INVESTIGATION INTO COLLISIONS FOR RIGHT TURNING VEHICLES

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Abstract

Despite on-going improvements in road design standards and a heightened public awareness of traffic safety issues, regrettably there still remains an unacceptable level of collisions on our road networks. Current Northern Ireland (NI) research and published statistics attributes the causation factors of these collisions for the most-part to driver error [1]. However, conflicting research indicates that road geometry and other physical elements contribute to Road Traffic Collisions (RTCs) [2]. This paper critically investigates and evaluates the issue of design standards and right turn RTCs and aims to indicate to what extent road geometry contributes to RTCs. The study adopted a two-fold approach, namely involving the analysis of quantitative right turn collision statistics, while identifying the qualitative opinions of professionals in the field of road design and safety engineering. Ultimately it was concluded that there is an association between the number and severity of right turn collisions and junction form.

Keywords: Road Geometry, Right Turn, Junction, Road Traffic Collision.

1 Background

There has been a steady reduction in the number of fatalities on Northern Ireland's (NI) roads in recent years. The average number of fatalities per year between the years 1996 and 2000 was 152, however this dropped to just 52 in 2011/2012 [1]. Possible contributing factors to the sudden reduction in the Killed and Seriously Injured (KSI) on the road network is the economic downturn and spiralling fuel costs, which has resulted in an associated decrease in the traffic volumes on the roads [3]. A reduction in car use would intuitively lead to a lower probability of a collision occurring and therefore, a fall in KSIs [4]. However, the Police Service of Northern Ireland (PSNI) published statistics have shown a contradictory increase of 1.7% in recorded Road Traffic Collisions (RTCs) between 2011/2012 compared with the previous year. Unofficial contact with the PSNI has confirmed that the trend has continued to rise between 2012/13.

There was 5,639 recorded injury RTCs in NI between 2011/12 [1], which resulted in 8,830 casualties. Of these, 8% (435) were incidents involving vehicles "emerging from a minor road without care". Another issue noted as being problematic within the PSNI report was "turning right without care", which caused 6% (536) of the casualties. These observations confirm that manoeuvres at junctions cause collisions. The associated PSNI commentary stresses driver error as the primary and only causation factor by suggesting that the driver acted "without care". However, there were no descriptions of the layout or geometry of the road in the vicinity of the collisions in the published statistics.

A PSNI guidance document published on the statistics also indicates that these collision histories are based on Police Officer's opinion and may not be as a result of an investigation [5]. The subjectivity in the causation factors inspires speculation regarding the reliability of the notion that collisions are occurring solely as a result of driver behaviour. This is something this paper explores.

2 Previous Research

For many years investigations have been conducted into the cause of road collisions to establish possible contributions to collisions [6,7]. Research carried out by Schwing [8] recognises the fact that there is more than one cause to most collisions, and his work has attempted to quantify the contributory factors to collisions. The PSNI statistics aforementioned attributes driver error as the main cause of collisions on NI roads. However, bodies like EuroRAP recognise that the physical engineering of the road network can have a major influence on collisions. The EuroRAP design assessment makes reference to roads being designed to be "forgiving", with side impacts at junctions being listed as one of the 4 types of collisions that account for disabling injuries and deaths across Europe [9]. Furthermore, it has been shown that there is a correlation between road markings distance between arms of a junction and the number and severity of collisions [10]. Moreover certain junction configurations have been shown to have an effect on the number of right turn collisions [2]. Research in the United States indicates that as many as 16% of all intersection reported crashes involve left turns, the same as right turns in the UK and Ireland [11]. Conversely, other researchers do not link road geometry to RTCs [12]. It is obvious that there is a lack of consistency in the research regarding causation factors, justifying this investigation into the issue of the influence of road geometry on RTCs.

3 Aims and Objectives

The aim of this work was to investigate the hypothesis that there is a correlation between road geometry and right turn collisions. To explore this premise, the following objectives were considered. Initially a study was made of previous research in the area inclusive of current and past design standards. Secondly the study relies on the quantitative data to deduce the association between road geometry and right turn RTCs; however, differently from previous studies this work considers the qualitative data reflecting the experience of working professionals. The consultations made with professionals in the field of Road Safety and Highway Design introduced experience and perspective into the qualitative analyses. This also ensured validity and included representation of current practice. This secondary aspect of the work allowed for cross referencing of results to ensure validity and reliability. It also enabled professional opinion and experience to be a factor in the types of quantitative analyses conducted.

4 Data and Methods

4.1 Data Collection

In order to identify the contribution that road geometry has in right turn RTCs, an exclusive PSNI dataset detailing previous right turn collisions was acquired. The data detailed 2838 right turn RTCs that occurred in NI over a ten year period from January 2001 until December 2011. Details included in the dataset were the date, the region and the junction form at which the collision took place, as well as the number of casualties resulting from each collision.

It was important that the conflicting opinions of research and statistics were investigated. Subsequently an open ended questionnaire was developed and communicated to professionals working in road design and safety engineering, to receive feedback on elements of the work including past and current design standards, and their opinions on junction geometry, turning movement collisions and causation factors.

4.2 Quantitative Analysis

Statistical Package for Social Sciences (SPSS) was utilised to analyse the primary quantitative PSNI data. Before commencement of analytical statistics, the dataset was refined to eliminate spurious elements that would invalidate the dataset. Next, the data had to be assigned a type of measure.

The type/measure of variables included in the dataset dictated the type of analyses implemented. The dataset provided by the PSNI was refined in such a way that there were no missing values. This increased the accuracy and reduced the likelihood of bias in the results.

Analysis types used included Descriptive, Parametric and Non-Parametric techniques. Descriptive analysis gave an overview of trends in the data through frequencies and cross tabulations. Other techniques explored the validity of the descriptive analysis. Parametric techniques were undertaken through T-Tests and one way Analysis of Variance (ANOVA). Non-parametric techniques were used where parametric techniques were not possible. The prominent type of non-parametric technique used for the analysis was the Chi-Square test. This test was used in conjunction with cross tabulations.

4.3 Qualitative Consideration

The questionnaire was designed to extract the maximum information from professionals working within industry. The wording of the questions was such that they allowed each individual to give an in-depth discussion on their own area of expertise which resulted in the broadest work-area perspectives. The qualitative data was also utilised to explain and validate the other trends in the quantitative data.

5 Results

5.1 Quantitative Results

Of the 2838 right turn collisions analysed, 1.1% (32) was fatal, 12.8% (363) were serious and 86.1% (2443) were slight collision. The following are the salient observations.

Time Trends

Most of the fatal right turn collisions (28%) occurred in the morning timeband of 0800-1200 (Figure 1).

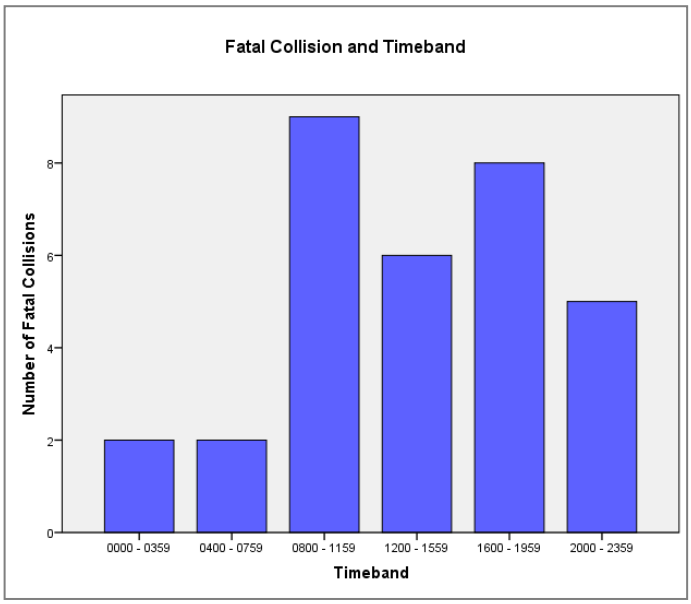

Figure 1 The time of fatal collisions

Conversely, most of the serious and slight collisions (35%) occurred in the evening timeband of 1600-2000. Overall, 82% (2318) of all the right turn collisions throughout NI occurred between 0800-2000, embracing the morning and evening rush hour traffic. The Chi-Square test confirmed a significant association between collision type and timeband, (10, n = 2838, p = .031). Additionally, more collisions occurred on a Friday (17%) than any other day of the week. These collisions occur in early afternoon (1200-1600) as expected.

The analysis revealed that 0000-0400 is a critical time for collisions at weekends. Of all the collisions that occurred in this time period, 61% (29) occurred on a Saturday or Sunday. ANOVA analysis also indicates that there are significantly more casualties at weekends F(1, 2836) = 11.121, p = .001).

Junction Type

A comparative analysis highlighted a linkage between collision numbers and junction type. As expected, the results indicate that 65.2% (1849) of all the right turn collisions that occurred over the ten year period happened at T-junctions. Staggered right junctions also perform poorly, contributing to 18.1% (514) of right turn collisions, as shown in Figure 2.

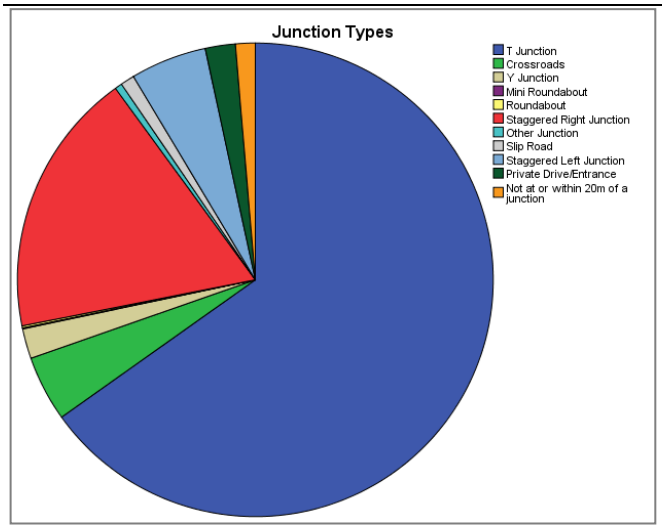

Figure 2 Outline of the frequency of collisions with junction type

An independent T-Test further explored the average number of casualties at T-junctions compared to all other types of junction, and highlighted a significant difference in these averages (assuming not equal variances) with p = .004, confirming more casualties occurred at T junctions than the other types of junction.

Location

The PSNI data recorded the general location in which the collisions occurred. The locations are described by 30 NI policing areas. The Moyle district had less than 1% (19) of all the right turn collisions, fewer right turn collisions than any other region. This is reflective of the rural nature of the area. The worst performing area is Lisburn which had 7% (205) of all the collisions that occurred. Other areas performing badly overall for right turn collisions include:

- South Belfast: 6.4% (182).
- North Belfast: 5.8% (167).
- East Belfast 5.7% (164).
- North Down 4.2% (118).

The analysis also shows that all 32 of the fatal collisions that occurred in NI pertained to only 16 areas. This figure suggests that collision history is localised and a function of population density, rural/urban and junction type predomination. These locations are shown in Figure 3.

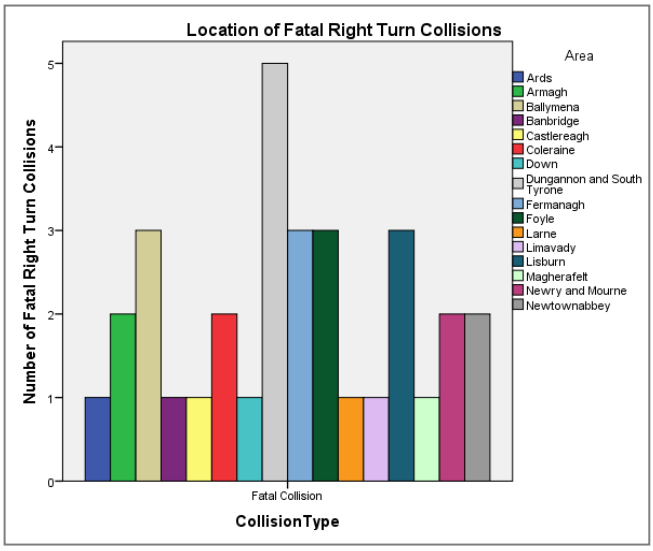

Figure 3 Location and number of fatal collisions in NI over 10 year period

Micro investigation into these locations would reap a deeper understanding of contributing factors to the collision history. Of all the fatal collisions that happened in NI over this ten year period, 16% (5) occurred in Dungannon and South Tyrone, a relatively rural area. This comes somewhat converse to the previous PSNI analysis which suggests traffic volumes influence right turn collisions. It can also be noted that Belfast had no fatal collisions, another region which experiences high traffic volumes. A refined analysis including additional information e.g. population density information, traffic volumes, collision details could help identify the major contributing factor, namely: traffic volumes, road type, or driver behaviour.

5.2 Qualitative Results:

The consultations with engineering practitioners yielded some interesting observations. All the professionals identify crossroads and staggered junctions as having significant safety issues within the transportation network. As expected all noted the relationship between traffic volumes and the number of collisions, which correlates with published research [4].

There was a wide range of conflicting answers regarding the causes of right turn collisions. A number of professionals made reference to the improved design standard for Major/Minor priority junctions, TD42/95. This standard details design issues that can arise with right turn movements and gives guidance on such. A minority of the professionals stipulate that right turn collisions arise due to driver error and incapacity to cope with certain situations. One professional recognises the in-consistency in police reporting which can lead to inaccurate diagnosis of causation factors, and subsequently incorrect statistical analysis and ineffective remediation. The majority of the interviewees agreed that junction configuration and turning movement has a significant factor for collision causation.

6 Discussion:

6.1 Time and Location

Statistical consideration of the data confirmed that most right turn collisions are slight collisions, with 86.1% of the collisions analysed being recorded as slight. 12.8% of the collisions were serious and 1.1% was fatal.

The analysis indicates that the most common time for serious or slight right turn collisions to occur between 1600-2000. 35% of all serious and slight collisions occurred at this time. This time coincides with the evening rush hour, where driver fatigue is a contributing factor.

The area with the highest number of serious and slight collisions was Lisburn, with 7% (26) and 7% (176) respectively, with most of these collisions also occurring at the timeband of 1600-2000. As expected Lisburn experiences disproportionate morning and evening peak traffic being a city itself, and also forming part of a commuter route to the wider Belfast area.

Interestingly Dungannon and South Tyrone had more fatal collisions than any other region, having 16% (5) of all the fatal collisions, only 2.7% (10) of the serious collisions and 2.7% (66) of the slight collisions. This is regarded as a more rural area, and less prone to the effects of rush hour traffic, which puts into question, if traffic volumes primarily contribute to the number or severity of right turn collisions.

Similarly Fermanagh, Foyle and Ballymena, locations that are deemed more rural than Lisburn, recorded 9% (3) of the fatal collisions each. These results suggest that rural locations have more fatal collisions than urban areas. Conversely, Lisburn had 9% (3) of the fatal collisions, and performs poorly for all types of right turn collisions. This pattern suggests that the miles of road network in the respective region, the number of junctions in an area, or specific problematic junctions are the key factors and not traffic volumes.

Urban and rural locations may have different driver mentalities as well as junction alignments and approach speeds, possible contributing factors in the respective areas. An investigation into this using Northern Ireland Statistics and Research Agency (NISRA) statistics [13] was conducted to compare similar regions with different statistics: Foyle and Lisburn. Both these regions recorded 9% of the fatal collisions, yet their social statistics differ greatly, as shown in Table 1.

Region	Foyle	Lisburn
Average Age	32.8	36.4
Population Density	2.71	1.85
No. Collisions	152	205
No. Fatal Collisions	3	3

Table 1 Statistics for Foyle and Lisburn

Overall, Lisburn has more favourable statistics, with a lower population density and higher average age, yet it has more collisions overall. This assists in demonstrating traffic volumes and driver mentality/maturity are not the sole causes of collisions. It verifies the hypothesis that the number of junctions and the road geometry must be contributing to the high instances of collisions. This is an area that will benefit from deeper microanalysis on a junction by junction basis.

6.2 Junction Type

The analysis has highlighted that more right turn collisions happen at T-junctions than any other junction type. The results demonstrated that 65.2% (1849) of all the right turn collisions analysed in the dataset occurred at T-junctions. This clearly proves that junction form has an influence on the number of collisions, which is reflective of previous research [2].

The analysis also demonstrates that 18.1% (514) of all the right turn collisions occurred at staggered right junctions. Other less significant junction forms were Staggered left junctions (5.2%) and Crossroads (4.5%). The remaining percentages are divided among Y-junctions (2%), Private drives and Entrances (2%), Slip Roads (1%) Roundabouts (0.2%) and those collisions which did not occur at a junction (1.3%) or at another form of junction (0.5%).

In Dungannon and South Tyrone, it has been observed that 80% (4) of the fatal collisions that occurred were at T-junctions, and 20% (1) occurred at Crossroads. While this local sample is small, it does confirm the overall hypothesis that turning movements at junctions and junction form are accident contributory factors.

A refined exploration of the collisions in Dungannon and South Tyrone, discovered two peaks in the number of collisions throughout the year. It was noted that more collisions occurred in February (11, 14%) and September (11, 14%) than any other time of the year. Subsequently, it was discovered that the DRD Road Service only maintain road verges twice a year in rural areas and five times a year in urban areas. This could reflect the increase in the number of collisions during times of flourishing vegetation, and a sudden drop after maintenance has occurred. These peaks could also reflect a change in or extreme weather conditions such as ice in February or a changing weather and darkness in September. Future work could aim to quantify what affect verge maintenance and climatic conditions have on the number of collisions, to verify this hypothesis.

7 Conclusions:

The analysis evidently draws out an association between time of day and the number of collisions. Similarly, the analysis indicates fatal collisions are more likely to occur in the morning hours of 0800-1200 and that serious or slight collisions are more likely to occur at 1600-2000. These are times when traffic volumes are heavier as a result of morning and evening rush hour volumes. This correlates with professional opinion and logic, and is validated in the fact that Lisburn, a busy city and commuter route, had the most right turn collisions (7%). However, the impact of traffic volumes associated with accidents warrants a refined analysis, so that the contribution of traffic could be quantified and eliminated from the investigation.

The study draws attention to the fact that fatal collisions occurred more on rural roads than urban roads, with the exception of Lisburn. A possible factor contributing to this is the variable speed limit between the rural suburbs and the urban hub which could explain the different severity characteristics between urban and rural locations.

The analysis concludes that 65.2% of the right turn collisions occurred at T-junctions, suggesting that there is an association between road geometry and the number of collisions. This quantitative result was at variance with professional opinion, who conjectured that Crossroads were the poorest of all preforming junction types. This highlights a lack of consistency between opinion and facts and reveals how detrimental assumptions or preceded knowledge/wisdom can be in highway design and collision prevention. Further investigation through parametric analysis also drew attention to the fact that more casualties occur as a result of T-junction collisions than any other right turn collision, further stressing the fact that junction form can have an influence on the number of injured persons involved in collision, but also the frequency of right turn collisions.

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