Characteristics of fatal and serious cyclist collisions in Ireland: Analysis of police investigation files

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Abstract Cycling has been increasing in popularity in many countries, including the Republic of Ireland. Concurrently, the modal share of cyclist casualties has been increasing. However, there has been limited analysis of the pre-crash manoeuvres and impact configurations of cyclist collisions in Ireland, which inhibits the prioritization of engineering solutions.

Accordingly, in this study, police investigation files are analysed for a convenience sample of 59 fatal and 45 serious cyclist collisions in Ireland between 2005 and 2015 to ascertain the distribution of pre-crash manoeuvres of the cyclist/vehicle and resulting impact configurations, and highlight important environmental factors.

A number of common scenarios have been identified. In particular, this study emphasizes the prevalence of left/nearside-turning Heavy Goods Vehicles (HGVs) at junctions in urban environments, and overtaking manoeuvres from bonnet-type vehicles in rural environments. Furthermore, we found that single cyclist collisions are common. Future safety interventions should aim to address these collision types.

Keywords Cycling, Road Traffic Collisions, Pre-crash manoeuvres, Impact configurations

I. INTRODUCTION

Cycling is increasing in popularity across Europe, and an increased emphasis is being placed on cyclist safety. Ireland has previously received two European Transport Safety Council 'PIN' awards in recognition of progress in improving national road safety, including achieving reductions in fatal Road Traffic Collision (RTC) figures [1]. However, these reductions are typically limited to motorized road users; in Europe significant reductions in road death have been achieved for all road users apart from cyclists [2]. Deaths of cyclists have actually increased in Ireland by 8% on average since 2010 compared to a 5% annual decrease in motorized road user deaths [2], though cyclist fatality numbers are low and quite variable (ranging from 5 to 14 in this period) making it difficult to identify a discernable trend. Furthermore, the modal share of cyclist casualties in Ireland (fatalities and injuries) has increased from 4% in 2009 to 13% in 2018 [3], reflecting an increase in cycling numbers. There have also been slight increases for pedestrians, from 11% to 14% over the same period (ibid.). Increased focus is therefore being placed on achieving casualty reductions among Vulnerable Road Users (VRUs) under Ireland's recently embraced Safe System approach [4].

Previous analyses of police-reported cyclist collisions in Ireland have investigated frequencies for various environmental, road, and human factors [5]–[7]. For example, main findings from a report in 2016 include 1) that collisions with motorized vehicles dominate (91%), 2) the majority occur in urban environments (i.e. roads with a speed limit of 60 km/h or less) (87%) and 3) roughly half occur at junctions [5]. However, non-fatal cyclist collisions are significantly underreported to the police [8][9]. Furthermore, collision details commonly available in police data are limited, and do not allow for an in-depth analysis of pre-crash road-user manoeuvres and impact configurations, which are essential for prioritizing engineering-based prevention strategies as part of a Safe System approach, e.g., infrastructural interventions, Advanced Driver Assistance Systems (ADAS).

Underreporting of cyclist collisions to police was further investigated in Ireland using a nationally distributed self-report collision survey, highlighting underreporting biases and classifying the most common pre-crash manoeuvres and impact scenarios for injurious and non-injurious cyclist collisions [9][10]. These findings highlight the relative prevalence of nearside-hooks, overtakings and doorings, and raise the importance of single cyclist collisions, which are particularly underreported in police statistics. However, due to the self-report nature of this survey, these findings are not based on fatalities or some life-threatening injuries. Therefore, this study aims to provide a detailed taxonomy of pre-crash road-user manoeuvres and impact configurations in serious and fatal cycling collisions in Ireland using data from police investigation reports.

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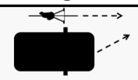
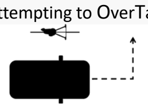
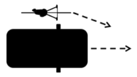
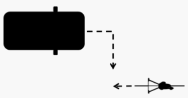
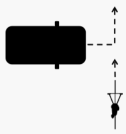
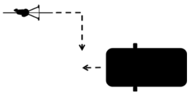
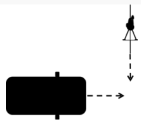
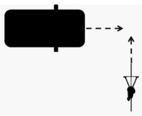
II. METHODS

We present an analysis of a convenience sample of 59 fatal and 45 serious cyclist collisions that occurred in Ireland between the years of 2005 and 2015. The data relating to fatal cases correspond to 57% of the overall cyclist fatalities, and a small proportion of serious injuries in Irish police statistics for 2005-2015. All data were extracted from files provided by the Irish National Roads Policing Bureau. Hardcopy files contain a forensic collision investigation report, a vehicle investigation report and a coroner's report/medical report. Detailed information was extracted from these files for analysis. We apply the taxonomy developed in [10] to code pre-crash manoeuvres and impact configurations based on the findings of police and forensic investigations. Pre-crash scenarios are defined by the directions of travel that the cyclist/vehicle were travelling, and the manoeuvres each road user was undertaking immediately before impact (see Table 1). Pre-crash directions of travel are defined by the relative directions of travel that the cyclist/vehicle were travelling in before the collision: 1) same directions of travel (SD), 2) opposing directions of travel (OD), or 3) crossing directions of travel. Ireland is a left-hand traffic country, therefore, for comparability to right-hand traffic environments, in the text we refer to vehicle driver's 'nearside' (vehicle side nearest the kerb) or the vehicle driver's 'offside' (side farther from the kerb). Impact configuration categories were coded by the regions impacted on the cyclist/vehicle (Figure 1). Cases generally involve one vehicle and one cyclist, however, cases with multiple cyclists/vehicles, secondary impacts, or bicycle passengers are highlighted in table footnotes. Road environmental details (road characteristics and lighting) are also presented for common pre-crash scenarios involving bonnet-type vehicles (Table 6) or Heavy Goods Vehicles (HGVs) (Table 9). In case files involving HGVs, a detailed investigation of direct/indirect vision was often included, these findings are also presented in Table 9.

TABLE 1: PRE-CRASH SCENARIO CODING SCHEME USED IN CYCLIST-MOTORISED VEHICLE COLLISIONS.

Code	Representative diagram and description	Code	Representative diagram and description
OT/SD	 Cyclist and vehicle initially travelling in the Same Direction, with a collision resulting from the vehicle attempting to OverTake the cyclist.	CL/SD	 Cyclist and vehicle initially travelling in the Same Direction, with a collision resulting from the vehicle Changing Lanes.
LT/SD	 Cyclist and vehicle initially travelling in the Same Direction, with a collision resulting from the vehicle taking a Left Turn across the cyclist's path.	SD/CL	 Cyclist and vehicle initially travelling in the Same Direction, with a collision resulting from the cyclist Changing Lanes.
RT/OD	 Cyclist and vehicle initially travelling in Opposite Directions, with a collision resulting from the vehicle taking a Right Turn across the cyclist's path.	LT/RD	 Collision resulting from a vehicle taking a Left Turn and cyclist approaching from the vehicle driver's Right Direction.
OD/RT	 Cyclist and vehicle initially travelling in Opposite Directions, with a collision resulting from the cyclist taking a Right Turn accross the vehicles's path.	SCP/LD	 Collision resulting from a cyclist and vehicle travelling with Straight Crossing Paths, with the cyclist approaching from the vehicle driver's Left Direction.
OD	 Collision resulting from a vehicle and a cyclist travelling in Opposite Directions.	SCP/RD	 Collision resulting from a cyclist and vehicle travelling with Straight Crossing Paths, with the cyclist approaching from the vehicle driver's Right Direction.

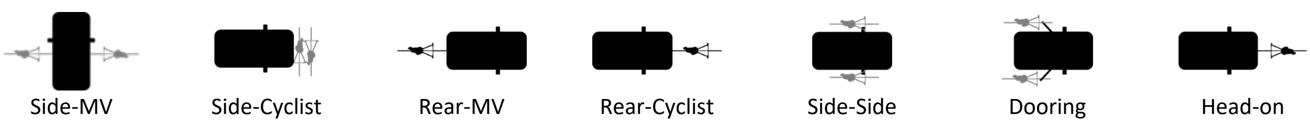


Fig. 1. Impact configuration coding scheme used in cyclist-motorised vehicle collisions.

For single cyclist collisions, 'direct causes' are coded, as per [10]–[12] (Table 2). These are general categories describing the object, action, or mechanism that caused the cyclist to fall, as indicated in the investigation file.

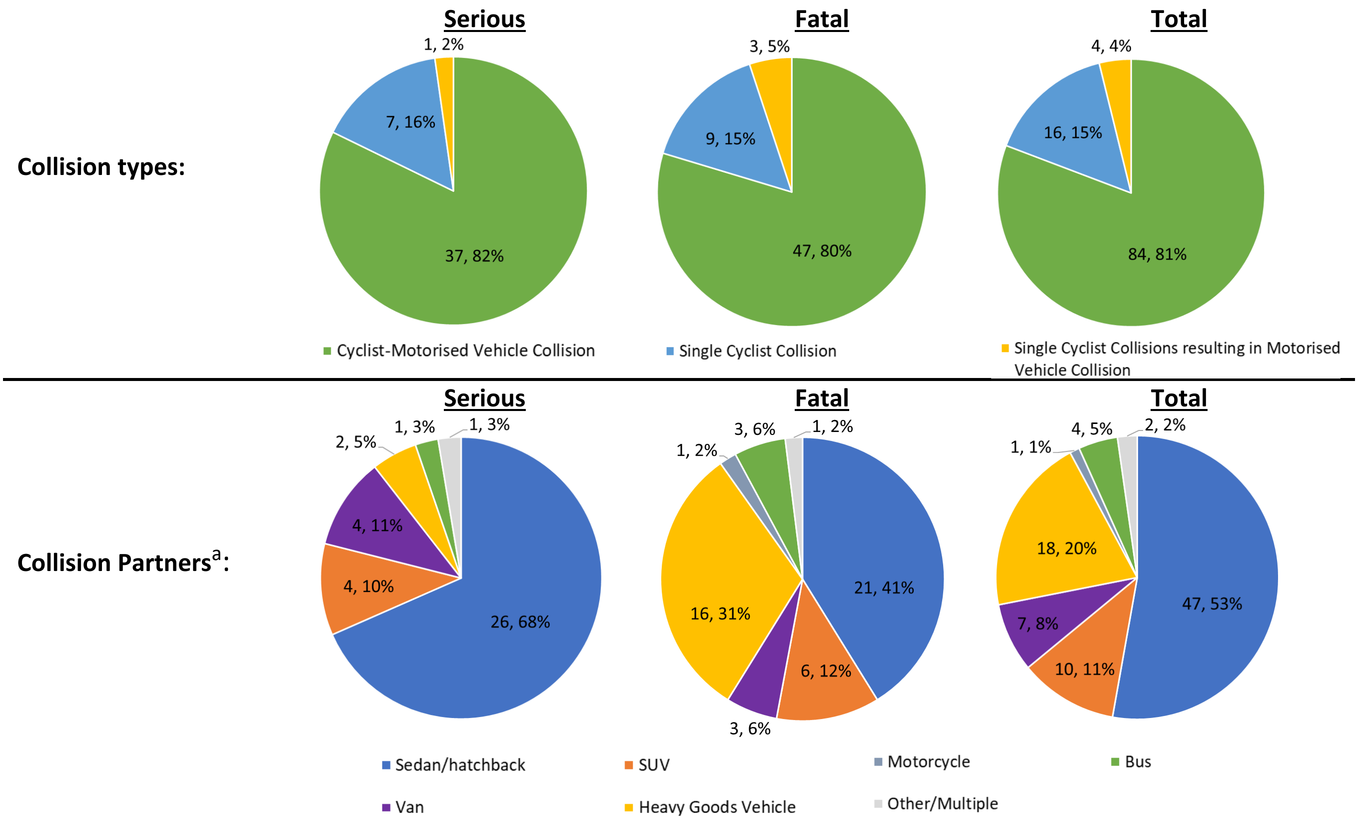
TABLE 2: CODING OF DIRECT CAUSES FOR SINGLE CYCLIST COLLISIONS.

1			**Infrastructure related:**
	a		Preceded by the cyclist inadvertently taking a dangerous riding line:
		i	Colliding with an obstacle on the roadway (deliberately) designed and built by road authorities, such as a road narrowing or bollard on the bicycle track to prevent cars from entering, and parked vehicles.
		ii	Riding off the road and colliding with a kerb or off-road obstacle.
	b		Linked to road surface quality:
		i	Skidding due to a slippery road surface.
		ii	loss of control due to an uneven road-surface (e.g. a pothole or damage from tree roots) or a loose object on the road surface (e.g. a branch).
2			**Road user related:**
	a		At low speed when it requires more effort to stabilize the bicycle, e.g. (dis)mounting.
	b		Due to something becoming lodged in or hitting the front wheel. e.g. baggage
	c		Road user behaviour:
		i	Cyclist taking an abrupt or adventitious steering/braking avoidance manoeuvre.
		ii	Cyclist making a braking mistake.
		iii	Cyclist making a turning mistake.
		iv	Cyclist doing a stunt/trick.
		v	Cycling too fast for the conditions
	d		Cyclist boxed in by traffic
3			**Bicycle malfunction**, e.g. chain break, broken part of the frame, etc.
4			**Other, or no recall.**

III. RESULTS

A. Collision partners

The majority of fatal and serious collisions, 84 (81%) were with motorized vehicles (MVCs) (Figure 2). Single cyclist collisions (SCCs) comprised N=9, 15% of fatalities and N=7, 16% of serious injury cases. For cases involving a motorised vehicle (including both MVCs, and SCCs resulting in MVCs), 64 (72%) were with bonnet-type vehicles (Sedans/Hatchbacks, SUVs, & Vans), 18 (20%) with HGVs, and 4 (5%) with Buses. A larger proportion of fatal collisions involved HGVs than serious injuries, N=16, 31% vs N=2, 5%.



a: including both MVCs, and SCCs resulting in MVCs

Fig. 2. Breakdown of collision types, and collision partners (for all cases involving a motorised vehicle) for serious and fatal cyclist cases.

B. Directions of travel

This sample includes all MVCs (N=84). For serious injuries, the largest proportion involved both the cyclist and vehicle travelling in the same direction (N=19, 51%), followed by both travelling in opposing directions (N=12, 32%) and lateral/crossing directions (N=5, 14%) (Table 3). Similarly, for fatal collisions the majority involved same directions of travel (N=29, 62%), followed by lateral/crossing directions (N=10, 21%) and opposing directions (N=8, 17%).

TABLE 3: PRE-CRASH DIRECTIONS OF TRAVEL FOR SERIOUS AND FATAL COLLISIONS

	Serious		Fatal		Total	
Directions of travel	**N**	**%**	**N**	**%**	**N**	**%**
Same directions	19	51%	29	62%	48	57%
Opposing directions	12	32%	8	17%	20	24%
Lateral/crossing	5	14%	10	21%	15	18%
Other	1	3%	0	0%	1	1%

C. Collisions with bonnet-type vehicles

This sample includes only MVCs involving bonnet-type vehicles (N=62). For both fatal and serious collisions with bonnet-type vehicles, the most common scenario was overtaking/passing (OT/SD) (N=20, 32%) (Table 4). For fatal collisions, the second most common scenario involved straight crossing paths with the cyclist approaching from the left, i.e., the vehicle driver's nearside (SCP/LD) (N=6, 21%). For serious collisions, the second most common scenario involved both travelling in opposing directions with the vehicle taking a right turn across the cyclist, i.e., an offside-hook (RT/OD) (N=6, 18%).

TABLE 4: PRE-CRASH MANOEUVRES FOR CYCLIST COLLISIONS WITH BONNET-TYPE VEHICLES

	Serious		Fatal		Total	
Pre-crash scenario	**N**	**%**	**N**	**%**	**N**	**%**
OT/SD	9	27%	11	38%	20	32%
RT/OD	6	18%	1	3%	7	11%
SCP/LD	1	3%	6	21%	7	11%
OD	1	3%	3	10%	4	6%
CL/SD	2	6%	1	3%	3	5%
LT/RD	1	3%	2	7%	3	5%
OD/RT	3	9%	0	0%	3	5%
SD/CL	1	3%	2	7%	3	5%
LT/SD	1	3%	1	3%	2	3%
SCP/RD	1	3%	1	3%	2	3%
Other	6	18%	1	3%	7	11%
Unknown	1	3%	0	0%	1	2%

The most common impact configurations for bonnet-type vehicles involved the vehicle impacting with the cyclist from the rear (Rear-Cyclist) (N=19, 31%) (particularly common for fatalities), or the vehicle frontally impacting with the side of the cyclist (Side-Cyclist) (N=15, 24%) (Table 5).

TABLE 5: IMPACT CONFIGURATIONS FOR CYCLIST COLLISIONS WITH BONNET-TYPE VEHICLES

	Serious		Fatal		Total	
Impact configuration	**N**	**%**	**N**	**%**	**N**	**%**
Rear-Cyclist	7	21%	12	41%	19	31%
Side-Cyclist	8	24%	7	24%	15	24%
Side-MV	5	15%	4	14%	9	15%
Head on	3	9%	4[c]	14%	7	11%
Side-Side	5	15%	2[a]	7%	7	11%
Rear-MV	2[b]	6%	0	0%	2	3%
Dooring	1[c]	3%	0	0%	1	2%
Unknown	2	6%	0	0%	2	3%

a: one case in this cell involved overrunning from a second vehicle
b: one case in this cell involved multiple impacted cyclists with serious injuries
c: one case in this cell involved a passenger on the bicycle who was seriously injured

Table 6 shows environmental details for common pre-crash scenarios with bonnet-type vehicles. The majority of collisions involving overtaking/passing manoeuvres (OT/SD) occurred on straight roads (N=18, 90%) without traffic separation for cyclists (N=14, 70%) in rural environments (speed limit greater that 60km/h) (N=14, 70%). A relatively high proportion of these cases involved dark/dusk light conditions (N=7, 35%), or low sun ahead of the driver (N=4, 20%).

TABLE 6: ENVIRONMENTAL DETAILS FOR COMMON SCENARIOS OF CYCLIST COLLISIONS WITH BONNET-TYPE VEHICLES

	OT/SD		RT/OD		SCP/LD		All	
	N	%	N	%	N	%	N	%
Road configuration								
Straight road	18	90%	0	0%	0	0%	33	53%
Bending road	0	0%	0	0%	0	0%	3	5%
Roundabout	0	0%	0	0%	0	0%	2	3%
Entrance	0	0%	1	14%	3	43%	4	6%
Junction (other)	2	10%	6	86%	4	57%	20	32%
Traffic separation								
None	14	70%	3	43%	5	71%	40	65%
Off-road segregated cycle lane	0	0%	0	0%	1	14%	2	3%
On-road painted cycle lane	0	0%	1	14%	0	0%	1	2%
Hard-shoulder	1	5%	0	0%	0	0%	2	3%
Unknown	5	25%	3	43%	1	14%	17	27%
Setting								
Urban	2	10%	5	71%	1	14%	20	32%
Rural	14	70%	1	14%	3	43%	26	42%
Unknown	4	20%	1	14%	3	43%	16	26%
Lighting								
Dark, poor/no street lighting	5	25%	2	29%	1	14%	12	19%
Dark, well-lit	1	5%	0	0%	0	0%	5	8%
Dusk, poor/no street lighting	1	5%	1	14%	0	0%	3	5%
Dusk, well-lit	0	0%	0	0%	0	0%	1	2%
Daylight, good visibility	7	35%	2	29%	3	43%	24	39%
Daylight, low sun[a]	4	20%	1	14%	0	0%	5	8%
Daylight, unspecified	2	10%	1	14%	2	29%	11	18%
Unknown	0	0%	0	0%	1	14%	1	2%

Urban: roads with a speed limit of 60 km/h or less, Rural: otherwise
a: low sun ahead of the driver

D. Collisions with Heavy Goods Vehicles

The following analysis involves cyclist-HGV collisions involving impact between a cyclist and an in-use HGV (not parked), and therefore includes 2 fewer cases than the number presented in Figure 2. Most collisions with HGVs involved both travelling in the same direction (N=14, 87%), and most commonly involved the vehicle turning left across the path of the cyclist (LT/SD) (nearside-hook) (N=7, 44%) (Table 7).

TABLE 7: PRE-CRASH MANOEUVRES FOR CYCLIST COLLISIONS WITH HGVS

	Serious		Fatal		Total	
Pre-crash scenario	N	%	N	%	N	%
LT/SD	2	100%	5	36%	7	44%
CL/SD	0	0%	2	14%	2	13%
OT/SD	0	0%	2	14%	2	13%
SD (other)	0	0%	3	21%	3	19%
Other	0	0%	2	14%	2	13%

Table 8 shows impact configurations for collisions with HGVs were commonly initiated by side to side contacts (Side-Side) (N=8, 50%), or initiated by the HGV impacting frontally with the rear of the cyclist (Rear-Cyclist) (N=5, 31%). The majority of cases (N=11, 69%) also resulted in the HGV overrunning the cyclist.

TABLE 8: IMPACT CONFIGURATIONS FOR CYCLIST COLLISIONS WITH HGVS

	Serious		Fatal		Total	
Impact configuration	N	%	N	%	N	%
Side-Side (overran)	2	100%	6	43%	8	50%
Rear-Cyclist	0	0%	3	21%	3	19%
Rear-Cyclist (overran)	0	0%	2	14%	2	13%
Side-Cyclist (overran)	0	0%	1	7%	1	6%
Head on	0	0%	1	7%	1	6%
Unknown	0	0%	1	7%	1	6%

Table 9 shows environmental details for common pre-crash scenarios with HGVs. All nearside-hook (LT/SD) collisions occurred at junctions/entrances, and the majority occurred in urban environments (speed limit 60km/h or less) (N=6, 86%) in daylight conditions with good visibility (N=5, 71%). Overall, based on investigations, 3 cases (19%) resulted from the cyclist being in the blind zone at the front or the nearside of the HGV, and 7 cases (44%) involved the cyclist being available to be seen by the driver at some point before impact, through either direct (line-of-sight), or indirect vision (mirrors).

TABLE 9: ENVIRONMENTAL DETAILS FOR COMMON SCENARIOS OF CYCLIST COLLISIONS WITH HGVS

	LT/SD		SD (all)		All	
	N	%	N	%	N	%
Road configuration						
Straight road	0	0%	4	29%	6	38%
Entrance	1	14%	1	7%	1	6%
Junction (other)	6	86%	9	64%	9	56%
Traffic separation						
None	2	29%	7	50%	9	56%
Off-road segregated cycle lane	1	14%	1	7%	1	6%
On-road painted cycle lane	3	43%	3	21%	3	19%
Advanced stop box	1	14%	2	14%	2	13%
Unknown	0	0%	1	7%	1	6%
Setting						
Urban	6	86%	9	64%	10	63%
Rural	0	0%	3	21%	4	25%
Unknown	1	14%	2	14%	2	13%
Lighting						
Dark, poor/no street lighting	0	0%	1	7%	1	6%
Daylight, good visibility	5	71%	10	71%	12	75%
Daylight, unspecified	0	0%	1	7%	1	6%
Daylight, overcast	1	14%	1	7%	1	6%
Unknown	1	14%	1	7%	1	6%
Vision						
Visible, direct vision	0	0%	2	14%	2	13%
Visible, indirect vision	3	43%	4	29%	4	25%
Visible, unspecified	0	0%	0	0%	1	6%
In blind zone, at front	0	0%	1	7%	1	6%
In blind zone, at side	1	14%	2	14%	2	13%
Not visible, poor lighting	0	0%	1	7%	1	6%
Unknown, no direct vision	1	14%	1	7%	1	6%
Unknown	2	29%	3	21%	4	25%

Urban: roads with a speed limit of 60 km/h or less, Rural: otherwise

E. Single cyclist collisions

Table 10 shows direct causes for single cyclist collisions (based on indications in the investigation file), with the inclusion of those resulting in a secondary impact with a vehicle. Direct causes are frequently multifactorial, with more than 1 direct cause (N=6, 30%), and a large share of cases involved the cyclist colliding with an obstacle on the roadway designed and build by road authorities (1ai) (N=5, 25%).

TABLE 10: DIRECT CAUSES FOR SINGLE CYCLIST COLLISIONS (INCLUDING THOSE INVOLVING SECONDARY IMPACT WITH A VEHICLE)

	Serious		Fatal		Total	
	N	%	N	%	N	%
1 direct cause						
1ai	1[a]	13%	2[a]	17%	3	15%
1aii	0	0%	1	8%	1	5%
1bi	0	0%	1[a]	8%	1	5%
1bii	1	13%	0	0%	1	5%
2b	0	0%	1	8%	1	5%
2ci	1	13%	1	8%	2	10%
2cii	1	13%	0	0%	1	5%
2cv	0	0%	1[a]	8%	1	5%
3	0	0%	1	8%	1	5%
4	0	0%	1	8%	1	5%
2 direct causes						
1ai & 1bi	1	13%	0	0%	1	5%
1ai & 2ciii	1	13%	0	0%	1	5%
2cv & 4	0	0%	1	8%	1	5%
1aii & 2ciii	1	13%	0	0%	1	5%
1bi & 2cii	0	0%	1	8%	1	5%
1bii & 2ciii	1	13%	0	0%	1	5%
Unknown	0	0%	1	8%	1	5%

a: one case in this cell involved a secondary impact with a vehicle

IV. DISCUSSION

This is the first analysis of the distribution of pre-crash scenarios and impact configurations for fatal and serious cyclist collisions in Ireland. However, these findings are based on a convenience sample of the total number of cases in the study period. The study sample contains over half of all fatal cycling collisions between 2005-2015, and a small proportion of serious injuries. Furthermore, the low number of cases available limits the level of analysis possible.

For single cyclist collisions, our previous study based on self-reported survey data highlighted the prevalence of single cyclist collisions among non-injurious and lower severity collisions in Ireland [9], [10]; the present findings based on police investigation files show their importance also for serious injury and fatal cases, with 15% of cases in this category, and a further 4% involving a single cyclist collision resulting in a subsequent impact with an in-use motorised vehicle. However, the proportion of single cyclist collisions among serious injuries here is lower than findings from other Irish studies involving self-reported data (ibid.) or hospital data [13], and far lower than rates seen internationally [14].

Collisions involving motorized vehicles account for a majority of fatal cases, as seen elsewhere [2], [14], [15]. In terms of pre-crash directions of travel for the cyclist/vehicle in collisions involving bonnet-type vehicles, internationally there are differences in prevalence, with some countries having a larger share of Side-Cyclist impacts resulting from crossing directions of travel, e.g., Germany [12][13], and others having a larger share of Rear-Cyclist impacts from longitudinal/same directions of travel, e.g., France [15], particularly overtaking manoeuvres (OT/SD) in rural environments. Our findings suggest that Ireland aligns with the latter (Tables 4 & 5), and demonstrate the importance of localized data for successful implementation of prevention strategies. The majority of these cases occur in rural environments (roads with speed limits over 60km/h) without traffic separation (Table 6). These cases also often occur in the dark/dusk, or in light conditions involving glare (low sun ahead of the driver/cyclist). These results supplement our earlier findings for lower severity collisions, where overtakings are the most common collision type in rural environments [10]. Offside-hook collisions (RT/OD) are also common among bonnet-type vehicle collisions, i.e., vehicle/cyclist travelling in opposing directions with a collision resulting from the vehicle turning right (to the driver's offside) across the cyclist's path. This collision type is common internationally [12][14][15], and was previously noted as a prevalent configuration among more severe self-reported collisions in Ireland [10]. Both collision types (OT/SD, & RT/OD) are currently included in recent changes to European consumer and regulated type testing for ADAS ((EU) 2019/2144, [19]). Installation of Autonomous Emergency Braking (AEB), Steering (AES), and Forward Collision Warning (FCW) systems in newer bonnet-type vehicles may reduce the occurrence of many collision types highlighted here, however, given the low rates of traffic separation among cases in this study (Table 6), infrastructural interventions should also be prioritized in Ireland, i.e., segregated cycle lanes, and cyclist-friendly junction design. In the European context, this will be supported by updates to the Road Infrastructure Safety Management (RISM) directive, which include VRU-specific safety management measures throughout planning, design, and operation of roads projects ((EC) 2008/96).

It is well-known that HGVs feature frequently among fatalities and serious cyclist injuries internationally [20]. Our findings indicate that most cyclist fatalities involving a HGV result from nearside-hooks (LT/SD), and the cyclist being positioned at the front/nearside of the HGV (Tables 7 & 8), supplementing international findings that indirect/direct vision issues in this region (the blind zone) are a contributing factor in most of these impacts [21]. Historically, European regulations limiting HGV lengths (for trailer and tractor) has led to designs with the driver cabin placed high above the engine. However, cabin height has been shown to reduce direct vision for drivers [22]. Currently, this is primarily mitigated using a range of mirrors, providing indirect vision for the space around the cabin, and underrun protection systems to prevent cyclists falling under the wheels in the case of impact. However, the effectiveness of underrun systems is unclear, and the majority of these cases in this study resulted in the HGV overrunning the cyclist (Table 8). Furthermore, incorrectly adjusted mirrors often result in impacts [23], and direct vision is preferable since the need to check multiple mirrors reduces reaction times, resulting in a temporal blind zone. Indeed, as indicated in Table 9, cyclists may often be available to be seen by the driver through indirect vision (mirrors) at some point before impact. Therefore, recent HGV designs have included ADAS for the blind zone, i.e., collision warning, and emergency braking systems. Furthermore, upcoming European regulations for HGVs will include mandatory blind zone detection systems for VRUs, as well as direct vision standards ((EU) 2019/2144).

V. CONCLUSIONS

This is the first detailed analysis of police investigation files for serious and fatal cyclist collisions in Ireland. Though the sample size is small, these findings emphasize the prevalence of 1) left/nearside-turning HGVs at junctions in urban environments resulting in side to side impacts and cyclist overrunning, and 2) overtaking manoeuvres from bonnet-type vehicles in rural environments resulting in rear impacts. Furthermore, we found that single cyclist collisions are an important component of fatal cycling cases. Future countermeasures and test protocols should address these pre-crash scenarios and impact scenarios.

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