Measuring the Influence of the Road and Roadside in the Safe System

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Abstract

The Australian Road Safety Strategy (2011-2020) recognises safe roads and safe speeds to be two cornerstones of the Safe System approach with great potential to reduce casualties. Aims of the strategy include assessing risk on the road network in order to target high risk sections and locations, and setting speed limits according to the risk and function of the road and roadside environment.

Central to achieving these aims is the measurement of the influence of the road and road environment on crash risk. Previous research, both in Australia and overseas, has focused mainly on relatively simple road environments (e.g. highways and rural roads) while urban environments have been somewhat neglected. This is likely due to the difficulty in obtaining the data to fully characterise such complex environments. To achieve the aims of the strategy, a more systematic approach is needed to develop risk assessment models for all roads in the road network. The first step is collecting the necessary data.

This paper will discuss the data requirements necessary for developing risk assessment models of the relationship between the design of the road and roadside environment and crash risk for any type of road. Other uses for such data will also be considered, e.g. asset management and other public health and safety-related research and reporting.

Background

The recently released Australian Road Safety Strategy (2011-2020)[1] recognises safe roads and safe speeds to be two cornerstones of the Safe System approach with great potential to reduce casualties. Aims of the strategy include assessing risk on the road network in order to target high risk sections and locations, and setting speed limits according to the risk and function of the road and roadside environment. This recognition that roads can, and should, be made safer in order to reduce the number of road-related deaths and injuries extends worldwide[2,3,4].

Systematically identifying high risk road sections and locations presents an enormous challenge. Notwithstanding the success of the Black Spot program[5], defining roads as high risk solely according to their crash history is an approach that is reactive, not proactive. There are roads that can be deemed high risk due to the presence of particular risk factors that do not (yet) have the required crash history to be classified as a black spot. The Black Spot program does allow for the treatment of locations that may be "accidents waiting to happen" after a Road Safety Audit has taken place[6]. There is a need for systematic methods to identify sites with the potential to markedly benefit from safety treatments.

Evidence-based tools are required for the identification of potentially high risk road segments or locations. Risk assessment tools, such as the International Road Assessment Program (iRAP), AusRAP[7] and NetRisk[8] calculate a risk score for a given road length that are used to identify high risk road sections and prioritise treatments. The risk score is based on characteristics of the road and roadside that have been demonstrated to be related to crash risk. Thus, development of such tools relies on good quality evidence from research studies. For practical reasons, the characteristics are also selected so as to be commonly available in administrative datasets and/or easily accessible for road safety practitioners[9]. This means that important risk factors may not be included in the tools.

To support the further development of risk assessment tools for practitioners, we need to better understand the road and roadside factors that affect the risk of a crash occurring. The development of accident prediction models is a powerful method for identifying these risk factors. Accident prediction models predict the expected number of crashes on a given road, given the presence or absence of particular risk factors using advanced multivariate regression models. Internationally, accident prediction models are being developed and incorporated into road safety manuals for practitioners[4]. Further development, testing and refinement of accident prediction models are essential if we are to design risk assessment tools to effectively identify and treat high risk roads on the Australian road network.

Development of effective accident prediction models relies heavily on having high quality data available on both the outcome (crashes) and potential risk factors (road and roadside characteristics) of interest. Much of the previous work that led to the development of accident prediction models was focused on relatively simple road environments, such as freeways and rural roads[e.g.10-13]. Investigations of crash risk in urban environments are rare, probably due to the difficult task of characterising complex urban environments. In addition, the models have often been developed using data from existing administrative data sources that were not necessarily intended for this purpose. This means that potentially important risk factors may not have been investigated because the data were not readily available. The lack of high quality data on the road and roadside characteristics is a major stumbling block when developing accident prediction models and risk assessment tools for all road types, but particularly so for complex environments. Part of the problem is that we do not fully understand what data are required for assessing risk in complex road environments.

The objective of this study was to determine the data required for measuring the influence of the road and roadside on crash risk. Given the past lack of emphasis on measuring risk in urban environments, particular effort was directed at ensuring the list covered potential risk factors for complex urban environments, in particular, the Melbourne metropolitan area.

Method

Identification of data requirements

Data requirements for measuring the influence of the road and roadside on crash risk were developed using a two-stage process.

Literature review

First, a literature review was conducted to identify the characteristics of the road and roadside that have been found to be associated with crash risk. The literature search focused mainly on multivariate modelling studies, although before-after studies were included where appropriate. Initially the focus was on studies published in the peer-reviewed academic literature. However, there exists in the grey literature a number of high quality reports in the area that have not been published in the peer-reviewed literature. Because this project involved amassing an exhaustive list of road and roadside factors that may impact crash risk, these reports were also included in the review. In addition, recent reports that sought to define data requirements for evidence-based road safety engineering practice were also consulted[2,3,4].

A list of factors related to the design of the road and roadside that may affect crash risk was compiled from these studies and reports[3,4,10-28]. As discussed previously, the focus in past studies has been on simple environments and so the authors added a number of factors that might be expected to affect crash risk, particularly in urban environments. These additional factors fell into two categories and were mostly related to the roadside environment, rather than the road itself. One category could be considered to be related to indicators of exposure to risk, particularly for vulnerable pedestrians. For example, the existence of certain facilities for children (e.g. childcare, schools), the elderly (e.g. aged care), or even potentially impaired road users (e.g. licensed premises) would act to increase the number of these vulnerable road users, and thus their exposure to risk. The second category comprised factors related to the complexity of the roadside (e.g. development height). The decision to include such factors was informed by consideration of human information processing capabilities and limitations.

Expert opinion

Once the list of potential risk factors related to the road and roadside was compiled, it was sent to a sample of experts in the field for comment. The group of experts comprised road safety professionals from VicRoads, Transport Accident Commission, Victorian Department of Justice, Victoria Police and MUARC with backgrounds in a broad range of relevant areas, e.g. engineering, human behaviour, and law enforcement. They were asked to comment on the items on the list, and to add anything they felt might be important for predicting crash risk, particularly in complex environments.

Identification of data sources

Once the list of potential risk factors was finalised, possible sources of data for each of the risk factors were investigated. It was not possible to find an existing data source with good quality data for all of the potential risk factors. For those risk factors where there are no available existing data, consideration was given to efficient methods for collecting the data.

Results and Discussion

Data requirements

Table 1 displays the list of road and roadside characteristics for which good quality data are required in order to measure their influence on crashes for a particular location or road segment. The characteristics are classified according to whether they are related to measurement of exposure, the area type, speed, law enforcement, sociodemographic characteristics or characteristics of the roadway, intersections, or the roadside. For completeness, Table 1 also lists the outcome (crashes) as a data requirement. In addition, examples are given of specific data items, or variables, that could be collected to measure the characteristic.

Table 1. Characteristics for which data are required to measure the influence of the road and roadside on crash risk

	Characteristic	**Example data items**
Outcome		
	Crashes	Date, time, location, severity, type, road users and vehicles involved
Exposure		
	Traffic volume	AADT, Peak hour volumes
	Vehicle mix	% heavy vehicles
	Cyclist volumes	
	Pedestrian volumes	
Speed		
	Travel speeds	Mean speed, 85^{th} percentile speed (all vehicles and free speeds)
	Speed limit	
	Variable speed limits	Presence, variable speed limits, times of operation
Area		
	Metropolitan/Rural	
Roadway characteristics		
	Road function	Freeway/ arterial/ municipal
	Road type	Divided/undivided
	Segment length	
	Direction of travel	One-way/two-way
	Horizontal curvature	Presence of curves, number of

	Characteristic	Example data items
		curves, distance between curves, curve angle
	Vertical curvature/grade	Presence, number, distance, % grade
	Carriageway width	
	Lanes	Number, width
	Shoulder	Type, width
	Median	Presence, type, width, number of access points
	Line marking (centre line, edge line)	Presence, type
	Dedicated turning lanes	Presence, number of right or left turning lanes, indicator of whether middle lane is a turning lane only.
	Driveways/laneways	Number, type
	Service road	Presence, number of access points
	Bridges	Presence, number
	Passing lanes	Presence, number, length
	Special lanes (Bicycle, bus, transit)	Presence, width, length
	Guardrails/barriers	Presence, length
	Speed management devices (e.g. speed humps, chicanes)	Number, type
	Guideposts	Presence, number
	Clearways	Presence, distance, hours of operation
	Keep clear zones	Presence
	Parking/loading zones	Presence, type, length
	Pedestrian crossings	Presence, number, type
	Public transport	Type of route (e.g. bus/tram), number and type of stops
	Railway level crossings	Presence, type
	Lighting	Presence, type
	Road surface	Sealed/unsealed, macrotexture, microtexture, roughness, rutting
Intersection characteristics		
	Minor intersections	Number, type (i.e. number of arms)
	Major intersections	Number, type (i.e. number of arms)
	Control	Type
	Signal phasing	Type of right turn control
	Dedicated turning lanes	Presence, type
	Bicycle facilities	Presence, type
	Lanes	Number
	Skew angle	
Roadside characteristics		
	Obstacles (e.g. poles, trees, signs)	Presence, offset distance, number of frangible/ non-frangible
	Nature strip	Presence
	Footpath	Presence

	Characteristic	Example data items
	Pedestrian barriers	Presence, length
	Land use	Zoning
	Development/ buildings	Number, height, offset
	Retail	Trading hours, footpath trading (yes/no)
	Licensed venues	Number, type, trading hours
	Educational facilities	Presence, number
	Healthcare facilities	Presence, number
	Aged care facilities	Presence, number
	Churches	Presence, number
	Public transport	Presence of train stations
Enforcement		
	Camera locations	Number, type
Sociodemographic factors		
	Population data	Population density, age structure
	Socio-economic status	Socioeconomic index
	Access to vehicles	Vehicle ownership rates

Measurement of environmental complexity

One of the main challenges in characterising urban environments is in capturing visual complexity. Thought was given to whether a single measure of the complexity of the visual environment might be appropriate for inclusion in accident prediction models. However, a univariate measure of visual complexity for dynamic, complex, real-world environments has not yet been developed. Previous research has identified a number of different features that make the driving environment appear more visually complex to a driver[29] and many of these factors are already included in the compiled list (e.g. number of signs, signals, on-street parking and other traffic). As such, a univariate measure of visual complexity was deemed unnecessary and may, in fact, serve to obscure which aspects of the complex visual environment contribute more to risk than others.

<u>Data sources: existing databases and methods for collection</u>

Existing databases that could be used to obtain the required data were identified. Data on some characteristics (e.g. crash data, traffic volumes for arterial roads, and a limited number of the roadway characteristics) is generally available from the administrative databases of road authorities. It is worth noting, however, that this is often only available for arterial roads (crash data are the exception to this). In addition, permission to use the data is often required, and there may be a cost involved. Other government department administrative databases may also be used for sourcing data on aspects such as zoning, location of enforcement cameras and liquor licences. Socio-demographic data can be obtained from the Australian Bureau of Statistics (ABS). It is important to note, however, that the population data only reflect the characteristics of the residents of a particular area, not those who regularly travel through that area. Better travel exposure data would be extremely useful for this purpose.

For many of the characteristics identified, no existing data sources were found with information about those characteristics. For example, travel speeds are not collected for every road (or even arterial road) on the network. Data on cyclist and pedestrian volumes is not consistently collected and is extremely limited.

Data on a large number of the roadway and roadside characteristics cannot be obtained from standard existing data sources. Many, however, can be obtained and coded from detailed maps, site visits or on-line imaging sources (e.g. data on medians, road shoulders, turning lanes, driveways, roadside furniture such as barriers, obstacles, on-street parking, presence of schools etc.). Collecting such data is time consuming and detailed information such as accurate distance measurements (e.g. offset distances) cannot be obtained. In this case, the digital video data of arterial roads collected by the ARRB group[30] for state road authorities (e.g. VicRoads) is an invaluable resource and can also be used to obtain data on many of the other road and roadside characteristics. There is a cost involved, either to purchase the software that is necessary to view and analyse the images, or to pay for ARRB personnel to rate (or code) the data according to specifications. In addition, permission is required from the authority that owns the digital video data.

Essential data characteristics

For the data to be useful for measuring the influence of the road and roadside factors on crash risk, it is absolutely vital to have geolocation information for many of these characteristics. When conducting this type of research on a small scale, the manual collection and coding of data for each road segment of interest can be time-consuming but is achievable. However, once accident prediction models and risk assessment tools are developed and ready to be applied to assess risk across the whole road network, it will be essential to have georeferenced data on the risk factors included in the models in order for them to be used widely. It is recommended that data collected on each of the characteristics are georeferenced accurately. Even if the model only requires a broad level of detail (for example, the proportion of the road segment with pedestrian barriers), having each instance of the particular factor (in this case, the location of pedestrian barriers) individually georeferenced means that if the definition of the start and end of the road segment changes, the raw data can still be used to derive the measure of interest.

Comparison to other lists of data requirements

In comparison to other researchers and organisations that have identified data requirements for accident models designed to investigate the effect of the road and roadside on crash risk[2,3,4], our list is larger and more comprehensive. The main difference lies in the much greater emphasis on collecting data on characteristics that describe the roadside and surrounding environment (e.g. development height, presence of schools, churches, licensed establishments).

Other uses for detailed data on the road and roadside

Although the main focus when developing these data requirements was on road safety planning, the data can also be used for other purposes. A georeferenced data source with information on the location, and potentially the condition, of the road and roadside assets would be of much benefit to road authorities for asset management purposes. In addition, the detailed data collected about urban environments in general could be used for research in other areas of population health, such as investigating the determinants of public transport safety or street violence.

Conclusions and future steps

We have identified a comprehensive list of characteristics of the road and roadside that may be related to crash risk, with a particular focus on complex urban environments. Although the list was compiled with the Melbourne metropolitan area in mind, with minor modifications according the local context, it would also be relevant for other regions in Australia and overseas. While research to develop accident prediction models may indicate that not all of these factors are predictive of crash risk, they cannot be ruled out as potential risk factors without explicitly assessing their impact. The next step is to determine which characteristics are predictors of crash risk using accident prediction models so they can be incorporated into risk assessment tools. Progress in the related activities of identifying data requirements and developing accident prediction models and risk assessment tools are essential if Australia is to achieve the aims of the Australian road safety strategy (2011-2020)[1].

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