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Driver injuries in heavy vs. light and medium truck local crashes, 2010–2019

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ABSTRACT

Objective: Multiple heavy truck driver injury studies exist, but there is a paucity of research on light and medium truck driver injuries. The objective of this study was to use first report of injury (FROI) data to: (a) compare demographic and injury characteristics; (b) assess workers' compensation (WC) claim disposition and lost work time status; and (c) describe injury scenarios by vehicle type for heavy truck and light/medium truck driver local crashes. *Method:* Kentucky Department of Workers' Claims FROI quantitative and free text data were analyzed for years 2010–2019. Of 800 total FROIs, 451 involved heavy trucks and 349 involved light or medium trucks. *Results:* There was a higher light/medium truck driver crash FROI rate compared to the heavy truck driver crash FROI rate. There was a higher proportion of younger light/medium truck driver crash FROIs compared to younger heavy truck driver crash FROIs. The retail trade industry made up the largest percentage of light/medium truck local crash FROIs (47%); the transportation and warehousing industry was most frequently cited in heavy truck FROIs (46%). The heavy truck types most frequently identified in FROIs were semi-trucks (13%) and dump trucks (11%). The most common light/medium truck type identified was delivery trucks (30%). Most commonly, heavy truck crash FROIs involved rollovers, driving off/overcorrecting on narrow roadways, and driving downhill/unable to downshift. Light/medium truck crash FROIs most frequently involved being rear-ended, running red lights, and turning in front of other vehicles. *Conclusions:* The utilization of WC FROI data highlighted top injury scenarios and specific vehicle types for targeting driver safety training among truck drivers, particularly light/medium truck drivers. Road safety policies regarding driver training, crash reviews, and in-vehicle monitoring systems are needed for truck drivers with previous crash injuries, especially for light and medium truck drivers. *Practical applications:* Enhanced safety training on speeding on narrow roadways, on nearing intersections, and on downshifting on hills is needed for semi-truck, dump truck, and coal truck drivers with previous crash injuries. Rear-end crash prevention training (e.g., gradual stopping and checking mirrors) is needed for drivers of furniture, automotive parts and accessories, and groceries and soft drink delivery trucks with previous crash injuries.

1. Introduction

In 2019, the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) counted 2,122 commercial transportation incident deaths, of which 471 were in truck transportation, 83 were in wholesale trade, and 59 were in retail trade (Bureau of Labor Statistics, 2021). Within the truck transportation industry, the fatality rate was 27.2 worker deaths per 100,000 full-time equivalent workers, compared to the U.S. overall worker fatality rate of 3.5/100,000. The nonfatal injury incidence rate of 3.6 injuries and illnesses per 100 full-time workers in the truck transportation industry is 20% higher than the U.S. overall rate of 3.0/100 (Bureau of Labor Statistics, 2020). These high numbers and rates have served as the justification for multiple research studies on injuries in heavy vehicles such as semi-trucks in truck transportation (Bunn, Slavova, & Robertson, 2013; Bunn, Slavova, & Rock, 2019; Combs, Heaton, Raju, Vance, & Sieber, 2018; McKnight & Bahouth, 2009; Zheng, Lu, & Lantz, 2018).

Relatively few studies have been published on injuries to light and medium vehicle drivers. A study by Karaca-Mandic and Lee (2014) on car and light truck crashes using linked crash and hospital discharge data found that light truck drivers had reduced odds for hospitalizations and fatalities compared to passenger car dri-

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vers. Pratt and Bell (2019) showed that age, gender, and job tenure were significant driver collision risk factors in a light vehicle healthcare industry fleet. Lack of seat belt use and high speed have also been shown to be associated with light vehicle serious crash injuries (Doecke, Baldock, Kloeden, & Dutschke, 2020; Pipkorn, Iraeus, Lindkvist, Puthan, & Bunketorp, 2020; Stuckey, Glass, LaMontagne, Wolfe, & Sim, 2010). In a follow-up study by Stuckey, LaMontagne, Glass, and Sim (2010) using linked vehicle registration and crash data, the authors estimated light vehicle fatality rates to be much higher than those reported using workers' compensation (WC) data alone.

Using an in situ driving data set, Hanowski, Hickman, Wierwille, and Keisler (2007) found that most vehicle crashes, near crashes, and crash-related conflicts involving both light and heavy vehicles were initiated by the light vehicle driver, with aggressive driving being the primary contributing factor, whereas the heavy vehicle driver-initiated events involved poor driving habits. Chen, Amandus, and Wu (2014) analyzed U.S. CFOI data and determined that of the total driver/sales worker and truck driver occupational fatalities, 85% were among heavy truck and tractor-trailer drivers and 9.5% were among light truck drivers. The authors acknowledged that their study was limited by a lack of appropriate employment data on driver occupation by industry and of worker characteristics for the occupational subcategories. They recommended that "data on circumstances and scenarios leading to a fatal truck crash are needed to better understand risk factors associated with highway fatalities in the group of truck drivers and driver/sales workers.".

WC data may not be the optimum data source for calculation of injury rates since its lack of information on self-employed workers and calculated injury rates would lead to an underestimation (Stuckey, LaMontagne, & et al., 2010). The primary advantage of analyzing WC data is that it contains free-text injury narratives that can provide additional information on the circumstances of a crash and specific driving actions performed by the drivers prior to the crash that other data sources (such as electronic crash data with no free-text narratives) cannot provide (Chandler, Bunn, & Slavova, 2017). The objectives of this study were to use WC first report of injury (FROI) data to: (a) compare demographic and injury characteristics between heavy truck driver, and light and medium truck driver local crash FROIs; (b) assess WC disposition and lost work time status associated with local heavy, medium, and light truck crash FROIs; and (c) describe injury scenarios by specific vehicle type to obtain additional information on the crash injury circumstances. Results from this study can be used to target new and enhance current light, medium, and heavy truck driver injury prevention strategies.

2. Methods

2.1. Data source

De-identified Kentucky WC FROIs for years 2010–2019 were obtained from the Kentucky Department of Workers' Claims (KDWC); information regarding reimbursement for medical expenses related to injuries was not available. The WC data set does not include FROIs on self-employed worker injuries. According to the KDWC, the following are acceptance criteria for FROIs:

1. All worker injuries that require at least one day off from work or result in a disability that extends beyond 60 days are required to be reported;
2. When a worker has lost at least seven days of work due to an injury or has a permanent partial disability with no missed work days due to an injury, the worker is eligible for indemnity and/or lump sum payments. Indemnity payments associated with FROIs or claims (litigated FROIs) are defined as paid income benefits to compensate for lost wages, functional impairment, or death; and.
3. When a worker has lost at least two weeks of work due to an injury, the worker is eligible for lost wage compensation retroactive to the first day of work lost.

The FROIs reflect the number of crash injuries (in reports submitted to KDWC) and do not reflect individual drivers involved in crashes.

2.2. Study selection and inclusion criteria

Inclusion criteria for heavy, medium, and light truck driver collision FROIs were based on a WC standard cause of injury code of (45) collision or sideswipe, (46) collision with a fixed object, (48) vehicle upset or rollover, or (50) motor vehicle "not otherwise classified." FROI standard cause of injury code 50 includes injuries due to sudden start or stop, being thrown against the interior of the vehicle, and vehicle contents being thrown against the occupant. Additional study inclusion criteria for FROIs included: (a) all accepted FROIs, including open and closed FROIs; (b) FROIs including all ages and those with unknown ages; and (c) FROIs regardless of the injury location (in-state and out-of-state FROIs). Based on these criteria, 11,790 FROIs were selected for inclusion.

2.3. Identification of industry, truck type, and local transportation

North American Industry Classification System (NAICS) super sectors were identified based on BLS classification (https://www.bls.gov/sae/additional-resources/naics-supersectors-for-ces-program.htm). NAICS codes were poorly populated in the final data set (3,017 of the 11,390 total had no or incomplete codes), and Standard Occupational Classification (SOC) codes were not available in the dataset, though an occupation description was included. To identify industry and occupation codes (SOC codes), the data set was processed using the National Institute for Occupational Safety and Health's (NIOSH's) auto-coding program (the NIOSH Industry and Occupation Computerized Coding System, or NIOCCS, https://csams.cdc.gov/nioccs/), a reasonably effective data set auto-coder for industry and occupation (Buckner-Petty, Dale, & Evanoff, 2019; Schmitz & Forst, 2016). Seventy-four percent (n = 8,373) of the total FROIs (n = 11,390) were coded with NIOCCS for industry and occupation. The selected FROIs were then narrowed to those coded with a heavy truck driver occupation SOC code of 53-3032 or a light (and medium) truck driver occupation 53-3033 SOC code and manually reviewed to exclude long-distance driver FROIs (n = 146 [145 heavy truck and one light/medium truck driver]) and passenger FROIs (n = 54); 800 final FROIs remained, and 32 of the 800 (4%) required additional manual review by three reviewers to assign codes. The final data set contained 800 total local crash FROIs: 451 heavy truck driver and 349 light or medium truck driver crash FROIs.

Analysis of the heavy, medium, and light truck FROI free-text narratives and industry and occupation codes was performed to identify the specific truck type involved in the crash and to better understand the precipitating factors that led to the driver injury. Truck classifications conformed to the Federal Highway Administration's (FHWA's) vehicle and weight class definitions (https://afdc.energy.gov/data/10380):

1. Heavy vehicle (26,001 lbs. and over): furniture truck, high-profile semi, home fuel truck, medium semi-tractor, refuse (solid waste) vehicle, tow truck, cement mixer, dump truck, fire truck, fuel truck, heavy semi-tractor, refrigerated van, and semi sleeper;
2. Medium vehicle (10,001 lbs. to 26,000 lbs.): beverage truck, rack truck, single axle van, stake body truck, bucket truck, city delivery truck, large walk-in vehicle, conventional van, landscape utility vehicle, and medium walk-in vehicle; and.
3. Light vehicle (0 to 10,000 lbs.): Utility van-type trucks.

Light and medium truck FROIs were combined for the analysis, as SOC codes are not specific for light and medium truck drivers in the FROIs and the NIOCCS needed to be used to code truck driver occupation. Only two SOC codes delineate truck type: heavy truck driver and light truck driver. SOC defines light truck drivers as those who "Drive a light vehicle, such as a truck or van, with a capacity of less than 26,001 pounds Gross Vehicle Weight (GVW), primarily to pick up merchandise or packages from a distribution center and deliver. May load and unload vehicle." Both medium trucks (10,001 to 26,000 pounds) and light trucks (0 to 10,000 pounds) fall within the SOC light truck driver code, so they could not be separated.

FROIs do not have a "vehicle type" data variable as crash data does, so the NIOCCS code was the only code available to us to identify truck type. To supplement the NIOCCS code, the injury narratives were searched for specific truck type; however, only 42% of the FROI narratives mentioned the general vehicle type. Mentions of solid waste trucks, concrete mixers, tow trucks, coal trucks, semi-trucks, and dump trucks in the FROI narrative were included in the heavy truck category, and mentions of delivery trucks, large vans, and other vehicles such as box trucks in the FROI narrative were included in the light and medium truck category.

Local transportation was identified through National Council on Compensation Insurance (NCCI) class codes (used to categorize and classify businesses to underwrite workers' compensation insurance); NAICS codes; and manual review of the industry field in the FROIs. Codes used to identify local transportation were: (a) NCCI class code 7228, Trucking: Local Hauling Only—All Employees and Drivers; (b) NAICS 48422, Specialized Freight (except Used Goods) Trucking, Local ("Local trucking establishments provide trucking within a metropolitan area that may cross state lines. Generally, the trips are same-day return"); (c) NAICS 484110, General Freight Trucking, Local ("Local general freight trucking establishments usually provide trucking within a metropolitan area which may cross state lines"); and (d) driver residence and crash location county. Specific distances were not available in the FROIs, but crashes were identified as local when the residence county was in Kentucky and the crash location county occurred in Kentucky or in a border state. Free-text industry names in the industry data field were also determined by the study authors to be local transportation (see definition above for NAICS codes) if the listed industries were florists, furniture stores, automotive parts and accessories stores, and other industries highly likely to only serve a local area. Long-distance transportation FROIs identified through NAICS code 48412, General freight trucking, long-distance, and key words in the free text (long-haul, over-the-road, etc.) were excluded from the study. Two reviewers reviewed the truck type and local transportation coding by the first reviewer and inter-reliability checks were performed.

Driver residence and crash location counties were determined through analysis of county names. Appalachian county designation was used as the proxy to identify rural versus urban area truck crashes. The counties identified as Appalachian in this study were derived from the Appalachian Regional Commission (https://www.arc.gov/appalachian-counties-served-by-arc/).

The institutional review board approved the study; because the study involved the analysis of secondary data with no personal identifiers, informed consent was neither required nor obtained.

2.4. Groupings of injured body parts, nature of Injury, and lost time

Injured body part and nature of injury codes are defined by the KDWC using the International Association of Industrial Accident Boards and Commissions' coding framework (https://www.wcio.org/Document%20Library/InjuryDescriptionTablePage.aspx). Injured body parts coded in FROIs were collapsed into five categories: (1) head, face, and neck; (2) back, torso, chest, abdomen, and groin; (3) upper extremities including shoulder; (4) lower extremities including pelvis; and (5) multiple body systems, whole body, or other. Nature of injury codes were collapsed into five categories: (1) concussion; (2) contusion/laceration; (3) fracture/dislocation; (4) strain/sprain; and (5) other. The "other" categories for both Nature of Injury and Body Part included FROIs where the individuals required medical attention but the record did not list a traditional injury (e.g., pregnancy concerns, elevated blood pressure).

Extent of lost time was grouped into three distinct categories (no lost time, lost time [defined as greater than one day of lost time], and fatality [first report of injury was a fatal injury]) and grouped by days of lost time (0–1 day, 2–6 days, 7–29 days, and 30+ days of lost time). Job tenure and days of lost time due to injury were calculated using dates in the dataset. Job tenure was defined as the number of days between the reported hire date and date of injury. Number of days of lost time due to injury was defined as the number of days between the date of injury and the return to work date. Completion of the return to work date field is optional in the FROI, so the days of lost time due to injury was poorly populated (59% missing data).

2.5. Injury scenarios

Free-text narratives were analyzed using keyword searches and manual review of each FROI to identify the specific truck types by the leading industries. Two reviewers reviewed the narrative coding of the truck type by the first reviewer and inter-reliability checks were performed. The top injury activity scenarios were described for each major truck group type that was identified.

2.6. Statistical analysis

This study incorporated a cross-sectional design. Frequencies were determined for demographics, industry, injury outcomes (e.g., injured body part, lost time, and cause and nature of injury), and award disposition variables. Chi-square tests were performed to assess the significant differences between the heavy truck, and medium and light truck local crash FROI groups on the above variables. All statistical analysis was performed using SAS Enterprise 8.2.

Denominator numbers by age and gender were not available to calculate age-adjusted local crash FROI rates; instead, Kentucky crude FROI rates for the heavy truck driver (SOC code 53-3032) and for the light/medium truck driver (53-3033 SOC code) occupational categories were calculated for years 2010–2019. Long distance could not be separated from local distance for the denominator, so two numerator types were utilized to develop FROI rates: (1) the final 451 heavy truck driver and 349 light or medium truck driver *local crash FROIs* based on all exclusion and inclusion study criteria and (2) the 596 heavy truck driver and 350 light/medium truck driver *local and long distance crash FROIs* based on all exclusion and inclusion criteria with the exception

Table 1
Demographic characteristics of heavy vs light and medium truck driver local crash first reports of injuries, 2010–2019.[1]

Demographic Characteristic	All First Reports of Injuries n = 800	Light/Medium Truck First Reports of Injuries n = 349 (%)	Heavy Truck First Reports of Injuries n = 451 (%)
Sex	**n = 798**	**n = 348**	**n = 450**
Male	732	300 (86%)	432 (96%)
Female	66	48 (14%)	18 (4%)
Age (Years)	**n = 800**	**n = 349**	**n = 451**
<25	60	42 (12%)	18 (4%)
25–44	321	140 (40%)	181 (40%)
45–65	360	134 (38%)	226 (50%)
>65	59	33 (9%)	26 (6%)
Job Tenure	**n = 735**	**n = 323**	**n = 412**
Less than 1 year	366	152 (47%)	214 (52%)
1–4 years	200	96 (30%)	104 (25)
5–10 years	91	40 (12%)	51 (12%)
Over 10 years	78	35 (11%)	43 (10%)
NAICS Industry[1]	**n = 800**	**n = 349**	**n = 451**
Natural Resources & Mining	18	<5	17 (4%)
Construction	37	10 (3%)	27 (6%)
Manufacturing	60	23 (7%)	37 (8%)
Trade, Transportation, & Utilities	518	245 (70%)	273 (61%)
Wholesale Trade	*105*	72 (21%)	33 (7%)
Retail Trade	*187*	164 (47%)	23 (5%)
Transportation & Warehousing	*215*	9 (3%)	206 (46%)
Utilities	*11*	0 (0%)	11 (2%)
Information	<5	<5	0 (0%)
Financial Activities	6	<5	<5
Professional & Business Services	80	18 (5%)	62 (14%)
Education & Health Services	<5	0 (0%)	<5
Leisure & Hospitality	30	19 (5%)	11 (2%)
Other Services	42	25 (7%)	17 (4%)
Government	6	<5	<5
County of Injury Region	**n = 800**	**n = 349**	**n = 451**
Appalachia	246	74 (21%)	172 (38%)
Non-Appalachia	504	254 (73%)	250 (55%)
Out of State	50	21 (6%)	29 (6%)

[1] Numbers less than five are suppressed in accordance with state data management policy.

of local versus long distance. The denominator data used for both numerator types were Kentucky heavy and light/medium truck driver occupational employment data (local plus long distance) obtained from BLS Occupational Employment and Wage Statistics (https://www.bls.gov/oes/tables.htm).

3. Results

3.1. Demographic characteristics

While the majority of all local light, medium, and heavy truck driver crash FROIs involved males, there was a higher percentage of female light and medium truck driver local crash FROIs (14%) compared to female heavy truck crash FROIs (4%) (Table 1).

The highest proportion of local heavy truck crash FROIs was for the 45–65 year age driver group (50%), while the 24–44 year age driver group represented the highest proportion of local light and medium truck crash FROIs (40%). The youngest (less than 25 years) age group was represented at a higher proportion in local light and medium truck crash FROIs compared to the same age group in the heavy truck crash FROIs (12% of young local light and medium truck driver FROIs vs 4% of younger heavy truck driver FROIs). There was no difference between the light and medium truck driver and heavy truck driver FROIs in regards to job tenure. About one-half of the heavy truck and light and medium truck FROIs were for workers with less than one year of job tenure, and between 25% and 30% were for workers with one to four years of job tenure.

There was a higher percentage of heavy truck driver crash FROIs in the transportation and warehousing industry (46%), and professional and business services industries (14%) compared to the light/medium truck driver FROIs that had the highest percentage of FROIs in the retail (47%) and wholesale trade (21%) industries. A higher percentage of the heavy truck driver local crash FROIs occurred in the rural Appalachian region compared to local light and medium vehicle driver crash FROIs (38% among heavy vehicle drivers vs 21% among light and medium vehicle drivers). In contrast, a higher percentage of local light and medium truck crash FROIs occurred in urban non-Appalachian regions (73%) compared to heavy truck crash FROIs (55%).

3.2. Driver injury characteristics

Collision or sideswipe with another vehicle was the primary cause of injury in the light and medium truck local crash FROIs (46%) and the second highest cause of injury in the heavy truck local crash FROIs (32%). A higher percentage of heavy truck driver crash injuries was due to vehicle upset, rollover, or jackknife (27%) compared to the light and medium truck local crash FROIs (9%). Crashes not otherwise classified, including sudden start or stop, represented 37% of both heavy and light/medium vehicle FROIs (Table 2).

Sprains and strains accounted for the highest percentage of light and medium truck driver crash FROIs (39%), whereas "Other" was the primary injury type listed for local heavy truck driver crash FROIs (43%), followed by sprains and strains (24%). When body part injured was examined, "multiple injuries" accounted for similar percentages of the light and medium truck driver crash FROIs (41%) compared to local heavy truck driver crash FROIs (45%). Multiple parts was the most frequent body part injured for both truck size FROIs. Head and neck injuries were more common

Table 2
Driver injury characteristics in heavy vs light and medium truck local crash first reports of injuries, 2010–2019.

Injury Characteristic	Light and Medium Truck First Reports of Injury n = 349 (%)	Heavy Truck First Reports of Injury n = 451 (%)	Chi-Square *p*-value
Cause of Injury	**n = 349**	**n = 451**	**<0.0001**
Collision or sideswipe with another vehicle	162 (46%)	145 (32%)	
Collision with fixed object	24 (7%)	19 (4%)	
Vehicle upset, rollover, or jackknife	33 (9%)	122 (27%)	
Not Otherwise Classified, including sudden start or stop	130 (37%)	165 (37%)	
Nature of Injury	**n = 349**	**n = 451**	**<0.001**
Concussion	8 (2%)	7 (2%)	
Contusion/laceration	52 (15%)	92 (20%)	
Fracture/dislocation	29 (8%)	50 (11%)	
Sprain/strain	135 (39%)	108 (24%)	
Other	125 (36%)	194 (43%)	
Body Part Injured	**n = 324**	**n = 437**	**0.410**
Head, face, and neck	51 (16%)	50 (11%)	
Back, torso, chest, abdomen, and groin	71 (22%)	88 (20%)	
Upper extremities, including shoulder	45 (14%)	64 (15%)	
Lower extremities, including pelvis	25 (8%)	37 (8%)	
Multiple parts, whole body, or other	132 (41%)	198 (45%)	

Table 3
Disposition status and lost work time in heavy vs light and medium truck local crash first reports of injury, 2010–2019.[1]

Disposition and Lost Time Status	Light/Medium Truck First Reports of Injury n = 349 (%)	Heavy Truck First Reports of Injury n = 451 (%)	Chi-Square *p*-value
First Report of Injury Resulted in Workers' Compensation Award[2]	**n = 349**	**n = 451**	**0.644**
No	263 (77%)	324 (76%)	
Yes	78 (23%)	104 (24%)	
Extent of Lost Time due to Injury	**n = 349**	**n = 451**	**<0.01**
No lost time	23 (7%)	46 (10%)	
Lost time	323 (93%)	389 (86%)	
Fatality	<5	16 (4%)	
Days of Lost Time due to Injury[3]	**n = 349**	**n = 451**	**0.064**
0–1 day	16 (13%)	38 (19%)	
2–6 days	45 (37%)	56 (27%)	
7–29 days	28 (23%)	36 (18%)	
30+ days	32 (26%)	75 (37%)	
Missing Return- to-Work Date[4]	228	246	

[1] Numbers less than five are suppressed in accordance with state data management policy.
[2] FROI resulted in Workers' Compensation award if disposition was in agreement approved—Administrative Law Judge (ALJ), award—ALJ, lump sum agreement on first report, agreement approved on first report. FROI resulted in no award if disposition was none, case dismissed—ALJ, consolidated ALJ dismissal, consolidated ALJ no money, medical dispute dismissed/denied. FROIs under review included assigned to ALJ, held in abeyance, medical dispute closed, ready to set for pre-hearing conference, scheduled for pre-hearing, set for hearing, submitted for ALJ decision, medical dispute set for proof time, proof time, ALJ opinion, medical dispute program.
[3] The days off work after injury field, being not required, is poorly populated, with 59% of 800 observations missing.
[4] Excluded from statistical analysis.

among light and medium truck driver crash FROIs (16%) compared to heavy truck driver FROIs (11%).

3.3. Disposition status and lost work time

Approximately-three-quarters of the FROIs for both groups did not result in a workers' compensation award, a proxy for injury severity since there was no settlement benefit for disability, impairment, or death; medical benefits could have been paid out on the FROI, but medical benefit data were not available, as KDWC does not maintain the medical data set. There was a significantly higher percentage of light and medium truck driver local crash FROIs with lost time due to injuries compared to heavy truck driver FROIs (93% of light and medium truck driver FROIs vs 86% of heavy truck driver FROIs) (Table 3).

While there was no significant difference between the two groups for the number of days of lost time, there was an indication that the drivers in heavy vehicle local crash FROIs had a higher percentage of 30 days or more of lost work time (37%) compared to drivers in light and medium vehicle FROIs (26%).

3.4. Driver injuries by truck type

Through free-text narrative analysis, the primary truck types identified in the heavy truck crash FROIs were semi-trucks (13%), dump trucks (11%), and solid waste trucks, tow trucks, and coal trucks (6% each of the total) (Table 4).

This is an undercount of the identification of the specific truck types since 54% of all heavy truck crash FROIs did not contain enough information in the free-text to identify the specific vehicle involved in the crash injury report. Not surprisingly, general freight trucking (local) and local trucking industries were listed most frequently for the semi-truck crashes and dump truck crash FROIs. Solid waste collection and refuse systems were the industries most frequently listed for the solid waste truck crash FROIs. Surprisingly, general freight trucking (local) was the industry listed for almost

Table 4
Driver injuries in heavy vs light and medium truck local crash first reports of injury by vehicle type and leading primary industry, 2010–2019.

Heavy Truck Type	n = 451 (%)	Leading Primary Industries	n (%)
Semi-Truck	59 (13%)		
		General Freight Trucking (Local), Local Trucking	17 (29%)
		Recyclable Material Merchant Wholesalers	7 (12%)
Dump Truck	50 (11%)		
		General Freight Trucking (Local)	18 (37%)
		Site Preparation Contractors	6 (12%)
Solid Waste Truck	27 (6%)		
		Solid Waste Collection	14 (52%)
		Refuse Systems	11 (41%)
Tow Truck	26 (6%)		
		General Freight Trucking (Local)	11 (42%)
		Automotive Services, General Automotive Repair	8 (31%)
Coal Truck	25 (6%)		
		General Freight Trucking (Local)	17 (68%)
		Bituminous Coal Underground Mining, Support Activities for Coal Mining	8 (32%)
Concrete Mixer	20 (4%)		
		Ready-Mix Concrete Manufacturing, Ready-Mixed Concrete, Concrete Work	16 (80%)
Unidentified Truck	244 (54%)		
Light and Medium Truck Type	**n = 349 (%)**	**Primary Industries**	**n (%)**
"Delivery Truck"	104 (30%)	Furniture	20 (19%)
		Automotive Parts and Accessories	13 (13%)
		Groceries and Soft Drinks	9 (9%)
		Florist	7 (7%)
		Motor Vehicle Supplies and New Parts Merchant Wholesalers	8 (8%)
		Tire Dealers and Manufacturing	6 (6%)
		Pharmacies and Drug Stores	6 (6%)
Van	9 (3%)		
Other Truck Types	14 (4%)		
Unidentified Trucks	**222 (64%)**		

half of the tow truck crash FROIs (42%); only 23% listed automotive services and general automotive repair as the associated industry.

For light and medium truck FROIs, the specific vehicle types identified were delivery trucks (30%), other vehicles such as box trucks (4%), and vans (3%). These percentages are again an undercount of the identification of the specific truck types since 64% of all light and medium truck FROIs were unidentified in the free-text narrative. The industries most frequently listed for delivery truck FROIs were the furniture industry (19%), automotive parts and accessories (13%), and groceries and soft drinks (9%).

3.5. Injury scenarios

The top injury scenarios associated with each identified truck type were extracted from the free-text narratives (Table 5).

For semi-truck FROIs, the top injury scenarios involved rollovers (41%) in situations such as the inability to stop in time when a vehicle was stopped or slowed in front of them. For dump truck FROIs, top injury scenarios involved rollovers (50%) and incidents where the dump truck ran off the road (20%) in incidents such as driving off the lanes of narrow roadways and overcorrecting while trying to bring the vehicle back onto the pavement, as well as the inability to stop in time for red lights, indicating that the truck may have been going too fast while approaching the intersection. Coal trucks running off the roadway (48%) in situations such as driving downhill and not being able to downshift was the most common scenario, as was jumping from the vehicle while it was in motion.

In the light and medium truck local crash FROI group, top injury scenarios for the furniture industry FROIs involved being rear-ended by other vehicles (35%) while the furniture truck was in motion or while stopped at red lights. The most common injury scenarios in the automotive parts and accessories industry FROIs involved trucks being rear-ended (46%). For the groceries and soft drinks industry FROIs, being rear-ended (67%) while in motion or while stopped were the most common injury scenarios.

Fig. 1 shows the heavy and medium/light trucker driver FROI rates by occupational category (SOC codes). The heavy truck driver occupation (local and local distance) comprised 1.5% of all Kentucky employment occupations, whereas the medium/light truck driver occupation comprised only 0.7% of all Kentucky employment occupations (data not shown). Using our study exclusion and inclusion criteria for the numerator (local distance only), the light/medium truck driver FROI rate was 64% higher than the heavy truck driver occupation FROI rate. When we examined the rate before our final long distance exclusion criterion was applied, the light/medium truck driver FROI rate (number of local + long distance FROIs/number of local + long distance truck drivers employed) was still 24% higher than the heavy truck driver FROI rate, indicating that, regardless of distance driven, light/medium truck drivers had higher FROI rates than heavy truck driver crash FROI rates.

4. Discussion

Our study results show that there were higher percentages of collision or sideswipe with another vehicle crash, lost time, and rear end crash FROIs involving light and medium truck drivers compared to FROIs involving heavy truck driver. Almost one-half of the light and medium truck driver local crash FROIs occurred in the retail trade industry, and approximately-three-quarters occurred in urban areas (non-Appalachia). The 2018 National Occupational Research Agenda (NORA) for the Wholesale and Retail Trade industries recommends additional motor- vehicle crash research on wholesale and retail trade drivers by vehicle type, driver abilities, and the need for refresher training (NORA, 2018). NORA also recommends identification of risk factors for the observed elevated transportation incidence rates in the following industry sectors: automotive parts and accessories, grocery and related product wholesalers, motor vehicles and parts wholesalers, and druggist goods and merchant wholesalers. The industries des-

Table 5
Top driver injury scenarios in heavy vs light and medium truck local crash first reports of injury, 2010–2019.[1]

Heavy Truck Type	Primary Industry	Incident type	Top Injury Scenarios
Semi-Truck (n = 59)	General Freight Trucking (Local), Local Trucking	Rollover (n = 24; 41%) Rear-end (n = 10; 17%) Ran off roadway (n = 6; 10%) Other (Sideswipe/backing up/Head-on/Pothole/Struck object) (n = 10; 17%) Not enough information (n = 9; 15%)	"Driver was driving the tractor/trailer on a haul road when he went into a curve and turned the tractor/trailer over." "He was driving a semi-truck. A car stopped in front of him to avoid an accident. He could not get stopped in time to avoid impact." "While employee was driving tractor/trailer unit he encountered a motorcycle in his lane. He swerved to avoid hitting motorcycle and the unit overturned."
Dump Truck (n = 50)	General Freight Trucking (Local)	Rollover (n = 25; 50%) Ran off roadway (n = 10; 20%) Rear-end (n = 8; 16%) Sideswipe/Not enough information (n = 7; 14%)	"Operating a dump truck dropped off roadway and overcorrected turning the truck on its side." "Driving dump truck on narrow road, overcorrected and turned truck over." "While driving a dump truck the worker applied the brakes and crossed an intersection and turned over." "Hauling dirt in dump truck. Worker approached a yellow light and couldn't stop the truck. Turned left to avoid oncoming car and tipped the truck." "Driver was loaded delivering rock when shoulder broke off the road and truck overturned."
Coal Truck (n = 25)	General Freight Trucking (Local)	Ran off roadway (n = 12; 48%) Rollover (n = 7; 28%) Head-on/Rear-end/Sideswipe/Not enough information (n = 6; 24%)	"Transporting driver was shifting gears going downhill and could not get truck in gear." "On way to pick up coal traveling on a haul road. Going downhill lost control and turned over." "Driving truck transporting coal; couldn't change gears and truck wouldn't stop so had to jump out of moving truck." "Worker was transporting coal when jumped from a moving vehicle."
Light and Medium Truck Type	**Primary Industry**		**Injury Scenarios**
"Delivery Truck"	Furniture (n = 20)	Rear-end (n = 7; 35%) Ran off roadway/Rollover/Sideswipe/Struck object (n = 8; 40%) Not enough information (n = 5; 25%)	"Employee was in delivery truck; motor vehicle struck truck in rear." "Employee was heading to customer's house for delivery in company truck when struck from behind by another vehicle." "Stopped in company vehicle at stop light when he was hit in the rear." "Rear-ended by another vehicle (passenger)."
	Automotive Parts and Accessories (n = 13)	Rear-end (n = 6; 46%) Struck by/struck object/Not enough information (n = 7; 54%)	"Driver was rear ended & has head injury." "Lost control of vehicle, ran into median and hit a tree. This was the first day of work for employee." "Employee was stopped at red light and was rear-ended." "Driver alleges he was blinded by the sun and did not see the red light. Allegedly ran the red light into the path of other vehicle." "Vehicle allegedly turned left in front of other vehicle and was struck."
	Groceries and Soft Drinks (n = 9)	Rear-end (n = 6; 67%) Not enough information (n = 3; 33%)	"Associate was rear-ended by a passenger vehicle." "Associate was involved in a motor vehicle accident. Struck from behind while stopped." "Employee was making a delivery and was rear-ended." "Employee was involved in a rear-end collision and sustained injuries."

[1] Numbers less than five are suppressed in accordance with state data management policy so incident types are collapsed into broader categories with the exception of the "Not enough information" category in Groceries and Soft Drinks.

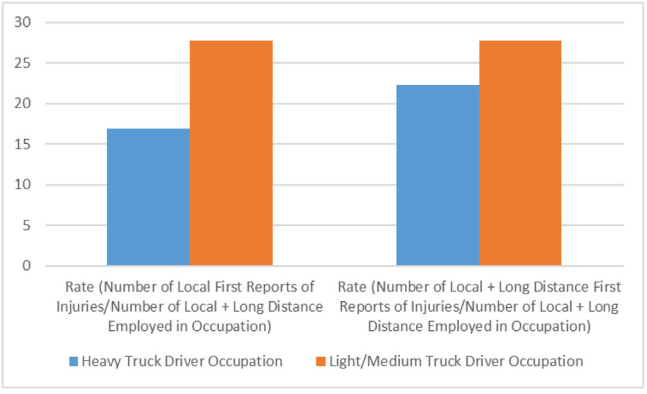

Fig. 1. Heavy and light/medium truck driver occupational first report of injury rates, 2010–2019.

ignated by NORA to need motor-vehicle crash research correspond to the industries and nature of the trucks identified in this study in the free-text narratives.

The NIOSH Center for Motor Vehicle Safety Strategic Plan identified the transportation and retail trade industries as priority industries for moto- vehicle safety research (NIOSH, 2020), particularly regarding the need for motor-vehicle safety programs in the wholesale and retail trade industries. There was a high percentage of FROIs for younger drivers of light/medium trucks who were employed in the retail trade industry (48%). Enhanced refresher driver safety training for younger drivers who have been in previous crashes with injuries is needed in the retail trade industry and especially in the furniture, automotive parts and accessories, and grocery subsectors identified in this study. Vivoda, Pratt, & Gillies, 2019, identified safety practices and policies such as road safety program duration and timely updating, company safety commitment, driver training, crash review and scorecard, and fatigue risk management as 'necessary ingredients' for improving driver safety on the roads.

Overall, light and medium truck driver FROIs involved more lost time due to injuries (higher percentages of crashes with another vehicle [rear-end crashes], sprains and strains, as well as head and neck-related and back and torso-related injuries) compared to heavy truck driver FROId. Due to the high frequency of light and medium truck rear-end collision FROIs described in the free-

text injury scenarios, light and medium truck employers should consider the inclusion of targeted curricula for light and medium truck drivers with previous crash FROIs that addresses distracted driving and emphasizing the prevention of rear-end crashes.

Our top injury scenarios for semi-truck rollover FROIs correlate with previous findings by McKnight and Bahouth (2009), where the authors found that one-half of the rollovers were due to high speed, unsafe brakes, and intersections. This study shows that local dump truck driver and coal truck driver FROIs also had a high frequency of rollovers due to tires dropping off the shoulder of the road and to losing control from being unable to downshift while driving downhill. States should consider implementing refresher heavy truck driver safety training, particularly for drivers with previous crash FROIs, that includes driving on narrow roads and roadway departure prevention and shifting gears on hills, in addition to speeding, unsafe brakes, and intersections, as highlighted by McKnight and Bahouth (2009).

4.1. Limitations

This study was limited in the ability to identify the specific truck types in the FROIs. Vehicle type is not a mandatory data field within KDWC; therefore, we needed to rely on the mention of the specific truck type in the free-text narrative. Approximately 60% of all local truck FROIs did not contain enough information in the free text to identify the specific vehicle types involved in the crash; therefore, the results may not be generalizable to all local-distance light, medium, and heavy truck crash FROIs.

Also, a study limitation was that this is a database of first reports of injuries and not a database of available truck drivers, therefore, conclusions are limited to those who were involved in a crash with a first report of injury. This is a first study to comprehensively describe injuries of light and medium truck drivers involved in local crashes compared to heavy truck drivers.

Last, another limitation was the inability to calculate age-adjusted FROI rates to accurately measure younger truck driver exposures. In the absence of Kentucky light, medium, and heavy truck driver occupation employment data by age and/or distance driven, we were only able to calculate crude FROI rates by heavy truck and light/medium truck occupation employment. Using this denominator, we show that, overall, FROI rates for light and medium truck drivers had higher crash rates compared to FROIs for drivers of heavy trucks.

5. Conclusions and practical applications

The utilization of WC data highlighted top injury scenarios and specific vehicle types for targeting driver safety training among truck drivers, particularly light/medium truck drivers. Road safety policies regarding driver training, crash reviews, and in-vehicle monitoring systems are needed for truck drivers, especially light and medium truck drivers. Implementation of entry-level (less than one year of employment) and refresher driver training for light/medium truck drivers should be considered to reduce truck driver crashes, similar to Federal Motor Carrier Safety Administration-mandated heavy truck entry-level driver training. In addition, in-vehicle monitoring systems have promising effectiveness in increasing driver safety (Furlan et al., 2020), particularly when monitoring includes both supervisory review and discussion as well as in-cab warning lights (Bell, Taylor, Chen, Kirk, & Leatherman, 2017).

Enhanced driver safety training on speeding on narrow roadways, nearing intersections, and downshifting on hills is needed for drivers of heavy trucks, particularly drivers of semi-trucks, dump trucks, and coal trucks. Driver safety training on the prevention of rear-end crashes (e.g., gradual stopping and checking mirrors) is needed for light and medium truck drivers of furniture trucks, automotive parts and accessories trucks, and groceries and soft drink trucks.

Future studies using WC data linked with crash data are needed to comprehensively identify the specific industries, vehicle types, and circumstances surrounding light and medium truck crashes.

Disclosure statement

The authors have no conflict of interest or financial interest to disclose.

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References

Bell, J. L., Taylor, M. A., Chen, G., Kirk, R. D., & Leatherman, E. R. (2017). Evaluation of an in-vehicle monitoring system (IVMS) to reduce risky driving behaviors in commercial drivers: Comparison of in-cab warning lights and supervisory coaching with videos of driving behavior. *Journal of Safety Research, 60*, 125–136. https://doi.org/10.1016/j.jsr.2016.12.008. Epub 2016 Dec 21. PMID: 28160807 PMCID: PMC5427714.

Buckner-Petty, S., Dale, A. M., & Evanoff, B. A. (2019). Efficiency of autocoding programs for converting job descriptors into standard occupational classification (SOC) codes. *American Journal of Industrial Medicine, 62*(1), 59–68. https://doi.org/10.1002/ajim.22928. Epub 2018 Dec 5 PMID: 30520070.

Bunn, T., Slavova, S., & Robertson, M. (2013). Motor vehicle injuries among semi truck drivers and sleeper berth passengers. *Journal of Safety Research, 44*, 51–55. https://doi.org/10.1016/j.jsr.2012.09.003. Epub 2012 Nov 20.

Bunn, T. L., Slavova, S., & Rock, P. J. (2019). Association between commercial vehicle driver at-fault crashes involving sleepiness/fatigue and proximity to rest areas and truck stops. *Accident Analysis and Prevention, 126*, 3–9. https://doi.org/10.1016/j.aap.2017.11.022. Epub 2017 Nov 22.

Bureau of Labor Statistics (2020). U.S. Department of Labor, in cooperation with state, New York City, District of Columbia, and federal agencies. December 2020. Census of fatal occupational injuries. URL accessed on June 24, 2021, at https://www.bls.gov/iif/oshwc/cfoi/cftb0331.htm.

Bureau of Labor Statistics (2021). U.S. Department of Labor, in cooperation with participating state agencies. Survey of occupational injuries and illnesses. URL accessed on June 25, 2021, at https://www.bls.gov/iif/oshwc/osh/os/summ1_00_2019.htm.

Chandler, M. D., Bunn, T. L., & Slavova, S. (2017). Narrative and quantitative analyses of workers' compensation-covered injuries in short-haul vs. long-haul trucking. *International Journal of Injury Control and Safety Promotion, 24*(1), 120–130. https://doi.org/10.1080/17457300.2016.1170041. Epub 2016 May 4. PMID: 27142559.

Chen, G. X., Amandus, H. E., & Wu, N. (2014). Occupational fatalities among driver/sales workers and truck drivers in the United States, 2003–2008. *American Journal of Industrial Medicine, 57*(7), 800–809. https://doi.org/10.1002/ajim.22320. Epub 2014 May 8.

Combs, B., Heaton, K., Raju, D., Vance, D. E., & Sieber, W. K. (2018). A descriptive study of musculoskeletal injuries in long-haul truck drivers: A NIOSH national survey. *Workplace Health & Safety, 66*(10), 475–481.

Doecke, S. D., Baldock, M. R. J., Kloeden, C. N., & Dutschke, J. K. (2020). Impact speed and the risk of serious injury in vehicle crashes. *Accident Analysis and Prevention, 144*, 105629. https://doi.org/10.1016/j.aap.2020.105629. Epub 2020 Jun 19.

Furlan, A. D., Kajaks, T., Tiong, M., Lavallière, M., Campos, J. L., Babineau, J., et al. (2020). Advanced vehicle technologies and road safety: A scoping review of the evidence. *Accident Analysis and Prevention, 147*, 105741. https://doi.org/10.1016/j.aap.2020.105741. Epub 2020 Sep 24 PMID: 32979820.

Hanowski, R. J., Hickman, J. S., Wierwille, W. W., & Keisler, A. (2007). A descriptive analysis of light vehicle–heavy vehicle interactions using in situ driving data. *Accident Analysis and Prevention, 39*(1), 169–179. https://doi.org/10.1016/j.aap.2006.06.016. Epub 2006 Aug 24 PMID: 16934736.

Karaca-Mandic, P., & Lee, J. (2014). Hospitalizations and fatalities in crashes with light trucks. *Traffic Injury Prevention, 15*(2), 165–171. https://doi.org/10.1080/15389588.2013.803279.

McKnight, A. J., & Bahouth, G. T. (2009). Analysis of large truck rollover crashes. *Traffic Injury Prevention, 10*(5), 421–426. https://doi.org/10.1080/15389580903135291. PMID: 19746305.

NIOSH (2020). NIOSH Center for motor vehicle safety strategic plan, 2020–2029. By Pratt S, Retzer K, Rodríguez-Acosta R, Olsavsky R, Fosbroke D. Morgantown. WV: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 2020-126.

NORA (2018). National occupational research agenda for wholesale and retail trade. NORA Wholesale and Retail Trade Sector Council, August 2018.

Pipkorn, B., Iraeus, J., Lindkvist, M., Puthan, P., & Bunketorp, O. (2020). Occupant injuries in light passenger vehicles—A NASS study to enable priorities for development of injury prediction capabilities of human body models. *Accident Analysis and Prevention, 138*, 105443. https://doi.org/10.1016/j.aap.2020.105443. Epub 2020 Feb 12.

Pratt, S. G., & Bell, J. L. (2019). Analytical observational study of nonfatal motor vehicle collisions and incidents in a light-vehicle sales and service fleet. *Accident Analysis and Prevention, 129*, 126–135. https://doi.org/10.1016/j.aap.2019.05.009. Epub 2019 May 28 PMID: 31150919.

Schmitz, M., & Forst, L. (2016). Industry and occupation in the electronic health record: An investigation of the national institute for occupational safety and health industry and occupation computerized coding system. *JMIR Medical Informatics, 4*(1), e5. Published online 2016 Feb 15. PMCID: PMC4771928.

Stuckey, R., Glass, D. C., LaMontagne, A. D., Wolfe, R., & Sim, M. R. (2010a). Risk factors for worker injury and death from occupational light vehicle crashes in New South Wales (Australia). *American Journal of Industrial Medicine, 53*(9), 931–939. https://doi.org/10.1002/ajim.20854. PMID: 20698024.

Stuckey, R., LaMontagne, A. D., Glass, D. C., & Sim, M. R. (2010b). Estimating fatality rates in occupational light vehicle users using vehicle registration and crash data. *Australian and New Zealand Journal of Public Health, 34*(2), 142–145. https://doi.org/10.1111/j.1753-6405.2010.00498.x. PMID: 23331357.

Vivoda, J. M., Pratt, S. G., & Gillies, S. J. (2019). The relationships among roadway safety management practices, collision rates, and injury rates within company fleets. *Safety Science, 120*, 589–602.

Zheng, Z., Lu, P., & Lantz, B. (2018). Commercial truck crash injury severity analysis using gradient boosting data mining model. *Journal of Safety Research, 65*, 115–124. https://doi.org/10.1016/j.jsr.2018.03.002. Epub 2018 Mar 17.

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