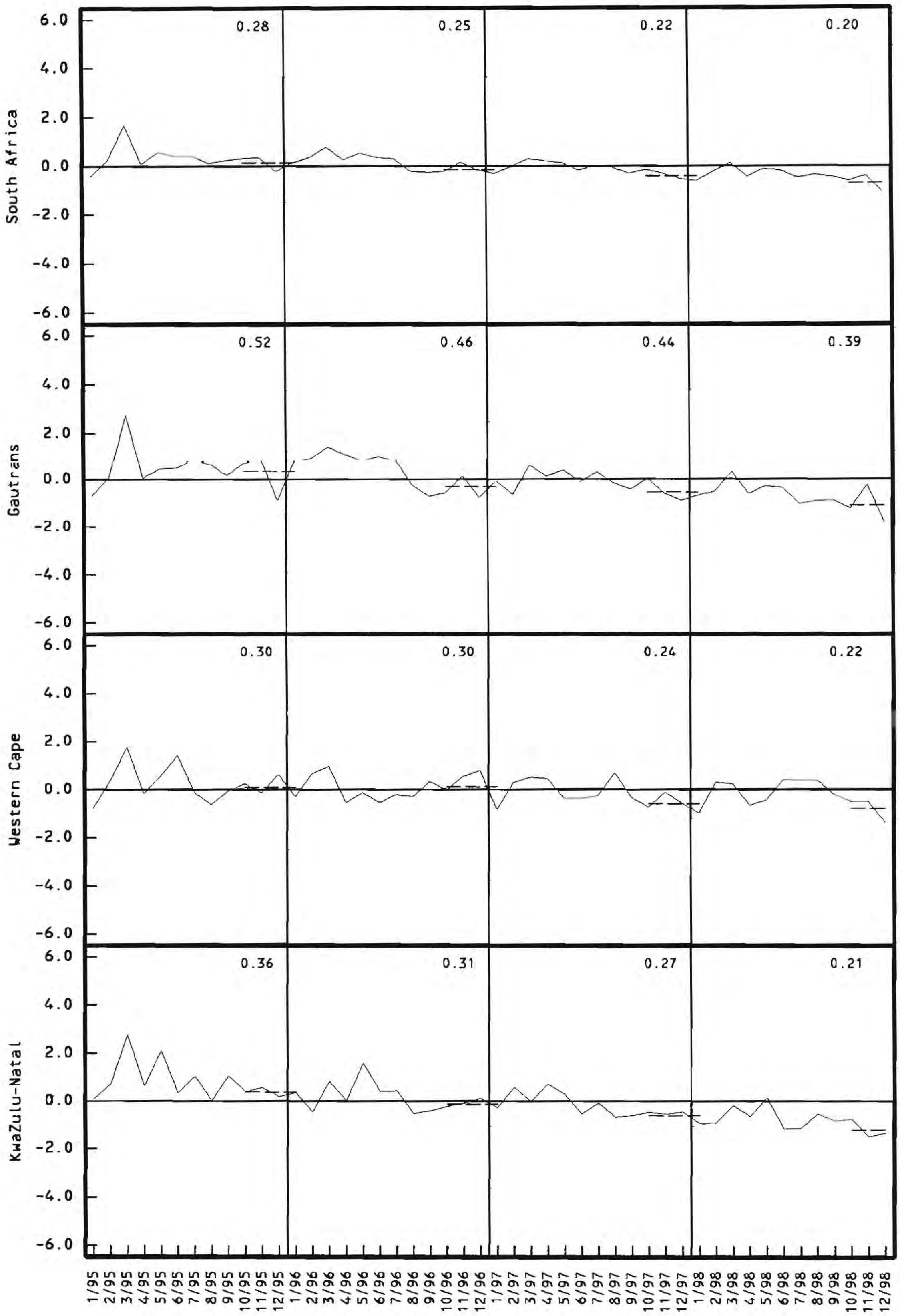
Graph C.13: Fixed object accident fatalities and severe injuries per Kilolitre fuel



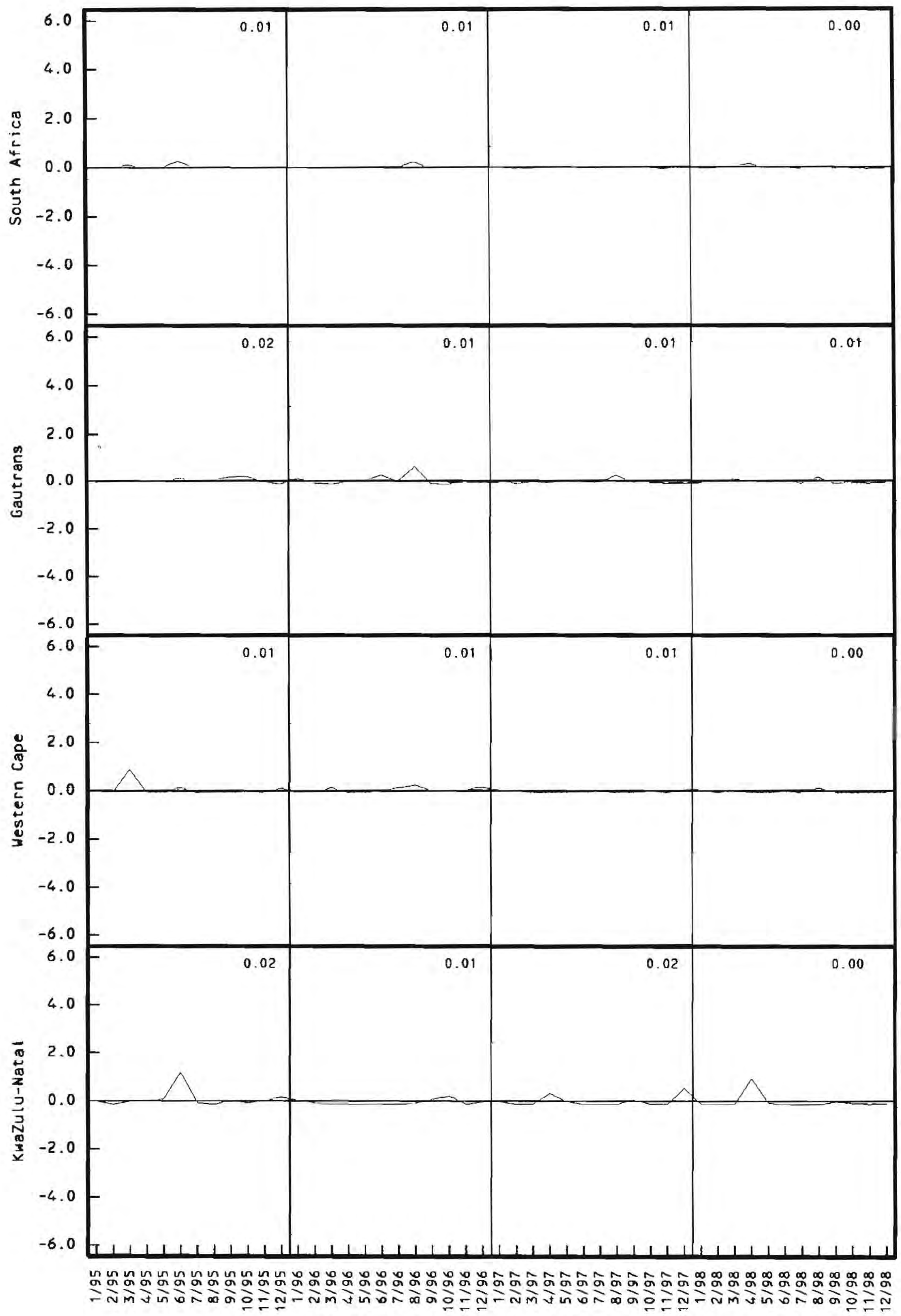
Graph C.14: Head on accidents per Kilolitre fuel



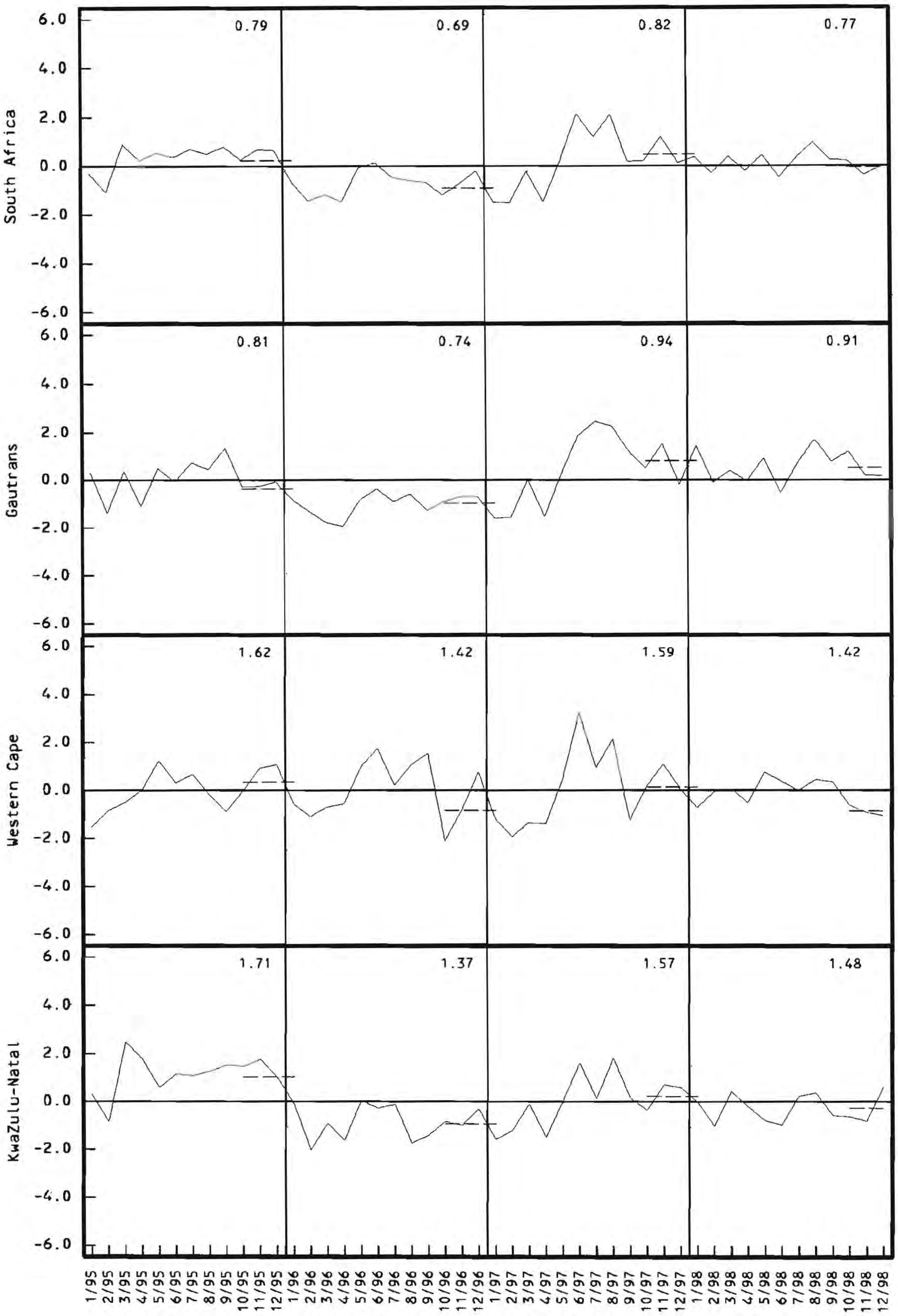
Graph C.15: Head on accident fatalities and severe injuries per Kilolitre fuel



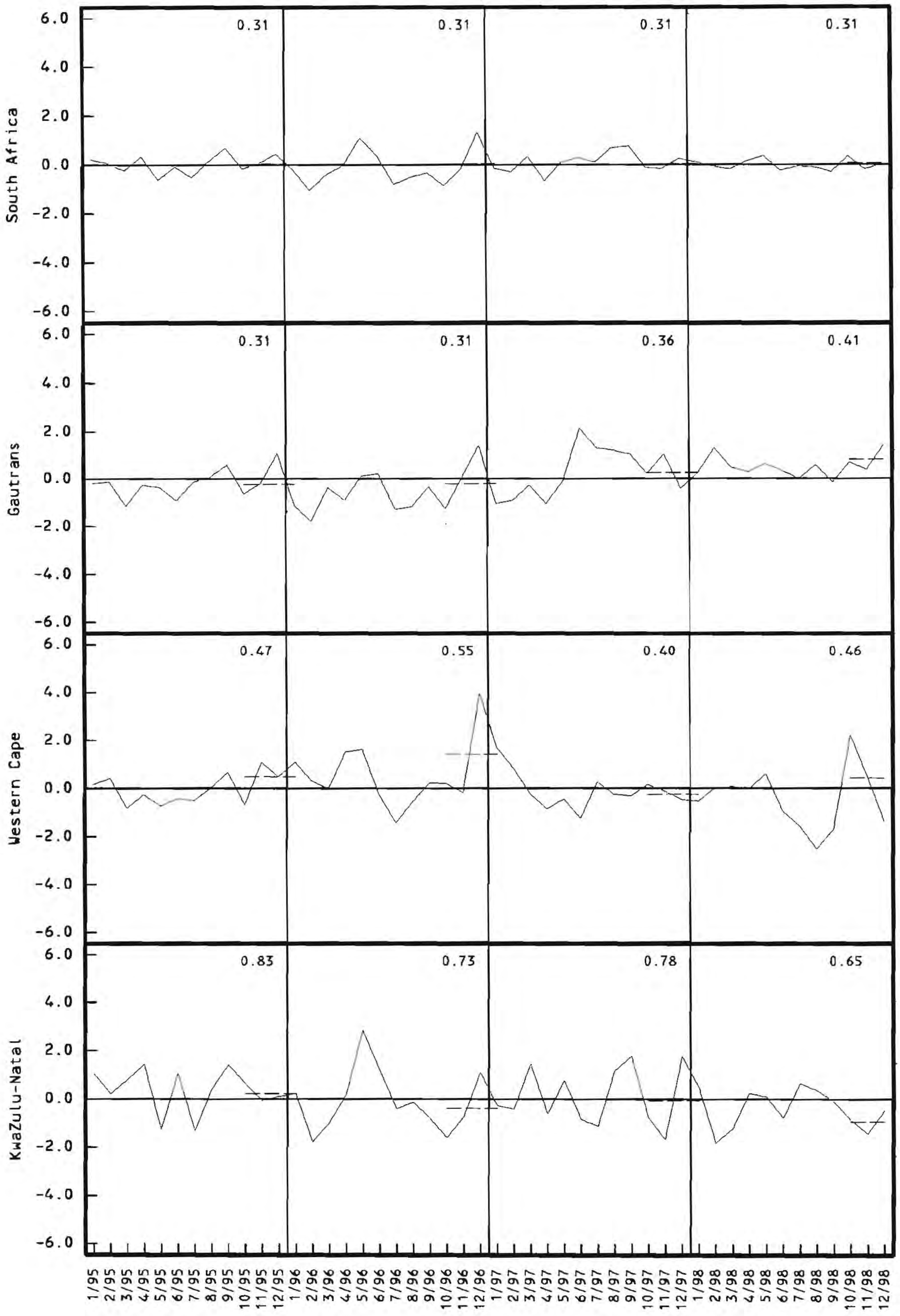
Graph C.16: Left turn (same)accidents per Kilolitre fuel



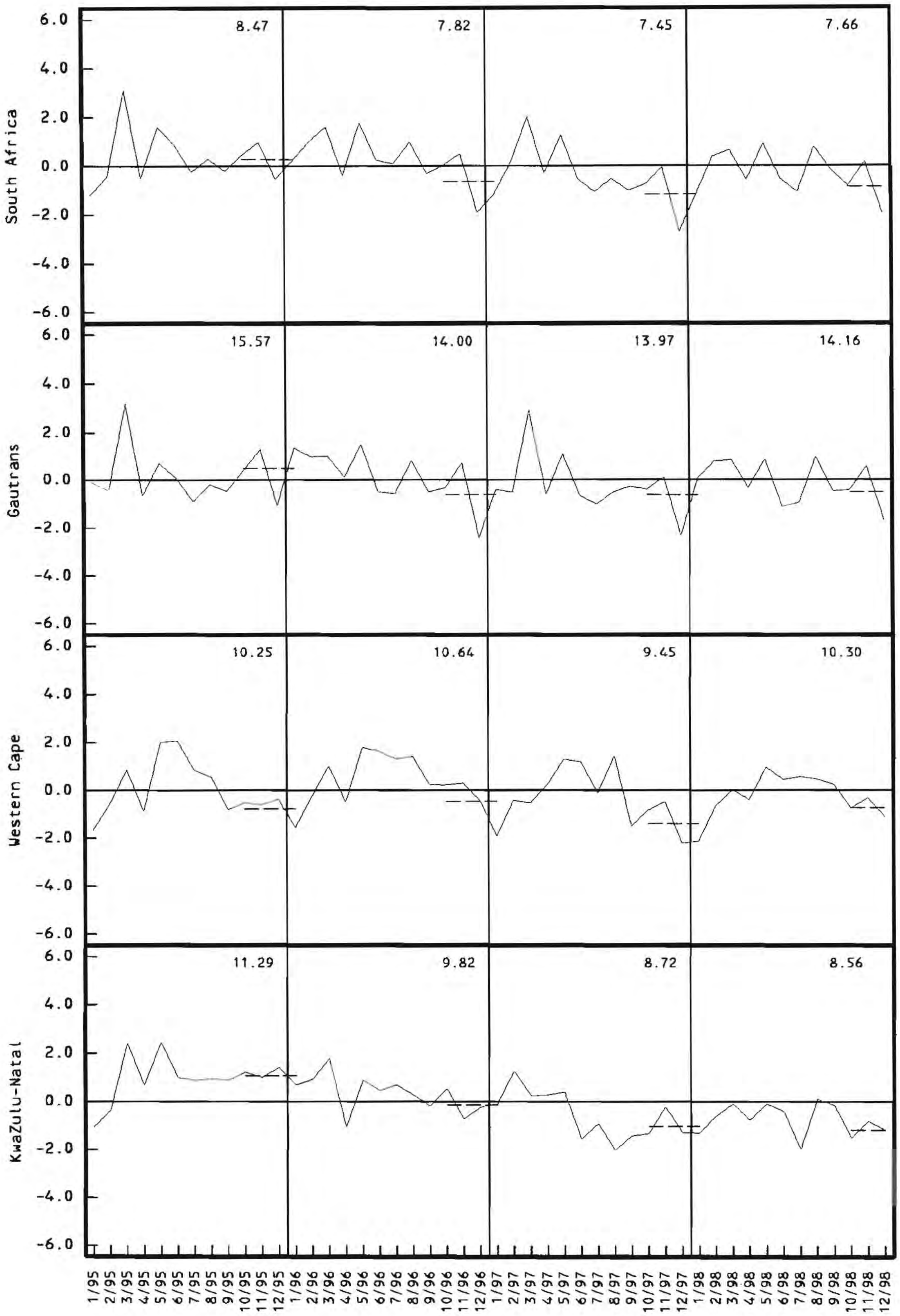
Graph C.17: Left turn (same)accident fatalities and severe injuries per Kilolitre fuel



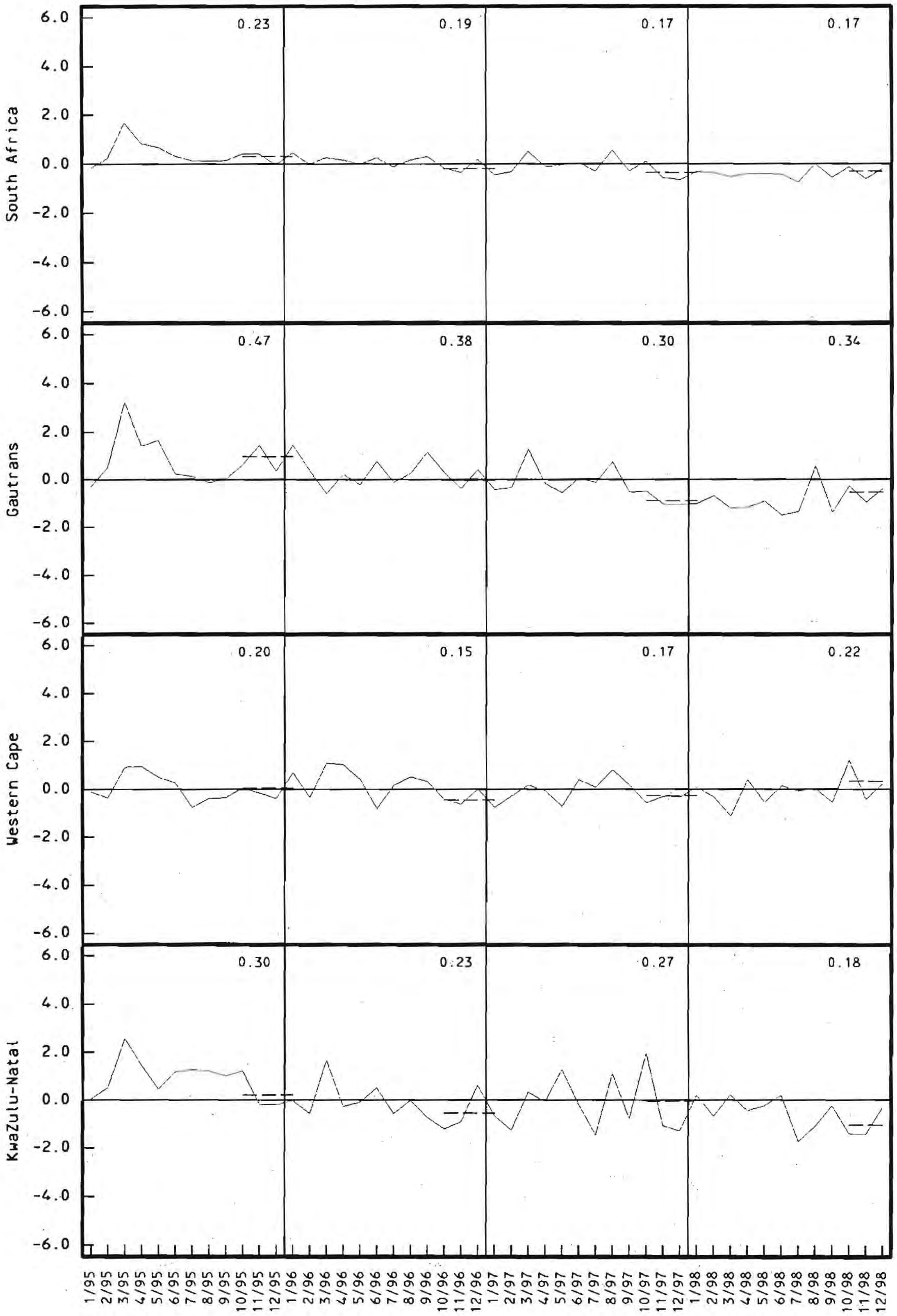
Graph C.18: Overturning accidents per Kilolitre fuel



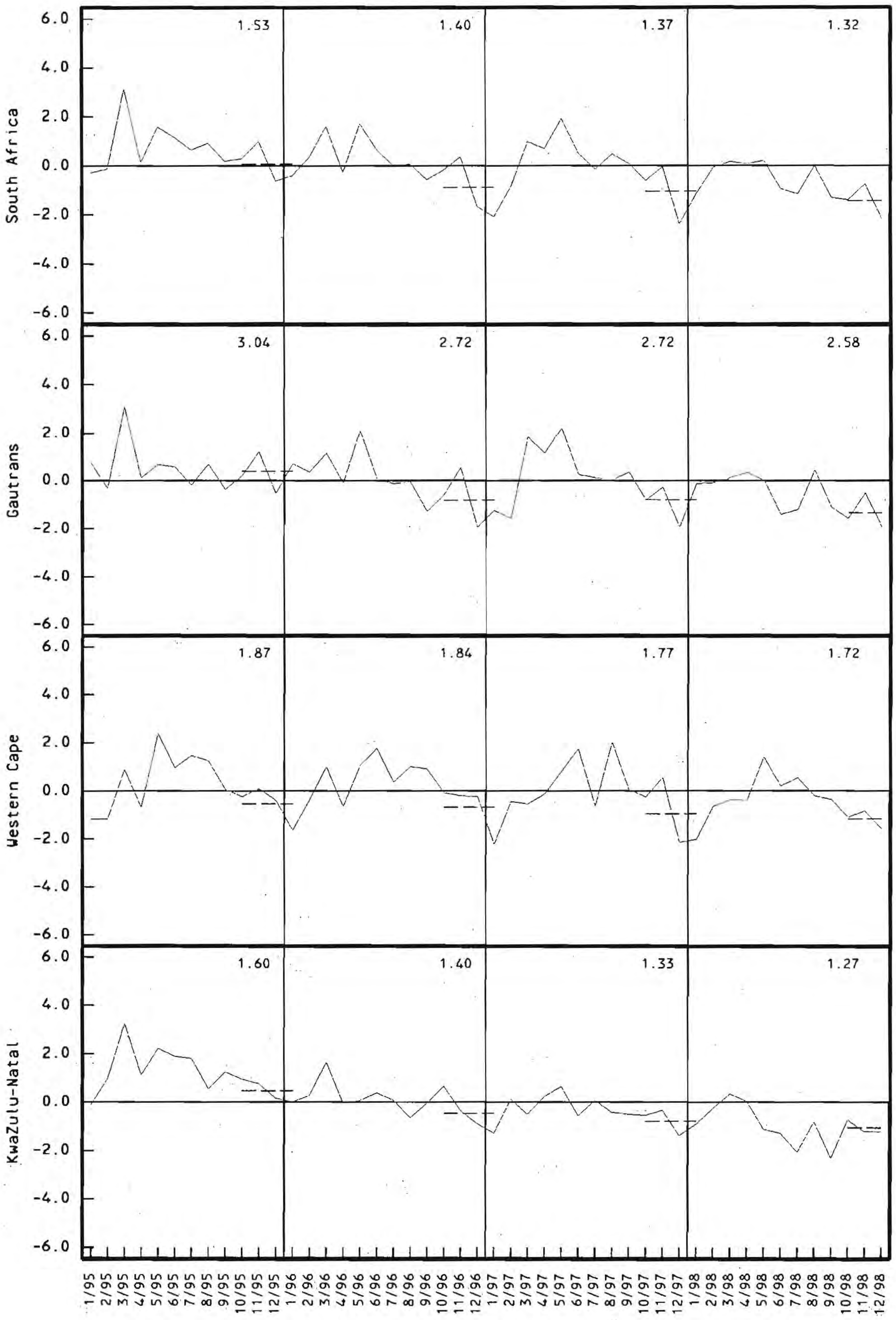
Graph C.19: Overturning fatalities and severe injuries per Kilolitre fuel



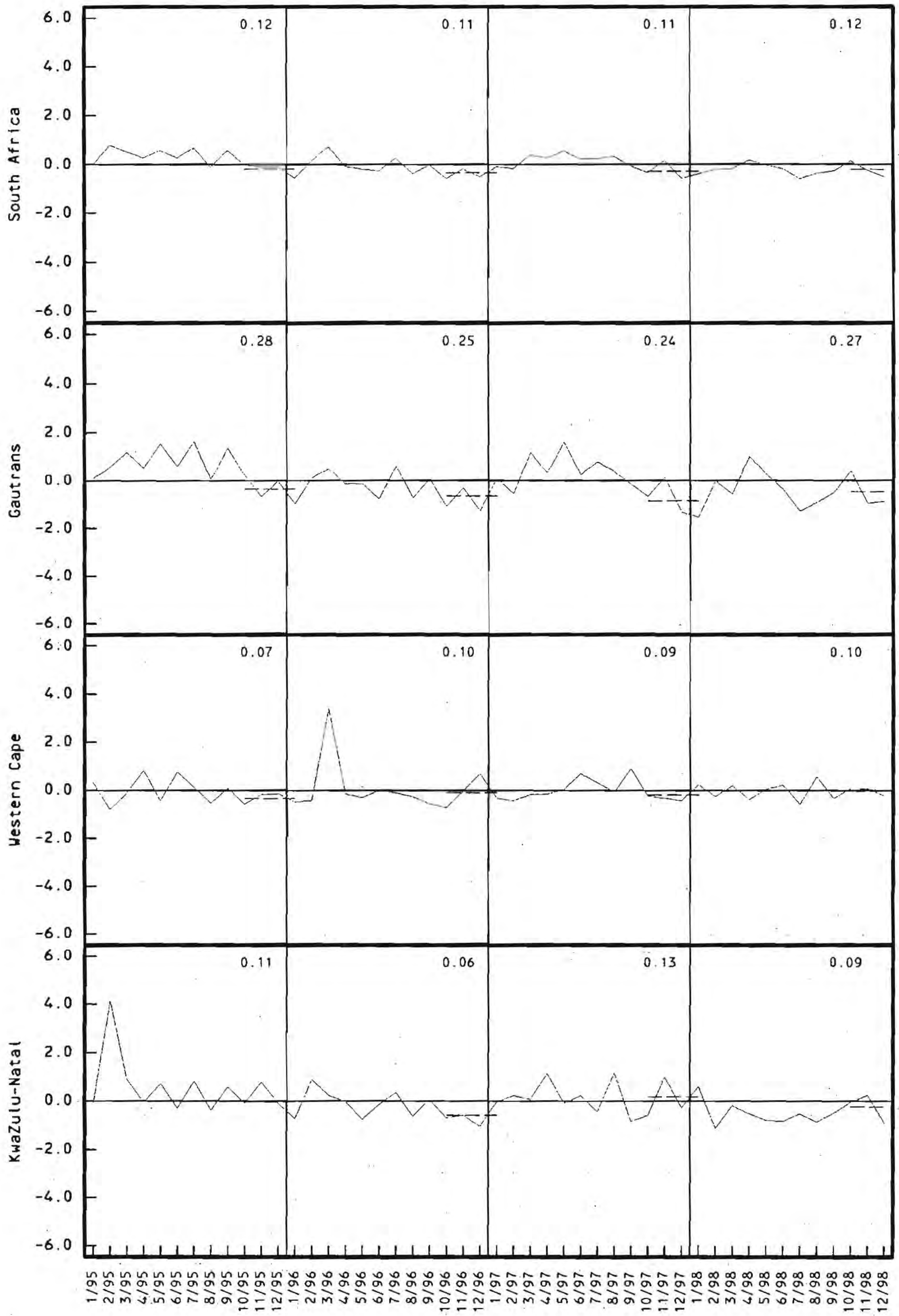
Graph C.20: Rear end accidents per Kilolitre fuel



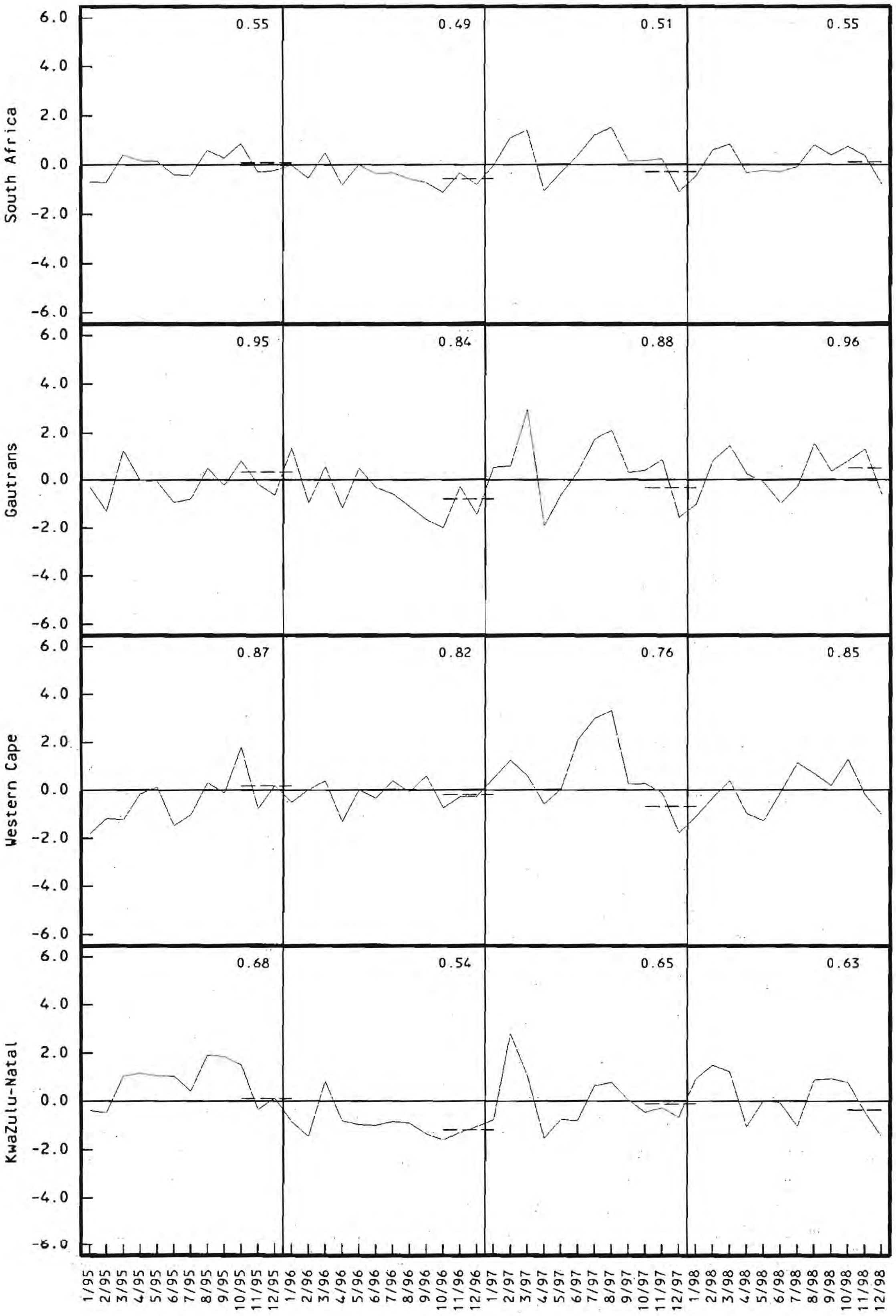
Graph C.21: Rear end fatalities and severe injuries per Kilolitre fuel



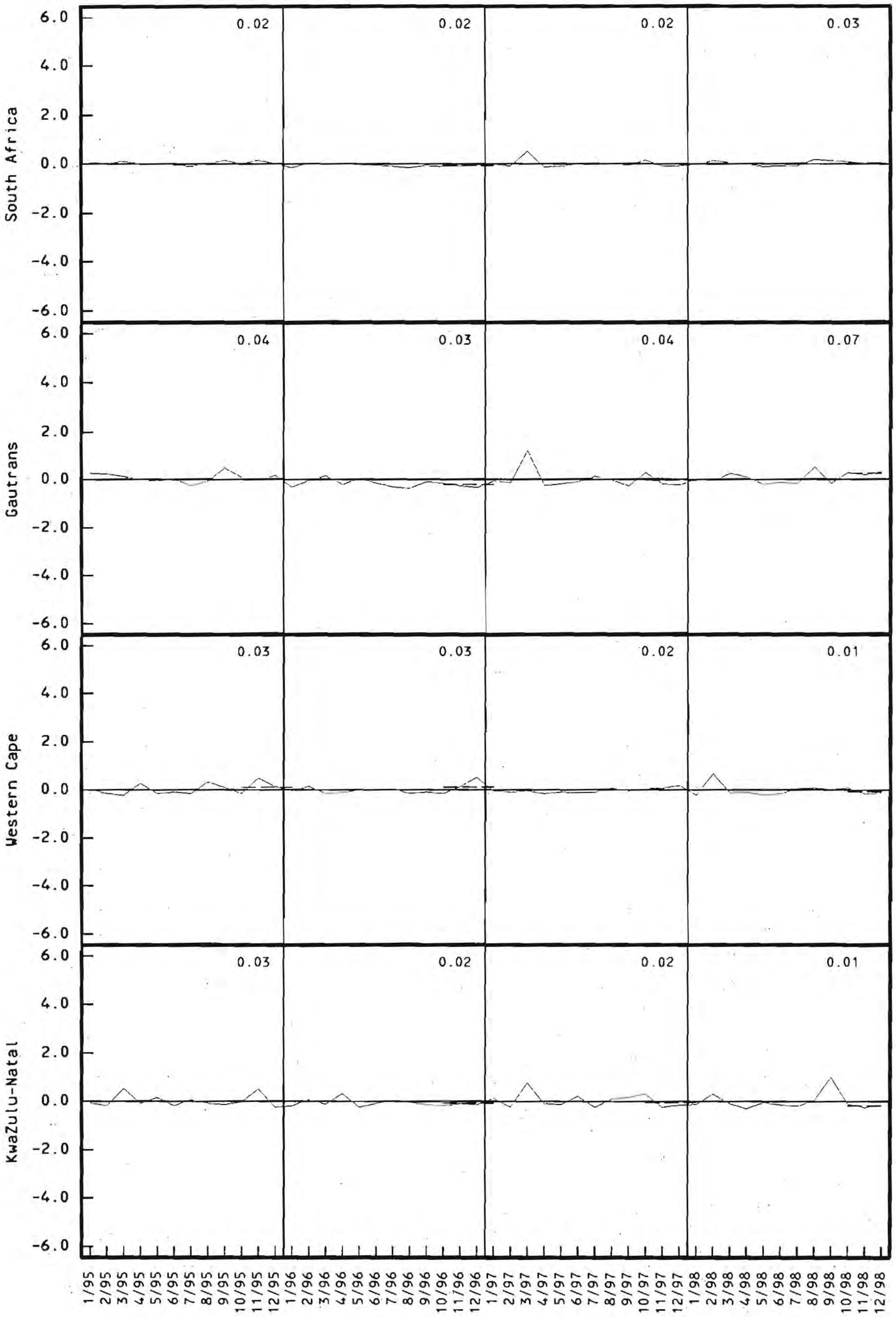
Graph C.22: Right angle (straight)accidents per Kilolitre fuel



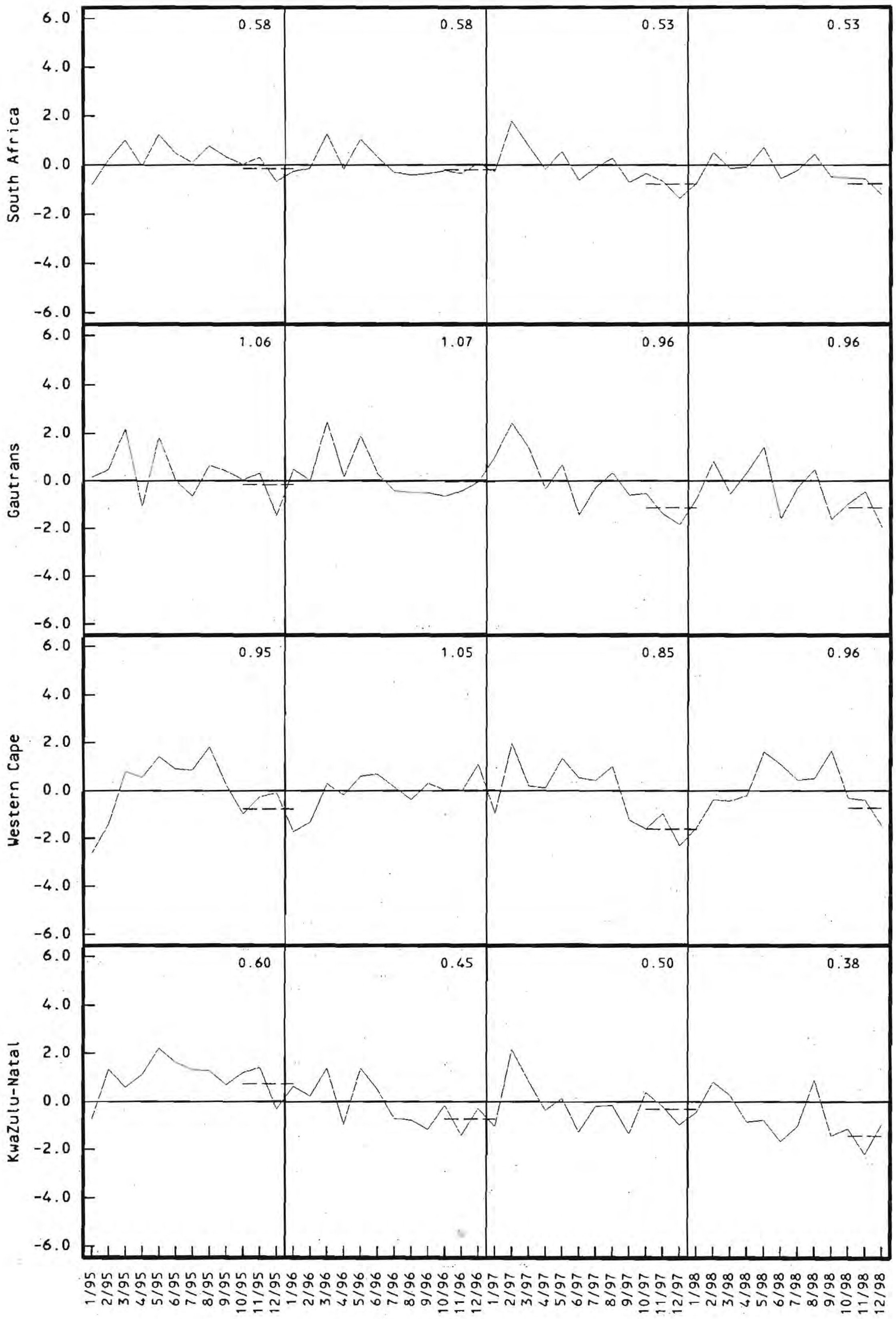
Graph C.23: Right angle (straight)accident fatalities and severe injuries per Kilolitre f



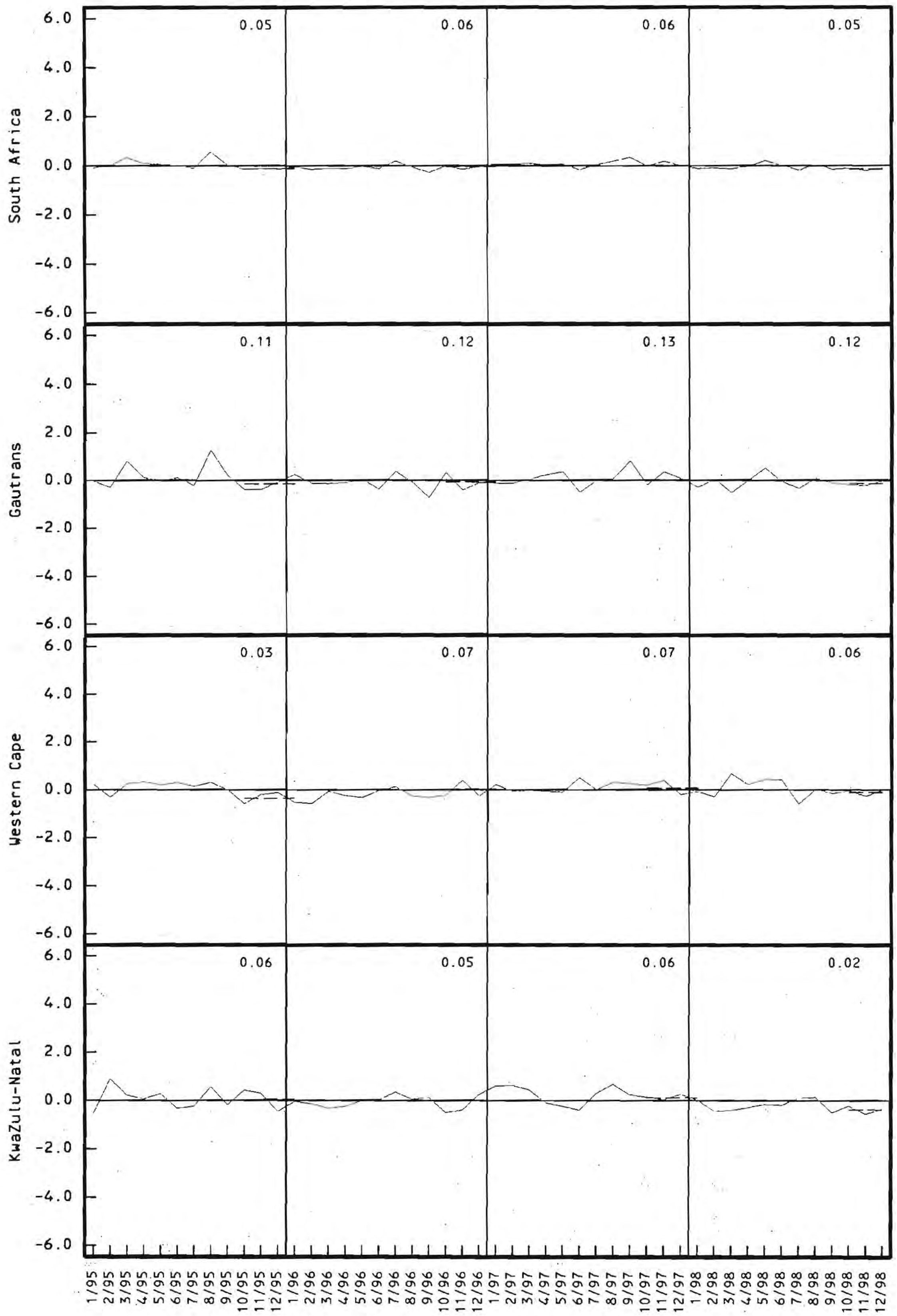
Graph C.24: Right angle (turn) accidents per Kilolitre fuel



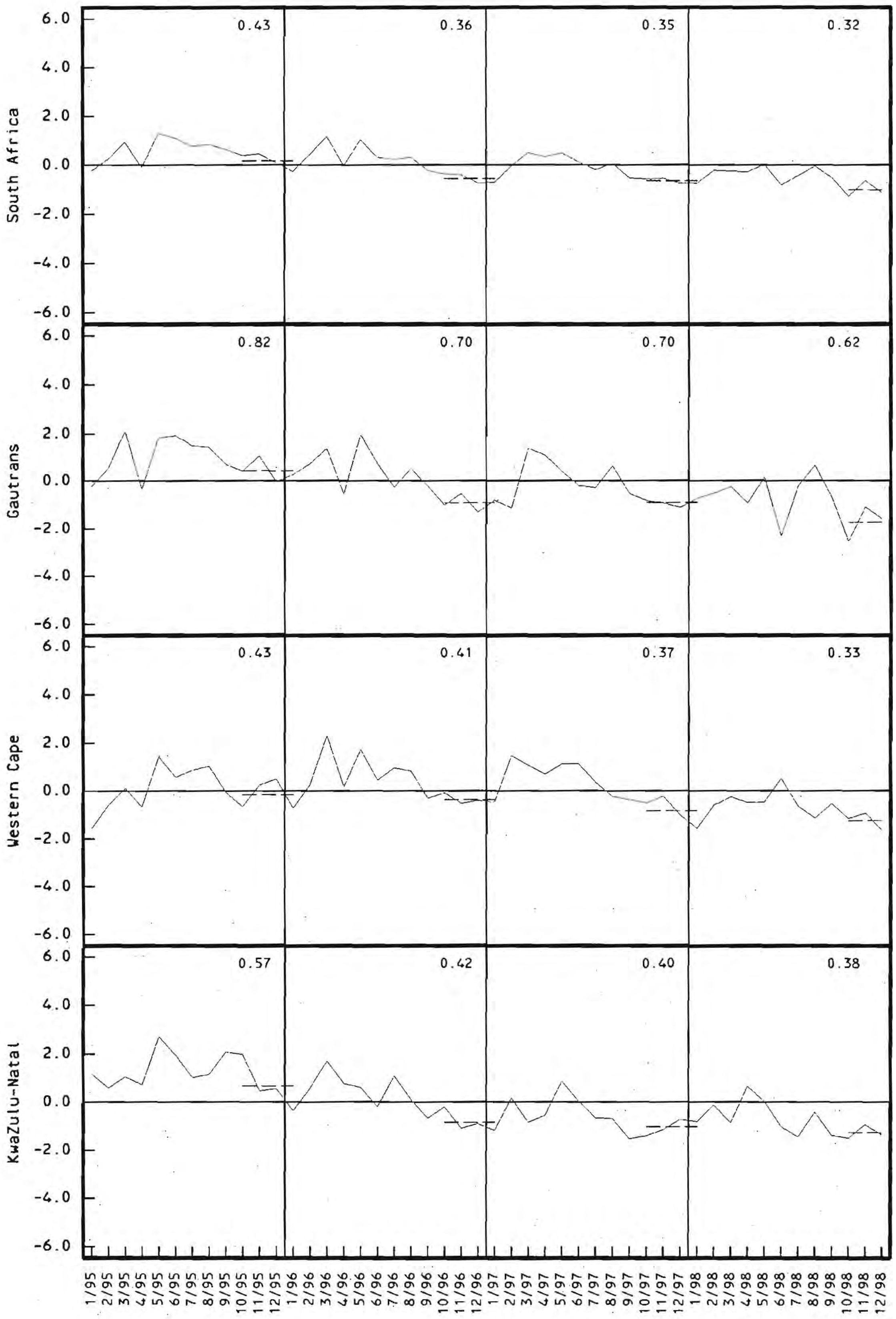
Graph C.25: Right angle (turn) fatalities and severe injuries per Kilolitre fuel



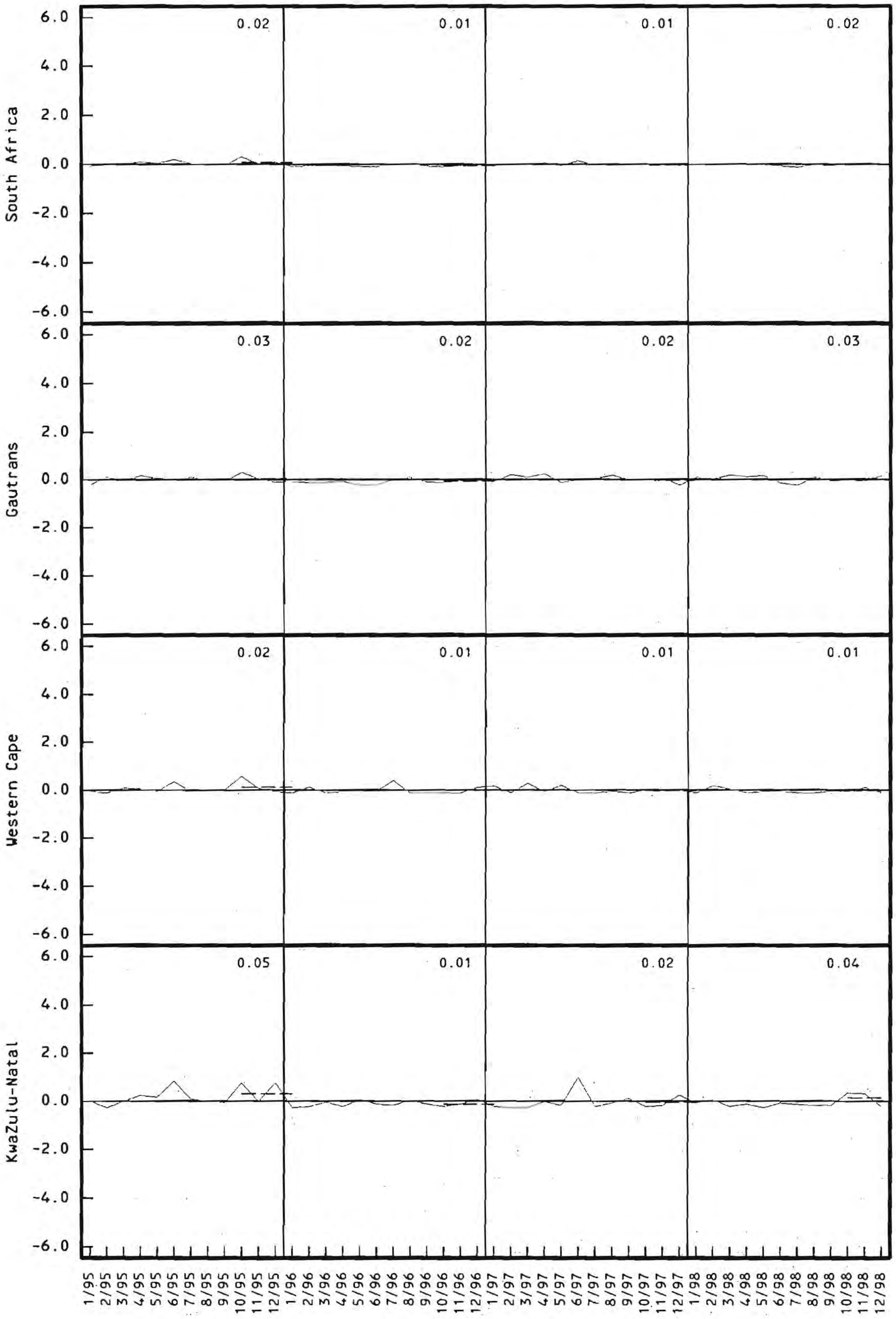
Graph C.26: Right turn (opp) accidents per Kilolitre fuel



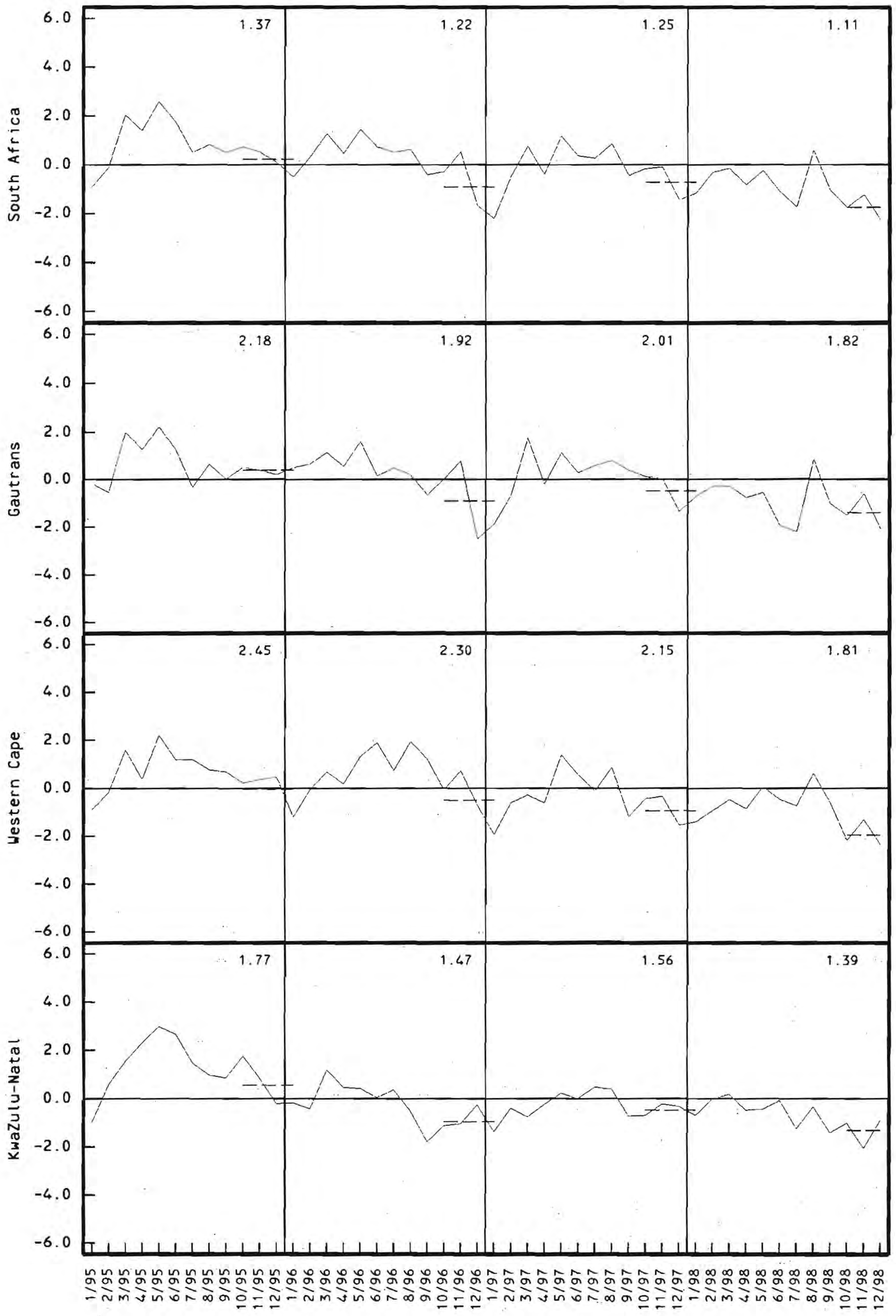
Graph C.27: Right turn (opp) fatalities and severe injuries per Kilolitre fuel



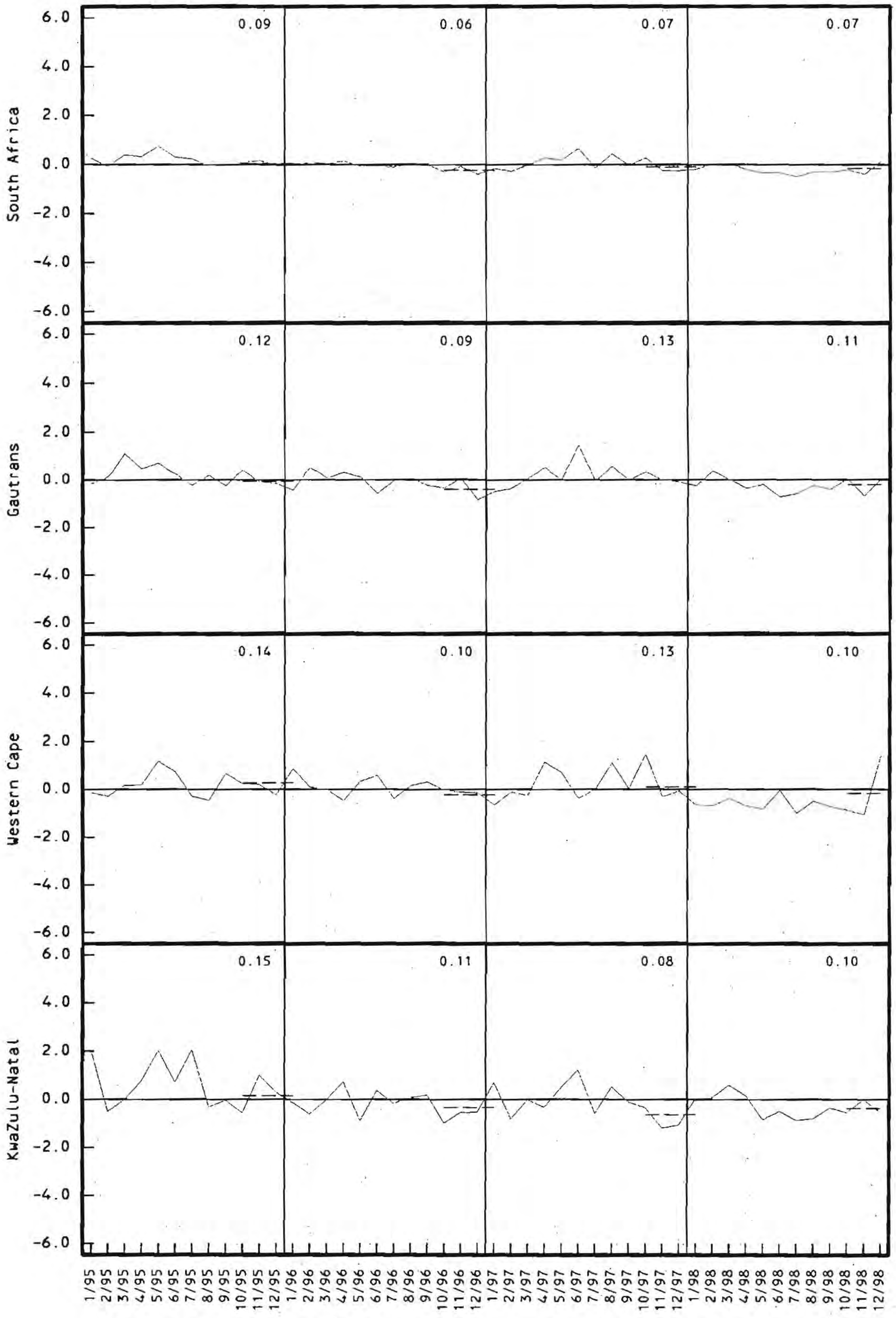
Graph C.28: Right turn (same) accidents per Kilolitre fuel



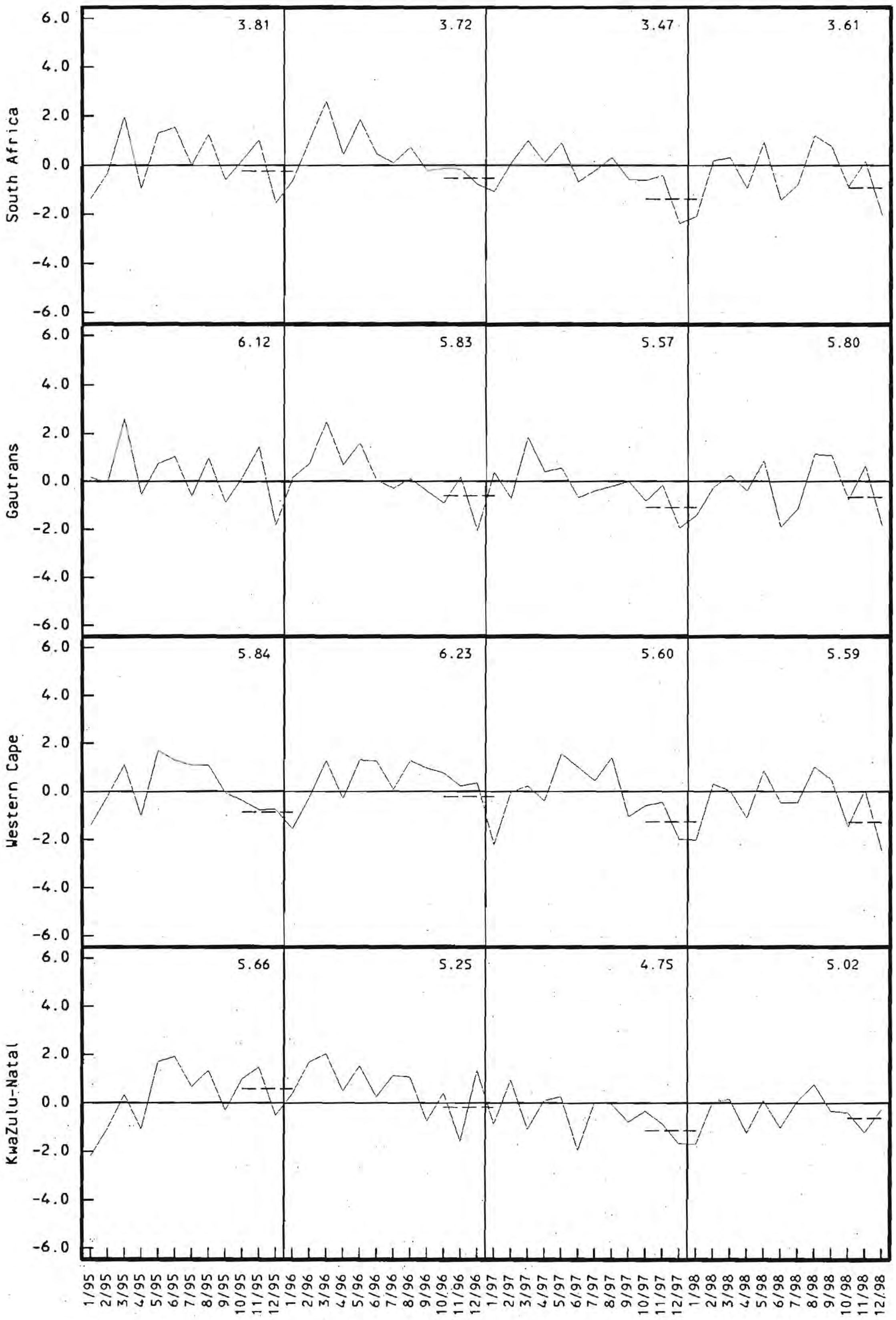
Graph C.29: Right turn (same) fatalities and severe injuries per Kilolitre fuel



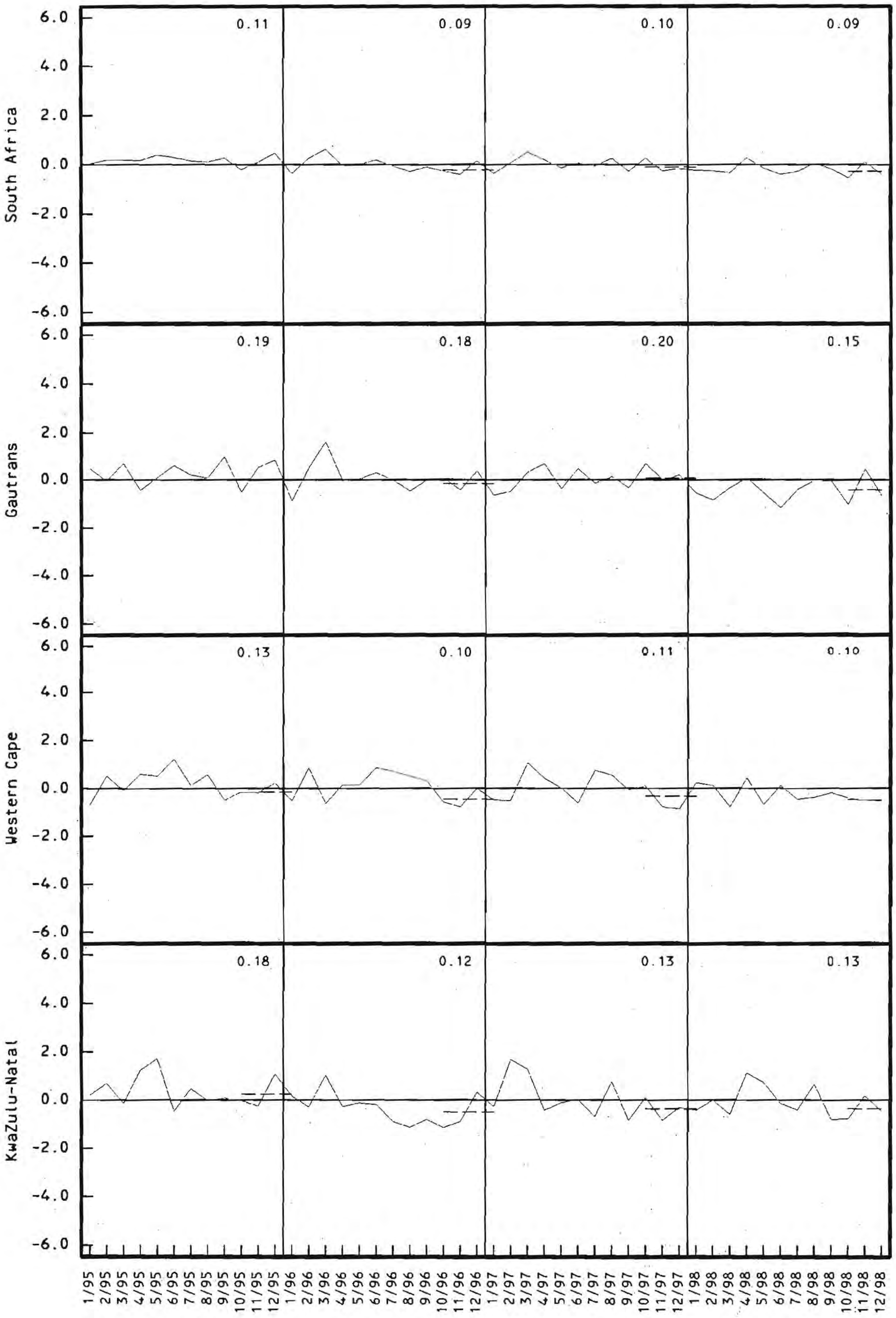
Graph C.30: Side swipe (opp) accidents per Kilolitre fuel



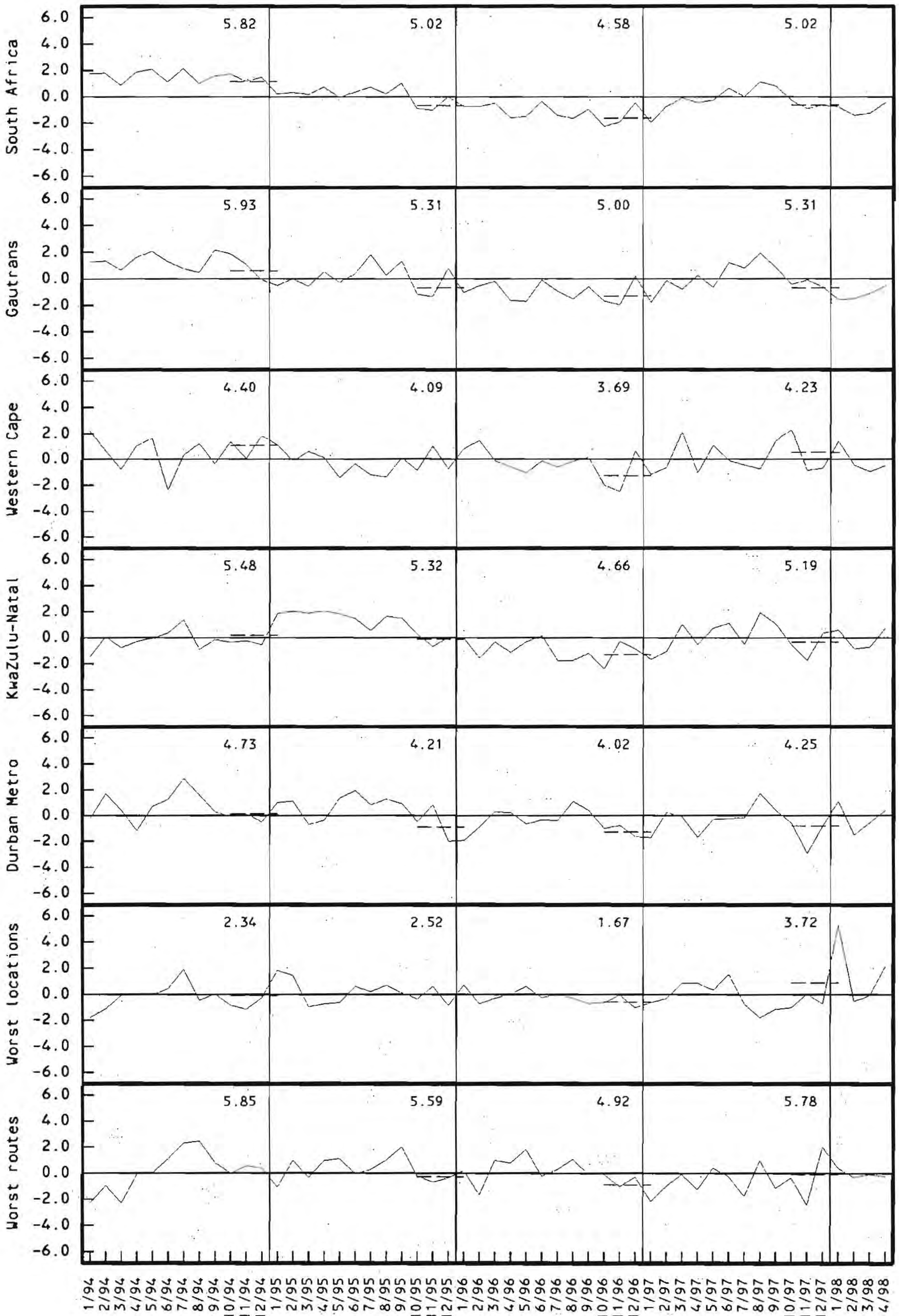
Graph C.31: Side swipe (opp) Total no of fatalities and severe injuries per Kilolitre fue



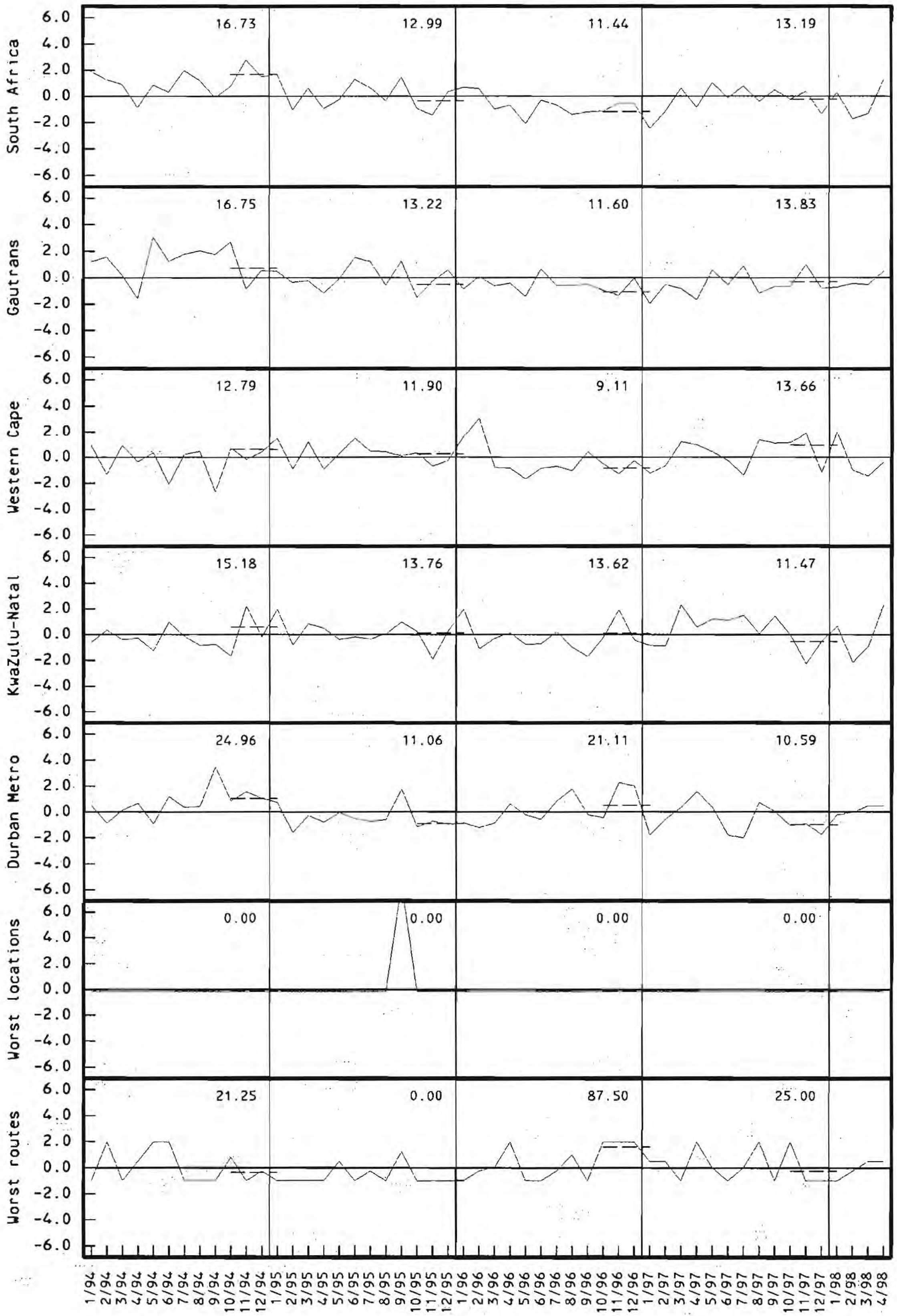
Graph C.32: Side swipe (same) accidents per Kilolitre fuel



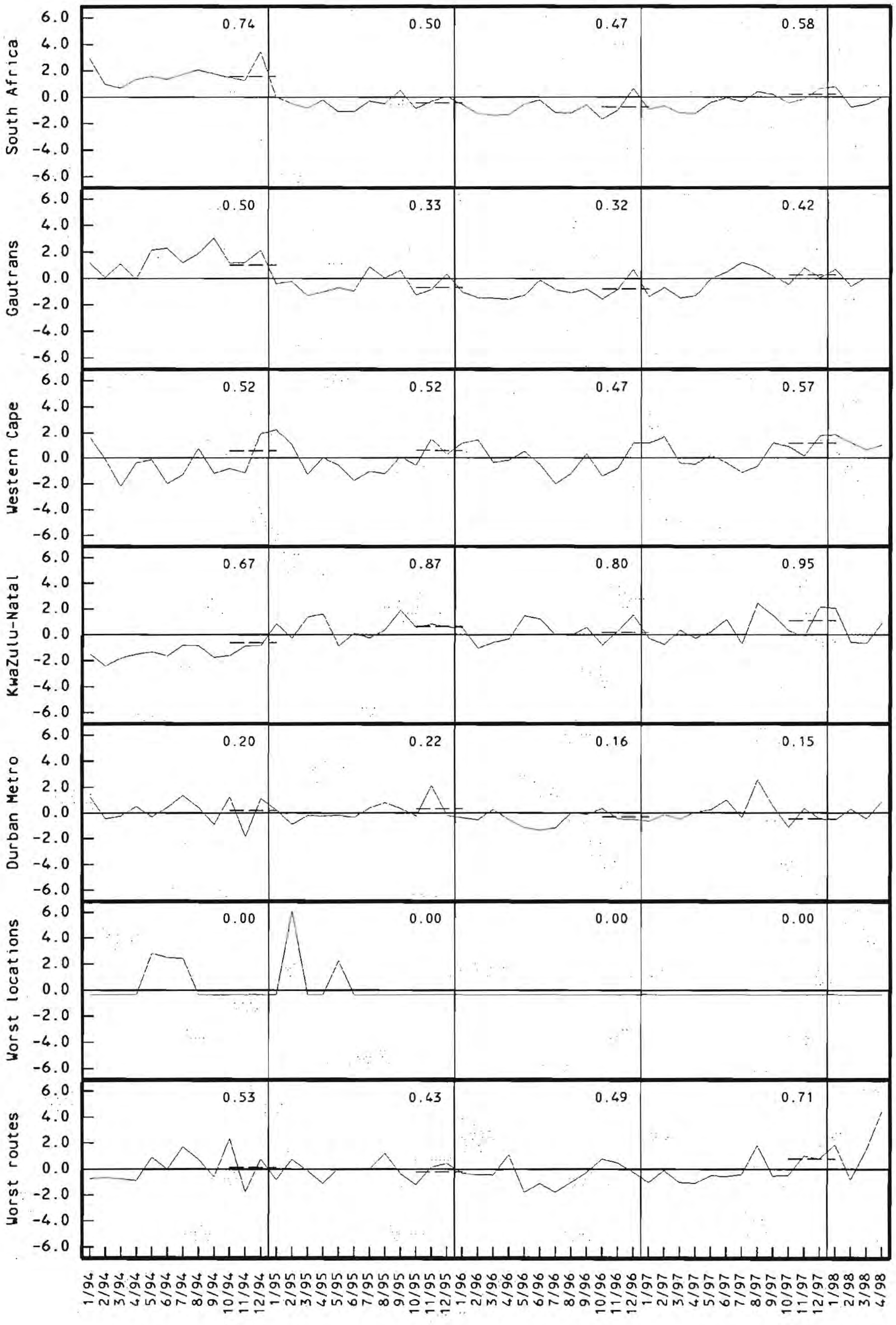
Graph C.33: Side swipe (same) fatalities and severe injuries per Kilolitre fuel



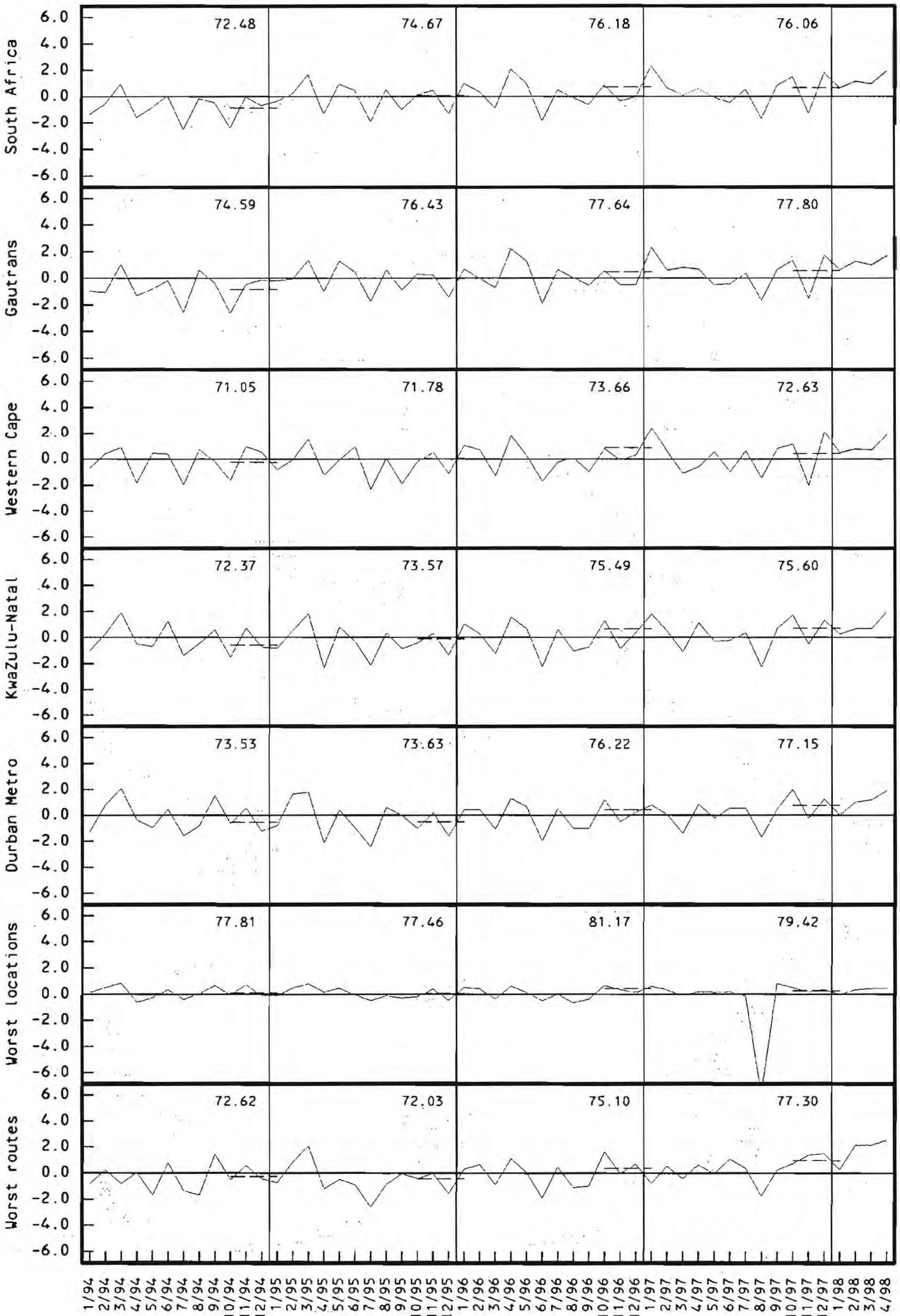
Graph C.34: Total: Degree of injuries



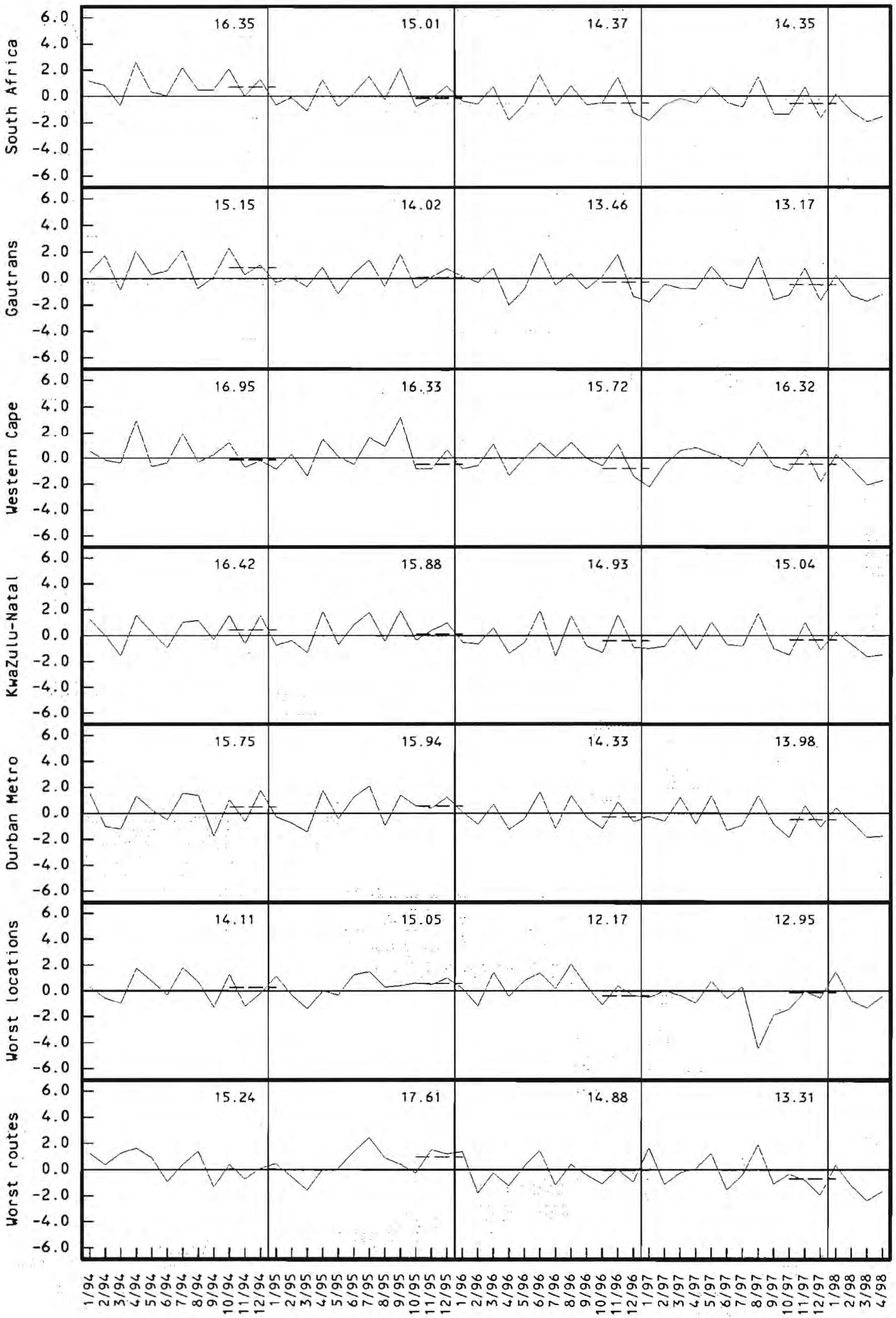
Graph C.35: Head on acc: Degree of injuries



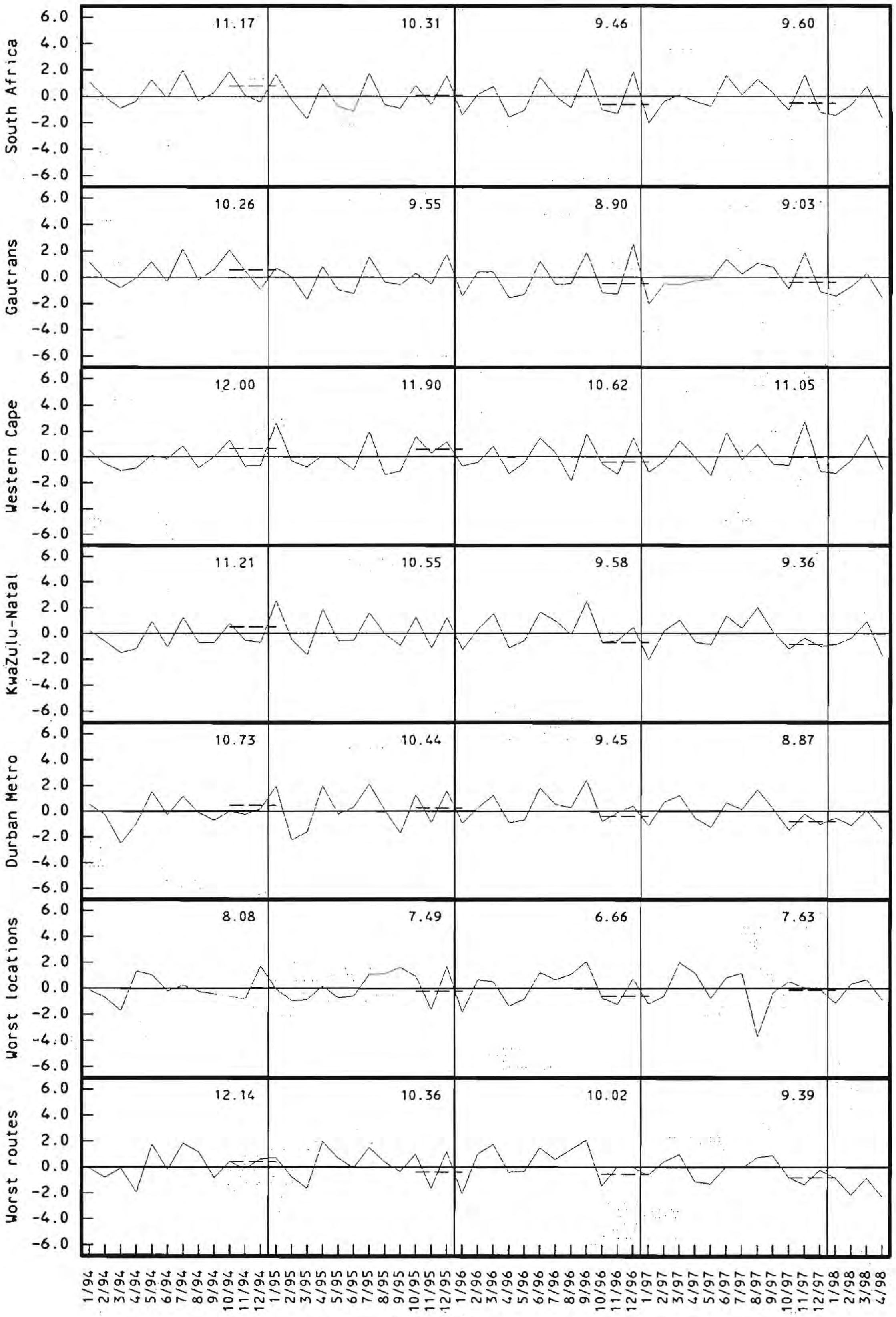
Graph C.36: Overturning acc: Degree of injuries



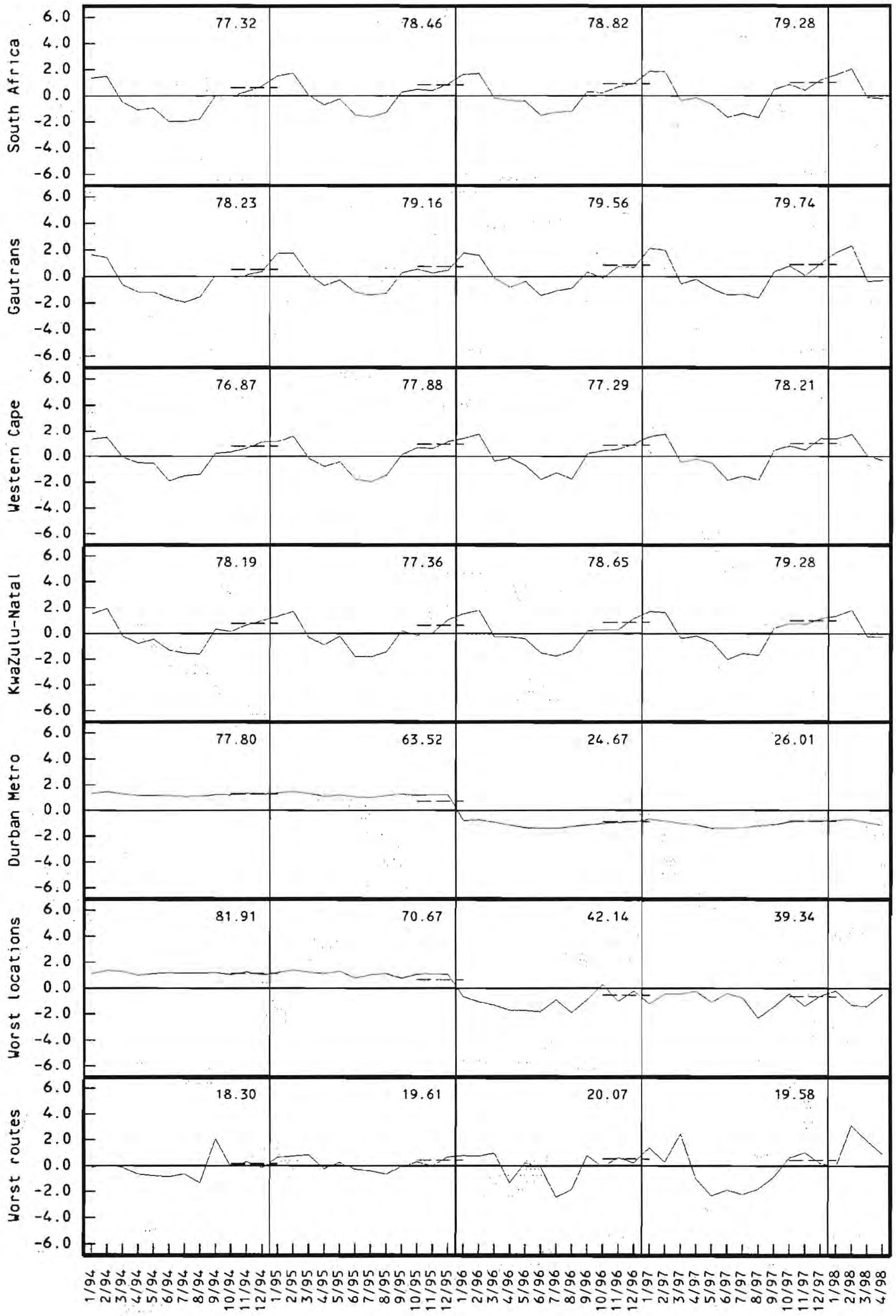
Graph C.37: Total: % weekday accidents



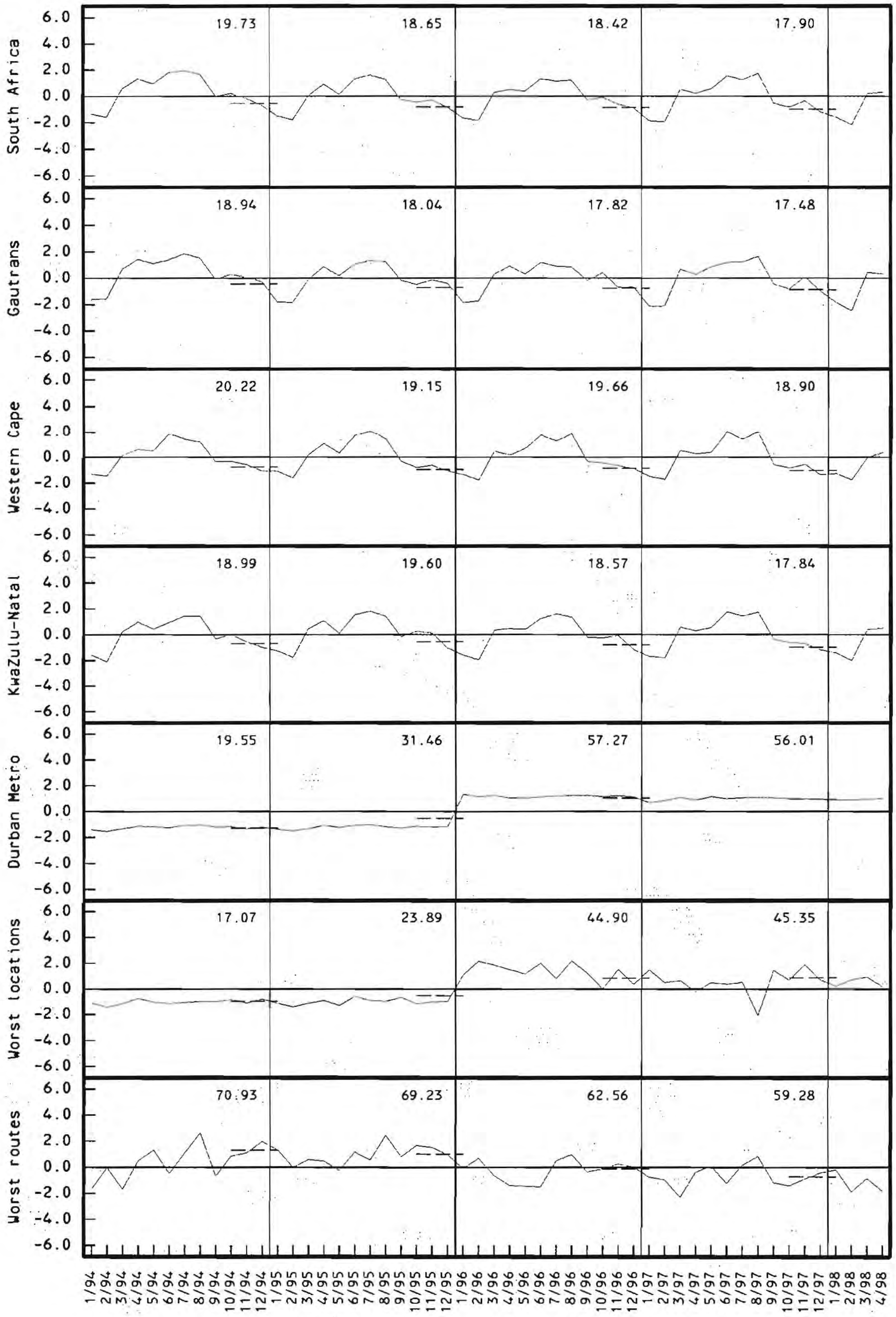
Graph C.38: Total: % Saturday acc



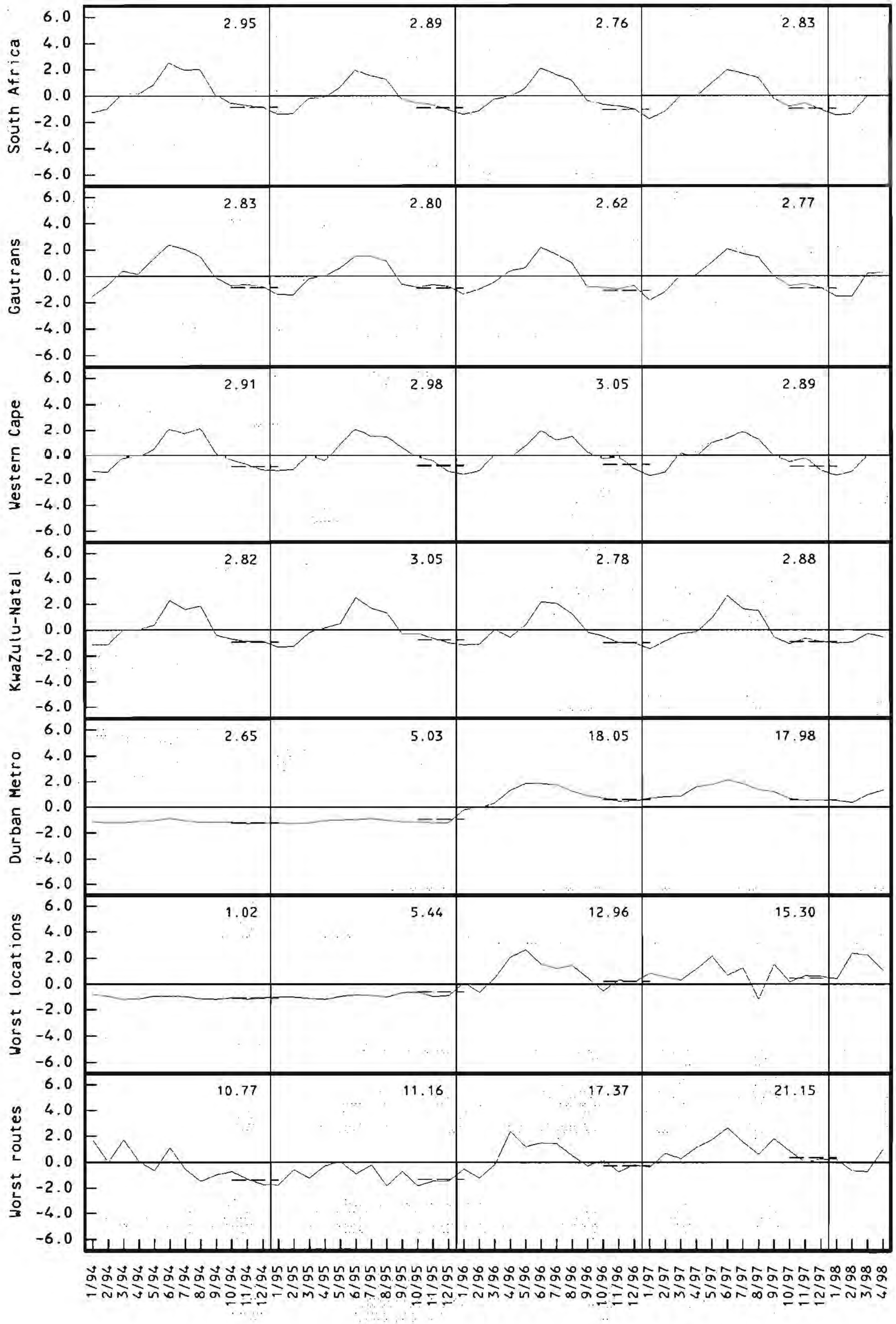
Graph C.39: Total: % Sunday acc



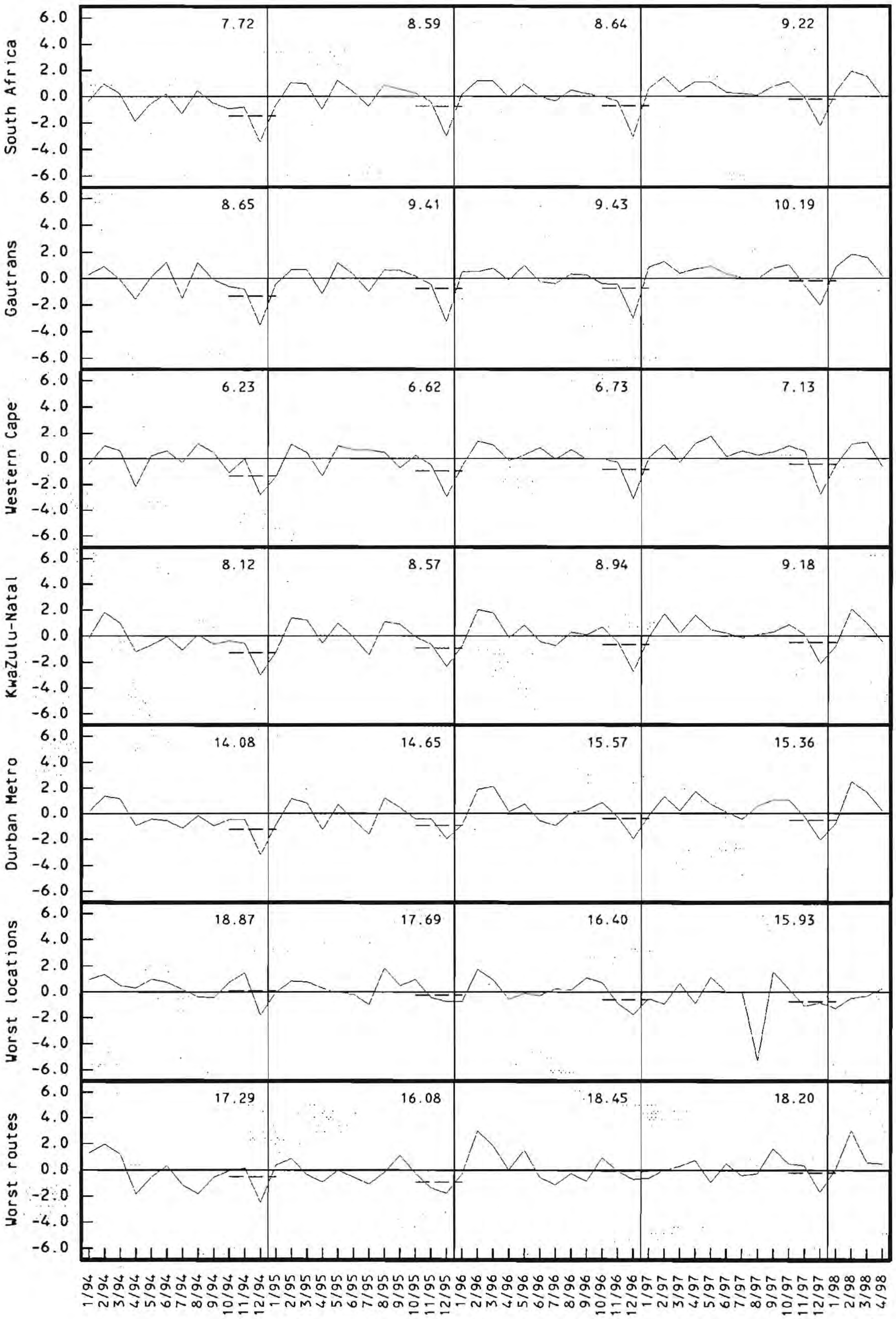
Graph C.40: Total: % daylight acc (visibility)



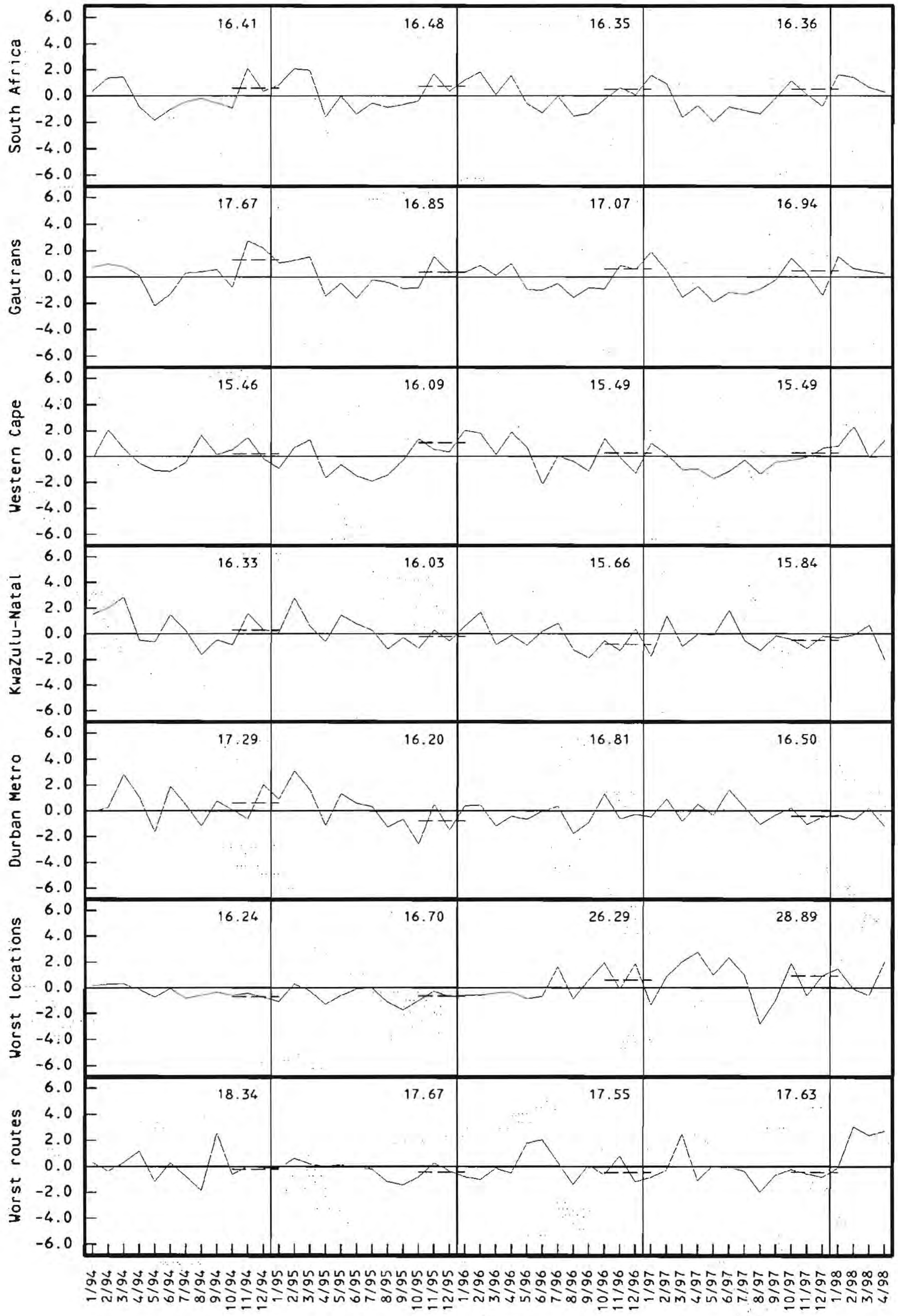
Graph C.41: Total: % night acc (visibility)



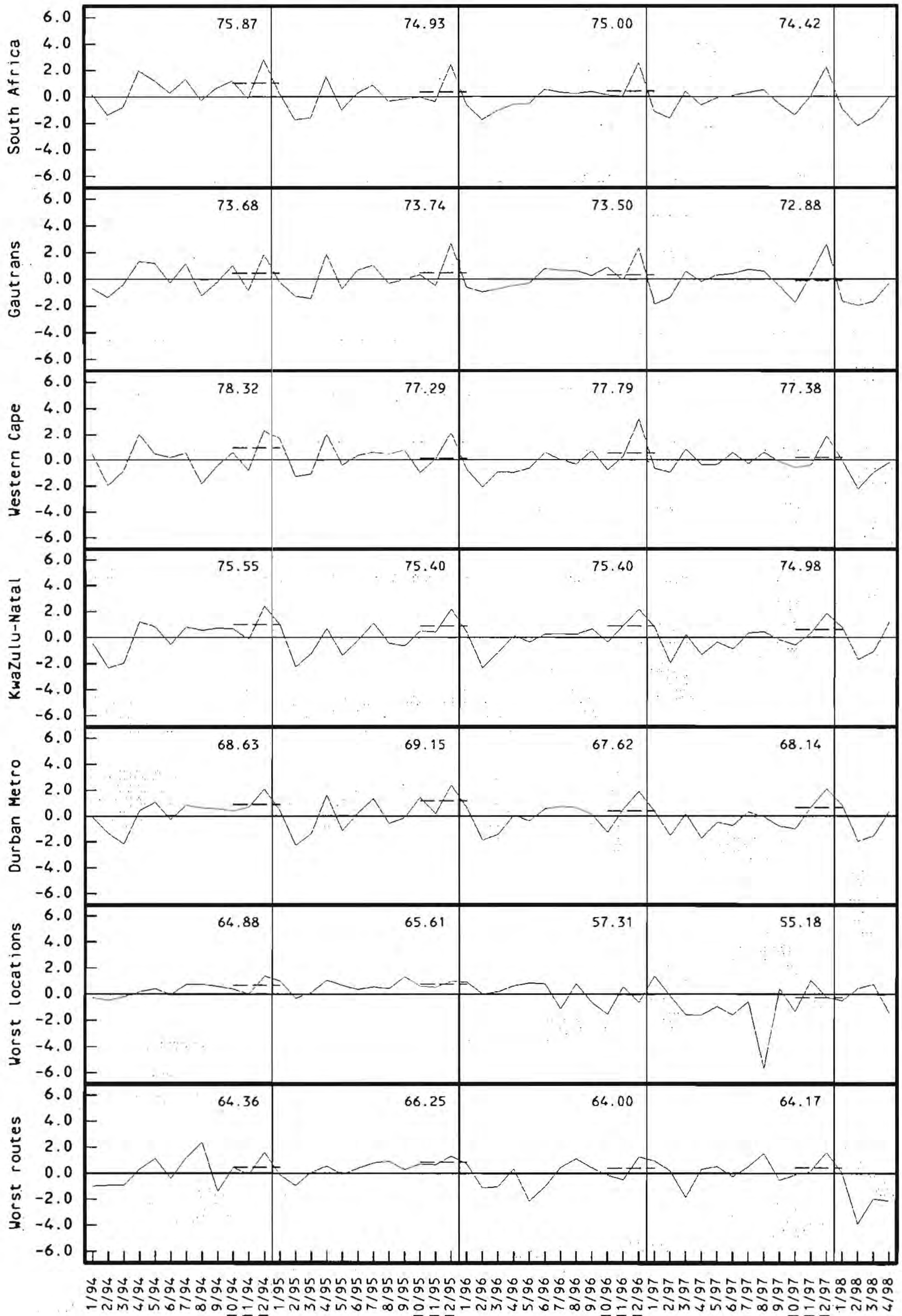
Graph C.42: Total: % twilight acc (visibility)



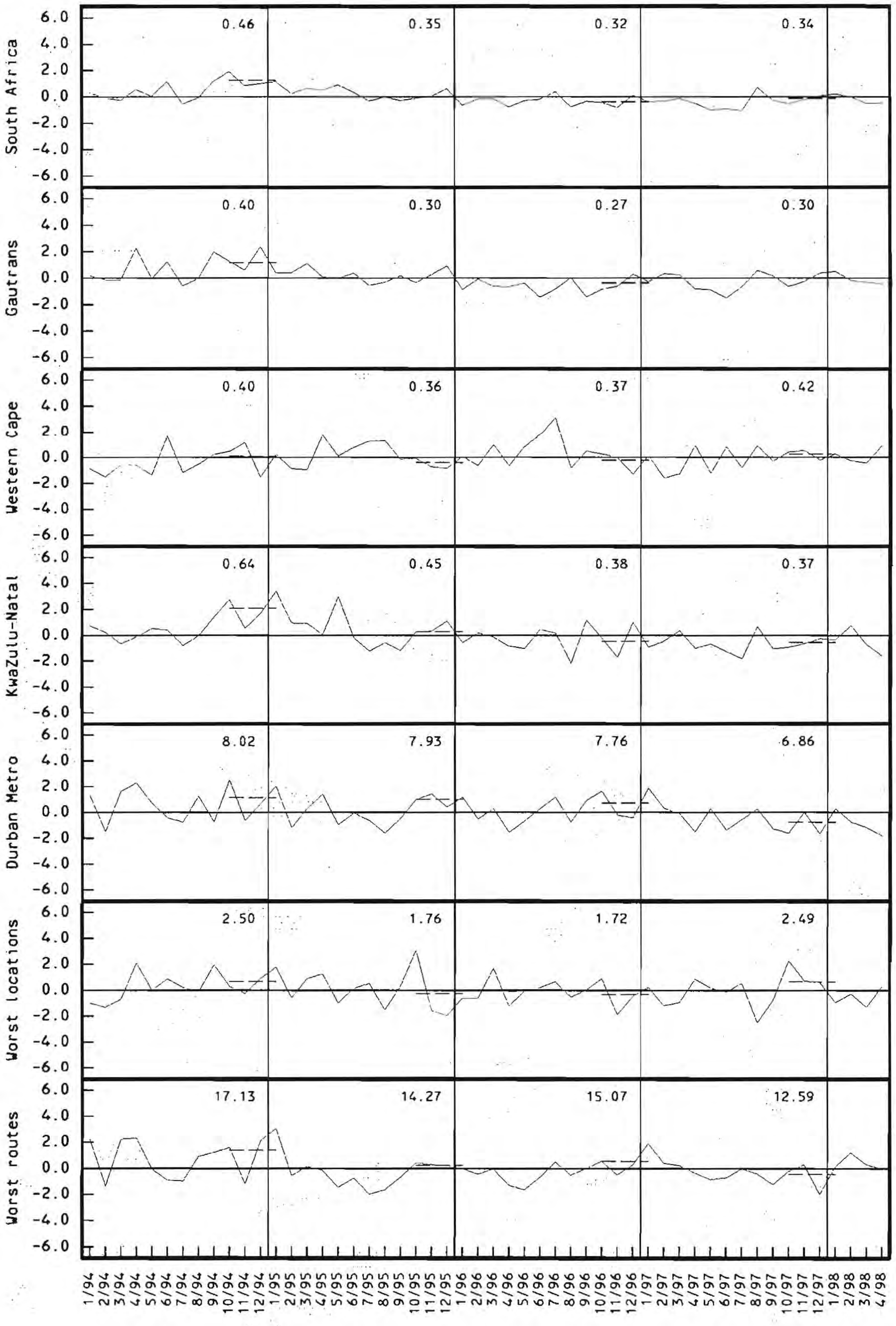
Graph C.43: Total: % AM-Peak acc



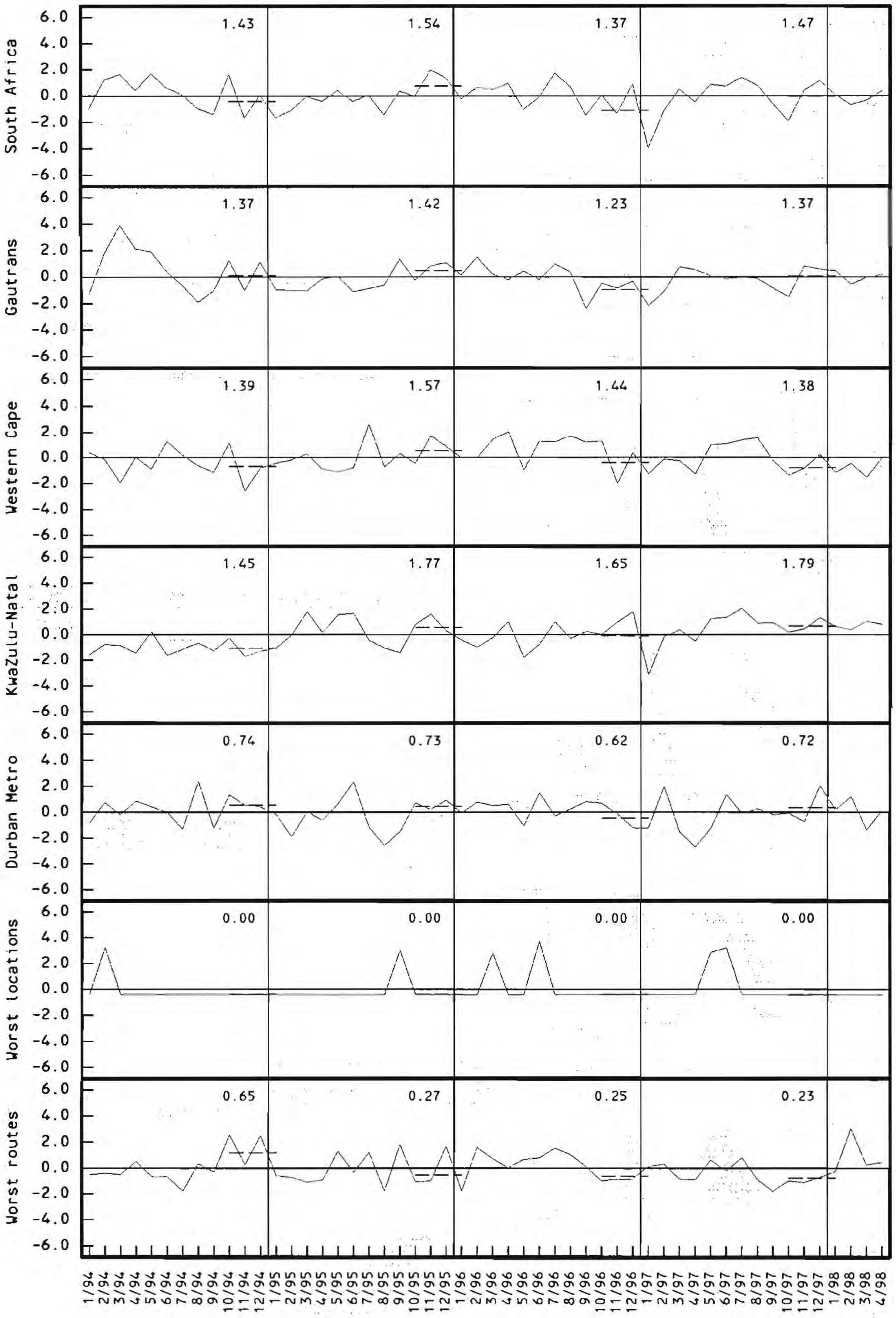
Graph C.44: Total: % PM-Peak acc



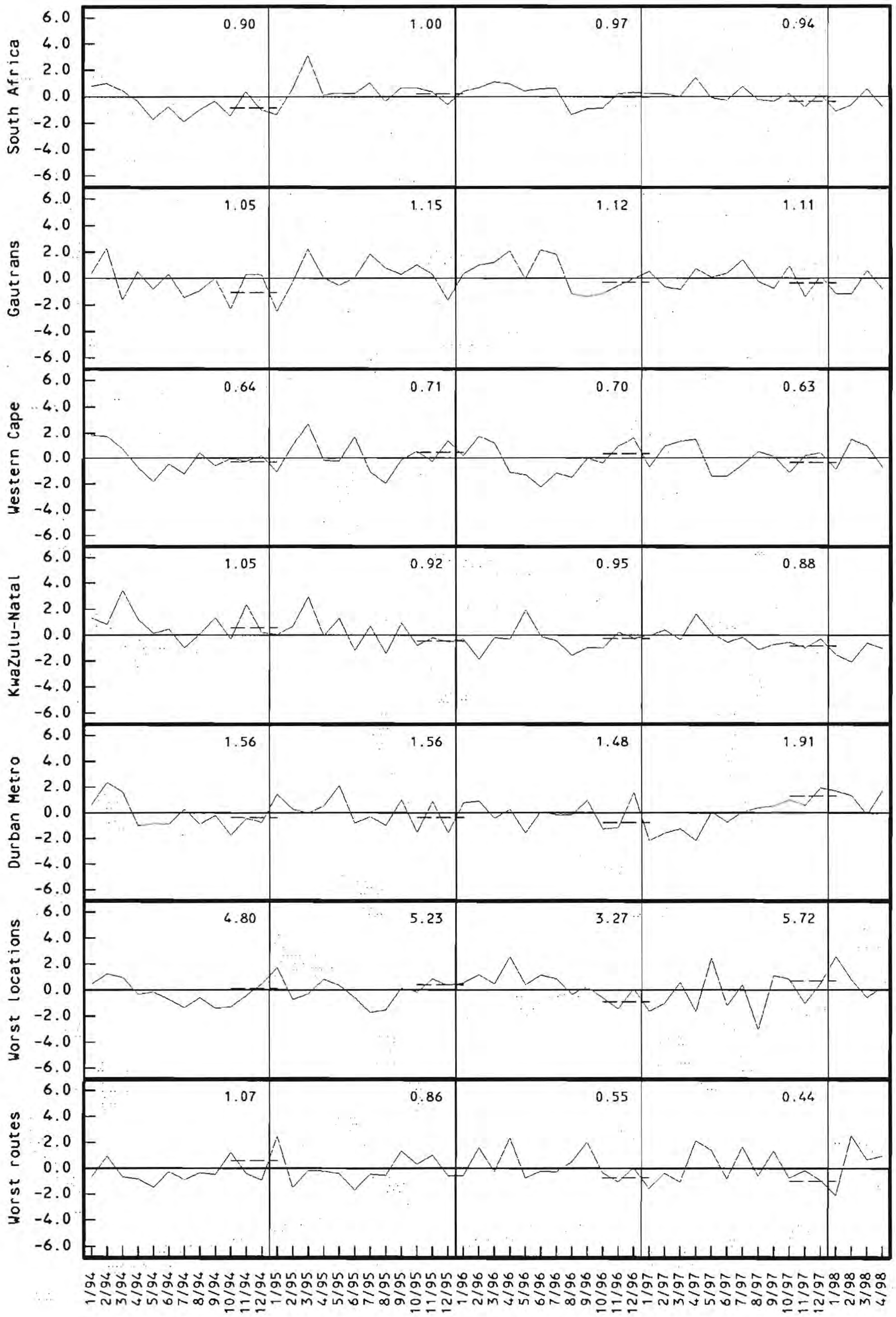
Graph C.45: Total: % Off-Peak acc



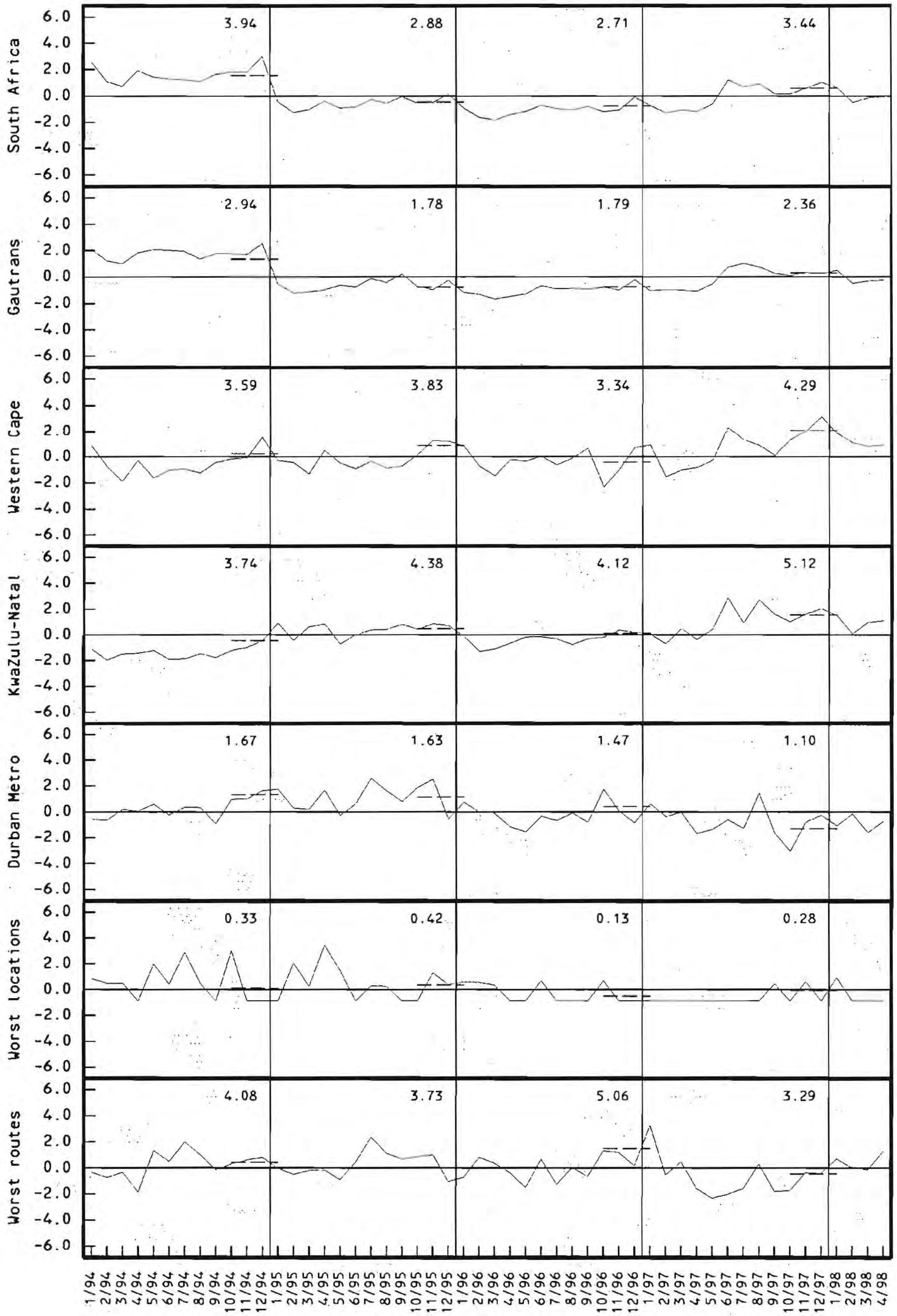
Graph C.46: Fixed object accidents as % of the total accidents



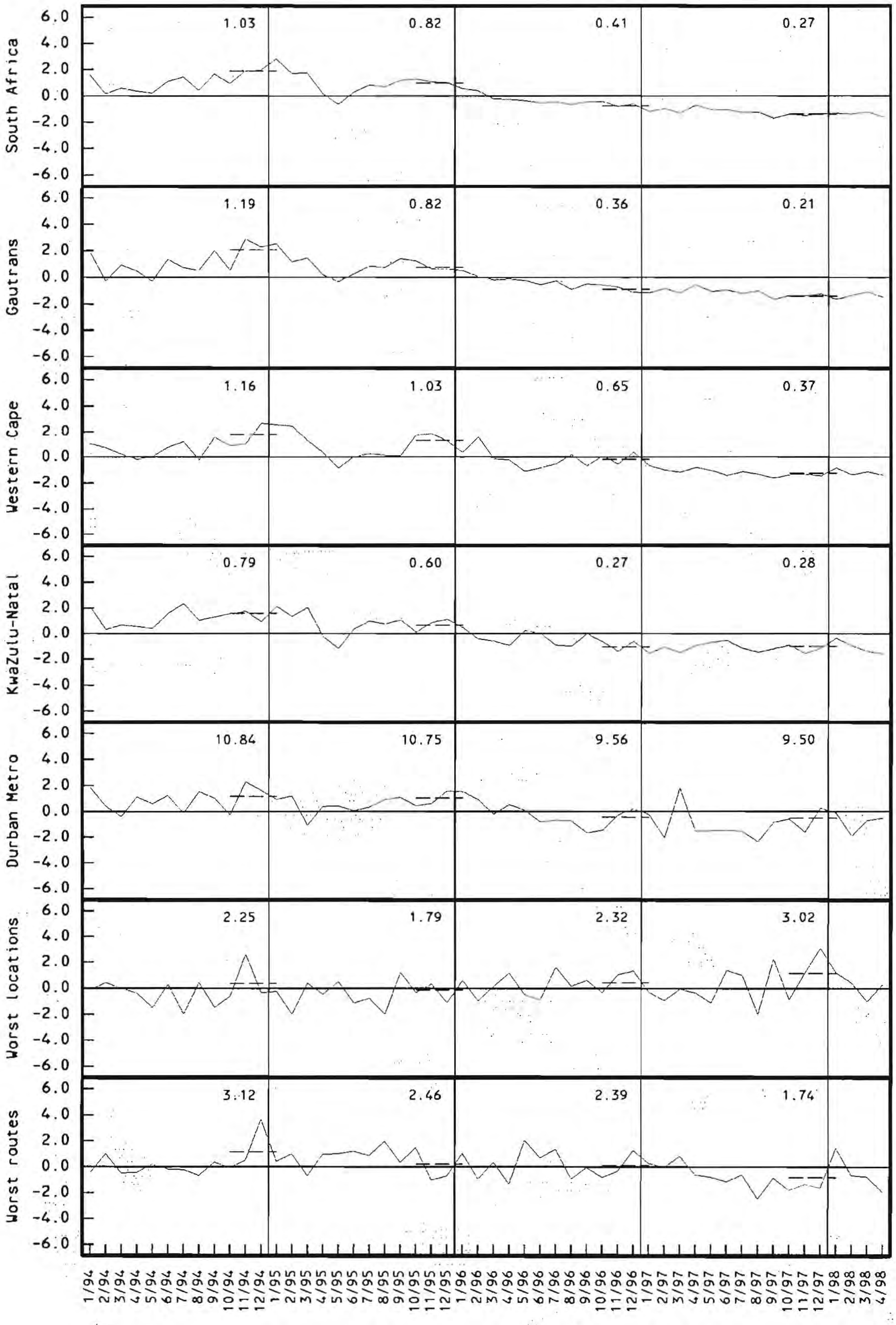
Graph C.47: Head on accidents as % of the total accidents



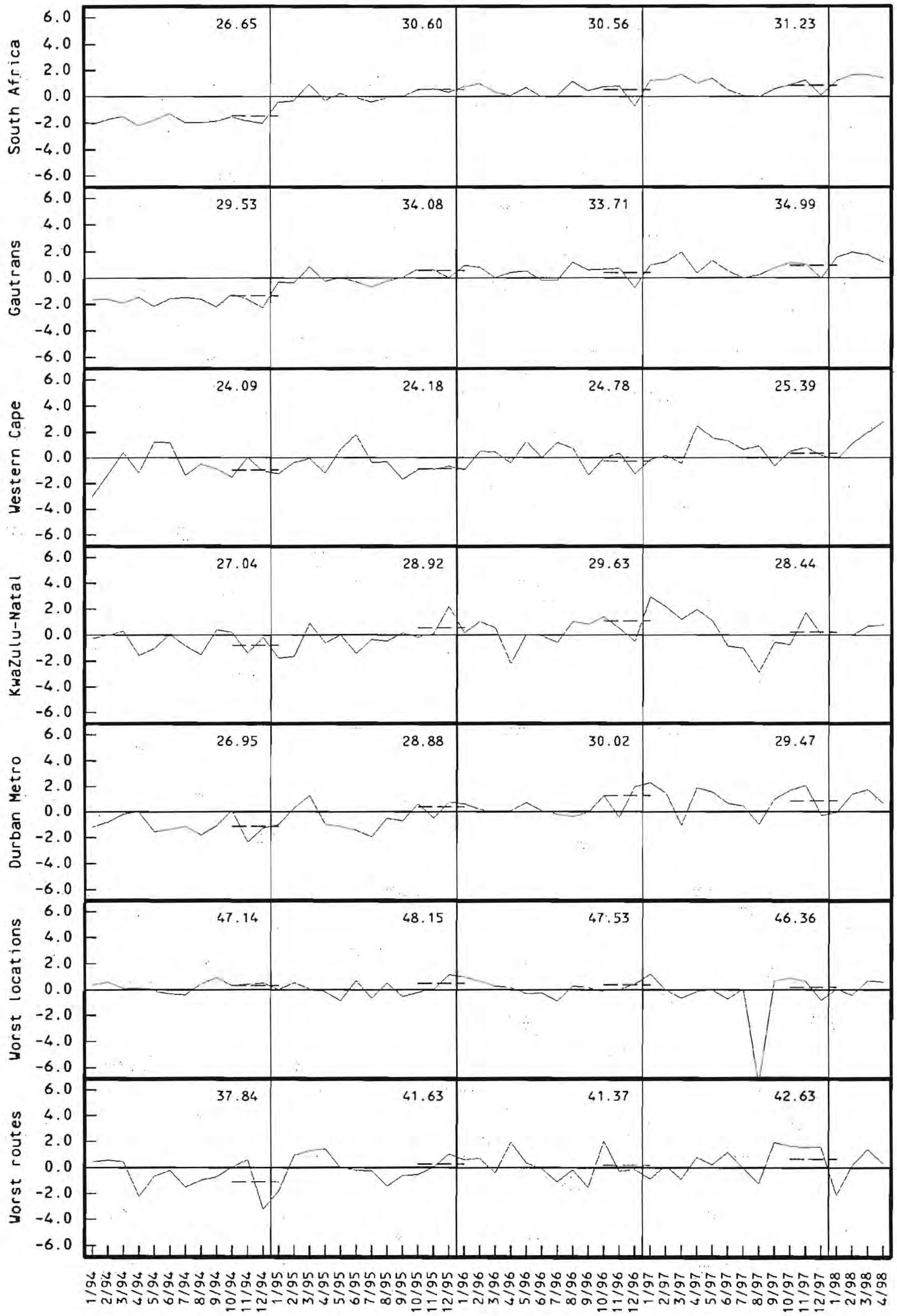
Graph C.48: Left turn (same) accidents as % of the total accidents



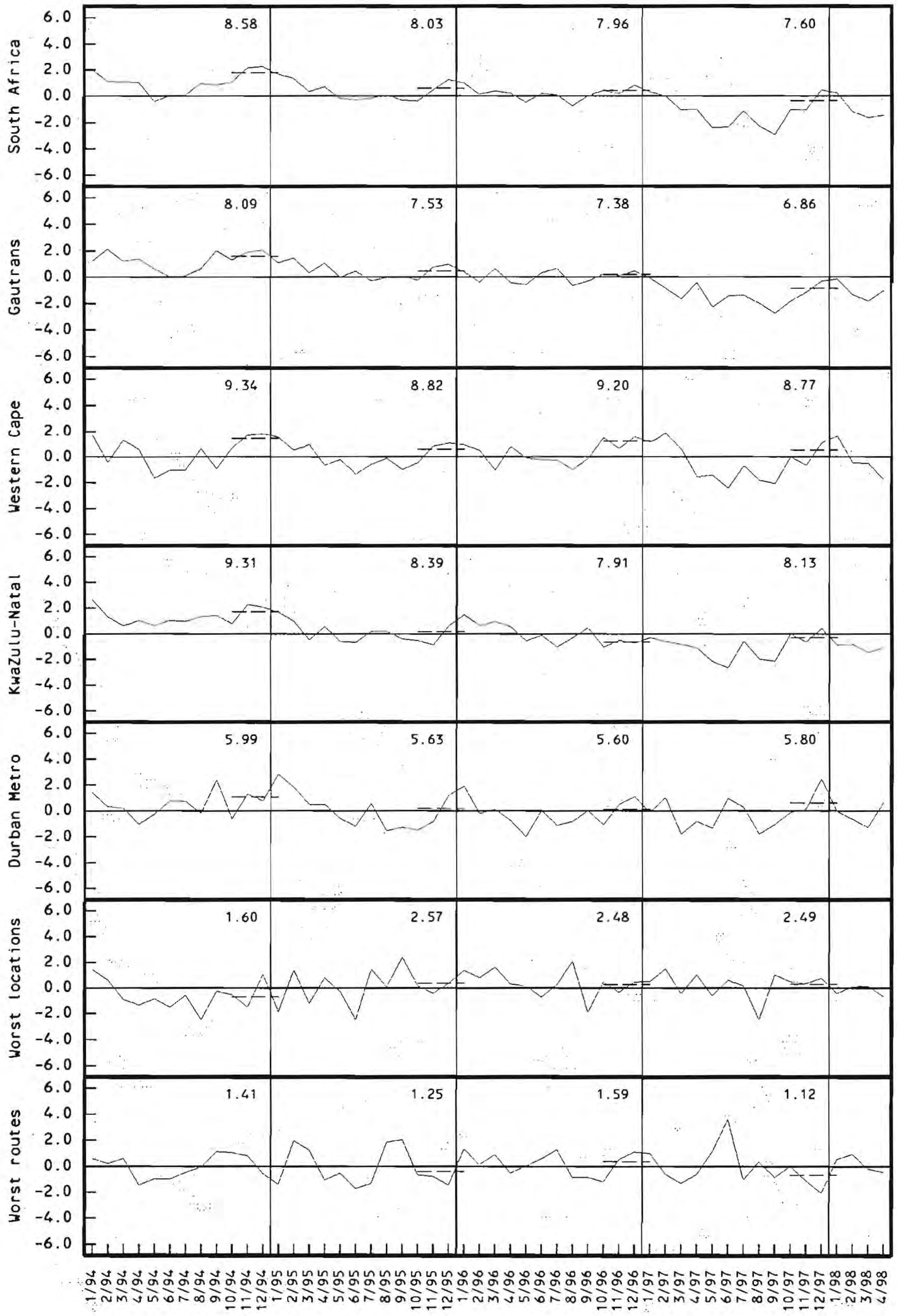
Graph C.49: Overturning accidents as % of the total accidents



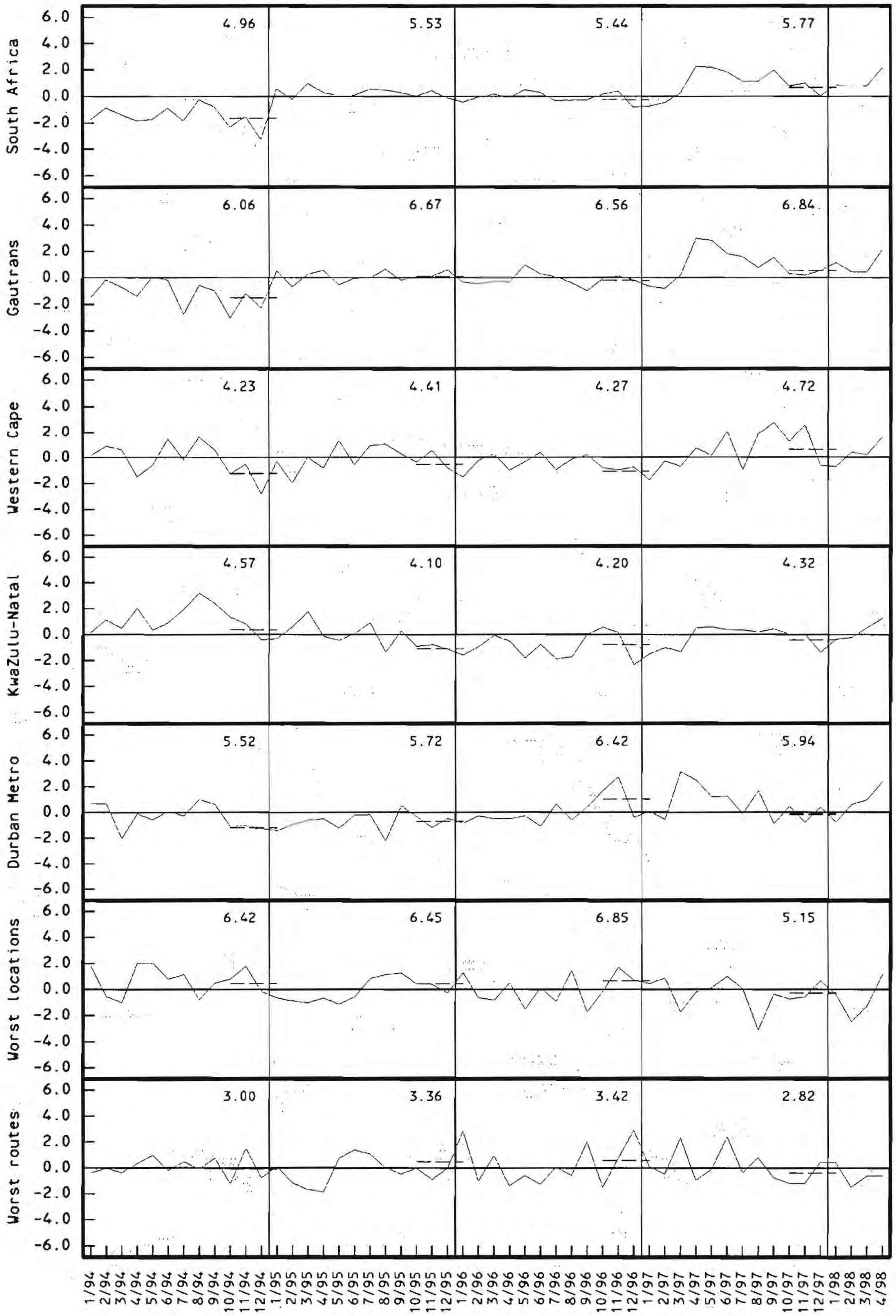
Graph C.50: Parked/ parking accidents as % of the total accidents



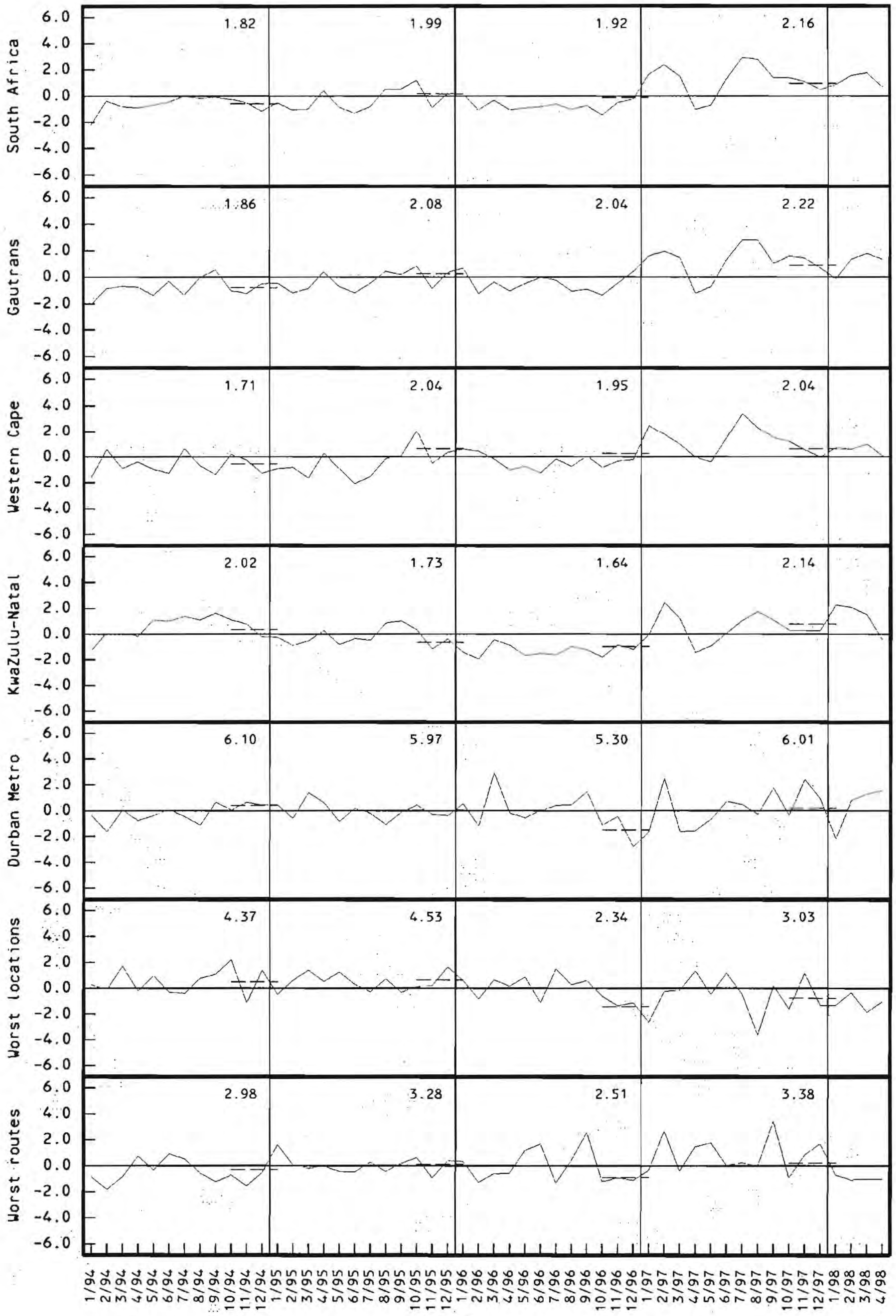
Graph C.51: Rear end accidents as % of the total accidents



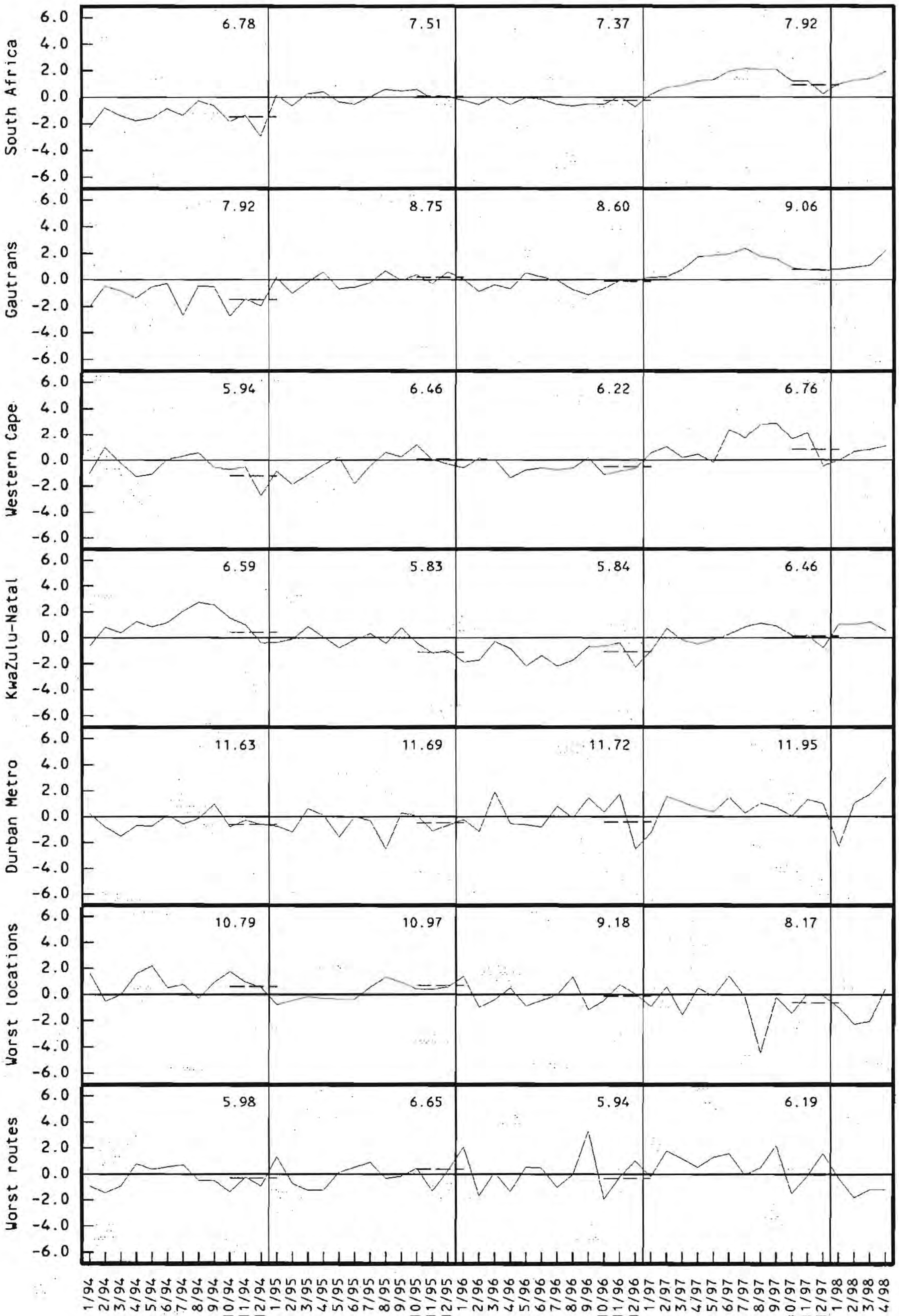
Graph C.52: Reversing accidents as % of the total accidents



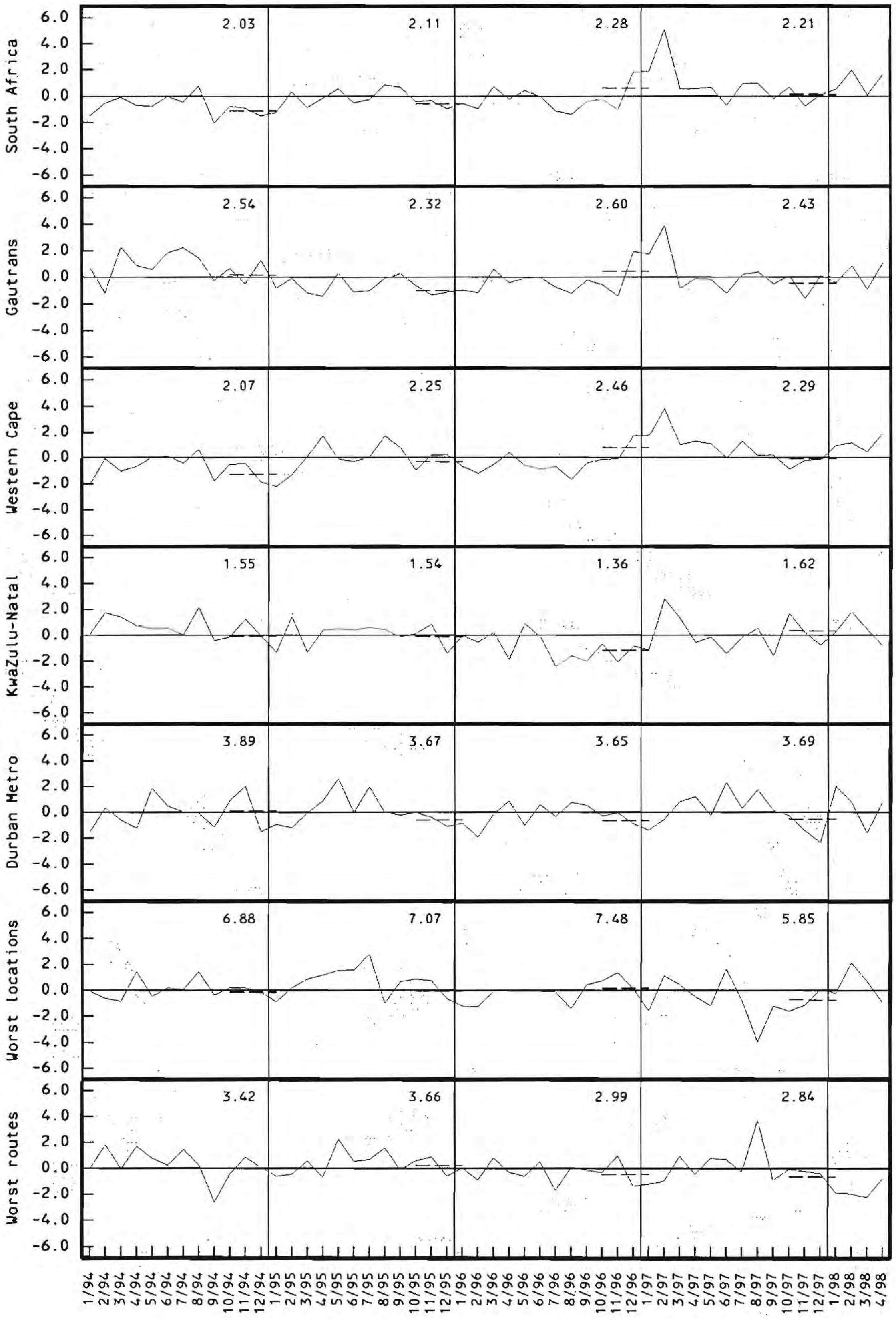
Graph C.53: Right angle (straight)accidents as % of the total accidents



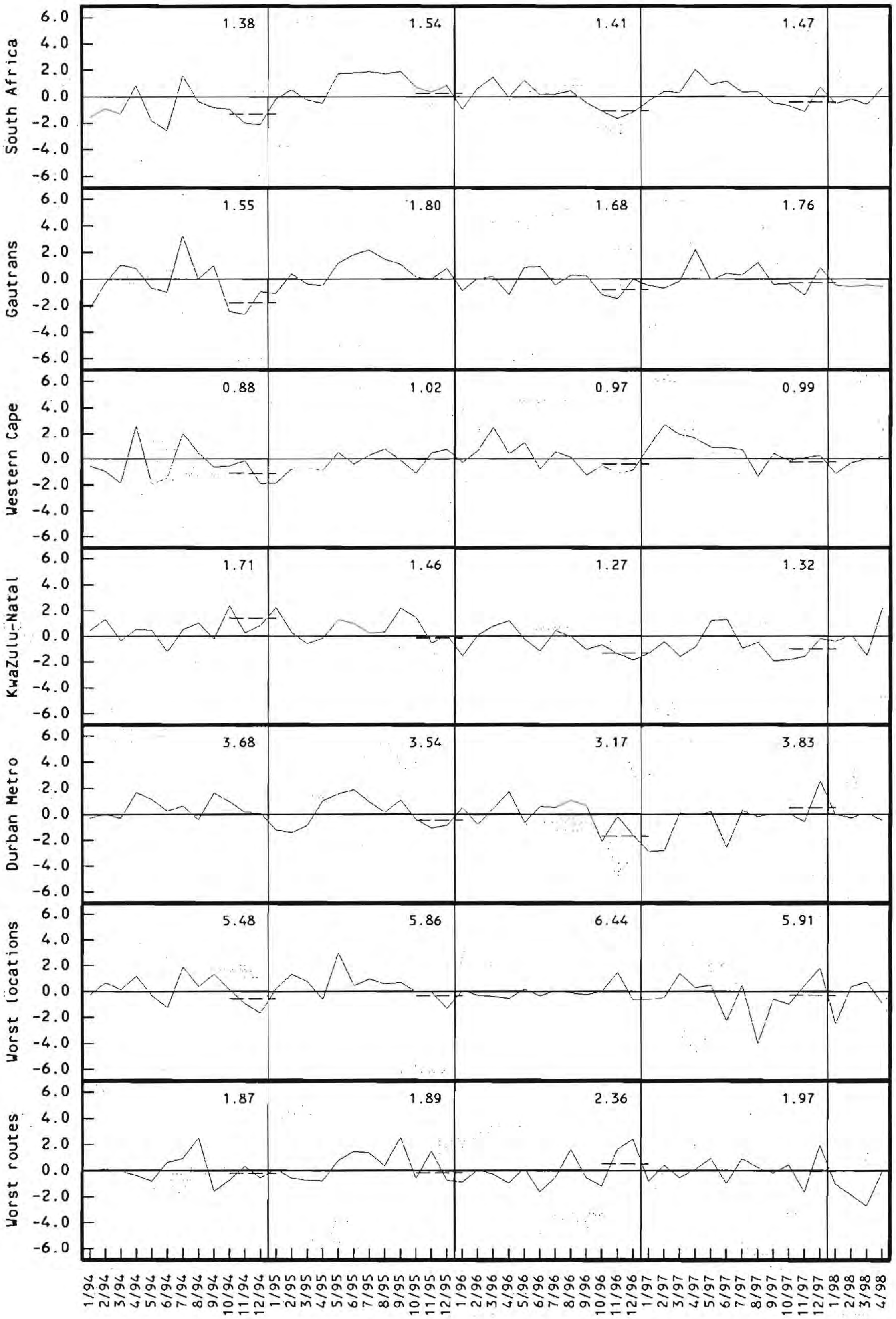
Graph C.54: Right angle (turn) accidents as % of the total accidents



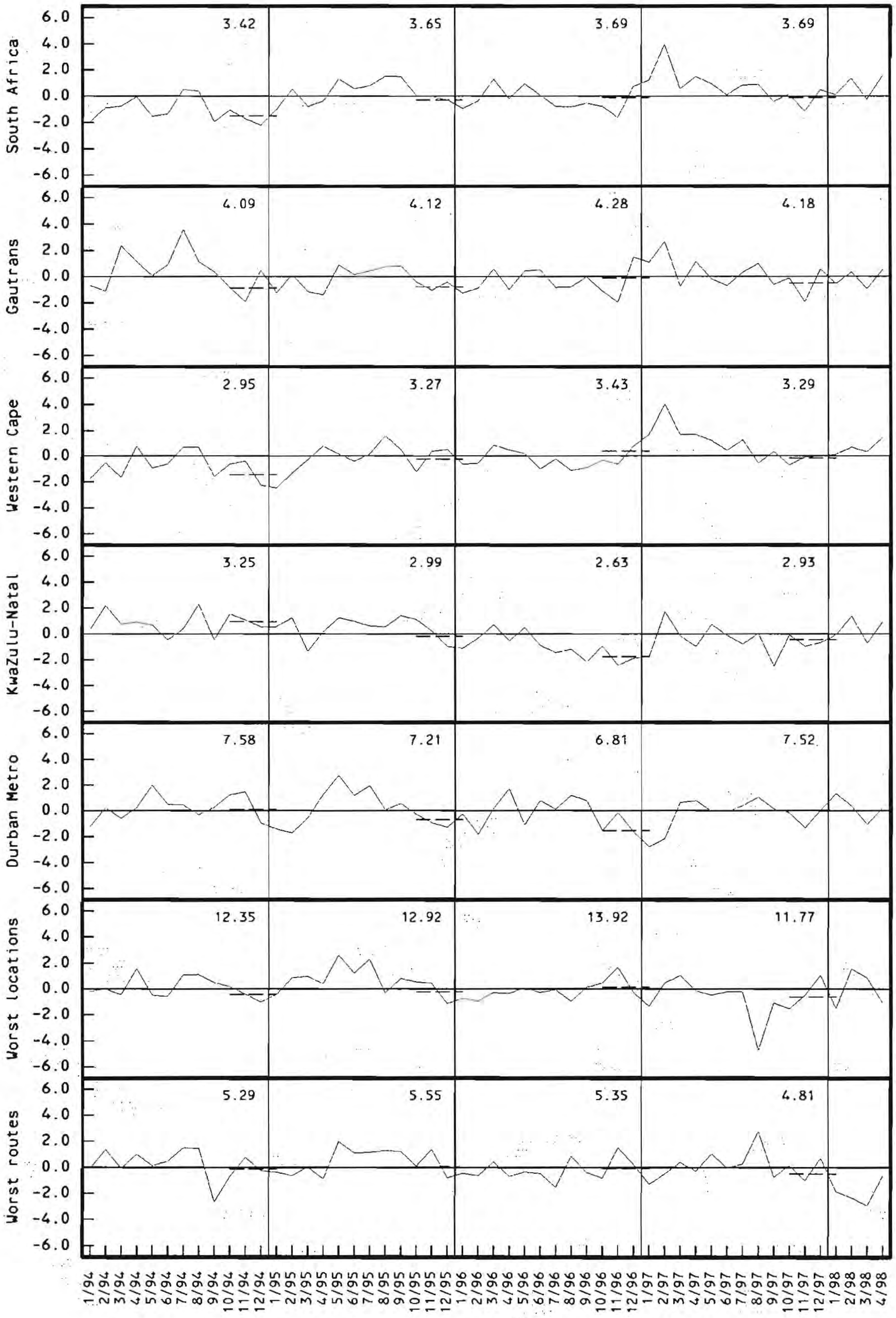
Graph C.55: Right angle accidents as % of the total accidents



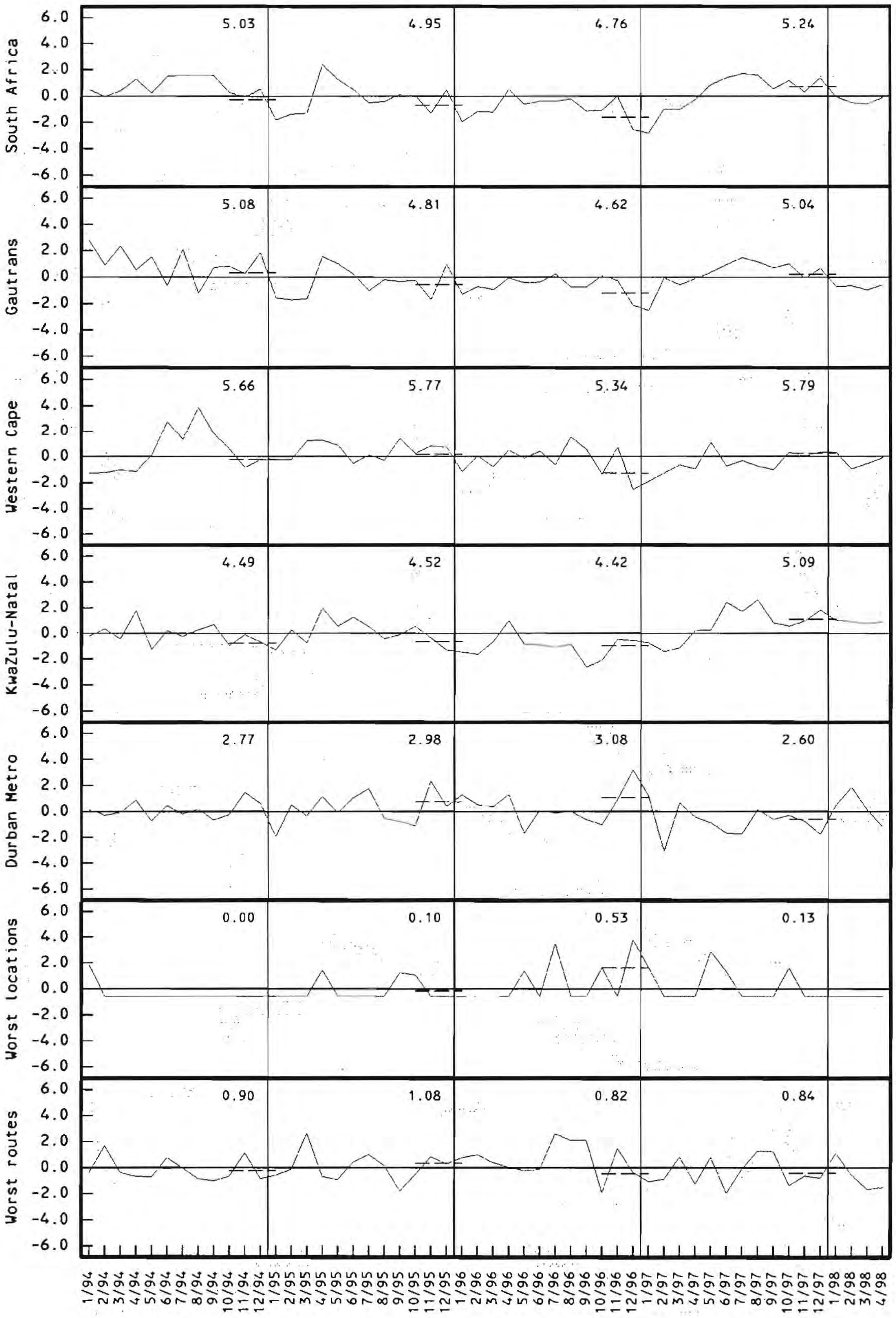
Graph C.56: Right turn (opp) accidents as % of the total accidents



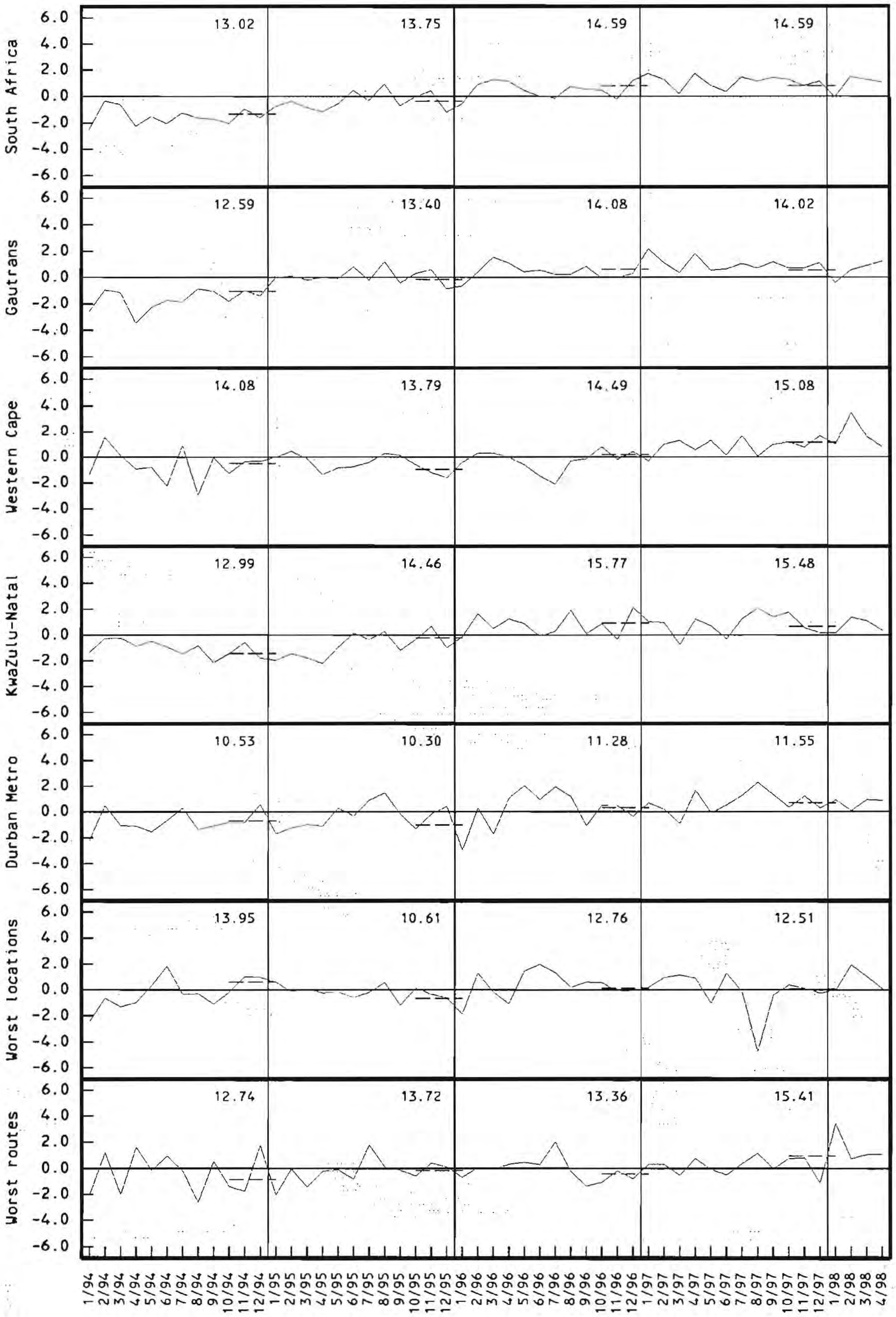
Graph C.57: Right turn (same) accidents as % of the total accidents



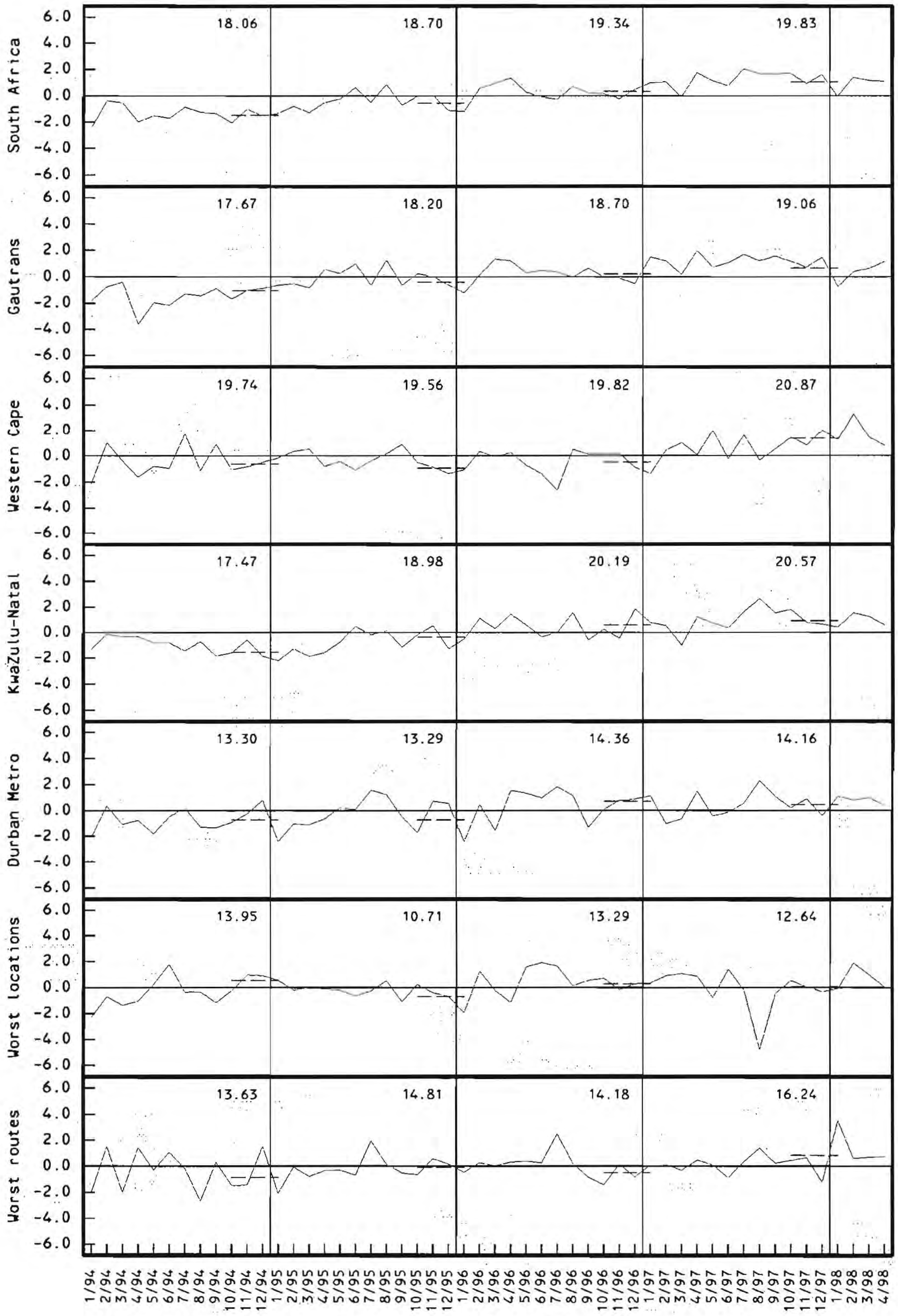
Graph C.58: Right turn accidents as % of the total accidents



Graph C.59: Side swipe (opp) accidents as % of the total accidents



Graph C.60: Side swipe (same) accidents as % of the total accidents



Graph C.61: Side swipe accidents as % of the total accidents

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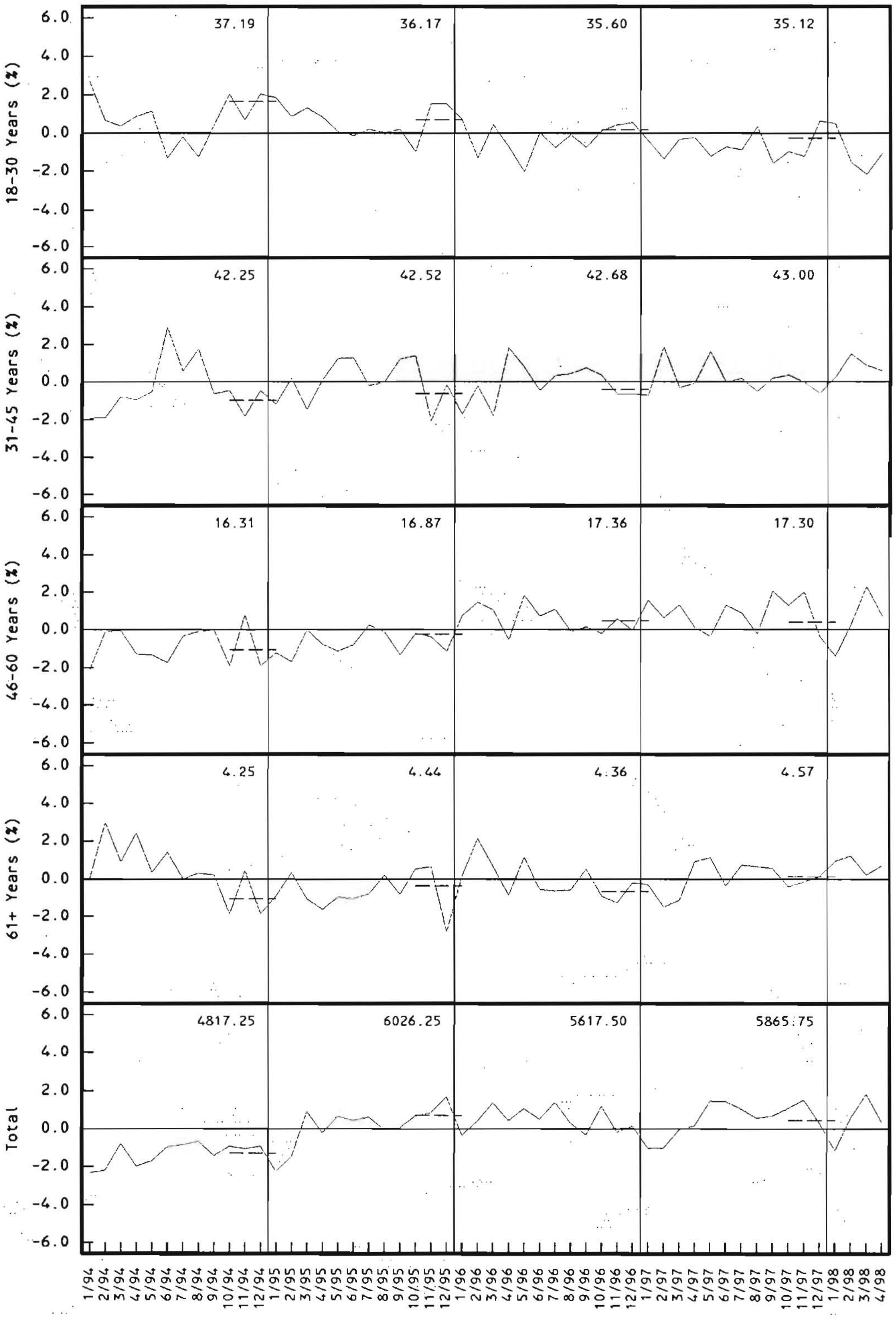
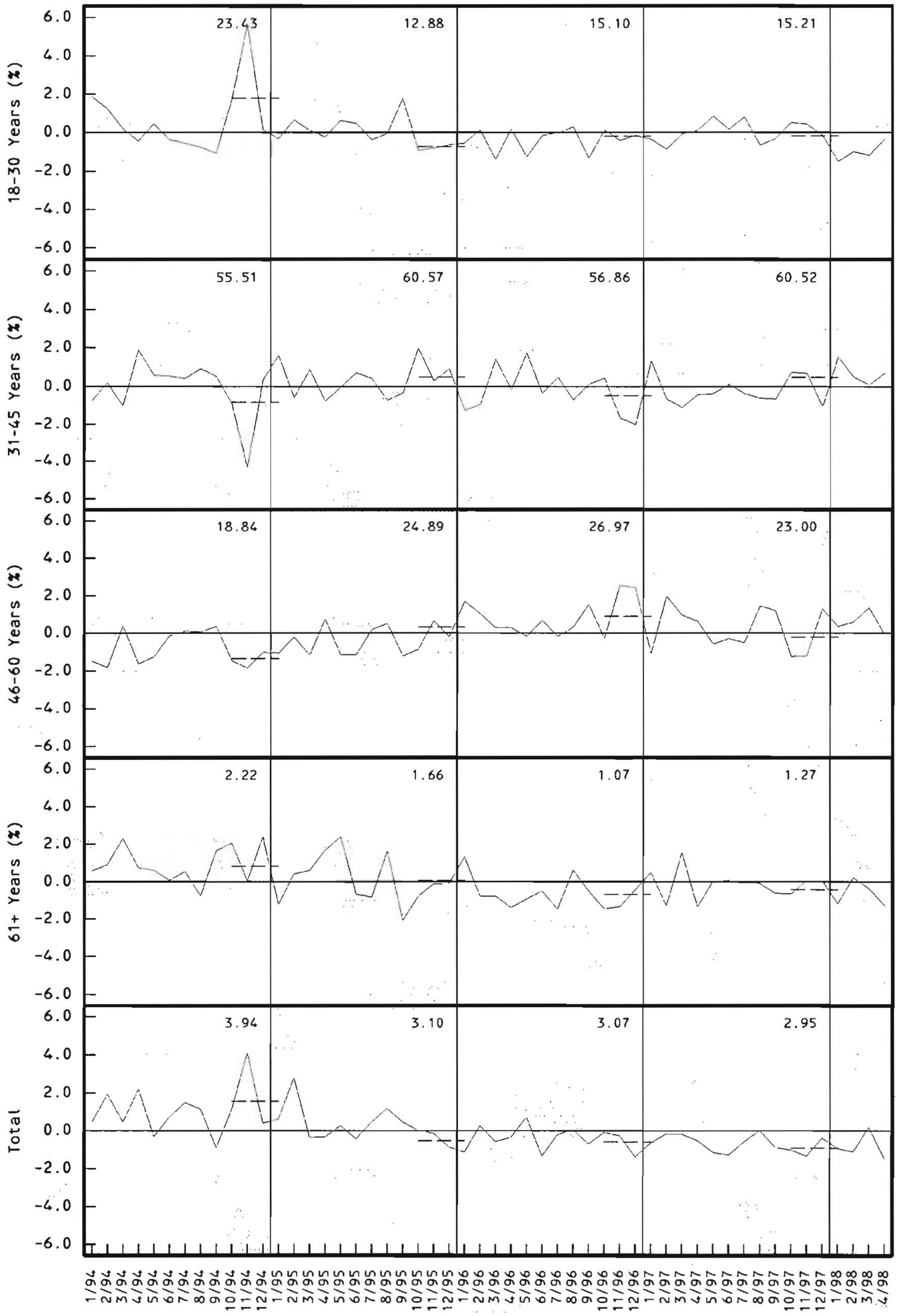
Appendix D:

The graphical representation of the distribution of driver and passenger ages involved in accidents in the Durban Metro area.

APPENDIX D: DRIVER AND PASSENGER AGE INVOLVEMENT DISTRIBUTION OF ACCIDENTS IN THE DURBAN METRO AREA

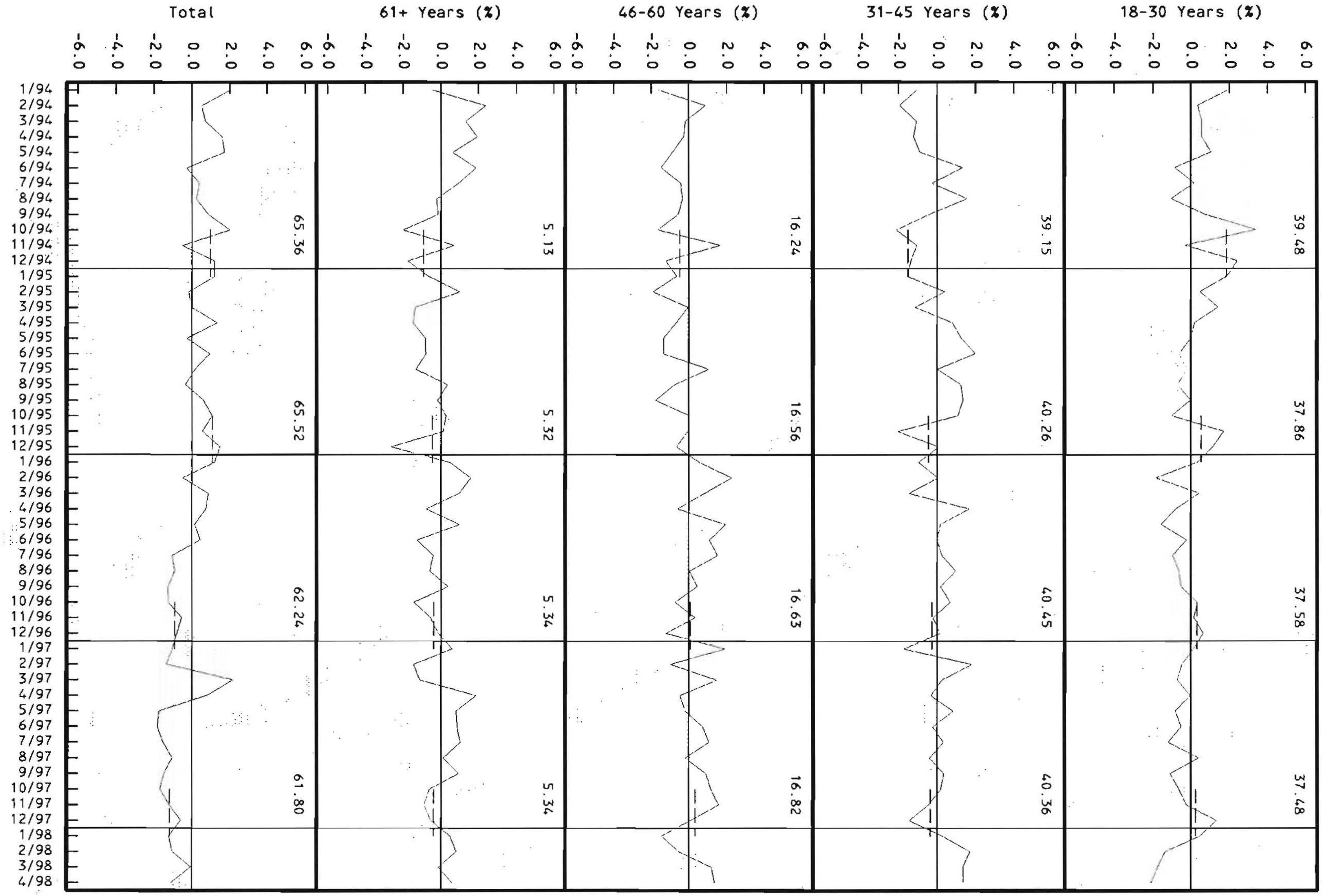


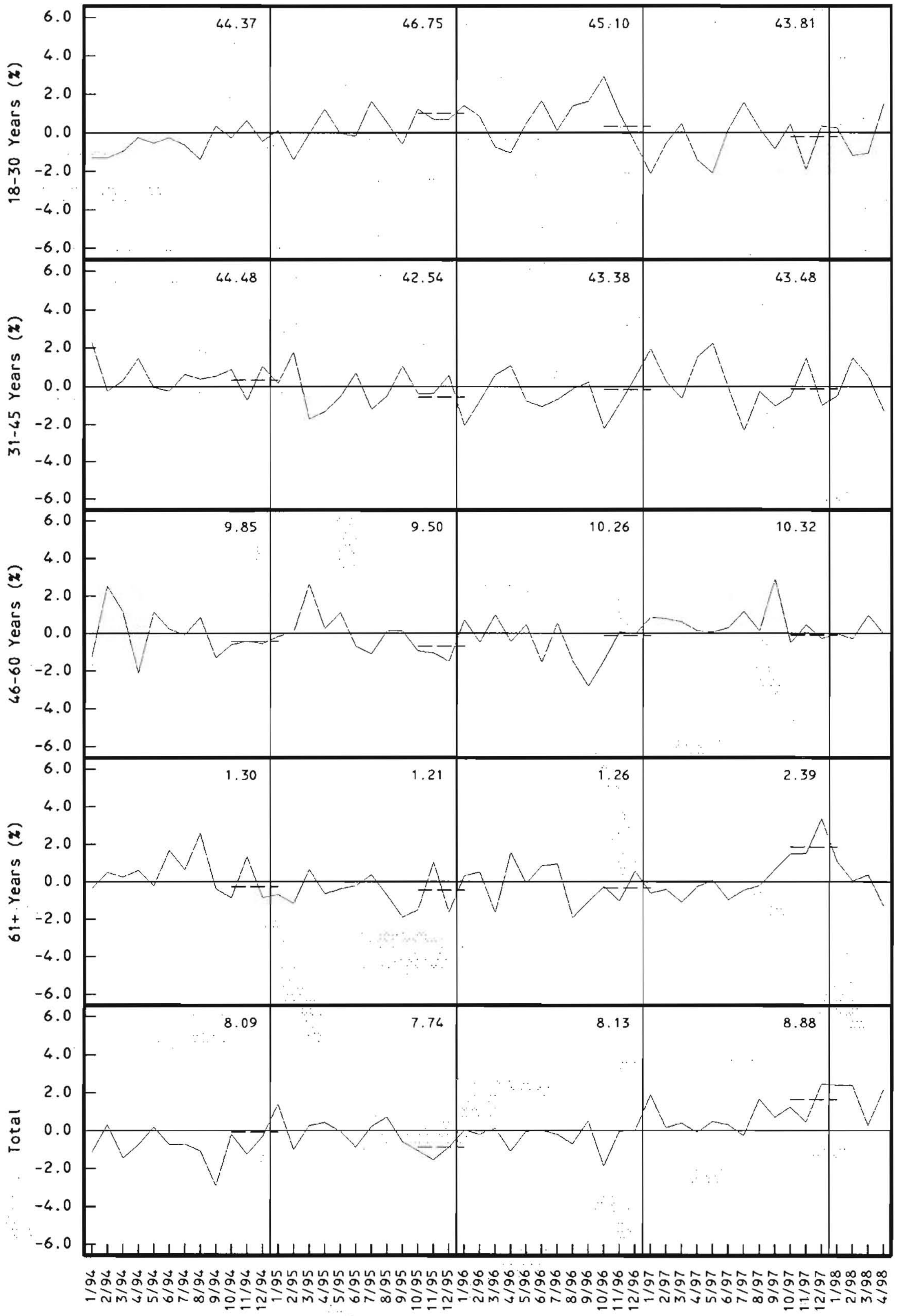
All drivers



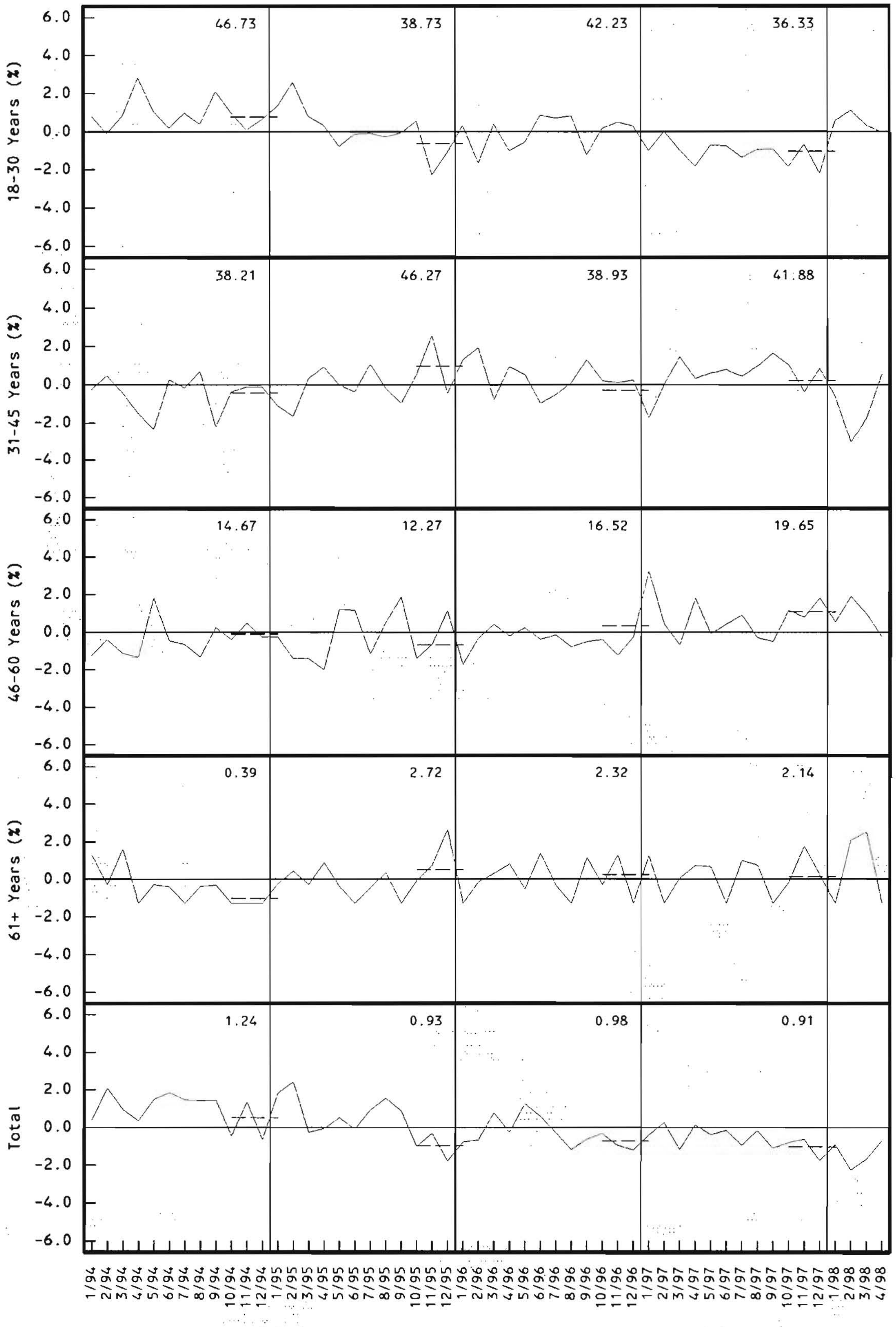
Percentage bus drivers

Percentage passenger car drivers

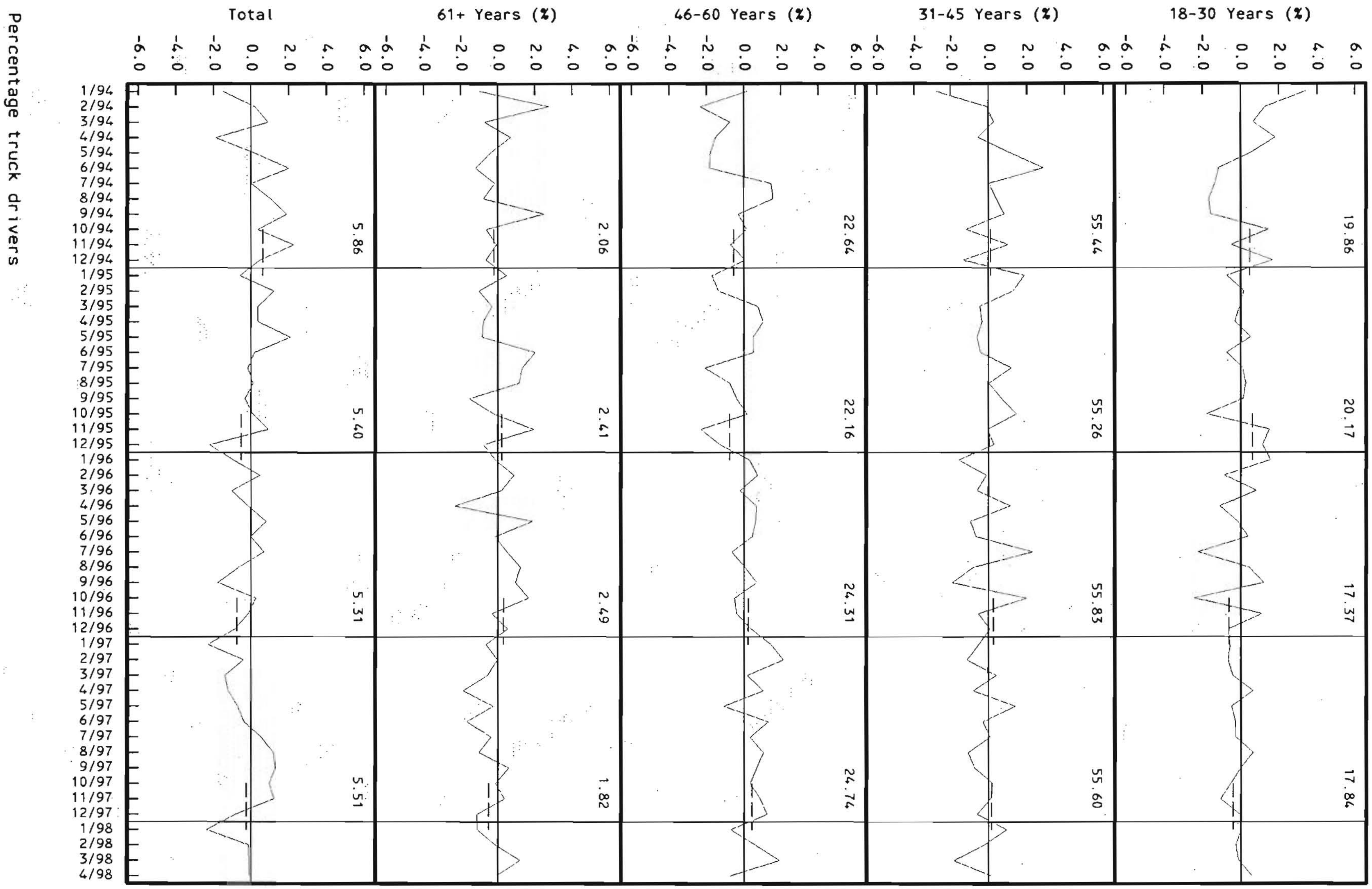


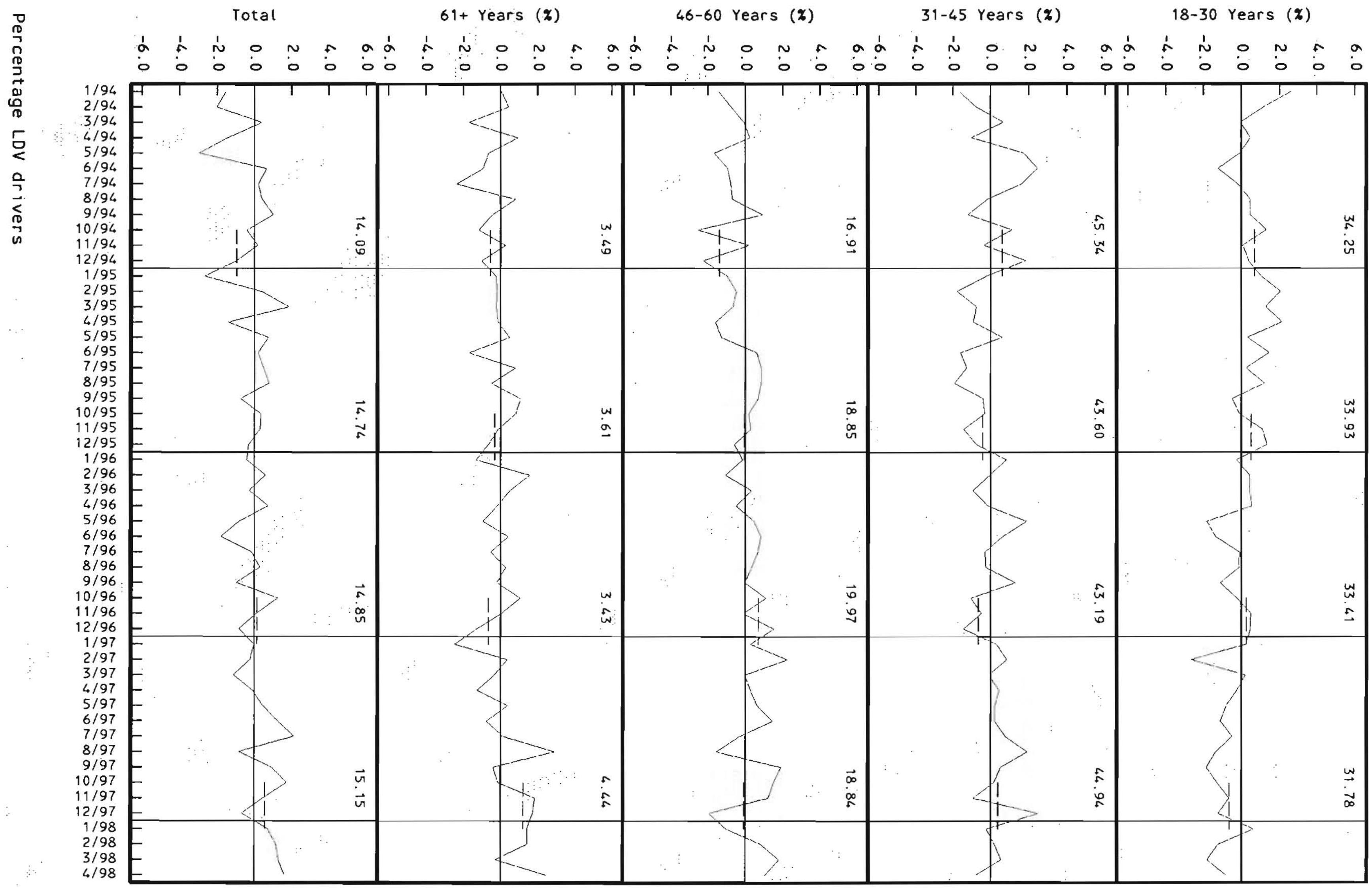


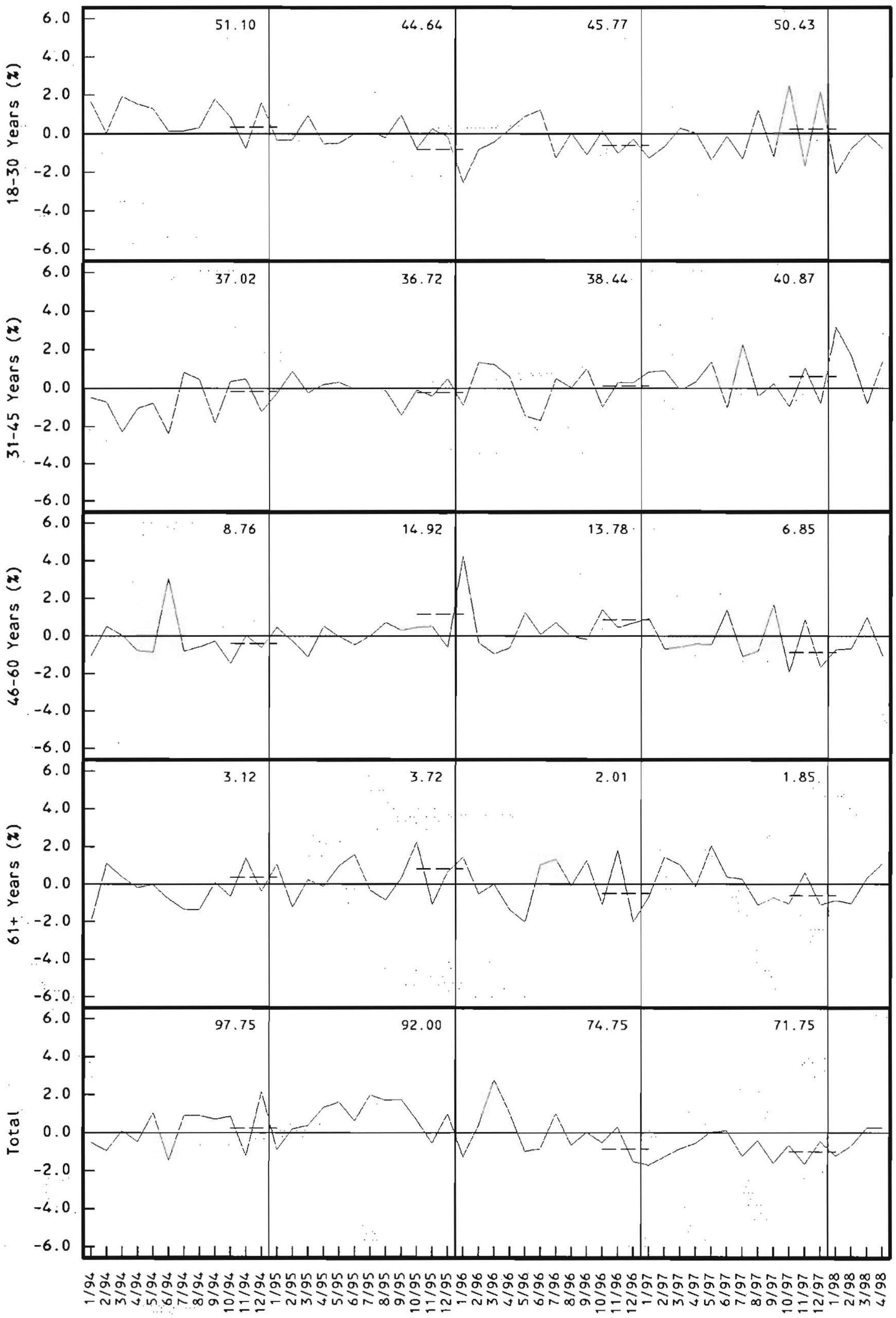
Percentage combi and mini-bus taxi drivers



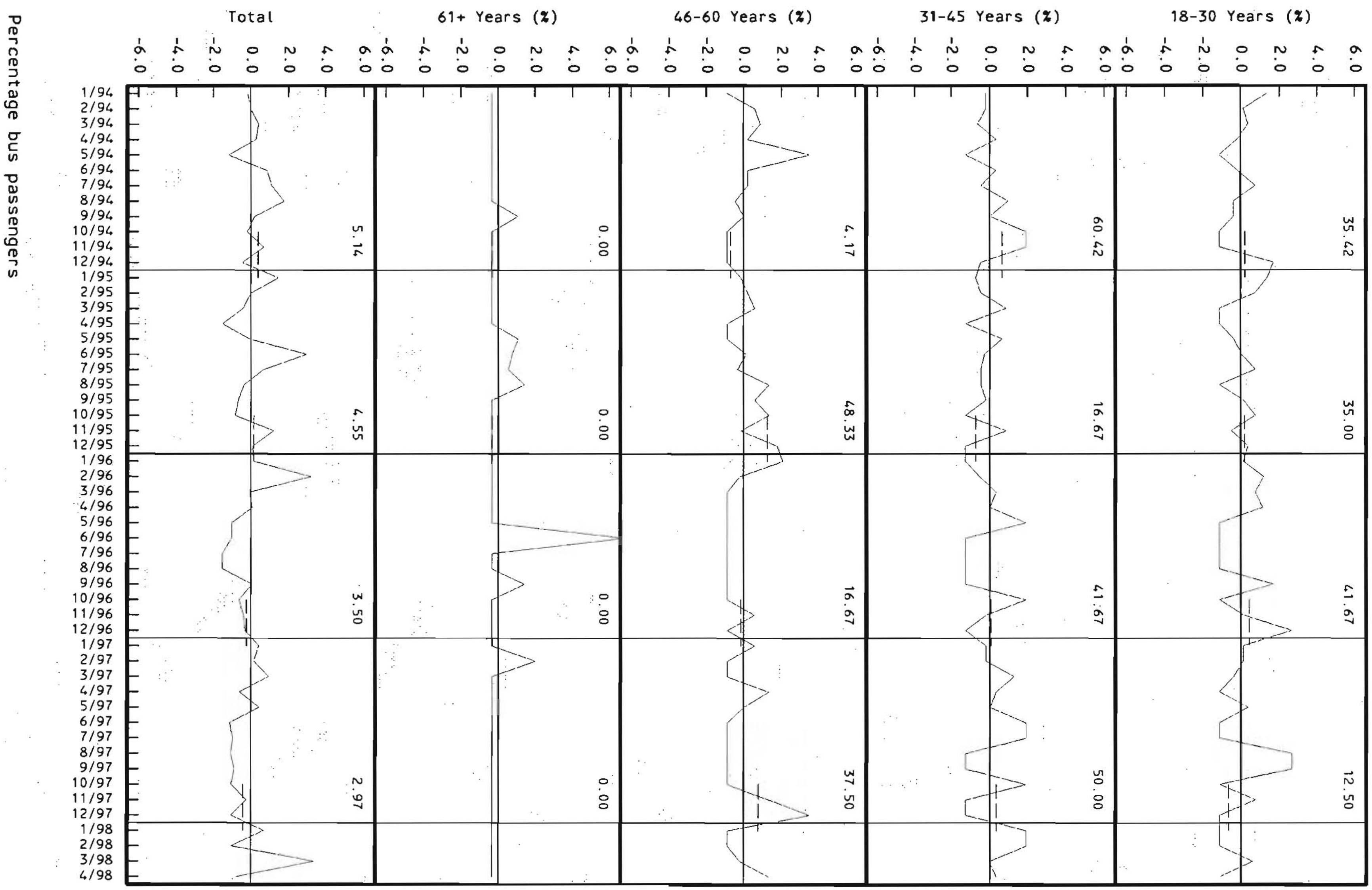
Percentage motor-cycle drivers


Percentage truck drivers
Total
61+ Years (%)
46-60 Years (%)
31-45 Years (%)
18-30 Years (%)
-6.0
-4.0
-2.0
0.0
2.0
4.0
6.0
1/94
2/94
3/94
4/94
5/94
6/94
7/94
8/94
9/94
10/94
11/94
12/94
1/95
2/95
3/95
4/95
5/95
6/95
7/95
8/95
9/95
10/95
11/95
12/95
1/96
2/96
3/96
4/96
5/96
6/96
7/96
8/96
9/96
10/96
11/96
12/96
1/97
2/97
3/97
4/97
5/97
6/97
7/97
8/97
9/97
10/97
11/97
12/97
1/98
2/98
3/98
4/98
5.86
5.40
5.31
5.51
2.06
2.41
2.49
1.82
22.64
22.16
24.31
24.74
55.44
55.26
55.83
55.60
19.86
20.17
17.37
17.84


Percentage LDV drivers
Total
61+ Years (%)
46-60 Years (%)
31-45 Years (%)
18-30 Years (%)
-6.0
-4.0
-2.0
0.0
2.0
4.0
6.0
1/94
2/94
3/94
4/94
5/94
6/94
7/94
8/94
9/94
10/94
11/94
12/94
1/95
2/95
3/95
4/95
5/95
6/95
7/95
8/95
9/95
10/95
11/95
12/95
1/96
2/96
3/96
4/96
5/96
6/96
7/96
8/96
9/96
10/96
11/96
12/96
1/97
2/97
3/97
4/97
5/97
6/97
7/97
8/97
9/97
10/97
11/97
12/97
1/98
2/98
3/98
4/98
14.09
14.74
14.85
15.15
3.49
3.61
3.43
4.44
16.91
18.85
19.97
18.84
45.34
43.60
43.19
44.94
34.25
33.93
33.41
31.78

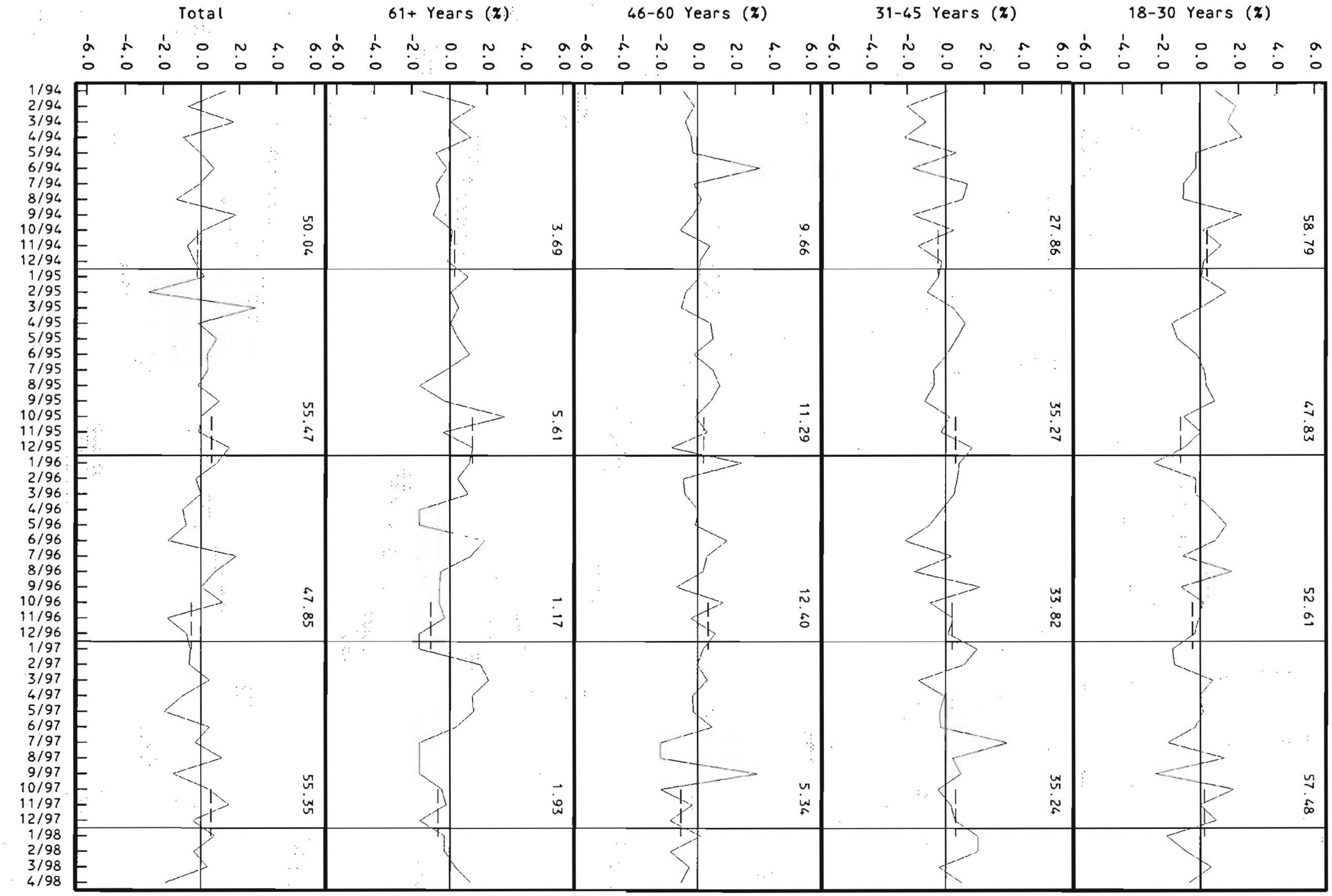


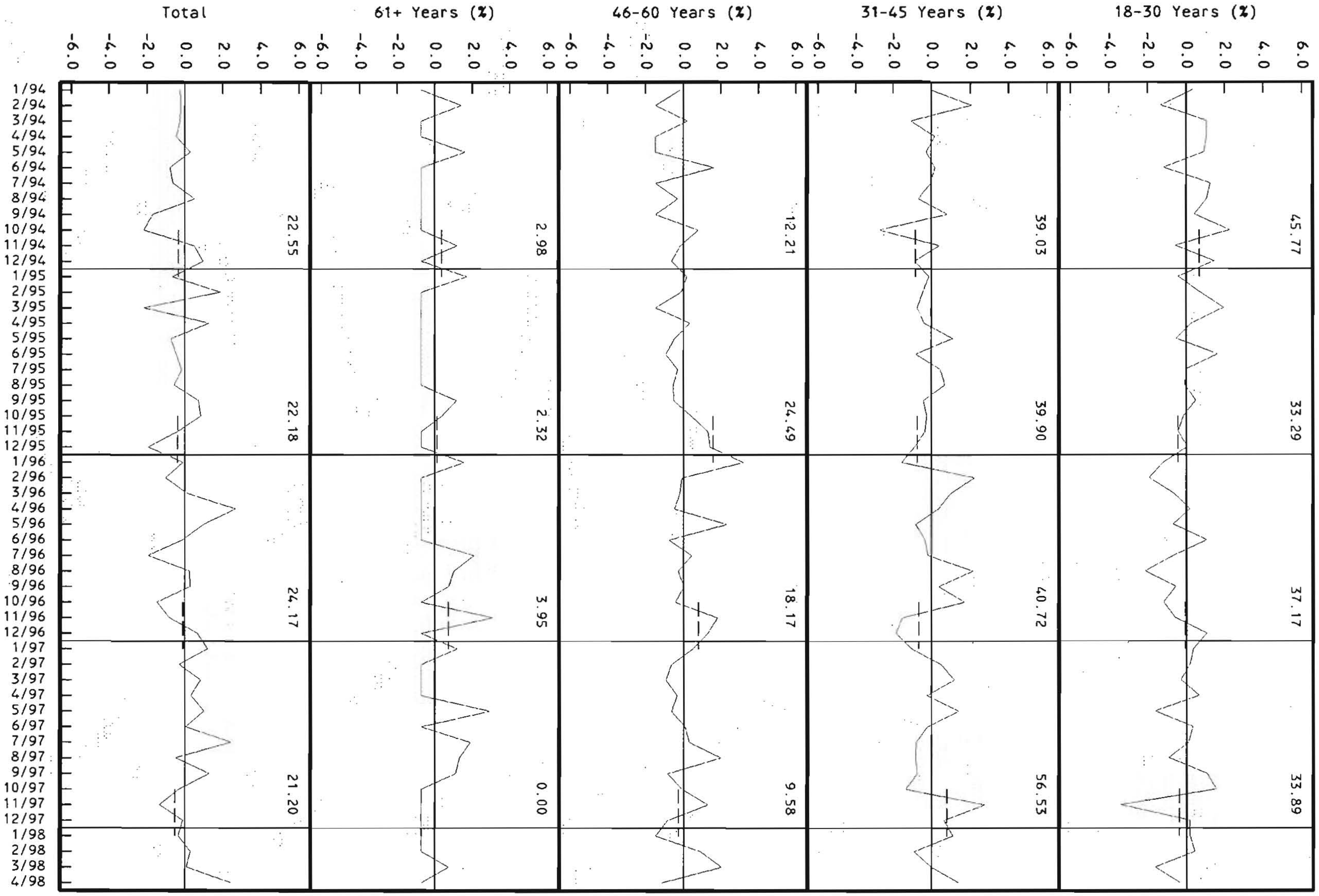
All passengers



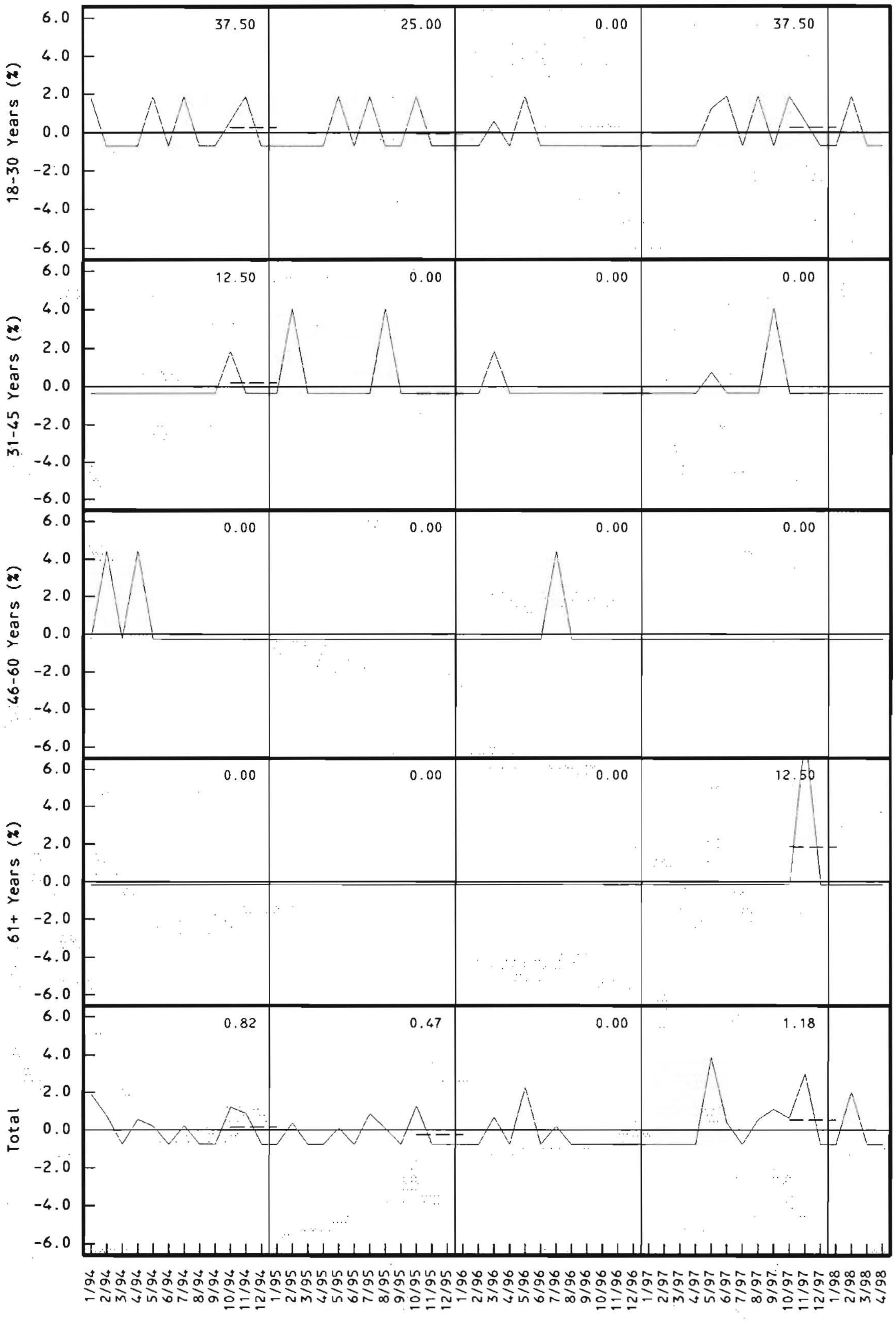
Percentage bus passengers
Total
61+ Years (%)
46-60 Years (%)
31-45 Years (%)
18-30 Years (%)
5.14
4.55
3.50
2.97
0.00
4.17
48.33
16.67
37.50
60.42
16.67
41.67
50.00
35.42
35.00
41.67
12.50

Percentage passenger car passengers

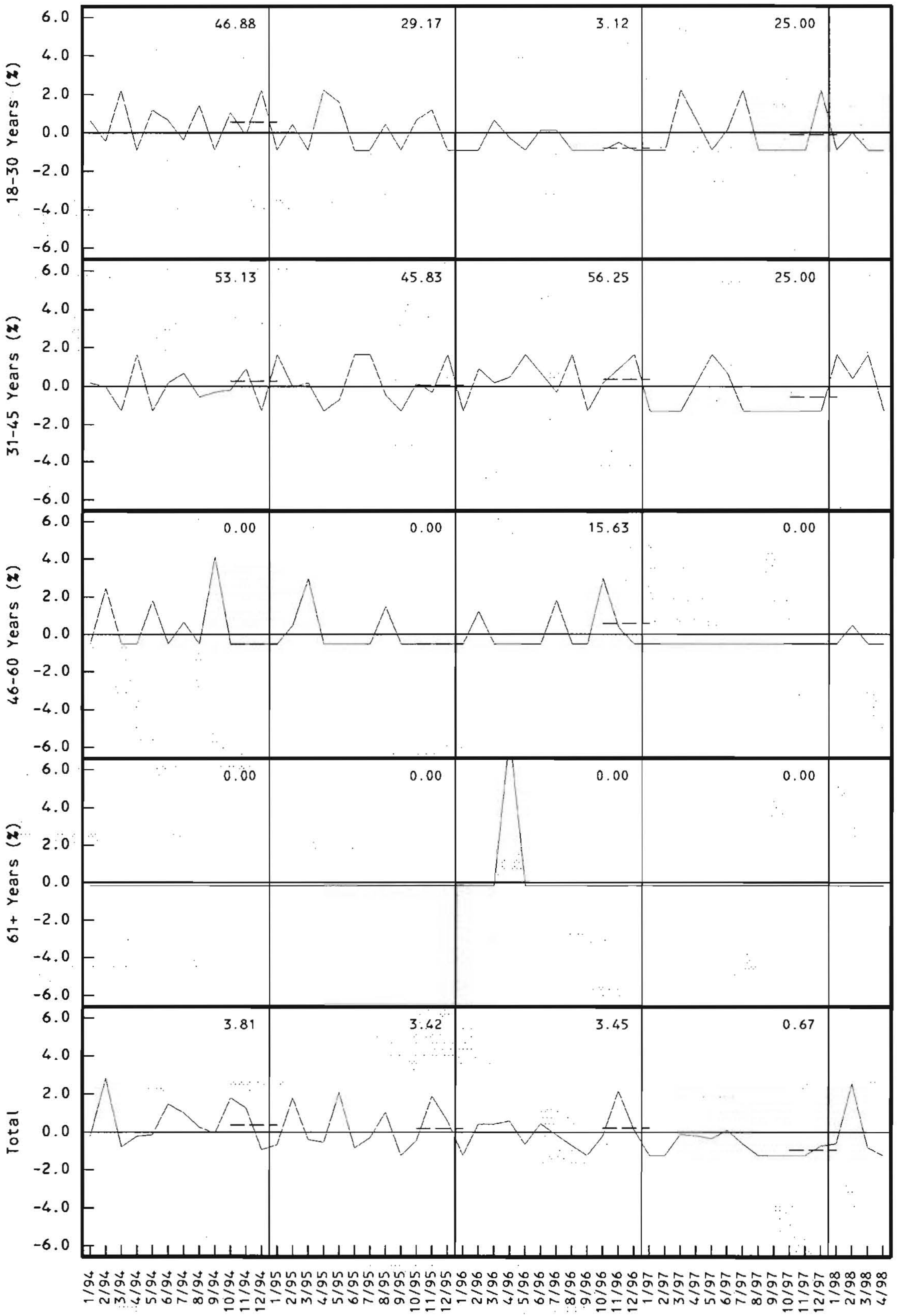




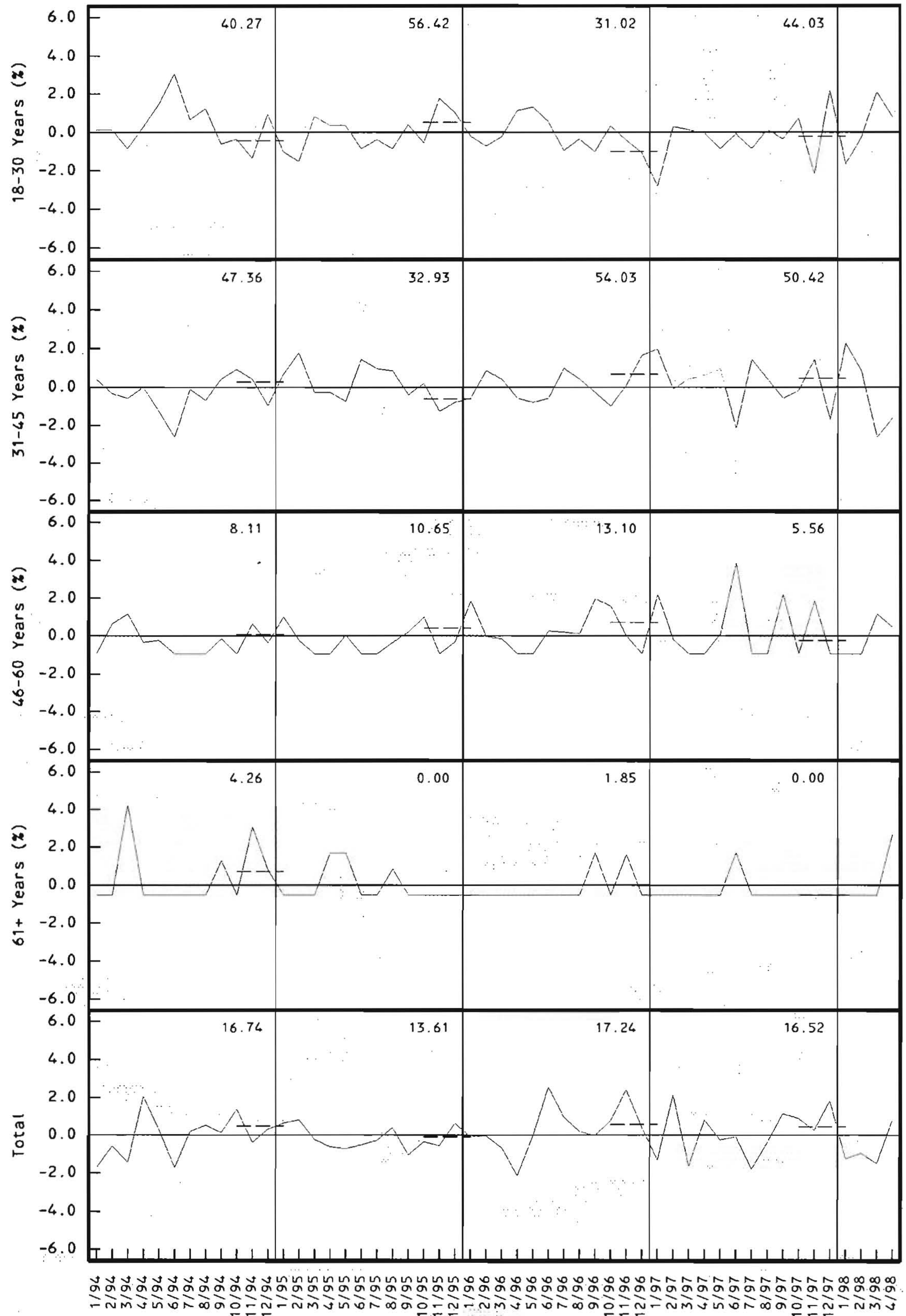
Percentage combi and mini-bus taxi passengers



Percentage motor-cycle passengers



Percentage truck passengers



Percentage LDV passengers