TOWARDS THE SECOND DECADE OF ACTION FOR ROAD SAFETY: IMPROVING CRASH DATA RECORDING IN SOUTH AFRICA

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ABSTRACT

The National Road Traffic Act, 1996 (Act 93 of 1996) (Department of Transport, 1996) requires that all crashes be reported to any police officer at a police station, or any office set aside by a competent authority (e.g., Metro Police), using the official Accident Report (AR) form. Although this form is relatively comprehensive in comparison to the USA and Europe, certain details are still filled in at the discretion of the official populating the form. One detail that is often omitted, is a spatial reference (coordinate) information of where a crash has taken place. Currently, virtually no fatal crashes reported to the Road Traffic Management Corporation (RTMC) have coordinate information included.

This research demonstrates the importance of coordinate data in crash reporting and subsequently, in implementing mitigating measures to reduce fatalities. The study draws from countries where the recording of spatial reference is well-implemented. This study is important for South Africa in the current conjuncture of road safety. South Africa is a signatory of the United Nations Decade of Action (UNDoA) for Road Safety, and part of the global efforts to reduce the number of crashes by half by 2030 (RTMC, 2022).

1. INTRODUCTION

In August 2020, The United Nations General Assembly issued a new resolution that proclaimed the period 2021–2030 as the Second Decade of Action for Road Safety, aiming to reduce road traffic fatalities and injuries by at least 50%. South Africa, as both a member state of the United Nations and a signatory to the declaration, has a responsibility to curb road carnages and reduce road traffic fatalities and injuries by at least 50% from 2021 to 2030.

Under this commitment, the National Road Safety Strategy (NRSS) 2016-2030 has been developed, embodying the principles of the Safe Systems Approach, giving effect to the five pillars of the United Nations Decade of Action (UNDA), a guiding framework for actions to improve road safety (Department of Transport, 2017). Following the UNDA, these pillars remain consistent in the NRSS as safe users, multimodal transport & land use planning, safe road infrastructure, safe vehicles & speed, and post-crash & medical care (iRAP, 2023).

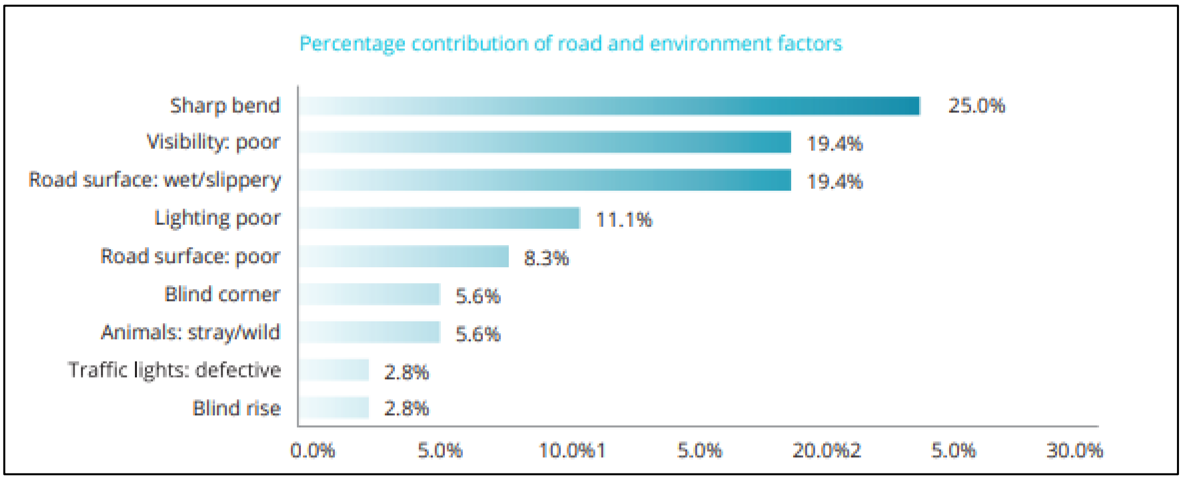

Figure 1: Road and environmental factors resulting in fatal crashes (RTMC, 2014)

The NRSS has emphasised the road & environment as an important factor behind road crashes. The role of the road and environment in South Africa is also consistent with other countries in Africa and the rest of the world (Borsos et al., 2015; Lomakin et al., 2018). In South Africa, the road and environment cause more than 10% of all fatal crashes (RTMC, 2014). Within the category, factors include sharp bends (25%), poor visibility (19.4%), wet road surface (19.4%), and many others as shown in Figure 1 (RTMC, 2014).

One of the primary objectives of the National Road Safety Strategy (NRSS) is to locate and address high-risk areas that pose road and environmental hazards. Identifying these areas, or 'hotspots', is critical to enabling authorities to take appropriate measures to mitigate risks. Simply identifying hazardous locations by a link, town, or section is insufficient to allow for effective mitigation measures that enhance road safety. Therefore, it is essential to implement various engineering interventions and other measures at these hotspots to mitigate the risks and improve road safety for everyone.

1.1 Aim of Paper

The objective of this research is to showcase the vital role of geographical coordinate data in crash reporting. This data can be leveraged to implement effective measures aimed at reducing road fatalities. The study draws inspiration from countries that have a well-established practice of spatial reference recording. The findings of this study hold immense significance for South Africa, particularly in the current landscape of road safety. South Africa's participation in the United Nations Decade of Action (UNDA) for road safety makes this research a crucial component of global efforts to reduce the number of crashes by half by 2030 (RTMC, 2022)

1.2 Problem Statement

The role of road and environment in crashes is well-documented in South African policies, such as the NRSS. Furthermore, the NRSS alludes to the need to identify crash locations to address road and environmental challenges. The National Road Traffic Act, 1996 (Act 93 of 1996) (Department of Transport, 1996) requires that all crashes be reported to any police officer at a police station, or any office set aside by a competent authority (e.g., Metro Police), using the official Accident Report (AR) form.

In terms of fatal crash data, the process of recording and consolidating road fatalities is the responsibility of the Road Traffic Management Corporation (RTMC). Culpable Homicide Crash Observation Report (CHoCOR) forms are used to collect fatal crash data daily. The South African Police Service (SAPS) is the primary source of the fatal crash data. RTMC receives a list of all recorded fatal crashes from SAPS, as well as the CHoCOR forms from the various police stations. The RTMC then captures, processes, and verifies the data to compile a consolidated annual report. Despite the failure to substantially reduce the number of fatalities, the contents of the form have never been interrogated. The quality of data on the forms, and the comprehensiveness of crucial infrastructure details that are recorded, have not been improved.

Although South Africa's policy and legislative framework for collecting and archiving crash data is relatively sound when compared to the USA, and Europe, certain loopholes still exist. For instance, the forms used to record crashes allow the official on duty, to decide which details to include. One crucial detail often omitted is the spatial reference (coordinate) information of where the crash occurred. Currently, all fatal crashes reported to the RTMC lack coordinate information, which means that the location of the crash is imprecise. The SAPS or metro police officer attending fatal crashes need to record this crucial bit of information onsite. In South Africa, crash data recording is still a manual process at the point of collection, as explained earlier in this paper. There are standard location variables recorded for each crash, including the province, district, municipality, and town name. Moreover, there are specific details used to capture the precise location of crashes, which will be discussed in more detail.

1.2.1 Intersection (node)

A node is a specific intersection within which a crash has taken place. Although this is by far the least erroneous and relatively precise compared to other methods used in South Africa, there are still errors, as some of the intersections are captured incorrectly, due to spelling mistakes. A serious concern with this method is that, if a crash is located outside the intersection area, the authorities often capture the crash at the intersection. Ideally, like other countries, such as the USA, UK, and Australia, when a crash is outside the intersection area, a 'link-node' method is used. An example is "100 meters from the South leg of the intersection of ABC and DEF Street''. This is relatively accurate as it takes into cognisance, the offset distance from the intersection. However, in the case of South Africa, the actual intersection is specified as the crash location instead of specifying the offset distance of the crash from the intersection. This leads to the crash location being incorrectly recorded. Another challenge is that the authority recording the names may use old street names. In cases where street signs are damaged or vandalised, the authority capturing the name might capture further inconsistencies.

1.2.2 Street/Road (link)

A link is a specific street or road where a crash has occurred. Using the street as the crash location is not enough, as some links are long and not easy to navigate. Using the town name to supplement provided link details is still not precise enough to be used as a crash location, as the link or road/street is still too long to use to identify a crash location. In the case of roads under the jurisdiction of the South African National Roads Agency (SANRAL), there are Kilometre markers to help road users navigate location and direction. These road markers are also used to alert emergency medical services in cases of crashes or vehicle breakdowns. On urban links, recording the house number adjacent to the crash location would assist in improving crash location information. Other markers such as street light pole numbers can also be used as reference points for indicating crash locations, but this is not done in South Africa.

1.2.3 Landmark

This is a specific, notable landmark, sign, or structure. An example could be a dam, building, or road sign. The problem with the use of landmarks without coordinates is that they cannot always be precise, as some landmarks, such as stadiums, schools, or hospitals, have a big footprint. Another challenge with the use of landmarks without the use of reference distances or coordinates is that, in cases where the crash is located some meters from the landmark, authorities do not specify the distance and they simply use the landmark as a location. This leads to crashes being incorrectly recorded.

After a car crash occurs, data is collected and recorded in the Road Traffic Management Corporation (RTMC) database using Microsoft Excel. Different variables related to the location of the accident are captured and arranged using various descriptors. However, certain variables, such as road grade and curvature, are difficult to measure accurately during a crash investigation, as the police officers on the site are usually in a hurry to clear the scene. Moreover, some variables require the expertise and training of specialised individuals like road safety auditors, accident reconstruction experts or engineers. Since police officers on the site are not trained road safety practitioners, the accuracy of their recordings is not guaranteed. Therefore, the database itself has certain limitations, as the recording of data on-site cannot be fully relied upon.

2. LITERATURE REVIEW

Section 1.2 outlines some of the challenges involved in recording crashes in South Africa. One of the main challenges is the national fatal crash database system, which is simply an Excel spreadsheet of crashes without geographical coordinates. This makes it difficult to map crashes accurately and prevents the data from being exported to other formats and applications like Geographic Information Systems (GIS) for further analysis. To address this, the authors have studied how other countries record crash data and what outputs are generated from their databases to identify best practice interventions that can be adopted in South Africa.

2.1 Global Best Practices on Crash Data Collection Methodology

Road crashes are spatial events tied to a specific location (Imprialou et al., 2014). Investigation of crash hotspots represents an important criterion in road safety management. Any errors in detecting high-risk segments result in identifying the risky segments as safe or vice versa and, therefore, can lead to inadequate allocation of financial resources (Mohaymany et al., 2013). Poor quality crash data hinders successful road safety analyses and therefore affects road safety interventions (Imprialou and Quddus, 2019).

However, crash reporting is still evolving and improving. Although there are significant improvements, the most fundamental information needed for records and analyses has not changed much. The five questions (five W’s): crash location (where?), crash time (when?), crash severity (what?), involved users and/or vehicles (who?), and crash contributing factors (why?), are the most important (Derdus et al., 2014). They inform data requirements when recording crash information. The process and ease of recording area-related question ‘where’ is evolving with much speed. Technological advances are making ways of recording crash locations both convenient and precise, with minimal to zero errors.

Due to a lack of financial resources, and in some instances, enforcement, and despite limitations, police crash reports are still the main source of data for road safety research

(OECD/ITF, 2015; Miler, Todic and Sevrovic, 2016). As a result of these methodological shortcomings, errors in crash data are prevalent in many countries around the world including the USA (Dutta et al. 2007, Qin et al. 2013), UK (Imprialou, Quddus, and Pitfield 2014, Imprialou, Quddus, and Pitfield 2015), Australia (Howard, Young, and Ellis 1979), China (Wang, Zhang, and Mao 2013), and Canada (Burns et al. 2014)). According to Ahmed (et al., 2019), the extent of error ranges from 7% to 88%. There are three main methods for the localisation of crashes, depending on the type of information recorded or supplied. These are as follows:

i) Link-node or address field

With a link-node or address field, the crash location is identified by using distance from a node or address approach, with known points along the road being identified as nodes.

ii) Route-kilometre point

Route-kilometre point uses a unique route number or location identifier. This is normally used on highways. In the case of National Roads under the jurisdiction of ~~the~~ Highways England, route markers are placed every 100 meters. Typically, they will bear two numbers, kilometres at the top and tenths below. On motorways, they will also have a symbol pointing to the nearest emergency telephone.

iii) GPS-based approach

This is the most precise of the three methods. A more exact location (geographic x-y coordinates) is obtained using Global Positioning Systems (GPS) units or more recently, mobile phones. Geographical coordinates are recorded at the scene of the crash. This method eliminates errors related to spelling or description of the area. This method is also easy and quicker to use. It is also more agile as it can be used with handheld phones and GPS devices.

2.2 The Use of Coordinates to Enable Formulation of a Geocoded Crash Database

GPS or satellite navigation systems are commonly used by authorities to accurately determine the location of a crash. Instead of using traditional terms like street names and distance markers, the person attending the accident scene can use GPS to pinpoint the exact location of the accident. This is particularly useful in rural areas where it can be difficult to identify landmarks and distance markers. Recording accident locations using a geographical information system (GIS) or digital mapping allows the data to be incorporated into a relational database, providing valuable information on road features, traffic flows, intersection layouts, and land uses. Advancements in technology have made it easier to collect and assess safety-related data. For example, many smartphones now have camera applications that record GPS information, which can be used to accurately record accident sites and pin pictures to map applications. This technology can greatly assist in conducting initial accident investigations, but it is important to be mindful of personal information protection (RTMC, 2022).

The use of coordinates as part of crash data collection is very imperative in the efforts to reduce road crash injuries and fatalities. The use of coordinates for crash data analysis allows crash data, roadway inventory data, and traffic operations data, to be merged to identify road crash hotspots. They can also be used to assess the effectiveness of safety improvements. Precise crash location attained with the use of coordinates also allows road safety practitioners to evaluate crashes as particular nodes, links along specific roadway segments, clustered around a specific roadway feature, or within a particular corridor. Road safety practitioners can also use GIS software to select subsets of crash data using any number of elements contained in the crash and roadway inventory data files. From this, they can establish possible relationships between crashes and particular features, such as geometry (curves) and topography (e.g., grade) (Sarasua et al., 2008). Furthermore, practitioners can use this data to study relationships between crashes and a variety of other variables, such as environmental and social characteristics, including alcohol outlets, schools, stadiums, etc (Bigham et al., 2009)

2.3 Features of a Good Crash Data Systems

According to The World Health Organization (WHO, 2009), a good crash data system should have the following features:

- Built-in quality check (algorithms and logic checks).
- GIS linkage to allow accurate identification of crash location.
- Ability to add new data fields without re-developing the database.
- Database navigation features such as drop-down menus, and clickable maps.
- Pre-defined queries and reports.
- Option for customised, user-defined queries and reports.
- Mapping ability, for data entry, crash selection and presentation of aggregated crash information.
- Ability to export data entry to third-party applications (e.g. Microsoft Excel, Statistical Analysis Software (SAS) for further statistical analysis.
- Inclusion of crash narrative sketches of crash scenes, photographs and videos linked to the crash.
- Automatically generated collision diagrams.

Most developed countries have most of these features and thus, good crash databases. Geographical coordinates are key to having a reliable crash database that can be subsequently used for further analyses. Table 1 illustrates similarities and contrasts between some developed countries and South Africa in terms of details of typical crash location variables.

Table 1: Variables used for crash location in different countries

Country	References	Variables used for crash location(s)	Outputs
EU	Montella et al., 2013	Crash location coordinates, name of the road(s), name of intersection	Geocoded crash database
UK	Imprialou et al., 2014 Imprialou et al., 2015	Crash location coordinates, road name type, vehicle direction of travel	Geocoded crash database
USA	Tegge & Ouyang 2009, Qin et al., 2013	Crash location coordinates, names of major intersecting highway/street, municipality, county, land use, land jurisdiction, distance from intersection	Geocoded crash database
Canada	Burns et al., 2014	Crash location coordinates	Geocoded crash database
China	Loo, 2006	Crash location coordinates, grid references, road names, district board	Geocoded crash database
Australia	Thompson et al., 2023	Crash location coordinates, location (metro or rural)	Geocoded crash database
South Africa	RTMC database, 2023	No crash coordinates, road name, municipality, town	Crash database **not** geocoded

The variables in Table 1 are explained in more details as follows:

European Union (EU)
The European Union (EU) directive on crash data is to measure the location 'as precise as possible location' (Montella et al., 2013). With this situation in mind, the recommendation for the Common Accident Data Set (CADaS), consisting of a minimum set of standardized data elements, was developed. The EU CADaS requires the use of GPS coordinates to measure crash locations by all member states (Montella et al., 2013).

United Kingdom
Typically, law enforcement officers are responsible for documenting data related to road traffic collisions. This includes identifying the crash location, which can be accomplished through various methods, such as spatial variables like road names and proximity to junctions, and linear referencing systems that utilise defined markers along the roadway or GPS or national grid coordinates (Imprialou et al., 2014).

United States of America
In the USA, at a national level, according to the Model Minimum Uniform Crash Criteria (MMUCC), the optimum definition of crash location is a route name and GPS or GIS information (Montella et al., 2013). All crashes are recorded with coordinates. In terms of keeping data, the United States has specialised safety databases at the national level such as the Fatality Analysis Reporting System (FARS) and the Highway Safety Information System (HSIS). FARS includes fatal injuries suffered in traffic crashes collected from all U.S. states (Montella et al., 2013).

Canada
In Canada, crash record coordinates are obtained directly from GPS units at the scene of the accident, mitigating errors related to address descriptors and spelling, and potentially enhancing location accuracy. Additionally, Canada employs geocoding techniques for Traffic Collision Record Mapping, as outlined in Burns et al. (2014).

China
China has advanced surveillance technology that enables them to locate road crashes with precision, both in Hong Kong and Mainland China. They use geographic information systems (GISs) to create measures of the built environment and the road network structure. This includes the road network, intersections, land-use characteristics (such as residential, commercial, and industrial), and the degree of development (such as population and employment densities). Studies have been conducted on these measures to gain more insight into road crashes in China (Loo, 2006; Hu et al., 2020)

Australia
To enable the geocoding of crash location for GIS purposes in Australia, the minimum requirements include street name, reference point (which is a significant local feature that can be located on a map), and direction and distance from the reference point. (Montella et al., 2013; Imprialou & Quddus, 2019).

2.4 Improving the Accuracy of Crash Location by Including Geographical Coordinates

While latitude and longitude play a crucial role in spatial analysis, they are not always included in crash reports. GPS technology is commonly utilised to pinpoint precise crash locations, but its accuracy can be impacted by a variety of factors, such as time of day, GPS orientation, site conditions, satellite availability, and weather conditions (Green &

Agent, 2004). Additionally, there are instances where latitude and longitude are inputted with errors or without sufficient precision. Even with integrated GPS in a laptop computer, incorrect coordinates may be acquired by activating the GPS away from the crash site or back at headquarters (Sando et al., 2010). In Louisiana, less than half of crash records had accurate coordinates within 10 meters of the road. It is therefore crucial to validate the accuracy of crash data and correct any inconsistencies. This issue has been identified as a significant problem in Italy and the United Arab Emirates and is considered one of the most significant challenges when it comes to crash data quality (Hawas et al., 2012). Researchers have since developed different types of algorithms to solve the geocoding problem. An early study was conducted by Levine and Kim (1998) to find the correct location of the crashes occurring in Honolulu. Others have since been developed and can improve accuracy by more than 95%.

A 2004 study in Hong Kong, could validate 99.1% of the crashes and could then be used for further analysis with 100% crash location accuracy (Loo, 2006). A study in Kentucky conducted between 2007 and 2009 found that GPS coordinates improved accuracy levels in the area by up to 71% when recorded manually, and by up to 92% when recorded digitally before being validated (Green and Agent, 2010). Bigham et al (2014) conducted a large-scale operation to geocode California collision data and determined that 91% of collisions from GPS data could be geocoded and that 97% of those locations were accurate.

Between 2009 and 2013, a thorough four-year study was conducted in Ajmer City, India, to address road safety concerns more methodically. The study utilized GPS technology to document crash locations and GIS to create a comprehensive database on road accidents. The findings indicated that GIS was an effective tool for analysing the intricate nature of these accidents. The study highlighted that road safety is often dealt with in an impromptu way, but the establishment of a database facilitated proper accident analysis and the development of effective traffic management strategies. In essence, this pilot study showcased how GIS can be practically applied to create an efficient database on road accidents, using Ajmer City as a prime example (Bhalla et al., 2014).

3. DISCUSSION

All countries in Table 1 (except South Africa) have geographical coordinates as a compulsory variable for crash locations. The countries reviewed have a geocoded crash database as a result. Over and above the geocoded database, these countries can carry out further analyses and research, as each location can be precisely identified. Good quality of data also means these countries are better equipped to come up with adequate intervention measures to reduce fatal crashes. The African Development Bank (2014) gives guidelines on how road safety authorities should approach problems relating to crash data. In the case of South Africa, where there is crash data but limited location information, the document recommends improvement of data through the inclusion of coordinates and area analysis as shown in Figure 2.

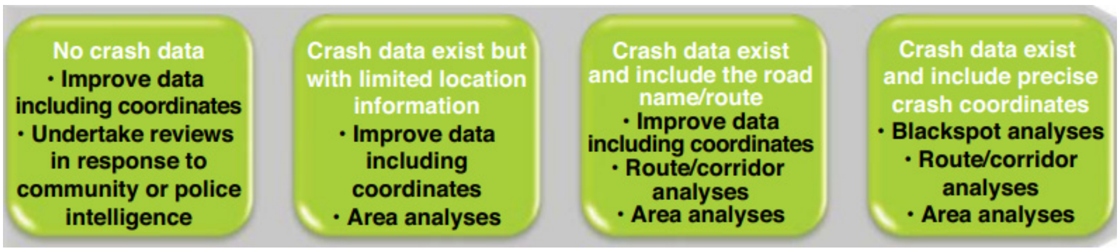

Figure 2: Managing road safety on existing roads (African Development Bank, 2014)

It has been identified through research that there are areas of improvement in South Africa's crash reporting system. These areas are related to the training of officials filling in crash forms, the process of recording crashes, and the crash database system. Firstly, officials recording crash data should be trained on how to record all variables consistently and accurately on the form. Secondly, it is important to ensure that geographical coordinates are filled in when recording crash data. While resources may be a challenge, GPS devices are no longer necessary, as smart cell phones can be used to provide data to police officers at crash sites. These interventions should be made compulsory to officials filling in accident forms on crash sites.

Capturing the geographical coordinates of accident scenes can provide valuable insights for road authorities and safety practitioners in South Africa to thoroughly analyse each fatal incident. By pinpointing the hotspots, appropriate measures can be taken, allowing for more accurate and effective improvements to roads and the surrounding environment. These enhancements can be evaluated through before-and-after studies, supported by a geocoded crash database and GIS-mapped incidents. Policymakers can then make informed decisions on potential investments based on cost-benefit analyses. While developed countries already possess geocoded databases, there is a lack of literature on this subject in developing countries, such as South Africa. By contributing to the global research community, South Africa can help to expand the body of knowledge and literature available on this topic.

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