Journal of The Ghana Institution of Engineers, Vol. 2, No 1, 2004, pp 9 – 18

A METHODOLOGY FOR IDENTIFICATION AND RANKING OF HAZARDOUS FEEDER ROAD SECTIONS IN GHANA

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ABSTRACT

The characteristics of accidents on selected feeder roads in the Ashanti Region of Ghana have been presented as a case-study in this paper. The study revealed that, although the general numbers may still be well below accidents recorded on urban and trunk roads, the overall growth rate and fatality index of accidents on feeder roads are more than one-and-a-half times the average for all road categories. Feeder road accidents also result in 30 per cent more fatalities at night-time and twilight hours and a high proportion of these fatalities are pedestrians walking along the road. Sixty percent of accident vehicles, mostly public transport mini-buses and saloon cars had one type of defect or another to which the accident was directly attributed. Tyre burst was the most common defect. It has been argued that on account of these peculiarities, accidents on feeder roads demand a more focused approach for which existing accident frequency-based safety evaluation criteria are inadequate. The broader concept of "road endangerment level (REL)" has been proposed. The REL is a simple but more precise composite criterion that does not only pool together the influences of the most common existing criteria, but also incorporates other factors peculiar to the risks associated with operations on feeder roads.

Key words: Feeder roads, traffic accidents, blackspot identification and ranking, road endangerment level (REL), Ashanti Region, Ghana.

1. INTRODUCTION

Road traffic accidents continue to be a problem for both developed and developing countries. However, whereas the problem (relative to vehicle population) has stabilized or is even on the decline in many developed countries it seems to be on the ascendancy in developing countries. To illustrate, whilst developing countries own only 40 per cent of the world's motor vehicles, they account for more than 80 per cent of all road deaths (Ghee and Astrop, 1997). The Africa region, in particular, has 11 per cent of all the world's reported traffic fatalities as against 4 per cent of motor vehicles (Stephanie, 2001).

The causes of these road traffic accidents may be many and varied but they are always rooted in the complex inter-relationship between the driver, the motor vehicle and the road. That there exist such grotesque disparities in the relative share of road fatalities to motor vehicle population between developed and developing countries is indicative of fundamental differences in the general nature and outcome of the driver-vehicle-road interaction. In seeking effective solutions, therefore, it is important to focus on the peculiarities of traffic and the operating environment so that relevant procedures for identification and ranking of 'blackspots' may be derived.

The overwhelming dominance of feeder roads in developing countries, for example, is one crucial peculiarity that is likely to influence the accident experience in a unique way. In Ghana, feeder roads make up more than 65 per cent of the overall national road network length of about 50,000k (Ministry of Roads and Transport, 2003).

In this paper, the characteristics of traffic accidents on selected feeder roads in Ghana are discussed. It has been argued that notwithstanding the strategic significance of traffic safety on feeder roads in countries like Ghana, conventional approaches to safety appraisal do not sufficiently capture the unique traffic environment and associated risks that feeder roads present and continue to focus almost exclusively on urban and trunk roads. Consequently, the main objective of the paper is to outline a simple but more precise methodology for accident blackspot identification and ranking with particular application to feeder roads. A case-study of selected feeder roads in the Ashanti Region of Ghana has been used for this purpose and also for the purpose of illustrating the general characteristics of accidents on feeder roads.

2. REVIEW OF RELEVANT LITERATURE

2.1 Characteristics of Accidents on Feeder Roads

A search of the relevant literature reveals that little, if any, material has been published on the subject of accidents on feeder roads. Available publications in Ghana are only in the form of annual statistics. Some of these publications (e.g. Salifu and Djokoto, 1999 and Afukaar *et al*, 2002) often lump statistics of accidents on feeder roads with that of major inter-urban highways in a category designated as "non-urban" or "rural" accidents. Afukaar *et al* (2002), for example, reported that over the period 1991 to 2000 inclusive, 64 percent of all accidents occurred in "non-urban" areas. Clearly, such bulk data is of little use in the current context since it is virtuallyimpossible to make the important distinction as to what part specifically pertains to feeder roads. In any case, given the relatively much higher levels of traffic activity on the trunk roads any subsequent analysis of the bulk data characteristics would be dominated by the attributes of the trunk road accidents.

Data on accidents occurring on feeder roads have been isolated and presented only in very few cases. In cross-tabulations of accident data for selected accident-prone sections of feeder roads in Ghana, Afukaar *et al* (2000) reported that pedestrian accidents and collisions involving other non-motorized modes of transport constituted between 60-70 per cent of accidents at the individual sites.

The next dominant accident type was accidents in which vehicles 'ran into roadside ditch'. The outcome of these collisions was often fatal. According to the authors, a much larger proportion of feeder road accidents (21.4%) is fatal, nearly three times as much as the average of 7.8 percent for accidents on all categories of road. If this trend holds true for other regions of Ghana, then it can be appreciated that feeder road accidents contribute a substantial part to the generally high traffic fatality rates in the country.

However, in order to deepen understanding of the phenomenon of feeder roads accidents and to design appropriate evaluation and remediation schemes some more targeted studies are required to throw light on the nature and circumstances of occurrence as well as the consequences of traffic accidents on feeder roads. This paper is a modest contribution in that direction.

2.2 Methodologies for Identification and Ranking of Accident-prone Road Sections

Various methods exist for the purpose of identifying and prioritizing accident-prone locations (blackspots) for treatment. These methods range from the basic, as in the use of accident frequency or annual accident total (AAT), to the rigorous and sophisticated, where accident prediction model estimates and observed accident frequency are combined using Empirical Bayesian statistical procedures to produce refined estimates of accident potential (e.g. Salifu, 2003). The AAT approach is the one currently used in Ghana (e.g. Afukaar *et al*, 2000) and, according to Maher and Mountain (1988), it also still finds favour with many local authorities even in the United Kingdom.

The appeal of this method is its simplicity but it comes with many disadvantages, such as its inability to account for the exposure to the risk of accident and its susceptibility to regression-to-mean effects. Consequently, the approach has the tendency to select highly trafficked sites or sites that are experiencing a purely random and momentary high accident frequency. Above all, the use of absolute numbers of accidents as a basis of comparison is not advisable because of differing comparative conditions. To provide an equitable basis for comparing different lengths of road, accident density may also be used in place of the annual accident totals. Accident density, as shown in Equation (1), measures the frequency of road traffic accidents during a certain time period on the observed roadway section (Lamm, et al, 1999).

$$AD = \frac{A}{L \times T} \qquad (1)$$

Where, AD = accident density (accidents per kilometer per year)

A = number of accidents on road section in given time period

L = length of the investigated road section (km)

T = length of the investigated time period (years)

The Equivalent Accident Number (EAN) and Expected Value Analysis (EVA) are also alternative accident frequency-based methods for blackspot identification and prioritization (Garber and Hoel, 1988). With the EAN approach accidents for each location in a given time period are categorized by severity class; namely, fatal, severe injury, minor injury and damage-only. The number in each severity class is then multiplied by an assigned weighting and the EAN for the particular site is obtained as the sum-total of all the products (i.e. accident frequency by severity x assigned weighting). Transport Research Laboratory (TRL) (1991), for example, assigns the following weights: 12 for a fatal accident, 3 for injury accident and 1 for damage-only. The priority list is then compiled, starting from the site with the highest EAN to the one with the lowest.

The shortcoming of this approach is that it tends to emphasize severity, which is essentially a manifestation of secondary collisions and might result from freak occurrences without any connection to underlying deficiencies in safety at the site. For example, a site with only one "accidental" fatal accident in a particular period would have EAN of 12 and this would be prioritized above another site recording 11 damage-only accidents (EAN=11) in the same period. In reality, however, the site with the 11 damage-only accidents could be the unsafe and "treatable" site if all or a substantial proportion of the accidents follow a pattern that is indicative of site deficiencies.

In Expected Value Analysis, the accident frequency of individual sites over a period is compared with the average for the same period across a collection of sites in a reference population to which the particular site belongs. If the site frequency is more than the population average within specified confidence limits then the particular site is deemed to be accident-prone. Subsequently all identified accident-prone sites are ranked in order of decreasing accident frequency. The difficulty in the application of this methodology lies in the selection of sites, which are reasonably homogenous in their characteristics.

Another popular criterion for comparing accident sites and identification of problem locations is the use of accident rates. These rates are determined on the basis of exposure data, such as traffic volume, and length of road section being considered. Commonly used rates are rate per million vehicles (applicable to junctions) and rate per million or 100 million vehicle-kilometers (applicable to road links). The corresponding formula for computing accidents rate is:

$$AR = \frac{A \times 10^6}{AADT \times L \times 365 \times T} \quad \ldots\ldots\ldots\ldots \quad (2)$$

Where, AR = accident rate (per million vehicle-kilo meters)

$AADT$ = average annual daily traffic (vehicles/24 hours)

L = length of the investigated road section (km)

T = length of the investigated time period (years)

Given similar accident frequencies, accident rates typically favor sites recording comparatively low traffic volumes. However, because feeder roads experience relatively fewer accidents as well as lower traffic volumes, they are more likely to fall outside any blackspots list compiled from accident rates. Ideally the status of sites that are truly blackspots ought to be confirmed in a consistent manner by all the different criteria outlined above.

Unfortunately, the reality is that blackspot lists would vary, depending on the criterion used for their selection. For example, whereas accident rate may be high for a given low volume road, the same road may be lowly ranked as a blackspot when accident density is the criterion of evaluation. The challenge, therefore, is to have a basis for selection of blackspots that will produce uniform and consistent results each time. Such a criterion would ensure that scarce funds are applied most effectively and in an optimum way when safety interventions are made.

In Ghana, as in many countries, accident reduction efforts focus on urban and trunk roads, which carry average to high traffic volumes because it is considered that risk reduction on low volume roads (e.g. feeder roads) can hardly be justified on economic grounds (Lamm *et al*, 1999).

However, in a situation where feeder roads constitute almost 70 percent of the total network of roads and consistently record fatal accidents whose proportion of overall accidents is nearly threefold the average for all roads, it is rather important that the procedure for blackspot identification is able to account sufficiently for feeder roads as well.

3. STUDY METHODOLOGY

3.1 Selection of Case-Study and Data Collection

The main objective of the case-study was to help highlight the basic characteristics of traffic accidents on feeder roads in Ghana using a relatively limited database. Selected roads in the database were also to be used to illustrate the proposed methodology for identification and ranking of accident blackspots.

The road sections in the case-study were selected from the Ashanti Region. Having a total feeder road length of 1379km and a corresponding density of 0.056km/km^2, the region has, arguably, the most extensive feeder roads network in Ghana (Ministry of Roads and Transport, 2003). Analysis of data for the period 1992-1996 also suggested that feeder roads in the Ashanti Region were relatively more prone to accidents and consistently recorded the highest number of casualties (Afukaar, 2000). Given this background the region was easily targeted.

An initial list of all feeder roads in the region, which recorded at least one accident per year between 1996 to 2000 inclusive was compiled from the national accident database at the Building and Road Research Institute. Subsequently, the top ten sites registering the most accidents in the 5-year period were selected to form the sample for analysis. The selected roads were: Effiduase-Ntunkumso-Krofrom; Abofour-Anyinasosu; Kokote-Wawase; Jacobu-Odumasi; Juaso-Morso-Krofa; Ejura-Kyenkyekura; Poano-Ntinanko-Adowaa; Juaben-Kubease; Mampong-Jetiase-Nsuta and Asokore Mampong-Parkoso-Gyinase.

In addition to accident data, data on traffic volumes (Average Daily Traffic), length of the road section and average time interval between the arrival of each vehicle and the next were gathered for each one of the selected roads. The Department of Feeder Roads of the Ministry of Roads and Transport provided the data on road section lengths and ADT. Field observations were however required to determine the average journey speed over the section of road and the time interval between successive vehicles arriving at specific points along the road. Reconnaissance surveys were also undertaken to collect information on the existence and type of health facility within the road corridor.

3.2 Data Analysis

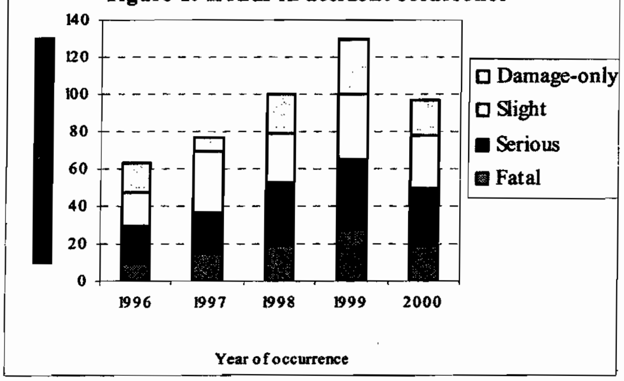
Analysis of the relevant accident data was facilitated by the existence of a computerized database, which provided the opportunity to conduct various cross-tabulations to bring out the key characteristics of accidents; particularly, in relation to the road environment, circumstances of occurrence, details of the parties involved and the consequences to each party thereof. A detailed location coding of the data also made it possible to extract accident data specific to the year of occurrence and the particular road corridor of interest.

4. CHARACTERISTICS OF ACCIDENTS ON THE SELECTED FEEDER ROADS

4.1 General Trends

A total of 467 traffic accidents were recorded for all the ten roads in the case-study over the five year period 1996-2000. These accidents resulted in 569 casualties of which 108 were fatal. The trend of accident numbers is illustrated in Figure 1. There is a clear upward trend in accident numbers up to the year 1999 and then a drop in the year 2000. Since no major intervention had taken place during the investigated period on any of the selected roads, it seems reasonable to assume that the drop in accident numbers in the year 2000 might have been due more to random factors or 'regression-to-mean' effects than a sudden improvement in safety. This assumption is partly supported by the proportions of accidents in the various severity classes in 2000, which reflect the pattern in the preceding years (see Figure 1).

Figure 1. Trends in accident occurrence



Thus the main character of accidents remained the same over the five-year period, a situation that is more likely to have changed had there been any significant change in the underlying accident risk across the studied sites.

Significantly, the average increase in accident numbers on the ten roads over the period 1996-2000 was 14.3 percent. This growth rate is one-and-a-half times the corresponding figure for all roads in the Ashanti Region (9.3 per cent) as reported by Afukaar *et al* (2002).

At first glance this observation might appear normal and expected, since the ten sites, after all, were the feeder roads that recorded the most accidents over the study period. However, the real import of it is that whilst traffic accidents on feeder roads may remain relatively small in comparison to urban or trunk roads, the problem nonetheless is appears to be growing rapidly and calls for some attention.

4.2 Typology of Accidents

The most dominant accident-type on the selected feeder roads was collisions with pedestrians. This accounted for 43.5 per cent of all fatalities and 27.1 per cent of serious injuries. These figures compare favorably with the corresponding figures reported for all roads in the Ashanti Region, which are 53.8 and 22.7 per cent respectively (Afukaar *et al*, 2002). It can be seen therefore that pedestrian accidents are nearly as much a problem on feeder roads as they are on urban or trunk roads. In fact, if the quoted figures were adjusted for the relative share of human and vehicular traffic, as well as availability and quality of pedestrian facilities, feeder roads could easily emerge as a high priority area for pedestrian safety interventions.

There is also a qualitative difference between pedestrian accidents on feeder roads and those occurring on urban and trunk roads. Whereas the former almost exclusively involve pedestrians walking along the road, on urban roads in particular, most pedestrian casualties are knocked-down whilst they are in the process of crossing the road (Salifu, 1996). Thus, the approaches to the solution of the problem cannot be the same in both cases; if safe crosswalk facilities are required in urban areas, for example, then for feeder roads what is needed is a clear roadway with sufficient and safe room for side-walking.

The next dominant collision-types on the feeder roads after pedestrian accidents were 'ran-off-the-road' and head-on collisions, the frequency of the former being more than twice that of the latter. The consequence of head-on collisions as might be expected, was relatively more severe. 14 percent of fatalities resulted from such collisions, as compared to only 2 per cent due to ran-off-the-road accidents. Incidentally, 13 per cent of fatalities on all categories of roads in Ashanti Region in the year 2000 resulted from head-on collisions. It is further worth observing that whilst the incidence of 'ran-off-the-road' accidents on the selected feeder roads is only slightly higher than for trunk roads, the phenomenon is practically non-existent on urban roads.

4.3 Environmental Conditions

4.3.1 Road surface condition

Just over one-half of all accidents occurred on road sections considered to be in good condition, whilst 37 and 11 percent, respectively, were on road surfaces generally deemed as fair and poor. Interestingly, inclement weather did not appear to be a problem as more than three out of four accidents happened under dry weather conditions. Only 4 per cent of accidents occurred on wet roads whilst fair-good surfaces accounted for 75 per cent of fatalities.

Given the non-paved status and poorer drainage facilities associated with feeder roads, one would have expected wet and slippery road surfaces as would occur in the rainy season to reflect more in the accident records. Presumably, the actual accident figures are a reflection of the dynamics of risk compensation. A good surface in good weather would convey the feeling of a low accident-risk operating environment and, in response, the average driver is tempted to increase his risk taking behaviour by, for example, increasing his speed. This in turn makes accident occurrence more likely and their consequences potentially more severe. On the other hand wet and slippery road surfaces are likely to induce more cautious behavior from drivers and through that result in much fewer accidents and less severe outcomes. It is hardly surprising therefore, that 45 and 30 per cent respectively, of driver errors were "loss of control" and "inattentiveness".

Both types of error obviously arise largely out of the driver's inability to react properly to objective constraints posed by the road environment such as poor skidding resistance (dry or wet) and ruggedness of the road surface, poor or un-engineered geometrics and the general difficulty in assessing or anticipating road-side hazards.

4.3.2 Light conditions and time of occurrence

About 56 per cent of accidents recorded on the selected roads during the five-year period 1996-2000 happened during day-time, between 6am and 6pm whilst night-time accidents formed 25 per cent. By comparison the proportional split of day to night-time accidents for all categories of road in Ghana in the year 2000 was 71percent/24 percent (Afukaar, 2002).

Thus a distinctive feature of feeder road accidents is that a much higher proportion than average (almost twice) occurs during twilight hours. The most striking difference however is that most fatalities on feeder roads (53 per cent) were registered at night and dawn/dusk whereas the corresponding figure for all roads in the year 2000 was 40 per cent.

The absence of a national ambulance service or other emergency response system for road traffic casualties, relatively sparse traffic, particularly at night and the generally poor quality of health facilities in rural areas, if they do exist at all, all combine to exacerbate the level of fatalities associated with feeder roads.

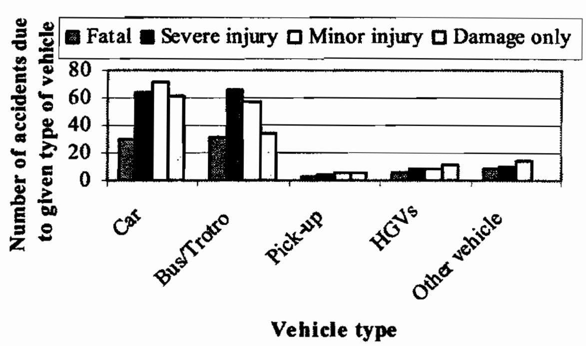
In Ghana, fatalities are deemed to have arisen out of a traffic accident when the victim dies at the scene of the accident or within 30 days of its occurrence. For those who do not die at the scene of the accident, therefore, the time it takes before they are rescued and transported to the nearest health facility and the quality of service available at the facility would be crucial in determining whether they survive and retain the status of "injured" or they die and are re-categorized as fatalities.

4.4 Characteristics of accident vehicles

4.4.1 Vehicle-types

A total of 492 vehicles were involved in the reported 467 accidents. This underscores a single vehicle character of accidents on feeder roads. Also, a 15 per cent fatality index (proportion of fatal accidents) means that feeder road accidents are nearly 1.5 times as lethal as the average accident on all categories of roads. Figure 2 presents the types of vehicle involved in accidents and the number by severity-type of accidents in which the vehicles were involved. It can be seen that the overwhelming majority of accident vehicles (46 and 38 percent respectively) were cars and trotros. Incidentally, whilst the cars were involved in 41 percent of fatal and severe injury accidents, the trotros were responsible for 51 percent.

Figure 2. Vehicle-types and their share of accidents



Given the fact that a substantial proportion of trotros in rural areas are originally all-purpose utility vehicles (e.g. pick-ups), which have been converted into passenger vehicles, it is not surprising that they are associated with a relatively high incidence of fatal accidents. Apart from the generally poor condition of all public transport vehicles operating on feeder roads, passenger seats in trotros are often improvised and fabricated locally from scrap metal and these pose the greatest danger to passengers during secondary collisions following accidents.

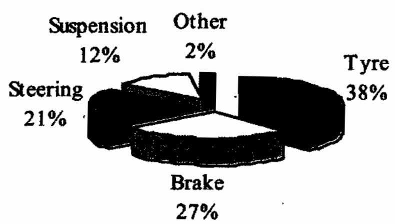
4.4.2 Vehicle condition

In all, 305 out of the 492 vehicles involved in all accidents recorded on the selected roads during the study period had one defect or another to which the accident could be attributed. Thus more than 3 out of every 5 vehicles on the feeder roads were "moving accidents merely looking for a place to happen"! And yet, this may not be entirely surprising.

Roadworthiness inspection for vehicles operating in rural areas is practically absent and it is common knowledge that a large majority of such vehicles are recycled from the cities and confined to operating in the countryside precisely because of their dubious roadworthiness. Figure 3 shows the types and distribution of these defects.

"Tyre burst" was the most common defect, followed by brake failure and steering dislocation. Together, these three types of defect accounted for almost 90 per cent of all defects and must have contributed in large measure to the predominance of "loss of control" accidents. They result primarily from poor vehicle maintenance but may also be induced by the rugged and dusty conditions characteristic of most feeder roads in Ghana.

Figure 3. Distribution of defect-types among defective accident vehicles



4.5 Characteristics of Casualties

4.5.1 Casualty Class and Sex

Most accident casualties were passengers on public transport vehicles (hire cars and minibuses). Pedestrian and driver casualties were also significant. Amongst male casualties passengers formed 49.4 percent whilst pedestrians and drivers constituted 28.6 and 22 percent respectively. Overall, male casualties were clearly over-represented as they accounted for 65 per cent of all casualties and 62 percent of pedestrian casualties. It was hardly surprising that no female driver casualties were recorded during the study period, given the preponderance of public transport and commercial goods vehicles on rural roads. Female professional drivers are nonexistent anywhere in Ghana.

The male dominance of other casualty classes is however less clearly understood and further in-depth studies may be required to unravel it. Against the backdrop of an overall national population split of 49 to 51 percent in favour of females it can only be surmised that the apparent male-proneness to accidents could be the direct result of a more active travel behaviour.

4.5.2 Age of Casualties

Statistics (e.g. Dzidonu, 2003) show that 44 percent of Ghanaians are below the age of 15 years whilst 51.3 per cent are in the age group 15-60 years. By contrast, however, only 17.4 percent of accident casualties on the selected feeder roads were below 15 years. The economically active population group of 15-60 years accounted for almost 80 per cent of all accident casualties and nearly 90 per cent of passenger casualties. As compared to their proportion of the overall national population, this age group does appear to be over-represented in the accident casualties and the reason might well lie in the travel activity associated with their role in society, e.g. the need to travel to work or other social engagements.

The below 15 years age group generates some interest when pedestrian casualties are looked at separately. In that case the group's share of casualties jumps from 17.4 percent (as in all casualties) to 42 per cent, a figure that is commensurate with the group's share of the national population. Thus as pedestrians, children below 15 years appear to be proportionately exposed to the hazards of traffic accidents on feeder roads in relation to other population groups.

5. PROPOSED METHODOLOGY FOR IDENTIFICATION AND RANKING OF HAZARDOUS FEEDER ROADS

5.1 Definition and justification of methodology

It might be argued that existing criteria for identifying and prioritizing accident-prone road sections for treatment should be sufficient for application on all categories of road, including feeder roads. However, as discussed earlier in this report, each one of the said criteria has their biases and cannot be relied upon individually to deliver a uniform and consistent ranking of problem sites. A more precise and holistic criterion is therefore required. Ideally such a criterion should be able to pool together the best attributes of existing criteria in a simple and logically consistent manner and to account sufficiently for the peculiar risks of accident on feeder roads. The concept of "road endangerment level" is introduced for this purpose. This is expressed as follows:

$$REL = \Phi(A, AR, AD, HF, WT) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where, REL – road endangerment level for the given road corridor

$\Phi()$ – a general function pooling the effects of the listed factors

A – total number of accidents recorded on the road section in time period under study

AR and AD – accident rate and accident density, respectively, as previously defined in Equations (1) and (2).

HF – type of health facility in the road corridor, and

WT – average accident casualty waiting time before being rescued

Thus, Equation (3) is a statement that the road endangerment level is some function of the accident frequency, accident rate, accident density, the type of health facility within the road corridor and the average casualty waiting time before being rescued. The first three parameters (i.e. *A*, *AR*, and *AD*) represent the most common existing criteria that capture the accident potential of the given road section. These are typically used to identify and prioritize accident blackspots. The parameters HF and WT, however, are introduced to capture the peculiar risks of operation on feeder roads, particularly in relation to the potential for escalation of casualty severity levels once an accident has occurred.

The general absence of quality health services and facilities in rural areas obviously compounds the dangers of traveling on feeder roads, which mostly run through some of the most isolated and desolate parts of the country. On the other hand, the average expected waiting time (i.e. time it takes between the occurrence of an accident and arrival of the next vehicle) is crucial to road safety because it represents the earliest opportunity for accident casualties to be rescued and sent to the nearest health facility. In the absence of any ambulance or emergency recovery services for accident casualties, the responsibility often falls on other road users to step-in to provide such assistance.

The waiting time is considered equivalent to the average time headway between successive traveling vehicles on the particular road section. The basic idea of introducing the two parameters (i.e. HF and WT) is that in circumstances when accident victim recovery time is long and/or there is no guarantee of decent medical attention, the potential consequences of accident occurrence are grave and all efforts need to be made to avoid the accidents in the first place.

The composite criterion ("road endangerment level") proposed replaces the "traditional" concept of "blackspot" as determined through derivative measures of actual accident history of road sections. As a result, identification of problem road sections is done not only on the basis of accident-proneness, but also from the additional perspective of the opportunities/challenges that exist for casualty injury mitigation.

Through this modification, the dangers of accident occurrence on feeder roads are more equitably appraised. Given the strategic importance of ensuring safety on feeder roads in a typical developing country, such as Ghana, the above-average fatality indices of accidents and the poor transport and social infrastructure on, or along, feeder road corridors, among others, it seems quite logical to suggest that higher premium should be placed on the prevention of accidents on feeder roads.

As things stand now, however, this objective cannot be achieved because the continued untampered application of solely accident-frequency based criteria of assessment for all categories of road, invariably, leads to the situation that feeder roads accidents are not considered as a priority issue for safety intervention. The criterion of road endangerment level is meant to address this imbalance. To facilitate practical application, Equation (3) is transformed as follows:

$$REL_i = R_{Oi}(A)+R_{Oi}(AR)+R_{Oi}(AD)+R_{Oi}(HF)+R_{Oi}(WT) \;\ldots\ldots \quad (4)$$

Where, REL_i - "road endangerment level" of *i*-th road section

$R_{Oi}(\,)$ – the ranking order (number) of the *i*-th road section according to the criterion listed in parenthesis, and $i=1,n$

Thus, the "Road Endangerment Level (REL)" for any particular road section is the sum of the section's priority ranking numbers as determined by the component criteria of accident frequency, accident rate, accident density, status of health facility within the road corridor and the expected average waiting time before accident casualties may be evacuated. To illustrate, if a road section is listed as 1st, 4th, 3rd, 5th, 1st, respectively, according to the component criteria, then its *REL* will be 1+4+3+5+1= 14. Because this value is a simple arithmetic sum of priority ranking numbers, the road with the lowest sum would be the one with the highest average ranking across the component criteria and such a road should subsequently come at the top of the priority list determined by the REL criterion. Thus the *REL* ranking is compiled, starting with the road having the least value (sum of rank numbers) down to the one with the highest.

Lamm *et al*, 1999 employ a similar criterion for appraisal of safety on low volume roads. The difference here, however, is that we propose to use the status of the health facility and average waiting time before casualties may be rescued where they have used average overall damage per accident, accident cost density and accident cost rate. Sufficiently accurate estimates of the latter parameters are generally unavailable in developing countries, such as Ghana, and, even where available, using them for the purpose of ranking accident sites does little to account for the peculiarities and risks of accidents on feeder roads.

5.2 Application of the Methodology

To demonstrate how the criterion of road endangerment level can be applied to select and rank feeder road sections for safety intervention, data on the case-study sample of ten (10) roads from the Ashanti Region of Ghana were utilized. Table 1 presents the summary sheet. Of the ten roads, the Abofor-Anyinasosu section was the longest (32.4km), whilst the section with the highest traffic volume was Juaben-Kubeasi, which posted an ADT of 579.

The lowest traffic volume of 18 ADT was on the Ejura-Kyenkyenkura road. Accident frequency in the five-year study period varied from a low of 7 to 129 accidents per site. All the road corridors under study had one type of heath facility or another in their catchment area and average time separation between successive vehicles (waiting time) ranged between one-half and three-quarters of an hour.

The health facilities represented were ranked 1, 2 and 3 respectively for an ordinary health center, a clinic and hospital. The rationale for such ranking is that when the standard of expected health service within a road corridor is relatively poor, the danger of casualty injury levels escalating is high and therefore any accident occurrence on the road would be less "tolerable".

The rest of the component criteria, namely, accident frequency, accident rate, accident density and average casualty waiting time have a direct relationship with the urgency of the need for intervention and the road sections are therefore ranked from 1 to 10, in descending order according to the value of each criterion. These rank numbers (orders) together with the resultant ranking by the composite criterion of *REL* are presented in Table 2.

The varying emphasis of the component criteria is apparent from the table. Without exception, none of the roads is consistently ranked in the same position by all the criteria. This underscores the need to pool the criteria together in a simple and logical manner so as to obtain a more broad-based composite criterion according to which roads should be prioritized for remedial interventions. That the overall ranking by *REL* is also uniquely different is a confirmation that the effort at outlining this methodology is well-founded. The criterion is simple to apply and yet more precise, because it levels out the biases associated with the individual component criteria and provides an opportunity for more effective utilization of resources in accident remedial interventions.

6. CONCLUSION

The foregoing presentation has shown that feeder road accidents in Ghana have some unique characteristics, which call for special attention. Although their general numbers may still be well below accidents recorded on urban or trunk roads there are indications that the growth rate of accidents on feeder roads is above average. Feeder road accidents also have a relatively high fatality index and the fatalities occur mostly between sunset and sunrise, involving pedestrians walking along the road. Significantly, more than 60 percent of vehicles involved in accidents on feeder roads had one type of defect or another to which the accident could be directly attributed. Tyre burst was the most common defect of the predominantly public transport vehicles in the form of hire cars or taxis and mini-buses. The casualty statistics indicated that males in the age-group 15-60 years were highly over-represented.

Against the background of these findings a new approach to the prioritization of road sections for accident remedial interventions was outlined, using data from a case-study. The concept of "road endangerment level" or *REL* was introduced as a replacement for the purely accident frequency-based criteria for accident blackspot identification and ranking. The strengths of the *REL* include the fact that it is a composite criterion that does not only pool together the influences of existing criteria but also incorporates other risk factors peculiar to the traffic environment on feeder roads.

Given the strategic role that feeder roads play in the national economy of Ghana, it is about time that a more focused approach was adopted in managing safety on them. The data analyzed buttress this need and the proposed criterion of road endangerment level (REL) provides a more equitable basis for doing so.

Acknowledgement

This paper has made use of some data originally presented by Master Razak as part of his final year undergraduate special study project at the Department of Planning of the Kwame Nkrumah University of Science and Technology, Kumasi. This contribution is gratefully acknowledged.

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Table 1. Characteristics of case-study road sections

Road Name	Length of Road Section	Average Daily Traffic (ADT)	Accident Frequency	Accident Rate (per million veh-km)	Accident Density (per km)	Average vehicle headway / Waiting Time (Hours)	Status of Health Facility
	(km)	No. vehicles./24 hours	(A)	(AR)	(AD)	(WT)	(HF)
Effiduase -	19.2	257	39	4.33	0.51	0.75	Health center
Ntunkumso-							
Krofrom							
Abofour-	32.4	213	21	1.67	0.16	0.66	Clinic
Anyinasosu							
Kokote-	24.7	226	35	3.44	0.35	0.5	Health Center
Wawase							
Jacobu-	5	152	17	12.26	0.85	0.75	Hospital
Odumasi							
Juaso-	10.9	120	16	6.70	0.37	0.75	Health Center
Morso-							
Krofa							
Ejura-	9.5	18	7	22.43	0.18	0.5	Health Center
Kyenkyenkura							
Poano-	12	120	41	15.60	0.85	0.66	Clinic
Ntinanko-							
Adowa							
Juaben-	22.8	579	121	5.02	1.33	0.5	Health Center
Kubease							
Mampong-	16.4	23	41	59.56	1.60	0.75	Health Center
Jetiase-							
Nsuta							
Asokore-	17.4	147	129	27.63	4.36	0.75	Hospital
Mampong-							
Parkoso-							
Ggyinase							

Table 2. Ranking order of case-study roads by existing and proposed criteria

Road Name	Ranking order of case-study road sections by selected criteria					Total Ranking Points	Ro (REL)
	Ro (A)	Ro (AR)	Ro (AD)	Ro (WT)	Ro (HF)		
Effiduase - Ntunkumso- Krofrom	4	8	6	1	3	22	**5th**
Abofour- Anyinasosu	6	10	10	2	2	32	**9th**
Kokote- Wawase	5	9	8	3	3	28	**8th**
Jacobu- Odumasi	7	5	4	1	1	18	**4th**
Juaso-Morso- Krofa	8	6	7	1	3	25	**6th**
Ejura- Kyenkyenkura	9	3	9	3	3	27	**7th**
Poano- Ntinanko- Ådowa	3	4	4	2	2	15	**3rd**
Juaben- Kubease	2	7	3	3	3	18	**4th**
Mampong- Jetiase- Nsuta	3	1	2	1	3	10	**2nd**
Asokore-Mampong-Parkoso-Gyinase	1	2	1	1	1	6	**1st**