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Interaction of Road Environment, Vehicle and Human Factors in the Causation of Pedestrian Accidents

Abstract

The UK On-the-Spot project (OTS) completed over 1500 in-depth investigations of road accidents during 2000-2003 and is continuing for a further 3 years. Cases were sampled from two regions of England using rotating shifts to cover all days of the week and all hours of the day and night. Research teams were dispatched to accidents notified to police during the shifts; arrival time to the scene of the accident was generally less than 20 minutes. The methodology of OTS includes sophisticated systems for describing accident causation and the interaction of road, vehicle and human factors. The purpose of this paper is to describe and illustrate these systems by reference to pedestrian accidents. This type of analysis is intended to provide an insight into how and why pedestrian accidents occur in order to assist the development of effective road, vehicle and behavioural countermeasures.

Introduction

The On-the-Spot accident research project (OTS) conducts in-depth investigations of road traffic accidents to build a database rich with findings about the causes of accidents and injuries. The project is funded by the UK Department for Transport and the Highways Agency and aims to provide a resource that will assist safety professionals in their efforts to make the roads safer for everyone. Investigators are deployed to the scene of 500 road crashes each year where they gather data that would otherwise be quickly lost. Arrival time to the scene of the accident is generally less than 20 minutes. Independent teams from Loughborough University and TRL Ltd sample accidents from the Nottinghamshire and Thames Valley regions respectively. The teams operate rotating shifts to cover all days of the week and all hours of the day and night. All road traffic accidents notified to police during the periods of operation are eligible for the sample. The first phase of data collection lasted 39 months and was completed in September 2003. A second phase scheduled for a further 3 years followed without interruption. Further descriptions of the project are available [1-4].

The data collected for OTS is highly detailed, wide ranging and sophisticated in structure. The forms and protocols that are used include new innovations and adaptations from earlier in-depth studies. This applies particularly to systems for describing accident causation and the interaction of road, vehicle and human factors. The purpose of this paper is to describe and illustrate these systems by reference to pedestrian accidents, at the same time providing an initial overview of pedestrian accidents investigated in OTS during the first phase of its operation.

Methodology

Upon completion of the first phase of OTS, case files from the two data collection groups were combined into a single database containing over 1500 accidents. The results presented in this paper are based on the 115 pedestrian accidents in the database. Records are held on 117 pedestrians and 130 vehicles from this group of accidents.

The results section begins with a short overview of pedestrian accidents using a small number of variables. This is followed by selected results to illustrate the systems for coding accident causation in OTS. It should be recognised that the scope and depth of the OTS database far exceeds the sample of results presented in this paper. The focus here is on the methodology for describing just one aspect of the investigations, accident causation.

Systems for Coding Causation in OTS

Based on their history and development, the full details of which cannot be given here, it is possible to distinguish 5 systems in OTS for describing accident causation: (1) the 1995 UK police system, (2) causative features, (3) crash causation code, (4) interaction codes and (5) self-reported assessments (questionnaire). In addition ‘defects and failures’ are directly identified by the accident teams where possible.

The 1995 UK police system was developed by the former Department of Transport with TRL and has been adopted by 18 police forces in the UK since 1997. It is a harmonised two-tier system which seeks to identify (a) the critical failure or manoeuvre which led to the accident and (b) the factor or factors which contributed to this failure or manoeuvre. These are referred to in OTS as the precipitating and causal factors respectively (see table 9, table 10 and table 11). This system was reviewed as part of the SCRAS Quinquennial Review and a revised form will be introduced nationally for all police forces in 2005. [5]

'Causative features' is a method of coding used in OTS to supplement the observed presence of a feature by an assessment of whether it was definitely, probably, possibly or not causative. It is widely used in association with parameters that describe the highway, physical surroundings or environmental conditions. In this report the separate categories of definitely, probably and possibly causative are aggregated into a single 'causality indicated' group (cf. table 12).

The 'crash causation code' provides a list of about 20 options for saying why a crash occurred. Almost all of these relate to the driver. It is understood that this list originates from earlier accident studies and was incorporated into OTS to provide direct comparability with earlier research findings (cf. table 13).

'Interactions' relate a road user to the road environment (highway), vehicle or road user, including him- or herself. There are 7 categories of interactions of which 3 are illustrated in this paper: perception, attention and impairment. 'Looked but did not see' is an example of an interaction in the perception category. The full list covers a very wide range of factors. This system was an innovation for OTS developed by TRL at the beginning of the study (cf. table 14 and table 15).

A questionnaire is sent out to road users involved in the OTS sample of accidents. Included are questions that ask the road user about factors that he or she regards as contributing to the accident. These self-reported causal factors are treated separately from the other systems because they do not represent the considered judgement of an OTS investigator-they purely report the opinions of the road user (see table 16).

Results

Overview of Pedestrian Accidents

Table 1 shows the number of pedestrian accidents in the OTS database by sample region and accident severity (as assessed at the time of the accident). Most accidents involved some degree of injury even though there was no pre-selection or filtering of cases within the sample regions.

Any accident in which a pedestrian was struck is included in the sample; hence a minority of accidents (14) involved two or more vehicles, as shown in table 2.

Table 3 shows the time of day in which the accidents occurred. The most frequent (44) time band spanned late afternoon to early evening, 1600-1959.

Precipitation at the time of the accident is given in table 4. No form of rain or snow is recorded in most cases (90).

	Non-injury	Slight	Serious	Fatal	Total
Nottinghamshire	2	49	18	5	74
Thames Valley	1	19	15	6	41
Total	3	68	33	11	115

Tab. 1: Pedestrian accidents by sample region and injury severity

Single vehicle	car	87
	light goods vehicle	2
	heavy goods vehicle	2
	bus	5
	motorcycle	1
Multiple vehicle		14
Other/unknown		4
Total		115

Tab. 2: Road user involvement

0000-0359	4
0400-0759	4
0800-1159	23
1200-1559	32
1600-1959	44
2000-2359	7
Unknown	1
Total	115

Tab. 3: Time of day

None	90
Light shower	6
Heavy shower	2
Drizzle	6
Moderate rain	5
Heavy rain	3
Light snow	1
Other/unknown	2
Total	115

Tab. 4: Precipitation

Most accidents (95) occurred in urban areas, as shown in table 5.

Table 6 shows the types of roads in which the accidents occurred ranging from motorways to unclassified roads. Where the accident occurred at a junction, the 'higher' class of road is coded (e.g. A-road in preference to C-road).

Table 7 shows that over half of the accidents (63) occurred in 30mph speed limit zones. Where the accident occurred at a junction, the higher applicable speed limit is coded.

Table 8 shows the age of pedestrians. Where known, about half (46) were under 18 years of age.

Urban	95
Rural	16
Other	4
Total	115

Tab. 5: Area

Motorway	1
A-road	49
B-road	17
C-road	13
Unclassified	30
Other	5
Total	115

Tab. 6: Road classification

15	1
30	63
40	7
50	1
60	6
70	2
Other/unknown	35
Total	115

Tab. 7: Speed limit (mph)

0-17	46
18-24	7
25-59	25
60-100	13
Unknown	26
Total	117

Tab. 8: Pedestrian age (years)

Description of Accident Causation

Precipitating factors in the 1995 UK police system are considered to have initiated the accident. In most cases only one entry should be mentioned for each accident. The most frequent entry (81) is pedestrians entering the carriageway without due care, as shown in table 9.

Table 10 and table 11 form a single table showing an extract of causal factors from the 1995 UK police system. These factors are considered to have contributed to the initiation of the accident.

Failure of driver or rider	Failed to stop	7
	Failed to give way	5
	Failed to avoid pedestrian	18
	Failed to avoid vehicle or object	4
	Failure to signal or misleading signal	1
	Loss of control of vehicle	4
Failure of pedestrian	Entered carriageway without due care	81
	Fell in road	4
Manoeuvres	Swerved to avoid object	-
	Sudden braking	3
	Poor turn or manoeuvre	4
	Poor overtake	-
	Drove wrong way	-
	Opened door carelessly	-
	Other	-

Tab. 9: 1995 UK police system-precipitating factors (115 accidents)

Personal factors	Impairment through alcohol	9
	Impairment through drugs	2
	Impairment through fatigue	-
	Impairment through illness	2
Distraction	Stress or emotional state of mind	3
	Object on or in vehicle	1
	Object outside of vehicle	2
Behaviour	Panic behaviour	-
	Careless, reckless, thoughtless	14
	Nervous or uncertain	-
	In a hurry	22
Other factors	Failure to judge other's path or speed	21
	Disability	1
	Failed to look	34
	Looked but did not see	22
	Inattention	28
	Dark or inconspicuous clothing	11
	Other	4
Pedestrian details	Cross from behind parked car	16
	Ignored lights at crossing	11

Tab. 10: 1995 UK police system-causal factors (115 accidents)

More than one can be nominated for each accident. The most frequent item mentioned is 'Failed to look' (34).

Table 12 illustrates a group of variables whose presence or absence is noted on the OTS database along with the assessment that they were definitely, probably, possibly or not causative. Here the first 3 categories are aggregated in the 'causality indicated' column. The road being icy was considered to be at least possibly causative in one case. A comprehensive examination of accident causation in OTS would need to take account of hundreds of such variables on the database.

The crash causation code allows investigators to nominate events, mostly concerning the driver, that caused the accident. A selection of items is shown in table 13. For this group of 130 vehicles involved in pedestrian accidents the most frequent choice was 'vehicle not to blame' (83). In a significant number of cases (13) the driver was considered to have looked but not seen the pedestrian.

Table 14 and table 15 form a single table describing relationships or 'interactions' between road users and objects in the vicinity (including themselves). In this presentation of results the number of road users is shown for whom at least

Vehicle condition	Tyre pressures wrong	-
	Tyre deflated before impact	-
	Tyre worn/insufficient tread	1
	Defective lights or signals	-
	Defective brakes	1
	Other	-
Local conditions	Poor surface at site	1
	Poor/no street lighting	2
	Inadequate signing at site	1
	Steep hill at site	3
	Narrow road at site	-
	Bend/winding road at site	1
	Road works at site	-
	Slippery road at site	3
	High winds at site	-
	Earlier accident	-
	Other	-
Obscuration	View obscured from window	1
	Glare from sun	3
	Glare from headlights	-
	By bend/winding road	-
	By stationary/parked vehicle	14
	By moving vehicle	-
	By buildings, fences, vegetation etc.	1
	Obscuration due to weather	3
	Failure to see pedestrian in blind spot	1
Animal	Out of control	1

Tab. 11: 1995 UK police system-causal factors (continued)

		Causality indicated
Weather-related	road damp (patches)	-
	road damp	8
	road wet (isolated)	2
	road wet (widespread)	13
	road icy	1
	road snow	-
	road frost	-
	road salty	-

Tab. 12: Sample 'causative features' data: weather-related (229 approaches)

Vehicle not to blame	83
Looked but did not see pedestrian	13
Driver made illegal road manoeuvre	2
Driver made reckless road manoeuvre	4
Dazzled by sun	1
Vision obscured	3
Error of judgement	3
Lost control of vehicle	2
Deliberate action	1
Vehicle fault	2
Other/unknown	16

Tab. 13: Sample crash causation codes (130 vehicles)

	Interaction	Driver	Pedes-trian
Perception	Did not look for	12	35
	Looked but did not notice item in plain view	5	1
	Looked but did not discern	3	1
	Looked but did not see-obstruction on carriageway	5	5
	Looked but did not see-obstruction off carriageway	1	1
	Looked but did not see due to carriageway geometry	2	
	Looked but did not see	2	7
	Saw but did not perceive a hazard	15	1
	Anticipated incorrectly likely position		
	Anticipated incorrectly likely path	3	1
	Anticipated incorrectly likely speed		2
	Anticipated incorrectly likely acceleration	1	
	Anticipated incorrectly likely deceleration		
	Anticipated incorrectly likely motion		1
	Misperceived the road layout		5
	Misperceived a likely event	9	11

Tab. 14: Sample interaction codes (126 drivers; 117 pedestrians)

	Interaction	Driver	Pedestrian
Attention	Distraction by a passenger in own vehicle	2	
	Distraction by an internal event		1
	Distraction due to another road user		3
	Distraction due to previous accident/incident		
	Distraction due to an external event		
	Inattentive due to panic/ nervousness		1
	Inattentive due to stress		
	Inattentive due to being in a hurry		20
	Inattentive due to personal reason		1
	Was inattentive	3	22
Impairment	Suffered non-fatal illness		
	Died of natural causes		
	Suffered illness		1
	Due to alcohol		6
	Due to recreational drugs		
	Due to medicinal drugs		1
	Due to consumed substance		
	Due to fatigue		
	Was locally temporarily visually impaired by glare	1	
	Was locally temporarily visually impaired by weather	1	
	Was locally temporarily visually impaired	1	1
	Was personally impaired		2

Tab. 15: Sample interaction codes (continued)

		Driver	Pedestrian
	Did weather contribute?	5	3
	Did road surface contribute?	6	4
	Did other road user behave in careless manner?	14	6
	Did other road user behave in confusing manner?	6	1
Contributory factors	Misleading road layout		1
	Badly positioned road signs		
	Traffic lights not working		
	Road works		
	Other road users	6	4
	Distracted by changing radio stations etc.		
	Distracted by looking for something in vehicle?		
	Looking at street name or road signs		
	Distracted by disturbance in vehicle		
	External distractions		
	Mobile phone		
	Fatigue		
	Unwell		1
	Late or in a hurry		2

Tab. 16: System 5. Sample questionnaire data (64 drivers; 62 pedestrians)

one instance of the applicable interaction code was registered. One pedestrian, for example, is registered as looking but not seeing an item in plain view: it is possible that this pedestrian failed several times to see objects in plain view.

The most frequent cell in table 14 (35) is pedestrians who 'Did not look for…'. The database contains the information on what object they failed to look for – in most cases it can be presumed to be the vehicle that struck them. In this paper only the type of interaction is discussed, not the object with which the road user interacted.

There are 7 groups of interaction codes, of which 3 are included in table 14 and table 15. The data in these tables is therefore not a full and balanced presentation of OTS 'interaction' results.

Table 16 present a sample set of results from the road user questionnaire sent out to persons involved in OTS accidents. The most frequent cell (14) in this table is drivers who said that the other road user, the pedestrian, behaved in a careless manner.

Discussion

Table 9 shows the precipitating factors of the 1995 UK police system. This list of factors is intended to identify the critical failure or manoeuvre which led to the accident. The result which stands out most clearly is 81 cases where the pedestrian entered the carriageway without due care. In contrast the driver is said to have failed to avoid the pedestrian in 18 cases. The following two tables seek to identify causal factors – the factors which contributed to the critical failure (or manoeuvre). Most frequent are 'failed to look' (34), 'inattention' (28), 'looked but did not see' (22), 'in a hurry' (22) and 'failed to judge other's path or speed' (21). Not explicit in this system is whether these descriptions apply to the driver or the pedestrian – this information can be ascertained from other fields in the OTS database.

Table 12 is a sample result from hundreds that could have been presented. It shows that the road (or path) being wet on the approach to the point of impact was considered to be definitely, probably or possibly causative in 13 cases. This result can be taken together with table 4 which records no precipitation at the time of the accident for 90 of

the 115 cases, indicating the importance of wet roads when they occur.

A result that stands out in table 13, the crash causation code, is 'Vehicle not to blame' (83). After this is 'Looked but did not see pedestrian' (13). This resembles the 1995 UK police system in suggesting that the behaviour of the pedestrian is a key factor in the causation of pedestrian accidents. The complete set of crash causation codes is not presented in this table and so caution must be exercised in drawing wider conclusions.

'Interactions', examples of which are shown in table 14 and table 15, provide a sophisticated system for describing relationships between a road user and (a) the road environment, (b) vehicles and (c) road users (including him- or herself). Interactions are shown here separately for drivers and pedestrians. The high number of entries in the 'Perception' category highlights the importance of perception in pedestrian accidents. The entry 'Did not look for…' occurs more often for pedestrians (12-35) whereas 'Saw… but did not perceive a hazard' occurs predominantly for drivers (15-1). This is confirmed and clarified in the 'Attention' group where 'Inattentive due to being in a hurry' and 'Was inattentive' occur far more for pedestrians than drivers (0-20 and 3-22 respectively).

A short extract from the results of the questionnaire survey for pedestrians and drivers involved in pedestrian accidents is given in table 16. A difference here is that drivers attribute careless and confusing behaviour more often to pedestrians than pedestrians do to drivers (14-6 and 6-1 respectively).

Conclusion

This short overview of systems in OTS for describing accident causation shows how the different systems highlight different aspects in varying levels of detail. The initial survey indicates that pedestrian behaviour, including attention and perception, is a key to understanding why pedestrian accidents occur. However the purpose of this paper is to illustrate OTS methodology by reference to sample pedestrian accident data, not to provide a balanced and detailed description of this class of accidents. Further analysis is required before it is appropriate to draw wider conclusions.

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Is ESP Effective on French Roads?

Abstract

Electronic Stability Program (ESP) aims to prevent the lateral instability of a vehicle. Linked to the braking and powertrain systems, it prevents the car from running wide on a corner or the rear from sliding out. It also helps the driver control his trajectory, without replacing him, in the case of loss of control where the driver is performing an emergency manoeuvrer (confused and exaggerated steering wheel actions). A new ESP function optimizes ESP action in curves with hard under steering (situations in which the front wheels lose grip and the vehicle slides towards the outside of the curve). A complementary feature prevents the wheels from spinning when pulling away and accelerating. The name given to the ESP system varies according to the vehicle manufacturer, but other terms include: active stability control (ASC), automotive stability management system (ASMS), dynamic stability control (DSC), vehicle dynamic control (VDC), vehicle stability control (VSC) or electronic stability Control (ESC).

This paper proposes an evaluation of the effectiveness of ESP in terms of reduction of injury accidents in France. The method consists of 3 steps:

- The identification, in the French National injury accident census (Gendarmerie Nationale only), of accident-involved cars for which the determination of whether or not the car was fitted with ESP is possible. A sample of 1 356 cars involved in injury accidents occurred in 2000, 2001, 2002 and 2003 was then selected. But we had to restrict the analysis to only 588 Renault Lagunas.
- The identification of accident situations for which we can determine whether or not ESP is pertinent (for example ESP is pertinent for loss of control accidents whilst it is not for cars pulling out of a junction).
- The calculation, via a logistic regression, of the relative risk of being involved in an ESP-pertinent accident for ESP equipped cars versus unequipped cars, divided by the relative risk of being involved in a non ESP-pertinent accident for ESP equipped cars versus unequipped cars. This relative risk is assumed to be the best estimator of ESP effectiveness.

The arguments for such a method, effectiveness indicator and implicit hypothesis are presented and discussed in the paper. Based on a few assumptions, ESP is proved to be highly effective. Currently, the relative risk of being involved in an ESP-pertinent accident for ESP-equipped cars is lower (-44%, although not statistically significant) than for other cars.

Introduction

"I do not seek answers. I seek to understand questions" (Confucius)

Electronic Stability Program (ESP) aims to prevent the lateral instability of a vehicle. Linked to the braking and powertrain systems, it prevents the car from running wide on a corner or the rear from sliding out. It also helps the driver control his trajectory, without replacing him, in the case of loss of control where the driver is performing an emergency manoeuvrer (confused and exaggerated steering wheel actions). A new ESP function optimizes ESP action in curves with hard under steering (situations in which the front wheels lose grip and the vehicle slides towards the outside of the curve). A complementary feature prevents the wheels from spinning when pulling away and accelerating. The name given to the ESP system varies according to the vehicle manufacturer, but other terms include: active stability control (ASC), automotive stability management system (ASMS), dynamic stability control (DSC), vehicle dynamic control (VDC), vehicle stability control (VSC) or electronic stability Control (ESC).

ESP has been a topic of considerable interest since the late 1990s because it concerns a high number of accidents. In 2002, in Europe (15 countries), 1 227 000 injury accidents occurred, 1 670 000 road users were slightly or seriously injured and