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RESEARCH ARTICLE

School Bus Crash Rates on Routine and Nonroutine Routes

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ABSTRACT

BACKGROUND: Although prior research has established that school buses are a safe form of transportation, crashes can produce catastrophic consequences. School buses have 2 types of routes: predictable, routine routes that take children to and from school and less predictable, nonroutine routes for school events. No studies have examined school bus crash incidence and characteristics by these route types.

METHODS: School bus crashes were identified from the Iowa Department of Transportation Crash Database from mid-2005 through mid-2010. Crash reports did not identify whether the bus was on a routine or nonroutine route, so a protocol to assign these based on day and time was developed. Bus mileage was provided by the Iowa Department of Education.

RESULTS: The school bus crash rate was 2.1 times higher on nonroutine routes than on routine routes (95% CI = 1.8-2.3). Most crashes involved an improper action by the driver of another vehicle. In crashes attributed to improper actions of school buses, failure to yield the right-of-way and disregarding traffic signs were more common on routine routes, while losing control, speeding, reckless, or aggressive driving were more common on nonroutine routes.

CONCLUSIONS: School bus crashes are more likely to occur on nonroutine routes.

Keywords: injury prevention; public health; child and adolescent health; school bus crashes.

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School buses provide one of the safest forms of transportation available to school-aged children.[1] The US National Highway Traffic Safety Administration[2] reported a total of 1386 school transportation-related fatalities between 2000 and 2009 in comparison to 179,936 motor vehicle occupant fatalities reported during that time.[3] Of those, a mere 107 were bus occupants. Such low rates of fatality and injury are encouraging, yet still pose a cause for concern. In order to reduce fatalities and injuries related to school bus crashes, a better understanding of contributing factors that increase crash risk is necessary.

In motor vehicle crashes with school buses, drivers of other vehicles are far more likely to be at fault than the school bus driver.[1] In cases where the bus driver is at fault, school bus driver characteristics have been attributed to crash risk. Bus drivers, both of school buses and other types of buses, who had increased citations, violations, and crashes were predicted to have a much higher risk of a crash than those who did not have a previous record.[4] In addition to previous driving record, driver age has been associated with crash severity. Rahman, Kattan, and Tay[5] found that crashes on non-highway roads involving bus drivers

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aged 25-44 were more likely to have a higher injury severity than crashes involving bus drivers younger than 25 years old. Road characteristics, such as increased traffic volume, higher speed limits, on-street parking, and an increase in the number of lanes, have also been associated with risk for bus crashes.[6] Several other contributors, such as occupant behavior and bad weather, can affect school bus crash risk.[7] Many of these factors are likely influenced by the specific routes taken by bus drivers. However, no studies have specifically examined the types of routes that school buses take, and if these routes pose specific risks for crashing.

School bus drivers typically drive on 2 types of routes. Routine routes involve transporting children to and from school, which are very predictable with regard to the route, time at each point on the route, and consistency in the number and specific individual passengers. Nonroutine routes involve transporting children to school-related events, such as field trips or school competitions. Nonroutine routes are not predictable with regard to route, time, or passengers. Route type has not been previously examined as a factor in school bus crash incidence or severity. The single study to examine route type involved all types of buses and found that intercity buses (transportation between cities) on a regularly scheduled route were the least likely to be involved in a crash in comparison with tour/charter, school, and transit buses.[4] Type of route may be important because operating a school bus in a familiar and predictable environment may reduce the risk of a crash. This reduced risk is likely even in crashes in which the other driver is at fault—drivers of passenger vehicles may be less likely to crash with a bus that is in the traffic environment at the same time and at the same place every weekday.

The current investigation describes rates and characteristics of school bus crashes that lead to fatal and severe injury according to the type of bus route. The data are from the state of Iowa, in which both comprehensive crash and bus mileage data are available.

METHODS

Study Design and Population

This was a retrospective study of school bus crashes reported in the Iowa Crash Database for the 5-year period (fiscal/school year) from July 1, 2005 through June 30, 2010 (N = 1080). The data are maintained by the Iowa Department of Transportation (IADOT), Office of Driver Services (ODS), and includes all investigating police officers' reports of motor vehicle crashes. The database is comprised of 3 levels of data (crash—including location, roadway and environmental characteristics, vehicle/driver, and person—including injury information) that were hierarchically linked. All crashes that included a vehicle code indicating a school bus were included in this analysis (N = 1050). All crashes included in our analysis have a vehicle configuration of ''school bus'' as indicated in each crash report, and these include only traditional school buses, which require a Commercial Driver's License to operate. Crash reports for other school transportation vehicles, such as vans, charter, or activity buses, which are not used for picking up at or dropping school children off at home, were not available. Denominator data for rate calculations were obtained from the Iowa Department of Education, which reports annual bus miles on routine and nonroutine bus routes, by school year, regardless of vehicle type. Annual bus mileage reports included miles traveled by each school's bus fleet, which consists primarily (80%) of typical school buses. Mileage reports included miles accrued by all school transportation vehicles.

Variables

The main outcome variable for this analysis was whether the crash occurred on a routine or non-routine bus route. Routine bus routes are those that are traveled on a regular schedule and route and are primarily routes to and from school. Nonroutine routes are those that are scheduled for nonroutine transportation, such as field trips. The Department of Transportation data does not designate whether or not the bus crash occurred during a routine or nonroutine route. Bus crashes were categorized as route and nonroute based on the time of day and day of week. All weekend crashes were considered non-route because no Iowa school system has weekend bus routes. Weekday morning crashes were considered being on a routine route if they occurred between 6:00 AM and 8:30 AM. These hours were chosen based on review of 47 school district websites to determine the most common 90-minutes before the beginning of school.

Weekday afternoon crashes were considered to be on a routine route if they occurred within 90 minutes of the end of the school day. Categorization of route and nonroute crashes in the afternoon was more difficult because in the state of Iowa, like many other states, some school districts have early release days 1 day a week in order to meet specific criteria for required teacher classroom hours and teacher's training. However, not all schools have early release days and schools that follow this model do not always have the same early release schedule. On early release days, school is dismissed 1 hour early (usually between 1:30 PM and 2:30 PM), which affected categorization of crashes between 1:30 PM and 2:59 PM. Of the 1050 school bus crashes, 113 (10.8%) occurred in this period. To classify each crash as either routine or

Table 1. **School Bus Crash Rates Overall and by School Year (N = 1050)***

School Year	Number of Crashes	Routine Route Miles	Crash Rate per Million Miles	Number of Crashes	Nonroutine Route Miles	Crash Rate per Million Miles	Rate Ratio (95% CI)		
05-06	114	43,248,523	2.64	71	3,507,928	5.26	1.99	1.48	2.68
06-07	137	42,381,788	3.23	83	13,546,112	6.13	1.90	1.44	2.49
07-08	141	41,930,980	3.36	97	13,398,808	7.24	2.15	1.66	2.79
08-09	129	41,656,125	3.10	82	13,536,797	6.06	1.95	1.48	2.58
09-10	112	41,561,331	2.69	84	13,040,029	6.44	2.39	1.80	3.17
Total	633	210,778,747	3.00	417	67,029,674	6.22	2.07	1.83	2.34

*One missing crash due to missing time, thus no route designation.

nonroutine route, researchers determined if the crash occurred on an early dismissal date by referencing the specific school district calendars. Specific information was found for 89 of the 113 crashes. For 85 (95.5%) of the 89 crashes that could be categorized by district calendars, the crash was considered to have occurred during a nonroutine route period because the day of the crash in question was not an early release day. Because such a high proportion of the crashes which we could verify were during nonroute hours, we categorized the remaining 24 crashes as nonroutine. A sensitivity analysis indicated that results were not significantly affected by categorizing either way.

Two variables were created based on injury severity, one for the bus and another for the other vehicle(s) involved in the crash; thus, severity is at the vehicle level and assigned the highest level of experienced injury. Severity was identified by the officer at the scene as fatal, incapacitating, minor, or no injury. Crashes were assigned to the most severe level of injury of any party in the crash. Crash contributing causes were assigned to each vehicle in the crash based on the assessment of the reporting officer.

Data Analysis

Crash rates were calculated for routine route and nonroutine route crashes per route million miles traveled, and rate ratios and 95% CI were estimated to compare rates by route across each year in the sample. Bivariate analyses compared crash injury severity, characteristics of the bus driver, and contributing causes by whether or not the bus was on a routine or nonroutine route. Characteristics of the contributing causes for school bus crashes were also examined for the bus and for other vehicles involved in the crash. Chi-square tests were performed to compare all bivariate distributions.

RESULTS

During the 2005 through 2010 school years, there were a total of 633 crashes on routine routes for an average annual crash rate of 3.0 crashes per million miles traveled (Table 1). Over the 5 academic years studied, the crash rate ranged from 2.6 to 3.4 crashes per million miles traveled. A total of 417 nonroutine route crashes led to a crash rate of 6.2 per million miles traveled (range = 5.3 to 7.2 million miles). Crashes on nonroutine routes were 2.1 times more frequent than crashes on routine routes (95% CI = 1.8-2.3). A Mantel-Haenszel test for trend over time indicated no significant changes in rate ratios during the 5-year study period ($p = .6$).

Injury severity was far lower for bus occupants than for occupants of other vehicles that crashed with the bus. Five crashes (0.8%) led to fatal or incapacitating injury for bus occupants, of which only 1 occurred on a routine route (Table 2). In contrast, 28 crashes (2.7%) led to fatal or incapacitating injury among occupants of motor vehicles that collided with the bus. A higher proportion of fatal and incapacitating injuries occurred to motor vehicle occupants when they were in collisions with a bus on a routine route (3.5%) than a nonroutine route (2.5%). Overall, however, crash injury severity did not differ by routine versus nonroutine route for either bus or motor vehicle occupants.

Younger bus drivers were significantly more likely to be involved in nonroutine than routine route crashes. Accordingly, over 13.2% of drivers under the age of 35 were in nonroutine route crashes compared with 5.6% of drivers in that age group for routine route crashes. A slightly higher proportion of routine route crashes involved a driver age 65 and over compared with nonroutine route crashes ($p = .001$; 29.7% and 25.4%, respectively).

The school bus drivers had actions that contributed to the cause of the crash in 40.1% of crashes. A total of 910 (86.7%) of the crashes involved another vehicle, in 53.7% of these crashes the other vehicle drivers had actions that contributed to cause the crash, in 40.1% of these crashes the school bus had actions that contributed to the crash, and in 6.2% of crashes contributing circumstances were unknown. Failure to yield the right-of-way was the most common improper action cited for both the bus drivers (27.1%) and the other vehicle drivers (20.5%), and was more common in crashes on routine routes than nonroutine routes for both the bus and other vehicle drivers.

Table 2. **Crash Severity and Other Characteristics by Routine/Nonroutine Status**

Crash Severity	Total (N = 1050) N (%)	Routine Route (N = 633) N (%)	Nonroutine Route (N = 417) N (%)	p-Value
Highest severity for bus				.135
Fatal	1 (0.1)	0 (0.0)	1 (0.2)	
Incapacitating	4 (0.4)	1 (0.2)	3 (0.7)	
Minor Injury	98 (9.3)	67 (10.6)	31 (7.4)	
No injury	939 (89.3)	559 (88.3)	380 (91.1)	
Unknown	8 (0.8)	6 (0.9)	2 (0.5)	
Highest severity for other vehicle(s)*				.69
Fatal	8 (0.9)	5 (0.9)	3 (0.8)	
Incapacitating	20 (2.2)	14 (2.6)	6 (1.7)	
Other injury (minor)	120 (13.2)	70 (12.8)	50 (13.9)	
No injury	695 (76.4)	421 (76.7)	274 (75.9)	
Unknown	67 (7.4)	39 (7.1)	28 (7.8)	
No other vehicle†	140			
Crash Characteristics				
Age of bus driver				.001
18-24	22 (2.1)	8 (1.3)	14 (3.4)	
25-34	68 (6.5)	27 (4.3)	41 (9.8)	
35-44	126 (12.0)	84 (13.3)	42 (10.1)	
45-54	259 (24.7)	155 (24.5)	104 (24.9)	
55-64	274 (26.1)	168 (26.5)	106 (25.4)	
65+	294 (28.0)	188 (29.7)	106 (25.4)	
Unknown‡	7 (0.7)	3 (0.5)	4 (1.0)	
Bus driver contributing cause				
No improper action	564 (53.7)	349 (55.1)	215 (51.6)	
Improper action	421 (40.1)	250 (39.5)	171 (41.0)	
Unknown	65 (6.2)	34 (5.4)	31 (7.4)	
Type of improper action§				
Failed to yield right-of-way	114 (27.1)	81 (32.4)	33 (19.3)	.016
Lost control	52 (12.4)	29 (11.6)	23 (13.5)	
Improper turn	36 (8.6)	21 (8.4)	15 (8.8)	
Disregarded traffic signs/signals/road markings	19 (4.5)	15 (6.0)	4 (2.3)	
Overcorrecting/swerving	18 (4.3)	12 (4.8)	6 (3.5)	
Speeding, reckless, or aggressive	17 (4.0)	7 (2.8)	10 (5.8)	
Followed too closely	17 (4.0)	10 (4.0)	7 (4.1)	
Inattentive/distracted	13 (3.1)	9 (3.6)	4 (2.3)	
Other improper actions	135 (32.1)	66 (26.4)	69 (40.4)	
Other vehicle/s driver contributing cause				
No other vehicle†	140			
No improper action	373 (41.0)	221 (40.3)	152 (42.1)	
Improper action	482 (53.0)	303 (55.2)	179 (49.6)	
Unknown	55 (6.0)	25 (4.6)	30 (8.3)	
Type of improper action§				
Failed to yield right-of-way	99 (20.5)	67 (22.1)	32 (17.9)	.017
Speeding, reckless, or aggressive	95 (19.7)	67 (22.1)	28 (15.6)	
Disregarded traffic signs/signals/road markings	74 (15.4)	43 (14.2)	31 (17.3)	
Lost control	66 (13.7)	38 (12.5)	28 (15.6)	
Followed too closely	41 (8.5)	27 (8.9)	14 (7.8)	
Overcorrecting/swerving	13 (2.7)	9 (3.0)	4 (2.2)	
Inattentive/distracted	11 (2.3)	8 (2.6)	3 (1.7)	
Improper turn	8 (1.7)	1 (0.3)	7 (3.9)	
Other improper actions	75 (15.6)	43 (14.2)	32 (17.9)	

*For highest severity (other vehicle, N = 849), it's only taking into consideration 1 of the other vehicles yet other vehicle contributing circumstances shows a higher total (N = 910) due to including contributing circumstances from all other vehicles (eg, crashes where there were greater than 2 vehicles involved, N = 60).
†Crashes that did not involve another vehicle were excluded from calculations of percentages.
‡One missing crash due to missing time, thus no route designation.
§Percentages calculated based on crashes in which the bus/motor vehicle contributed an improper action.

Speeding, reckless, or aggressive driving; disregarding traffic signs, signals, or road markings; losing control of the vehicle; and following too closely while not common, were more frequent contributing causes by the other vehicles drivers than the school bus drivers.

Speeding, reckless, or aggressive driving; disregarding traffic signs, signals, or road markings; losing control of the vehicle; and following too closely were all more common contributing causes by the other vehicle drivers than the school bus drivers. Improper turns; overcorrecting or swerving; and inattention/distraction were more common contributing causes of the bus drivers than the other vehicle drivers.

There was a significant difference in the types of contributing causes, on the part of the bus and other vehicle drivers, reported in nonroutine versus routine crashes. Among buses, failure to yield the right-of-way and disregarding traffic signs were more common on routine than nonroutine routes, whereas losing control and speeding, reckless, or aggressive driving were more common on nonroutine routes. Among other vehicles, failure to yield the right-of-way; speeding, reckless, or aggressive driving; following too closely; and inattentive or distracted driving were more frequent when the bus was on a routine route. Disregard for traffic signs; losing control; and improper turns were more frequent actions by other vehicles when the bus was on a nonroutine route.

DISCUSSION

We found that Iowa school buses crash at a rate of 3 per million miles driven, supporting existing literature that likewise documents the low crash risk associated with school bus transportation.[1] Our study presents additional information that, although rates are low, bus crashes are more frequent on nonroutine routes (for field trips or school events) than on routine routes to and from school. Injuries to bus occupants are also uncommon: in the 5 school years studied, only 1 severe and no fatal injuries occurred to bus occupants on a routine bus route and fewer than 1% of crashes on nonroutine routes led to severe or fatal injury. Injuries were far more frequent among occupants in vehicles that crashed with buses than among the bus occupants.

Furthermore, bus crashes were far more likely to be caused by the drivers of other vehicles in the collision than by the bus driver. And, contributing causes related to major driving violations were more frequently exhibited by the drivers of vehicles that crashed with buses than the bus drivers themselves. For example, the most frequent causes among other vehicles included reckless or aggressive driving and disregard for traffic controls. In crashes where the school bus contributed to the crash, contributing causes were associated with difficulty in maneuvering the bus, such as overcorrecting and improper turns.

Examining crash patterns in bus crashes that occurred on routine and nonroutine routes does lead to some prevention priorities. Younger bus drivers were more likely to be involved in crashes on nonroutine routes, which may be due to the likelihood that younger drivers more frequently drive these routes but could also be due to inexperience with bus driving. Policies that assign newer drivers to routine routes while they gain experience might help reduce crashes on nonroutine routes. Although uncommon among bus drivers, speeding/reckless/aggressive driving and losing control of the bus were more common on nonroutine routes. Although the reasons for this difference are unknown, time pressures for school events and field trips could be higher on nonroutine than routine routes, and driving conditions could be more challenging and unpredictable on less familiar roads. Inattention and distraction were also infrequent, but was a more common cause among buses than other vehicles, and more common among buses on routine than nonroutine routes. Vigilance in attention to driving is imperative, although bus drivers are often distracted by activities of the children they are transporting, including being responsible for problem behavior.[8,9] Educating bus drivers on tactics to limit distraction caused by occupant behavior might help to alleviate the incidence of crashes due to distraction.

Other vehicles more frequently contributed to crashes on routine routes by failing to yield the right-of-way and speeding. The high frequency of contributing causes among other vehicles suggests that efforts to educate or enforce driving rules during the hours of routine school bussing and on bus routes would be helpful in reducing crashes.

Although crashes in this analysis included only traditional school buses, the mileage accrued could have included other forms of school transportation such as activity buses. These types of other transportation are more likely to be used for nonroutine routes when fewer children are transported. Smaller vehicles used for school transportation may not require a Commercial Driver's License to operate (although if the driver was an official bus driver, they would have this type of license). Although the mileage accrual for nonroutine routes could include other vehicles, the vast majority of Iowa school transportation is by school bus. Inclusion of these miles would artificially increase the denominator and would thus lead to an underestimation of nonroutine route crashes. This contribution would account for a small proportion of miles traveled and would not likely affect crash estimates reported here. However, these vehicles may have a substantively different crash experiences than school buses and should be considered in school transportation studies when possible.

Limitations

This study has several limitations. Information on total bus miles traveled by route status was available from the Department of Education, but the specific purpose of the bus trip was not included in the crash report. Thus, we developed a proxy system to categorize crashes by routine and nonroutine routes based on school hours. This categorization may have some misclassification if school hours vary widely, although we verified school hours using thorough examination of a large number of school district websites. Bus crashes that occurred on nonroutine trips that were at the same time as routine routes would be systematically misclassified as occurring on routine routes, which would bias our results toward the null. We examined the potential influence of a 5% error and found no differences in study findings. Other forms of school transportation, such as activity buses, were not available for analysis. It is possible that activity buses, which do not require a Commercial Driver's License to operate, contributed to nonroutine route bus miles although they would not have been counted as bus crashes. Although not possible in this study, differentiating the type of school buses involved in routine and nonroutine crashes in future investigations will illuminate more possible contributors to school bus crashes.

Conclusions

School buses provide among the safest alternatives for roadway transportation. When school bus crashes do occur, they are more likely to occur on nonroutine routes (those not going to and from school).

IMPLICATIONS FOR SCHOOL HEALTH

Knowing that bus crashes are more likely to occur when on nonroutine routes has several implications for reducing the likelihood of these crashes in the future. For instance, amending training programs for school bus drivers to include scenarios of bus crashes on nonroutine trips could alert drivers to this issue and potentially provide insight into ways to avoid these crashes. Training of this kind would be helpful both in the classroom and during hands on instruction in the field. As other drivers were more likely to contribute to the crash, programs designed to increase driver awareness of this issue could also be beneficial in reducing school bus crashes. General driver education could add to sections on school bus safety by describing the challenges that come with encountering large vehicles like buses on city and highway roads and the potential for collision with larger vehicles like buses when sharing the roads with passenger vehicles.

Human Subjects Approval Statement

The Internal Review Board at the University of Iowa approved this study.

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