THE IMPORTANCE OF EXPOSURE DATA FOR A COMPREHENSIVE ACCIDENT DATABASE

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ABSTRACT

This research paper was undertaken to investigate the importance of exposure data and how it can be used with existing accident databases. It is hoped that greater awareness on this topic will be created.

It is the aim of this paper to highlight the importance of exposure data as well as using it with other dimensions of road safety (i.e. consequences and risk) described in the paper, in order to arrive at a comprehensive accident database. Exposure in terms of vehicle.km is not always reliable and the move towards **person.km** is promoted in this paper. (Vehicle.km's looks at the vehicle only, whereas person.km's looks at all road users i.e. pedestrian, drivers, passengers)

The paper will also show the use of a formula that uses cross-multiplying and dividing of dimensions that expresses the road safety problem better.

It further shows the use of three (3) dimensional graphs in presenting the exposure, risk and consequences simultaneously. This method can be used for different road users and age groups with examples and a case study which is included.

It also highlights the fact that road traffic safety is a multi-dimensional multidisciplinary science that focusing on one dimension will not solve the problem. Haddon's Matrix is therefore also used to show that the three dimensions (consequences, exposure and risk) can be used to arrive at remedial measures for road safety in conjunction with the three dimensional graphs.

In conclusion, it shows that various data sources are available in the country but not always integrated with one another, hence the need for a comprehensive accident database with exposure data forming a vital component.

1 BACKGROUND

How does one measure road safety in South Africa and compare the problem with other countries? Immediate answers will be the number of crashes/accidents or the number of fatalities. The answer is of course only half-correct as these absolute numbers are only indicators which have a high and direct validity to the problems (road safety). These figures have a low reliability when analysed in isolation. There are also various sources where one can source these figures and data to correlate and incorporate for a comprehensive crash/accident database. This unfortunately is not happening, as recent statistics show that 14000 road users die on our road annually. – Source: from the Road Traffic Management Corporation's police (SAPS) data. However accident data from hospitals show that the figure could be as high as 18000. – Source: National Road Safety Strategy, 2006 onwards. Other data sources like Statistics SA and Insurance companies for example are not always incorporated with databases from SAPS and/or hospitals.

2 AIM OF PAPER

The purpose of this paper is to highlight the important issue of risk in terms of exposure data and using with these other measures mentioned above to come up with a comprehensive road safety picture. Exposures in terms of vehicle.km are also not reliable and the move towards <u>person.km</u> is promoted in this paper. Its main purpose is to create awareness of the topic as well and the where to source the data for integration.

3 THE THREE MAIN DIMENSIONS THAT AFFECT ROAD SAFETY

3.1 <u>Exposure, risk and consequence</u>

Traffic safety problems are often just presented as a one-dimensional problem i.e. the distribution of accidents, injured or fatalities per vehicles types, age groups, roads etc. In order to discuss or apply remedies there is a need to identify and describe the extent of the problem. One way in doing this is to get a 'picture' of the problem by simultaneously showing different dimension to the problem. The 'picture' referred to is in the form of 3D-graphs instead of only looking at the commonly used bar charts and tables. Too often are these dimension describe one by one instead of simultaneously.

The dimension of risk must be incorporated more, by relating fatalities and injuries to exposure. The most accurate, we feel, form of exposure data is person.km's. The country (SA) does relative well in capturing exposure data in terms of vehicle.km's. The problem with vehicle.km is that vehicle ownership or motorisation varies from country to country and even province to province. Whereas person.km focuses in the individual that use the transport system whereby putting him- or herself at risk. It includes all road users such as pedestrians, drivers and passengers.

For a good understanding of road safety developments and road safety problems, exposure data is indispensable. Exposure data provides information about how, where and how far people travel. We can shortly refer to this as trip-exposure. Together with crash information, this information allows for calculating the relative risk of travelling in general, or for particular transport modes, particular types of road or particular groups of people. For example: pedestrians.

Accident risk is defined as "the probability that a specific road user is involved in an accident when using the road". The risk factors influence not only the accident risk but also the consequence. The number of situations or the magnitude of traffic is called the exposure. In order to estimate risk, exposure data is needed. Risk is usually defined or calculated as a ratio between the number of accidents or casualties and exposure.

Using the accident information, we can describe the accident consequences in number of injuries and fatalities or in accident costs, i.e. hospital days. The safety situation can then be presented in terms of accidents, injured or fatalities, corresponding risks and exposures for different combinations of inhabitant groups, vehicle groups and road groups.

The background theory of the traffic safety problem is that the change in the traffic safety problem is not only directly proportional to the change in traffic exposure but is also influenced by changes in accident risk and accident consequence.

Factors contributing to accidents are multifaceted in nature. These dimensions are often described one by one, but not simultaneously. The concept of exposure, risk and consequences are often mentioned (COST 329 1998, Elvik et al 1997), but seldom presented in comparisons of the traffic safety situation between different groups, comparisons between modal use, age and gender for example.

Examples are given in the case study under heading 4 below.

The three dimensions can be expressed on three axis as illustrated in Figure 1.

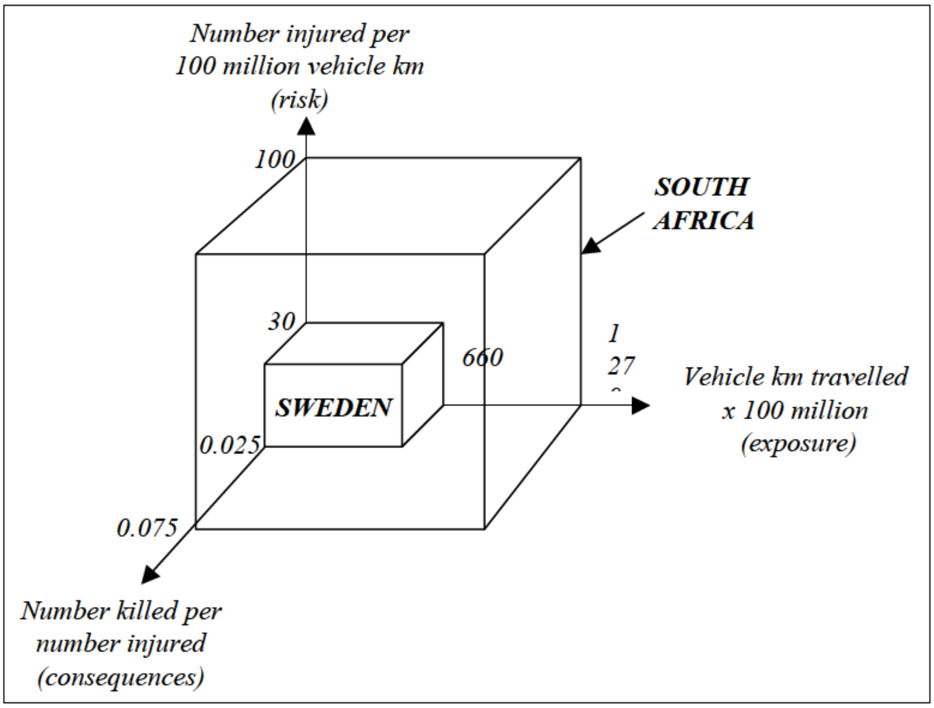

Figure 1: Comparison of the road safety problems in Sweden and South Africa, using risk, exposure and consequences. (Vagverket, 1999b and Central Statistical Services, 1999)

This approach provides a three-dimensional (3-D) representation of the problem, where the volumes of the cubes are the magnitude of the problem. The risk bars are presented as volumes. The volume bars illustrate the magnitude of the exposure dimension by the width of the bars and the height of the bars represents the magnitude of the risk dimension. The depth (thickness) of the bars illustrates the magnitude of the consequence dimension and thereby the safety problem has an exposure, risk and consequence dimension

It can also be expressed with the following formula (1):

$$\textit{traffic safety problem} = \textit{risk} \times \textit{consequence} \times \textit{exposure} \qquad (1)$$

For example:

$$\textit{fatalities} = \frac{\textit{accidents}}{\textit{exposure}} \times \frac{\textit{fatalities}}{\textit{accidents}} \times \textit{exposure}$$

A numerical example for equation above can be taken from Table 2 in the case study under 4 below:
The age group- less than 18 had 54 fatalities in 2009, therefore

$$\text{Fatalities} = \frac{(54+1013)}{603} \quad X \quad \frac{54}{(54+1013)} \quad X \quad \frac{603}{1}$$

A graphical example using the three dimensions:

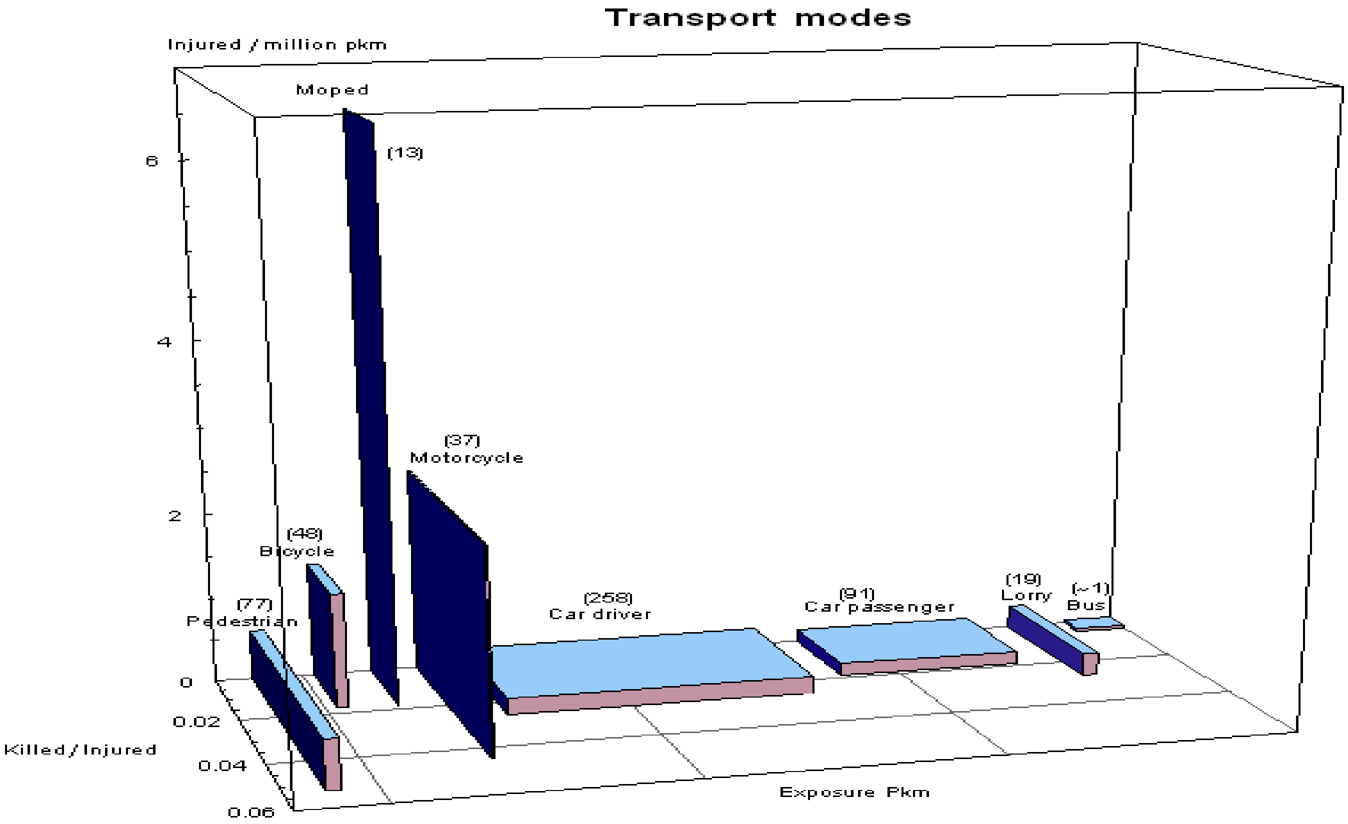

Figure 2: The traffic safety situation – Average number of fatalities annually for different transportation modes in Sweden 1997-1999

It can be seen for example that:

- Pedestrians have the highest consequence ratio, as they are more exposed to traffic than bus passenger for example.
- Persons on Mopeds are the most at risk in terms of injuries or the most probable to be involved in an accident. They have the highest risk in the traffic population in Sweden
- Car driver being the biggest road user are the most exposed at 259 p.km, but because it is in a 'protected shell' as apposed to mopeds, their risk and consequence ratios are not as high as pedestrians bicycles, motorcycles.
- A bus seems to be the safest mode of road transport in Sweden.

According to the abovementioned equitation (1), any remedial measure that reduces any or all of the above factors will improve road safety. A fatality rate can be obtained by multiplying risk, consequences and exposure data.

Table 1 illustrates how the three dimensions can be used to strategise on what remedial measure/s to implement depending on what the particular 3-D graphs reveal.

TABLE 1: HADDON'S MATRIX

Measures act on	**Remedial Measures directed to**		
	Infrastructure *(Environment)*	**Vehicle** *(Machine)*	**Road user** *(Man)*
Exposure *(person-km)*	*-Improve public transport (BRT)* *-Park & Ride* *-Pedestrian street*	*-Taxes/Fuel levies* *-Increase Insurance costs*	*-Tele conference* *-Restrict driver by age*
Probability of crash / RISK *injuries/person-km)*	*-Traffic Calming* *-Seperation*	*-Speed limiters/governers* *-Alcohol locks*	*-Education* *-Attitudes* *-Enforcement* *-Reflective clothing*
Consequence of crash (*Killed/injuries)*	*-Crash barriers* *-Middle/Mediam barriers* *- Cables/Gaurdrails*	*-Safety belt technology* *-Air Bags* *-Crash worthiness (NCAP)*	*-Helmets* *-Belts usage*

The three dimensional figures will assist in the analysis of the safety problem in addition to conventional tables and may also influence the identification of the most important problems to some extent.

4 CASE STUDY WITH DATA FROM ETHEKWINI TRANSPORT AUTHORITY, ETHEKWINI MUNICIPALITY, DURBAN

NOTE that this has never been done with this type of data in South Africa of its kind.
Key findings from the graphs are found in the small table. Titles/List of figures:

Figure 3: Exposure, risk & consequence for pedestrians by age in 2009
Figure 4: 2009 exposure, risk & consequence for pedestrians by age - AM peak (4:30- 8:30)
Figure 5: 2009 exposure, risk & consequence for pedestrians by age - PM peak (15:30-18:30)

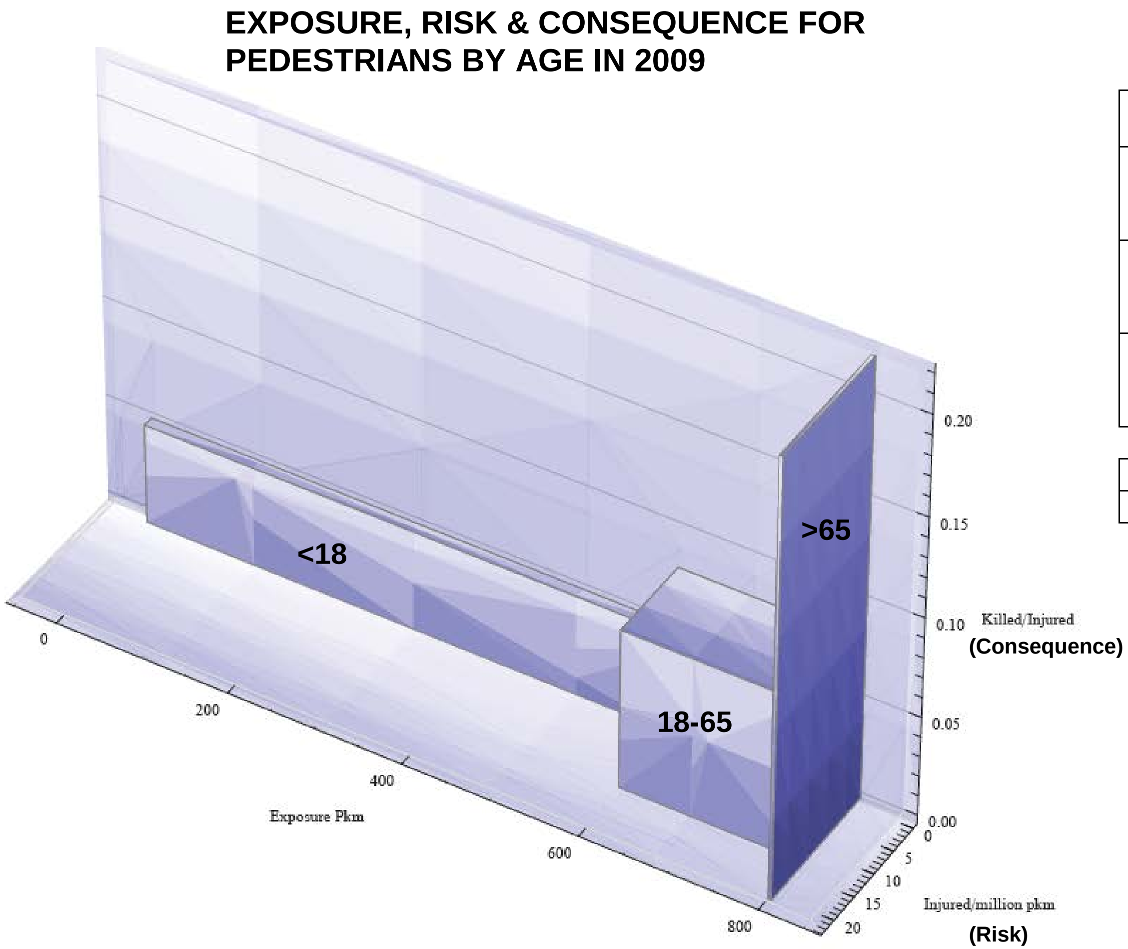

FIGURE 3: EXPOSURE, RISK & CONSEQUENCE FOR PEDESTRIANS BY AGE IN 2009

TABLE 2: EXPOSURE, RISK AND CONSEQUENCE FOR PEDESTRIANS BY AGE IN 2009

	Age		
PEDESTRIAN 2009	**Less than 18**	**18-65**	**>65**
Million pedestrian kilometres per year (EXPOSURE)	603	203	4
Injured Pedestrians/ Million pedestrian kilometres (RISK)	1.68	14.09	22.25
Pedestrian Fatalities/ Injured Pedestrians (CONSEQUENCE)	0.05	0.08	0.22

Fatal	54	223	20
Injured	1013	2860	89

- Pedestrians in the less than 18 age category are most exposed as they have the highest pedestrian km per year (603), pedestrians in the 18-65 age category are the second highest (203) and pedestrians that are greater than 65 years of age are the least exposed (4).
- The risk of pedestrian's increases with age with pedestrians in the greater than 65 age category having the highest risk (22.25), with pedestrians in the 18 to 65 age category being the second highest risk with (14.09) and the less than 18 age category being the lowest at (1.68).
- Fatal consequence increases with age with the pedestrians that are greater than 65 with the highest (0.22), which means that the injury risk and the fatal consequence together create an increasing fatality risk with age.

2009 EXPOSURE, RISK & CONSEQUENCE FOR PEDESTRIANS BY AGE – AM PEAK (4:30- 8:30)

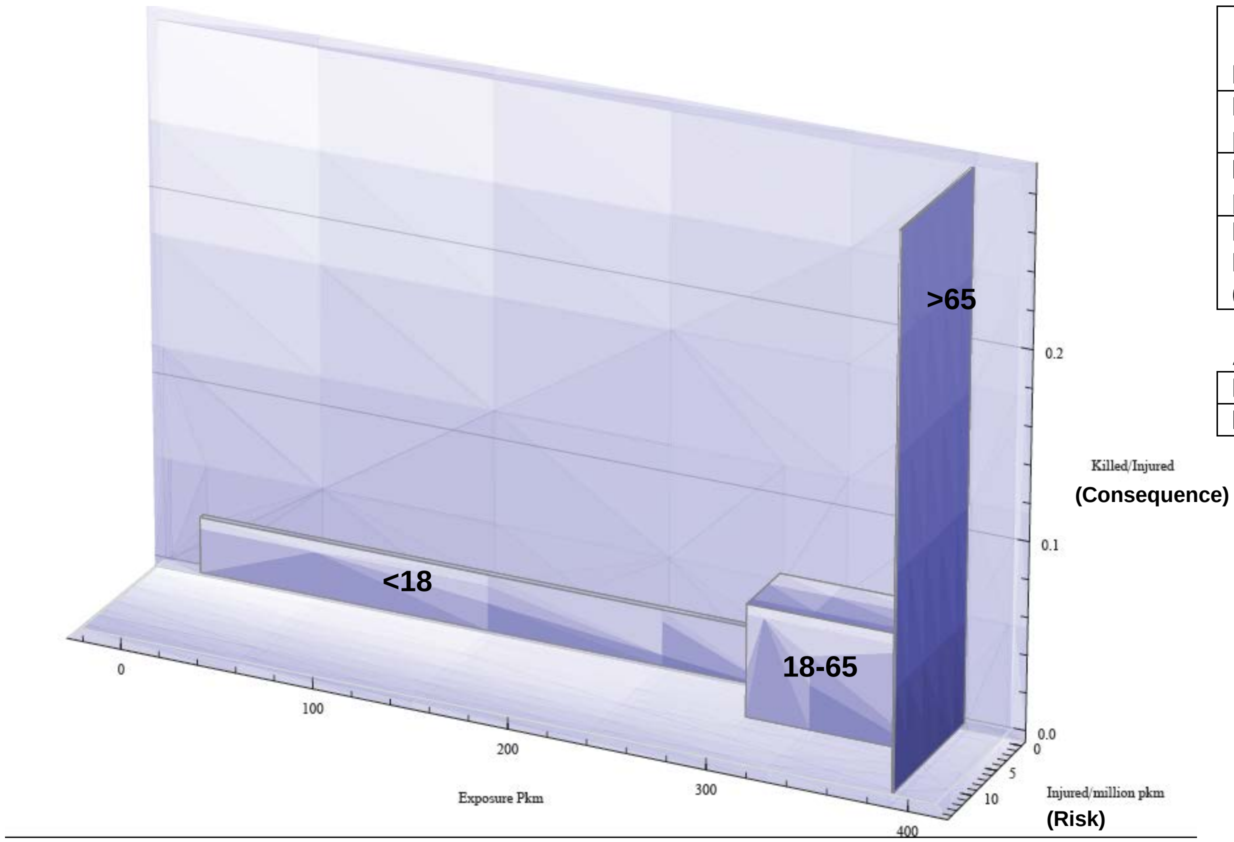

FIGURE 4: 2009 EXPOSURE, RISK & CONSEQUENCE FOR PEDESTRIANS BY AGE - AM PEAK (04:30 to 08:30)

TABLE 3: EXPOSURE, RISK AND CONSEQUENCE FOR PEDESTRIANS BY AGE-AM PEAK

	Age		
PEDESTRIAN 2009	**Less than 18**	**18-65**	**>65**
Million pedestrian kilometres per year (EXPOSURE)	298	92	1
Injured Pedestrians/Million pedestrian kilometres (RISK)	0.62	6.47	14.00
Pedestrian Fatalities/ Injured Pedestrians (CONSEQUENCE)	0.03	0.06	0.29

AM Peak (4:30 am to 8:30 am)

Fatal	6	36	4
Injured	185	595	14

- Pedestrians in the less than 18 age category are most exposed in the AM peak as they have the highest pedestrian km per year (298), pedestrians in the 18-65 age category are the second highest (92) and pedestrians that are greater than 65 years of age are the least exposed (1).
- In the AM peak the risk of pedestrian's increases with age with pedestrians in the greater than 65 age category having the highest risk (14.00), with pedestrians in the 18 to 65 age category being the second highest risk with (6.47) and the less than 18 age category being the lowest at (0.62).
- Fatal consequence increases with age with the pedestrians that are greater than 65 with the highest (0.29), which means that the injury risk and the fatal consequence together create an increasing fatality risk with age.

2009 EXPOSURE, RISK & CONSEQUENCE FOR PEDESTRIANS BY AGE – PM PEAK (15:30 to 18:30)

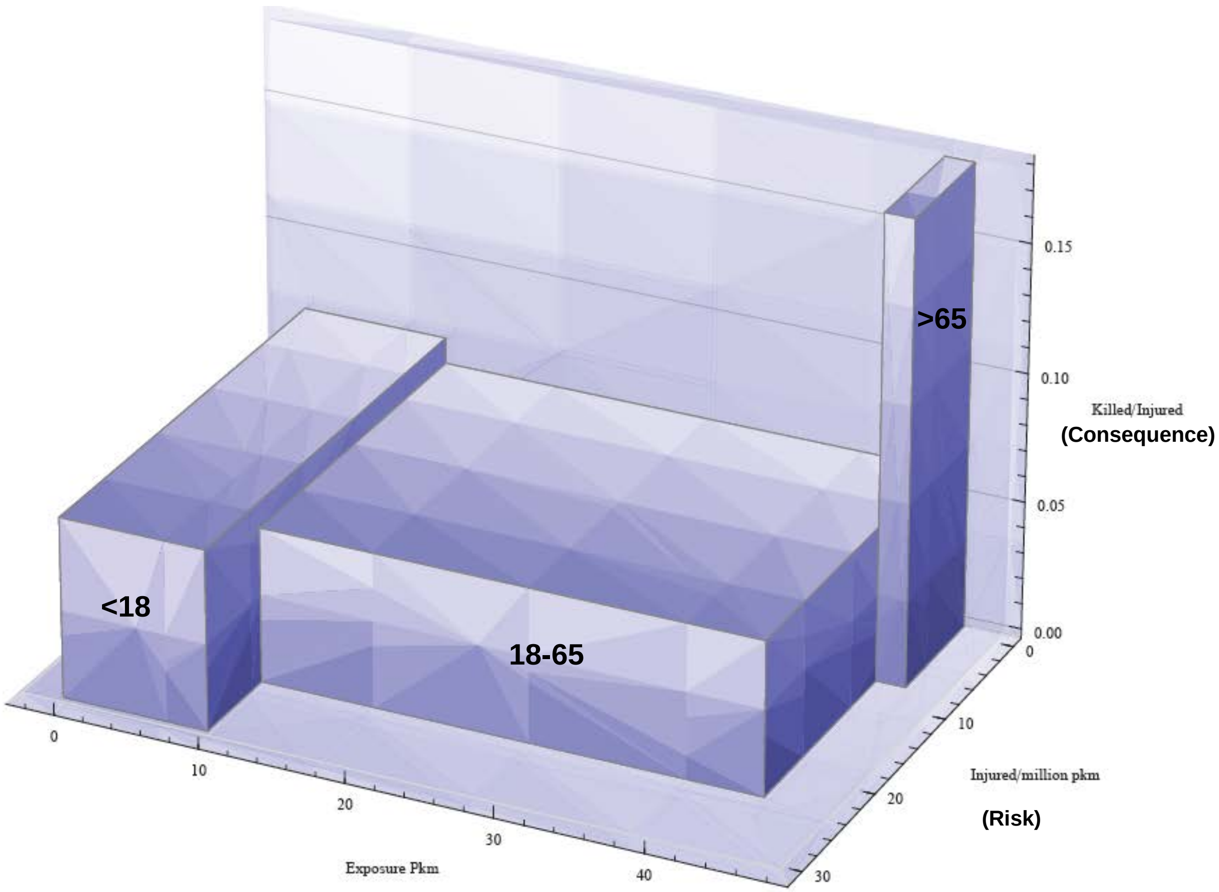

FIGURE 5: 2009 EXPOSURE, RISK & CONSEQUENCE FOR PEDESTRIANS BY AGE – PM PEAK (15:30 TO 18:30)

TABLE 4: EXPOSURE, RISK AND CONSEQUENCE FOR PEDESTRIANS BY AGE-PM PEAK

	Age		
PEDESTRIAN 2009	**Less than 18**	**18-65**	**>65**
Million pedestrian kilometres per year (EXPOSURE)	10	34	2
Injured Pedestrians/ Million pedestrian kilometres (RISK)	30.80	24.09	8.50
Pedestrian Fatalities/ Injured Pedestrians (CONSEQUENCE)	0.07	0.06	0.18
PM Peak (15:30 pm to 18:30 pm)			
Fatal	22	52	3
Injured	308	819	17

- Pedestrians in the 18 to 65 age category are most exposed in the PM peak as they have the highest pedestrian km per year (34), pedestrians in the less than 18 age category are the second highest (10) and pedestrians that are greater than 65 years of age are the least exposed (2). Exposure for the less than 18 age category is much lower because there are no school trips in the PM peak.

- In the PM peak the risk of pedestrian's decreases with age with pedestrians in the less than 18 age category having the highest risk (30.80), with pedestrians in the 18 to 65 age category being the second highest risk with (24.09) and the greater than 65 age category being the lowest at (8.50).

- Fatal consequence increases with age with the pedestrians that are greater than 65 with the highest (0.18), which means that the injury risk and the fatal consequence together create an increasing fatality risk with age.

5 CONCLUSIONS AND RECOMMENDATIONS:

1) The report highlighted the fact that road traffic safety is a **multi-dimensional problem** and that focusing on one dimension will not solve the problem.

2) There are various **data sources** available in the country but it is **not** always **integrated** i.e.

    a) Household survey data for the important exposure data – person km. It is therefore recommended that this type of data be collected as part of the national population census and/or regular household surveys.

    b) Road accident data from hospitals are not used to verify police data. The Road Traffic Management Cooperation are aware of this issue and are therefore included it in the new accident record system that would be rolled out soon.

3) The use of **three dimensional graphs** should be **promoted** i.e. visualisation of the problem – A reason for this not being regularly used is the fact that a standard graphical software program like MS Excel cannot produce these types of graphs. Software that can produce these graphs are very expensive and only used by research institutions i.e. Mathematica 8.01 by Wolfram Research. It is evident that these types of graphs reveals a lot more than two dimensional graphs which will assist in developing remedial measures (e.g. Haddon's Matrix).

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