Pergamon

Journal of Safety Research, Vol. 29, No. 4, pp. 249–262, 1998

0022–4375/98 $–see front matter

PII S0022-4375(98)00051-6

The Relationship Between Road Accident Severity and Recorded Weather

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Road accident severity may be influenced by a number of factors. This article investigates the relationship between weather and road accidents in England and Wales. The weather information recorded on Police Accident Report Forms was taken as the prevailing weather at the time of the accident. At the local authority level, accident severity for the various adverse weather categories of rain, fog, and high winds is compared with the nonhazardous condition of fine weather. Severity ratios are then calculated. Findings establish that accident severity decreases significantly in rain compared with fine weather, while severity in fog shows geographical variation. Evidence for accident severity in high winds remains inconclusive. © 1998 National Safety Council and Elsevier Science Ltd

Keywords: Accident severity, weather, rain, fog, high winds

INTRODUCTION

It has long been recognized that road accidents are the consequence of the combined effects of behavioral, technological, and environmental factors. In recent years increased attention has been directed at determining the effects of weather on road accident frequency (Andrey & Olley, 1990; Codling, 1974; Edwards, 1996; Palutikof, 1991), with the understanding that while weather may not be the principal cause of accidents, it is nevertheless an important environmental component.

The relationship between weather and road accidents is not a simple, nor an obvious one. For instance, accident numbers increase in wet weather (Bertness, 1980; Smith, 1982), partly as a result of road users deciding to take their cars rather than walk or use public transportation; but may show a decrease in snow, with drivers either taking more care in their driving or canceling their journeys altogether.

Several studies have examined the incidence of road accidents with reference to a single weather hazard (Andrey & Yager, 1993; Brodsky & Hakkert, 1988; Edwards, 1994; Musk, 1982). Few studies, however, have investigated the relationship between accident severity and weather conditions, and those that are available have been limited to studies based on U.S. data (Bertness, 1980; Sherretz & Farhar, 1978). This paper investigates the relationship between weather as recorded by the police, and the severity of road accidents in England and Wales. The term “weather-related” has been used where possible on the understanding

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that the weather might be a contributing factor in an accident, although not necessarily the principal one.

Road Accident Data

Recording of severity.

Data concerning road accident severity in Great Britain first became available at the national level in 1926 (Plowden, 1971); prior to that year, only information concerning fatal accidents was collected. Today, published national road accident data are compiled by the Department of Transport based on information received from local authorities. These authorities in turn are sent details of all personal-injury road accidents notified to the police. Particulars of all injury accidents are recorded on the Police Accident Report Form, commonly known as the Stats 19. The county-specific data outlined in this study have been extracted from information recorded on these Stats 19 forms.

Accident severity in England and Wales is determined by the severity of the most severely injured casualty (Department of Transport, 1996). A fatal accident is one in which at least one person is fatally injured (excluding confirmed suicides) and dies within 30 days of the accident as a result of that accident. An accident is defined as serious when nobody is killed but at least one person is seriously injured. Examples of serious injuries may include fractures, internal injuries, severe cuts and lacerations, concussion, and severe general shock. A general indication of a serious injury is the requirement to detain the casualty in the hospital as an in-patient (Department of Transport, 1990). A slight accident is one in which nobody is fatally or seriously injured but at least one person is slightly injured, including injuries such as sprains, bruises, and cuts judged not to be severe.

The severity levels are those recorded at the time of the accident report being filed (Andressand, 1985). These may need to be amended subsequently if the diagnosis of an injury changes with time. In the case of a fatality, deaths are not counted in the accident record when the person dies from natural causes (inclusive of a heart attack) or suffocates or chokes on their own vomit with no other death-causing injury present. Moreover, if the injured person dies after the 30 days immediately following the accident, even when their death is a direct result of the accident, the police would not regard the incident as a fatal road accident for their records. Mackay (1990) estimated that a reversal in procedure to include such "delayed-death" accidents within the fatalities total would increase the overall number of fatalities by only some 5%.

Admission to the hospital as an in-patient is a very useful guide for the police officer wishing to define the severity of an accident, as such a procedure usually indicates a more serious incident (Bull & Roberts, 1973). However, injuries such as fractures, concussions, and serious lacerations not requiring in-patient treatment are subject to more qualitative judgment. Tunbridge (1987), in his Scottish study, noted that approximately 5.5% of linked in-patient hospital data and police reports were miscoded as slight when they should have been coded as serious.

Conversely, a person merely detained overnight to await examination or for observational purposes may not in fact have sustained concussion or other injury (Andressand, 1985; Chapman & James, 1973). Such misclassification of serious injuries by the police is hardly surprising, as they are without medical training and must allocate a suitable severity category to the injured person without the benefit of a physical examination or diagnostic equipment (Agran, Castillo, & Winn, 1989). This is borne out by Adams (1988), who found that a number of police questioned over the distinction between slight and serious shock thought the question referred to electrical shocks.

In the case of slight injuries, a police officer has to decide whether an injury has occurred or not. This is not an easy task, as the definition of "slight" is open to highly subjective interpretation, and the completion of the Stats 19 is often the responsibility of the attendant officer, who has more pressing duties, such as summoning emergency services and traffic control.

In addition to the incorrect identification of accident severity, a significant number of injury accidents go unreported. In fact, British legislation does not necessarily require the reporting of injury accidents to the police (Her Majesty's Stationery Office [HMSO], 1988). However, as a general rule the greater the accident severity, the more likely that the accident will be reported (Maas & Harris, 1984). As a result, the reporting of slight injuries suffers the greatest discrepancy, while research has shown that fatal accidents are by far the most comprehensively notified (Nicholl, 1981).

Recording of weather conditions.

In Great Britain, data concerning weather at the time of an accident have only been available since 1969, when the weather conditions categories were first included in the Police Accident Report Form. Current information concerning the weather condition at the time of an accident is recorded under one of nine codes (Section 1.22, Stats 19), supported by guidance for completion given in the Stats 20 (Department of Transport, 1990). Table 1 lists these nine weather codes. Again, the recording of weather is not exempt from police errors (Shinar, Treat, & McDonald, 1983). For example, an accident may have occurred during a shower of rain, yet may be recorded under the fine weather category if the rain had ceased by the time an officer had arrived at the accident scene. Similarly, snow may be present on the ground, although not actually falling, and yet the weather condition of snow could be incorrectly recorded. In addition, the category of "other" (code 8) has a very subjective and varied interpretation. Edwards (1992) found that police forces often included weather conditions, such as hail and sleet, under this code when such conditions should have been recorded in one of the previous seven categories. It was equally evident that weather conditions were being confused with road surface conditions (Section 1.23). Additional inclusions under the code of "other" noted frost, ice, and damp, all of which are categories currently contained within the road surface category, Section 1.23 on the Stats 19 (Edwards, 1992).

METHODS

Numerous factors determine road accident totals, such as the size of the local authority, its population, vehicle kilometers traveled within that area, and length and quality of the road network. Thomas (1996) stated that one failing of many empirical studies is that the size (and shape) of aggregated statistical units are not controlled. This study was dependent on the data supplied by local authorities, which were aggregated at the county level. Therefore, to eliminate comparative difficulties, accident rates rather than actual numbers have been calculated, enabling direct comparison between local authority areas.

Table 1. Weather Conditions, Section 1.22, Stats 19

Code	Weather Condition
1	Fine without high winds
2	Raining without high winds
3	Snowing without high winds
4	Fine with high winds
5	Raining with high winds
6	Snowing with high winds
7	Fog (or mist if hazard)
8	Other
9	Unknown

Source: Department of Transport 1981–91 (1990).

Accident severity can be expressed in a number of ways, either in terms of absolute values or as a percentage of the overall total. This study uses severity ratios to examine the relationship between accident severity and the presence of a weather condition. Several authorities throughout England and Wales use such a technique to demonstrate accident severity. The ratio is calculated by illustrating the number of fatal and serious accidents (shown as K and SI respectively) as a proportion of the total. For example, the expression 16:237 would define 1,000 accidents of which 16 resulted in death and 237 involved serious injury. The remaining 747 accidents would be those resulting in slight injury. All three ratio figures combined add up to 1,000.

A drawback of using this technique occurs when accident numbers are small. In such cases, accident statistics commonly display great variability, both temporally and geographically. Misleading information may be generated, for example, when a local authority records only a handful of snow-related high-wind accidents a year (code 6). The severity ratio for five such accidents, two of which were fatal and the remaining three slight, would be 400:0, a totally meaningless ratio.

For this research, details on the accident severity, the weather conditions at the time of the accident, and the time of year when the accident occurred (expressed in terms of monthly aggregations) were used. All local authorities in England and Wales were approached to supply data for the period 1980–90. Each local authority that responded to this request was included in the analysis regardless of the level of their response. Approximately 70% of all local authorities supplied data (Table 2), which, once assembled, formed a database of over one million road accidents ($n = 1{,}075{,}944$). The location of each local authority within England and Wales is shown in Figure 1. Initial examination of this database reveals that the vast majority of accidents occur in fine weather ($n = 863{,}191$), with rain accounting for a further 14% (n = 152,202). High winds (n = 41,364) and fog-related accidents (n = 11,676) will also be considered. In the case of accidents in snow (n = 7,511), the overall accident total conceals both the spatial variability and, in some areas, the scarcity of available data. To illustrate, two counties failed to record a single fatal road accident in snow, and 22 counties reported 3 or less such accidents for the entire research period. Even when examining the seriously injured category, only four authorities recorded over 100 such snow-related road accidents during the study period. This is compared with fog, whereby just seven local authorities recorded fewer than five fatal accidents in fog, and 14 counties recorded in excess of 100 serious accidents in fog. On this

Table 2. Road Accident Data: Local Authority Response

		Road Accident Data	
Region	**Local Authority**	**Available Dates**	**No. of Years**
SW	Cornwall	1980–89	10
SW	Devon	1980–89	10
SW	Dorset	1980–89	10
SW	Gloucestershire	1986–90	5
SW	Wiltshire	1980–89	10
SE	East Sussex	1982–89	8
SE	Kent	1980–89	10
SE	West Sussex	1982–90	8
Eastern	Bedfordshire	1980–90	11
Eastern	Essex	1980–90	11
Eastern	Hertfordshire	1980–89	10
Eastern	Suffolk	1980–89	10
Eastern	Cambridgeshire	1981–90	10
East Midlands	Derbyshire	1980–89	10
East Midlands	Leicestershire	1980–89	10
West Midlands	Nottinghamshire	1980–90	11
West Midlands	Hereford & Worcester	1980–89	10
West Midlands	Staffordshire	1982–89	8
Wales	Warwickshire	1980–89	10
Wales	Dyfed	1980–90	11
Wales	Mid Glamorgan	1980–89	10
Wales	North Wales[a]	1980–89	10
Wales	Powys	1980–89	10
Wales	South Glamorgan	1980–89	10
NW	West Glamorgan	1980–89	10
NW	Cumbria	1980–90	11
NW	Greater Manchester	1985–90	6
NW	Lancashire	1981–90	10
Yorks & Humberside	Humberside	1986–89	3
Yorks & Humberside	North Yorkshire	1985–90	5
Yorks & Humberside	West Yorkshire	1981–90	10
Northern	Durham	1984–90	6
Northern	Northumberland	1980–90	11
Northern	Tyne & Wear	1980–89	10

Note: The following counties have been omitted due to a lack of data: Avon (SW), Somerset (SW), Berkshire (SE), Hampshire (SE), Oxfordshire (SE), Surrey (SE), Buckinghamshire (Eastern), Cambridgeshire (Eastern), Norfolk (Eastern), Lincolnshire (E. Midlands), Shropshire (W. Midlands), West Midlands (W. Midlands), Gwent (Wales), Cheshire (NW), Merseyside (NW), South Yorkshire (Yorkshire & Humberside), and Cleveland (Northern).

[a]Combined data for Gwynedd and Clwyd.

FIGURE 1. Location of counties in England and Wales.

basis, and in order to avoid erroneous and misleading findings, the condition of snow will not be examined in the analysis of local authority data.

Before detailed analysis of the county-wide dataset is undertaken, it is necessary to consider for comparative purposes the severity ratios of weather conditions at the national level. Therefore, data published by the Department of Transport were used in this analysis.

RESULTS

National Accident Data

During the period 1980–90, 60,148 fatal accidents, 772,185 serious accidents and 2,743,787 slight accidents were reported to the police in Great Britain (Department of Transport, 1981–91). Such figures give an overall accident severity ratio of 17:216 for this period.

Regarding weather at the time of an accident, the Department of Transport compiles and publishes information on the following conditions: *fine* (which includes the category of “other”), *raining*, *snowing*, and *fog*. It is assumed that accidents in high winds have been subsumed within these four categories as no specific reference is made to this condition. Table 3 lists overall severity ratios by weather and lighting conditions for the period 1980–90. Clearly, accidents in fog result in the most severe injuries for all lighting conditions (25 out of 1,000 fog-related accidents were recorded as fatal compared with 15 out of 1,000 for snow, the lowest proportion for fatal accidents).

Examining lighting conditions in relation to accident severity (Table 3) reveals that under all weather conditions accidents in darkness are consistently more severe than those occurring during daylight hours. For example, accidents in fine weather recorded severity ratios of 17:223 in daylight but 32:268 in darkness.

Unfortunately, accident data at the local authority level outlining lighting conditions were not made available for this project, although clearly this is an issue that requires further investigation at some future time.

Local Authority Accident Data

When all the local authority accident data were taken into consideration, fatal accidents accounted for relatively fewer accidents than those categorized as serious or slight. Calculations from the project dataset gave the overall severity ratio for the period 1980–90 as 16:188, which indicated that around 80% of all accidents were classified as slight.

Table 3. Average Accident Severity Ratios, 1980–90

Weather	Lighting Conditions	Severity Ratio/1,000 1980–90
Fine	Daylight	17:223
	Darkness	32:268
	All	21:235
Raining	Daylight	14:206
	Darkness	24:260
	All	18:227
Snowing	Daylight	13:210
	Darkness	18:252
	All	15:227
Fog	Daylight	21:235
	Darkness	29:282
	All	25:256

Source: derived from Department of Transport (1981–91).

The overall severity ratios for fine weather, rain, fog, and high winds are shown in Table 4. Initial examination of these ratios indicates that the KSI ratio for rain is less than that for fine weather, while the ratios for fog and high winds have increased by comparison. When the chi-square test was applied to the accident data, a significant difference was found between the accident severity in rain and that for fine weather at the 0.1% level. The null hypothesis of no association was therefore rejected. The results for accident severity in fog and high winds, however, were found not to be significant.

Fine without high winds.

Average severity ratios for each local authority are given in Figure 2. Spatial variations within this condition were not generally apparent, with only Powys, Northumberland, and Warwickshire recording fatality ratios above 30/1,000, the normal range lying between 20–25/1,000. The southwest as a region (including south Wales) recorded some of the lowest severity ratios for fatal accidents. Dyfed had the greatest proportion of serious accidents (434/1,000), with the mainly rural counties of Devon, Cornwall, Powys, North Yorkshire, and Suffolk not far behind. The exception is Warwickshire, which despite being a relatively urbanized county, also recorded high SI ra-

Table 4. Association Between Weather Conditions and Accident Severity

Condition	Severity Ratio	Killed	Seriously Injured	χ^2
Fine weather without high winds	22:240	19,413	207,589	
Rain without high winds	19:232	2,952	35,250	28.69
High winds	23:263	970	10,879	1.88
Fog without high winds	27:260	312	3,041	2.30

tios. The metropolitan area of Greater Manchester recorded the lowest KSI ratios for all authorities with fine weather.

Raining without high winds.

When the condition of rain was examined (Figure 3), with few exceptions, the KSI ratios fell consistently below those for fine weather accidents. This supports the findings of the aggregated ratios—a greater proportion of accidents in rain were recorded as slight compared with fine weather conditions.

Unlike the spatial pattern for rain-related accidents, which depicts an east-west trend approxi-

FIGURE 2. Fine weather accident severity ratios.

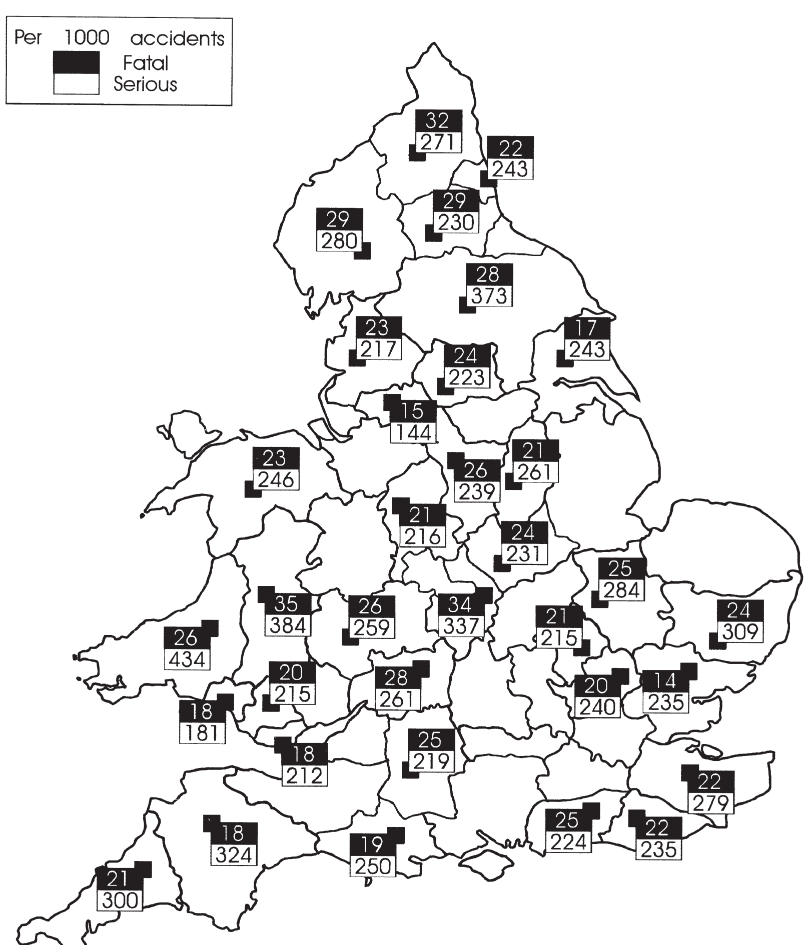
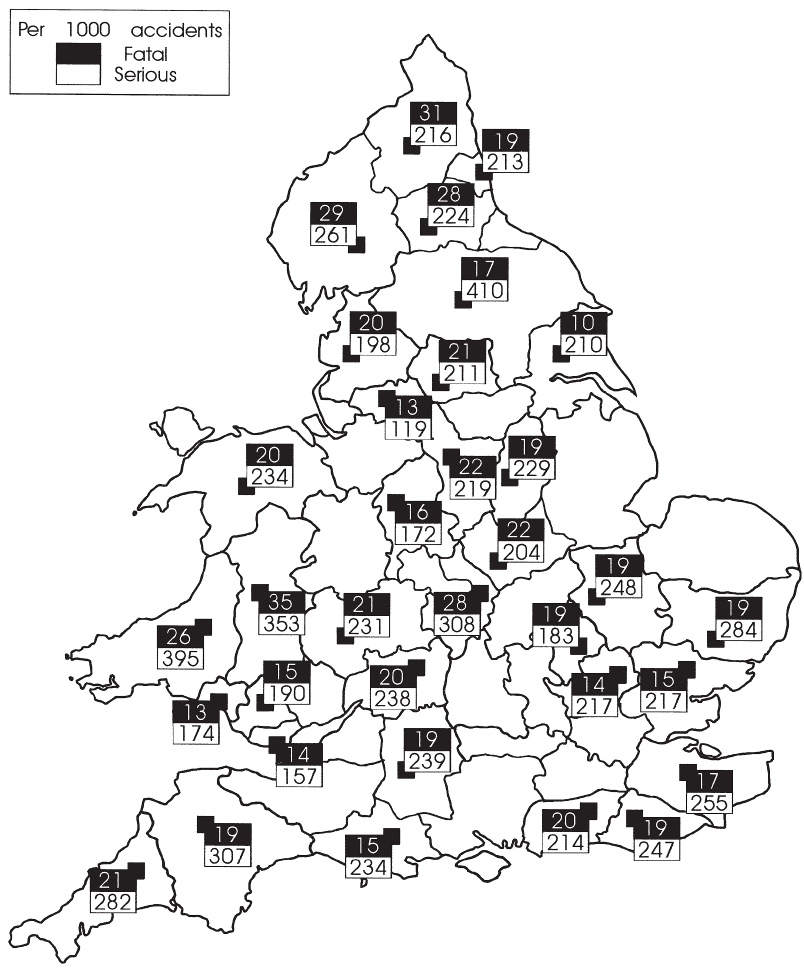


FIGURE 3. Rain-related accident severity ratios.



mate to the geographical distribution of rainfall (Edwards, 1996), there was no detectable spatial arrangement to the rain-related severity ratios. Again, with the exception of Warwickshire, the more remote authorities of west and central Wales and the north of England recorded the higher severities.

High winds.

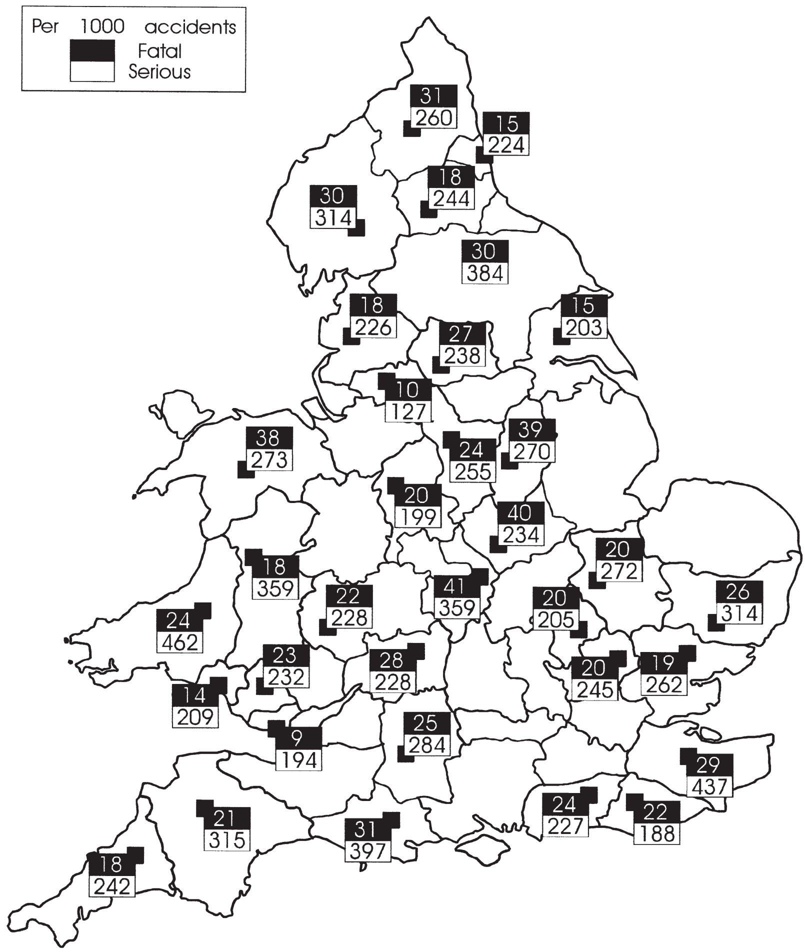
Wind-related road accidents for the purposes of this study have been defined as those accidents that have been recorded under the weather codes 4, 5, and 6 (*fine*, *raining*, and *snowing with high winds*). This is the only weather category on the Stats 19 whereby at least one of the vehicles should have been adversely affected by the prevailing weather for that condition to be registered. In all other categories the weather is recorded regardless of its impact on the accident (Department of Transport, 1990).

Figure 4 gives the overall accident severities for high winds. Some local authorities, for instance Greater Manchester, Powys, and Durham, had improved severity ratios in high winds compared with fine weather, while other authorities had far worse severity ratios during this condition, notably Warwickshire and Nottinghamshire. Thus, severity ratios in high winds show no consistent trend.

Fog.

Examination of fog-related severity ratios (Figure 5) revealed a similar pattern to the ratios in high winds. Approximately half of the local

FIGURE 4. High-wind-related accident severity ratios.

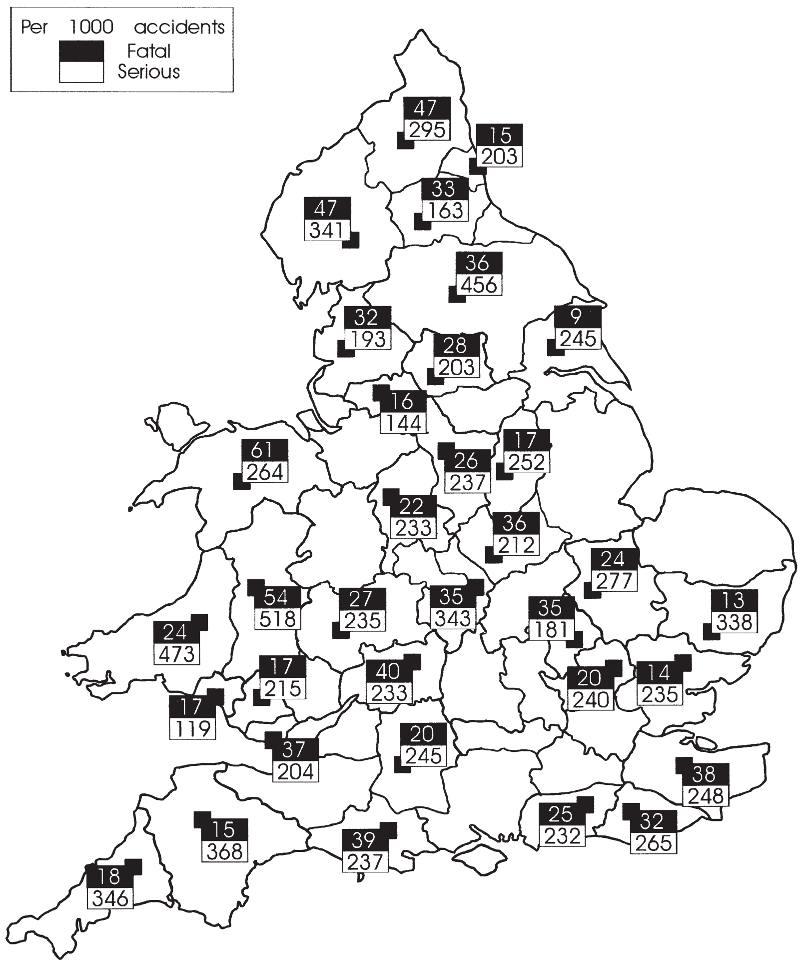


authorities recorded an increase in their KSI accident severity in fog compared with fine weather, with Powys, Cumbria, North Yorkshire, North Wales, and Northumberland showing a considerable increase in the proportion of KSI accidents in fog. The majority of the remaining local authorities recorded a decrease, albeit slight, although two counties registered no change in their fog KSI ratios compared with fine weather.

DISCUSSION

Fine weather does not in itself affect driving adversely (with the exception of glare from the sun), and as the vast majority of accidents occur in this condition (Edwards, 1996), the category of fine weather has been used as the control against which the other, more hazardous conditions have be assessed. When examining fine weather ratios, there appears to be a distinction between relatively urban counties and the more rural areas. Rural authorities tend to record higher KSI ratios (in fact, an observation common throughout all the weather conditions, not just for fine weather). Several factors may play a part in this finding. Generally, urban counties have greater traffic densities and a higher level of infrastructure than their rural counterparts. Street lighting is also a beneficial feature of such built-up areas. Rural counties, however, tend to have less traffic, and fewer vehicles are encountered on these routes. Consequently, rural motorists are able to drive at higher speeds owing to less traf-

FIGURE 5. Fog-related accident severity ratios.



fic, and often on poorer (unlit) roads that were not designed for such speeds. It seems reasonable that these differences might result in greater accident severity in rural areas.

This urban-rural distinction is also present in wet weather. Rain is the most common weather hazard to affect the British Isles, with approximately 15% of all accidents occurring in this condition (Smith, 1982). Analysis of British accident data established that accident frequency increases in wet weather conditions (Smith, 1982; Transport and Road Research Laboratory [TRRL], 1974), yet no national study has examined the quantitative effects rain may have on accident severity.

Those published studies were confined to North America and identified no apparent relationship between rainfall and accident severity, defined as the number of injuries per accident (Bertness, 1980; Sherretz & Farhar, 1978). Such findings, however, are not directly comparable with this work, as the mean number of casualties is not a reliable indication of the likely severity of the worst affected casualty, but a function of the number of vehicles and the number of occupants.

From the information in Figure 3, it appears that the risk of being involved in a fatal or serious road accident is actually reduced when the accident occurs in rain compared with fine weather. Such a finding may have several interpretations. Drivers may take more care in wet conditions by adjusting their speed and driving habits accordingly, although research is limited in support of this assumption (Hawkins, 1988). A more likely explanation, however, is that during rainfall a greater number of vehicles are involved in minor collisions caused by drivers not taking into consideration the resultant wet road surfaces. It has been well documented that in wet conditions changes occur to the skid resistance of the road surface (Miller & Johnson, 1973; Young, 1981). Subsequently, a greater frequency of minor accidents would arise from skidding on these wet roads, resulting in an increase in the number and proportion of slight accidents being recorded. This in turn would advantageously offset accident severity in favor of the KSI ratios. However, it is clear that further research would be necessary to substantiate such claims. Nevertheless, the severity outcome for accidents in rain remains consistently (and significantly) less severe than for fine weather conditions. Only three local authorities recorded an increase in their severity ratios for rain, compared with 31 authorities recording a decrease (Table 5).

Such a relationship between the weather hazard and "normal" fine conditions is not apparent when examining high winds. Britain is one of the windiest countries in the world, largely because of its location in the mid-latitude westerlies (Perry, 1981). This meteorological circumstance, however, is further exacerbated in road transport terms as traffic generally occurs in a northwest to southeast movement, up and down the trunk of the country, and as such, this movement is at right angles to the strong, prevailing westerly winds (Perry, 1990). Notwithstanding such circumstances, the Department of Transport fails to publish information concerning wind-related accidents and, as a result, previous studies have been limited, in the main, to individual high wind events (Baker & Reynolds, 1992).

This project has demonstrated that the effects of high winds on accident severity are inconclusive (Table 5). Some local authorities record an increase in their accident severity during high winds compared with fine weather, while others (often adjacent local authorities) display a decrease in such conditions (Table 6).

Table 5. Number of Counties by Weather Hazard with Increases and Decreases in Their Severity Ratios Compared with Fine Weather

	Increase	Decrease	No Change
Rain	3	31	0
High winds	20	14	0
Fog	18	14	2

When questioning why severity may increase in high winds, various explanations may be proposed. High winds may affect a vehicle either directly by causing the vehicle to deviate from its course or turn over, or indirectly by obstructional dangers being present in the road, such as fallen trees, or walls and paneling being blown over. When high winds are an infrequent occurrence in a locality, drivers experience the condition on an irregular basis and are not anticipating it, such that effects on the control of a vehicle may be much more severe. Of the counties which recorded increased accident severity in high winds, as opposed to fine weather, Nottinghamshire in particular is known for its infrequency of high winds. This would support the theory that the less experienced a person is in coping with adverse weather, the more likely it is that any accident will be severe. The effects of this *familiarity hypothesis* would not be expected in rain, as rainfall is a common, year-round phenomenon in all parts of England and Wales, and therefore all drivers experience the condition on a regular basis. However, the hazards of fog and high winds are much more variable in their occurrence, with drivers in some areas encountering one or both of these conditions frequently (especially during the winter months), and other drivers almost never having to drive in such adverse conditions. Sheppard (1975) identified a correlation between increased frequency of experiencing certain climatic hazards and the reduction in drivers' perceived concern. Drivers most feared the hazard that they least often experienced (notably, encountering thick fog on a motorway).

Thus the amount of exposure to a hazard may in part explain the pattern of fog-related severity ratios. Fog is the weather hazard that drivers fear most (Musk, 1991), yet driving only becomes hazardous in fog when visibility falls below 200 meters and the fog is said to be thick. Consequently, several studies have examined fog-related accidents, with particular emphasis on motorway class roads, as it is in this condition in which a driver is most at risk of being involved in a serious accident (Musk, 1988). Moore and Cooper (1972) noted that despite a 20% decrease in traffic in thick fog, there was an increase of 16% in the total number of personal injury accidents. Nevertheless, fog is recorded as the prevailing weather in very few road accidents (less than 2% of annual accidents occur in this condition), and

Table 6. Counties of England and Wales: Change in Severity Ratios by Weather Hazard Compared with Fine Weather

Region	Local Authority	Rain	High Winds	Fog
SW	Cornwall	−	−	+
SW	Devon	−	−	+
SW	Dorset	−	+	+
SW	Gloucestershire	−	−	−
SW	Wiltshire	+	+	+
SE	East Sussex	+	−	+
SE	Kent	−	+	+
SE	West Sussex	−	+	+
E	Bedfordshire	−	−	−
E	Essex	−	+	+
E	Hertfordshire	−	+	=
E	Suffolk	−	+	=
E	Cambridgeshire	−	−	−
E. Midlands	Derbyshire	−	+	−
E. Midlands	Leicestershire	−	+	−
E. Midlands	Nottinghamshire	−	+	−
W. Midlands	Hereford & Worcester	−	−	−
W. Midlands	Staffordshire	−	−	+
W. Midlands	Warwickshire	−	+	+
Wales	Dyfed	−	+	+
Wales	Mid Glamorgan	−	+	−
Wales	North Wales	−	+	+
Wales	Powys	−	−	+
Wales	South Glamorgan	−	−	+
Wales	West Glamorgan	−	+	−
NW	Cumbria	−	+	+
NW	Greater Manchester	−	−	+
NW	Lancashire	−	+	−
Yorks & Humberside	Humberside	−	−	−
Yorks & Humberside	North Yorkshire	+	+	+
Yorks & Humberside	West Yorkshire	−	+	−
N	Durham	−	+	−
N	Northumberland	−	−	+
N	Tyne & Wear	−	−	−

+ symbol = increase in KSI ratio compared with fine weather.
− symbol = decrease in KSI ratio compared with fine weather.
= symbol = KSI ratio the same as for fine weather.

it would appear that the highest proportion of fog accidents directly correlate with the incidence of the hazard (Edwards, 1996).

With regard to accident severity, the Organisation for Economic Co-operation & Development [OECD] (1976) stated that on motorways, fog tends to increase fatality rates. Two British studies of the early 1970s give weight to this argument. Codling (1974), in his 1969–70 study, observed that about 60% of accidents in fog could be described as either fatal or serious, compared with about 40% in clear conditions. Johnson (1973) came to a similar conclusion over the same study period, establishing that 111 out of 192 accidents occurring in fog (58%) involved fatal or serious injury. Both cases, however, chose a limited time period, and the resultant small sample sizes may have given misleading conclusions. Equally, in both cases the overall KSI ratios are very high in comparison with this study's aggregated ratios, possibly indicating more severe accident outcomes on motorway class roads or that severity ratios were generally higher in the 1970s than in the 1980s.

This study includes all classes of accident severity recorded in fog, although it does not distinguish between road classification type. Powys had the largest overall severity increase, from 35: 384 in fine weather to 54:518, although this could be attributed in part to the small number of fog accidents recorded in Powys, just 56 accidents in total over the 10-year period 1980–89. Those local authorities that record a decrease in their accident severity in fog show only slight deviation from fine weather ratios. Areas that are known to be fog-prone (the more centrally-located authorities of the Midlands) show a decrease in severity ratios in fog (Table 6). One explanation for this spatial pattern may rest with the possibility that drivers in such areas are aware of the problems caused by fog and adjust their driving behavior accordingly, resulting in less serious accidents. Alternatively, in areas of high fog occurrence, some drivers may have devised alternative modes of travel or merely will have chosen to cancel their journeys altogether. Again this would be a symptom of familiarity with having to tackle the hazard, and any preventative adjustment would result in either a decrease in accident involvement or a lessening of severity outcomes.

CONCLUSIONS

In summary, many factors contribute to the overall severity of an accident, and this preliminary study has only considered one—the *recorded* weather at the time of an accident. Analysis has revealed a relationship between accident severity and the prevailing weather during certain hazardous conditions. Fine weather conditions have been used as the nonhazardous control, against which accidents in other conditions have been assessed. Rain-related accidents show a consistent (and significant) decrease in severity when compared with accidents in fine weather. However, the exposure to rain and any risk compensation resulting from familiarity with such wet weather conditions are factors that need additional examination before the full impact of wet weather and accident severity can be assessed. Nevertheless, rain remains the most frequently encountered hazard in the British Isles, and therefore the motoring population needs to be attentive to the increased risks associated with wet weather. This study has indicated that the frequency of accidents resulting in slight injury increases during rain. Consequently, drivers need to be encouraged to adapt their driving behavior to the prevailing conditions by reducing speeds and increasing the gap distance between vehicles during rain. Yet wet weather warning signs advising of slippery surfaces and the need to take care with speeds are absent from the vast majority of the British road network. This is in direct contrast to the French highway authorities, who impose a lower maximum speed limit in wet weather, thus acknowledging the increased risks of losing vehicle control, and the greater stopping distances required. In the absence of similar measures, British authorities must rely on educating drivers to modify their behavior. No such campaign is currently underway for the condition of rain.

The relationship between high winds and accident severity was not found to be significant in this study, yet in Britain drivers are warned about the likelihood of high winds (especially cross winds in exposed locations) through the use of motorway wind socks. Moreover, certain structures, such as viaducts and suspension bridges, are subject to restrictions of use when wind speeds are hazardous.

Evidence for accident severity in fog is far from conclusive, although generally a reduction in accident severity during periods of fog has occurred in the Midlands. Again, such findings may suggest an exposure “learning process” by drivers. Fog warnings are given by the activation of fog detectors and police-activated matrix signs. Nevertheless, speed remains a major contributory factor in many of the multiple pile-up accidents on British motorways in fog. Drivers fail to take heed of the advice to slow down.

This study has examined actual accident severity during adverse weather. Subsequent research is required to examine the likelihood of increased risks of accident involvement and the resultant effects on accident severity during hazardous weather. Those measures taken thus far to reduce accident risk and severity are generally of a technical nature, warning drivers of the prevailing conditions. In the future, modification of driver behavior during adverse weather will be a key factor in risk reduction.

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