

Horse and Buggy Crash Study I: Common Crash Scenarios between a Motor Vehicle and the Amish / Old Order Mennonite Horse and Buggy

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Abstract

Horse and buggy transportation is spreading as rapidly as its Amish and Old Order Mennonite users are, as are buggy crashes with motor vehicles. This study examines the primary causes of 76 reported horse and buggy crashes in Pennsylvania in 2006. The main crash types identified include a motorist rear-ending a forward-moving buggy, a motorist striking the buggy while attempting to pass, buggy struck while crossing an intersection, and buggy struck while making a left turn. While causative factors varied, major factors include the motorist or buggy driver incorrectly comprehending speed differentials, the motorist acting carelessly around the buggy, and miscommunication between the motorist and buggy driver. Within these crash types, buggy conspicuity was not commonly a potential cause.

Keywords

Amish; Old Order Mennonite; slow-moving vehicle (S.M.V.); glare; conspicuity; passing; left turn; intersection; Lancaster County

A Note about the Horse and Buggy Crash Studies Series

This article is the first of three by the author addressing horse and buggy crashes. The other two articles are in the same issue, pages 100-115 and 116-124.

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Introduction

The Old Order Mennonites and Old Order Amish (hereafter “Old Orders”) are two of the fastest growing groups in the United States. The Amish population, for one, is doubling approximately every 21.25 years (Donnermeyer, Anderson, and Cooksey 2013). These sects reject personally owned automobiles and thus use a variety of transportation means. A common form of non-motorized transportation is horse power to pull passenger carriages and farm equipment. Crashes between automobiles and horse and buggies have been a concern since the two began sharing the same thoroughfares around a century ago (Bachman 1942). Further, as Old Order populations grow and settle new locations, roadway safety challenges move beyond historic settlements, becoming increasingly germane to a diversity of locales. Few formal studies explore the causative factors of crashes, a prerequisite to implementing useful preventative measures. By using crash data from Pennsylvania, this study categorizes crashes into four of the most common scenarios.

The brittle wood and fiberglass materials from which buggies are made make them especially susceptible to extensive damage when motor vehicles strike them. Investigating crash causation is important to Old Order health, physical well-being, and property protection. Buggy crashes with motor vehicles constituted the second highest reason for Amish hospital admissions; of all injury types, buggy crashes brought the highest odds of surgery and greatest expenses, and second longest hospital stays (Vitale, et al. 2006). In another study, 43% of buggies in crashes sustained extensive damage or were destroyed, and about 10% of buggy crashes involved a fatality (Piacentini 2003). Mortality rates are highest in Amish buggy crashes when they involve a motor vehicle (Aaland and Hlaing 2004). Amish and Old Order Mennonites are concerned about crashes, having created educational materials about driving practices on their own and in conjunction with state outreach efforts (Burkholder [n.d.]; Lancaster County 2004; Pathway Publishers 1993; Yarosh et al. 1992), but nevertheless, crashes persist.

Background

Buggy Characteristics

The specific styles and attributes of buggies vary among and within settlements. Figures 1 and 2 show typical Amish horse-drawn buggies in Lancaster County, Pennsylvania (Appendix A shows other types). The width of a standard buggy is around six feet. Buggies have been made of oak, poplar, hickory, but more recently fiberglass is used. Buggies have foot pedal or hydraulic brakes. While most horse drawn transportation among the Amish and Old Order Mennonites is uniform in design, style variation, including horse-drawn farm equipment, flatbeds, and two-wheeled single occupant attachments, creates additional variables in diagnosing crash causation. Most communities prefer buggies with enclosed cabins, though a handful of settlements require open buggies. The standard-bred is used for pulling buggies. Horses used for farm work are rarely utilized for pulling passenger vehicles (Scott 1998[1981]).

Figure 1: Typical Amish Horse and Buggy (Lancaster County), Front



Photo credit: Cory Anderson

Figure 2: Typical Amish Horse and Buggy (Lancaster County), Rear



Photo credit: Cory Anderson

Buggy Markings and the Issue of “Visibility”

Amish and Mennonites may use any or a combination of L.E.D. lights, reflective tape, the S.M.V. (slow-moving vehicle) emblem, or a lantern to mark the buggy. Lighting must follow the standard format motor vehicles use: red lights on the back and amber lights on the front (Lancaster County 2004). Any other lighting pattern or light colors, such as blue, are illegal (Eberly 2007), though enforcement varies. Standard rear lighting patterns may include either one red light placed in each of the two lower corners or one red light in each of the four corners. Buggy drivers set these lights to flash at night, though increasingly with energy efficient technology rear lighting remains constant. Strips of reflective tape are often placed either at the rear corners or along the perimeter of the rear, either parallel with the buggy’s perimeter or angled like slashes (Eicher, Bean, and Buccalo 1997). However, patterns vary, and the arrangement of lights and tape can be irregular. Most buggies have the S.M.V. emblem affixed on the rear, as about half of all states legally require. Several particularly orthodox Amish groups, including the Swartzentruber Amish, have won legal exemption from the mandatory S.M.V. emblem requirement in certain states, including Pennsylvania (Garvey 2003; Herman 2002), Minnesota (Zook 1989; Zook 2003), Kentucky, and others. Such Amish groups use a lantern attached to the side of the buggy instead of the SMV emblem.

The issue of “visibility” has been at the center of many discussions in motor vehicle crashes with the horse and buggy. The Old Orders or local community may respond to a crash with a call for more and better rear markings. However, “visibility” has remained vaguely defined, with little explanation of what it entails. This study differentiates among three types of visibility:

1. Visibility or *conspicuity* of the buggy itself, that is, the ability of the buggy to catch motorists’ attention in otherwise optimal conditions.
2. Visibility of the buggy due to *illumination*. That is, during broad daylight the buggy is fully illuminated, but in pure darkness, is completely non-illuminated.
3. Visibility of the buggy related to *obstruction* and sight distance, such as a buggy being blocked from sight by road grade, road geometry, adverse weather, or another vehicle.

Since buggies travel at slow speeds, motorists may be taken off guard by how quickly they approach a buggy. The sooner a motorist is able to identify a buggy as such, the more time he has to react. Old Order populations and safety officials given focused attention to increasing buggy conspicuity (James 2001). However, certain equipment, such as the S.M.V. emblem and/or L.E.D. lights, has been resisted by conservative Amish groups, notably the Swartzentrubers. From legal proceedings in several states, the state and researchers have re-evaluated the actual effectiveness of certain markings and the causes of crashes. The effectiveness of the S.M.V. emblem as both a marker of identity and conspicuity has been questioned (Anderson 2014; Garvey 2001; Garvey 2003; Lehtola 2007; Walczak, et al. 2002). Yet, the numerous court cases

about the S.M.V. emblem have not addressed whether or not conspicuity is the most significant factor in buggy crashes.

Previous Buggy Crash Research

The most common approach to diagnosing buggy crash causation has been to analyze aggregate crash data. Ives and Brotman (1990) analyzed aggregate data for Pennsylvania for 1984, 1985, and 1986, finding high incidences of D.U.I.s and speeding as factors for fatal crashes. They speculated that the camouflaged appearance of the buggies was a risk factor (i.e. conspicuity), and this correlates with the high incidence of rear end collisions. In Lancaster County, PA, Dempski (1993) concluded that, in order of frequency, improper entrance (buggy), careless passing, and tailgating, among others, were major causative factors. Supplementing the crash data analysis with field observations of county roads, she postulated that poor sight distance (i.e. obstruction) contributed to accidents. A similar study for Ohio (Office of Urban and Corridor Planning 2000) analyzed Ohio police reports, supplementing the findings with anecdotal information, public meetings, and surveys. The study concluded that the top three causes of crashes were motor vehicle misjudgment of speed differences, lack of visibility because of poor illumination at dusk / dawn and hilly topography, and poor actions made by either buggy or motor vehicle drivers.

However, analyzing a single factor in a set of aggregate data divorces the combination of actions and events that culminate in a crash. Ives and Brotman (1990), Dempski (1993), and, to a lesser extent, the State of Ohio (Office of Urban and Corridor Planning 2000) reached their conclusions by isolating each crash characteristic and ranking them against each other based on frequency. This is a problematic approach because it removes the action from its context. In addition, these studies relied on police reports that used check box categories for crash descriptions, such as “speeding” and “careless passing.” These categories were developed largely to describe standard auto crashes, not buggy crashes, and police may select categories that do not adequately describe the unique attributes of buggy crashes when viewed in isolation of other factors. Thus, without compiling all the characteristics for each crash, a single attribute or description may be misleading outside.

Methods

The goal of the research design was to analyze characteristics of individual crashes—reconstructing each accident into a narrative—and categorize them into resultant types rather than analyze single factors in aggregate data. The target population was all reported crashes in Pennsylvania in 2006 between an Amish or Old Order Mennonite horse-drawn vehicle and a motor vehicle. PennDOT Protected Crash Reporting System Data served as a sampling frame for this population.² The data were from police crash reports. Seventy-seven cases of a horse-drawn vehicle crash were identified in the database. Since the database was designed to make aggregated inquiries about single characteristics of crashes (as conducted in previous studies)

and not an examination of individual cases, the 77 cases were extracted by matching incident codes to corresponding data. Ideally, ten years worth of data would provide greater confidence in the findings. However, PennDOT releases each annual database at a set cost, and for the scope of this study, ten years of data were not feasible to acquire. Thus, all findings in this study must be qualified by the low sample size. Nevertheless, this sample size should be adequate enough to at least identify the major crash scenarios—the primary goal of this article—and then project possible complexities within each crash type for future analyses with larger datasets.

The examination of the 77 cases consisted of reviewing all pertinent data for each crash. These included road information, environmental and lighting conditions, time and date of crash, geographical location, noted causative actions, sequence of events, injuries, information about the motor vehicle, and impact point. Two components that may have aided this study were not included in the received data: a diagram of the crash and a description, both of which were in the actual crash form but remained confidential. One of the 77 incidents was eliminated from the sample since the crash occurred in a county with no Old Order settlements and the details of the crash would have been unusual for an Old Order case.

Using the available data, each crash was described in a narrative form. The narratives were then cross-referenced with available newspaper reports about these crashes to verify the data and reconstructed narrations. Newspaper articles were located for 13 of the 76 crashes. Most reports came from papers in Lancaster County, which has the largest Old Order population in Pennsylvania. The stories verified the accuracy of the thirteen matching narratives developed from the crash data, giving legitimacy to the narrative approach in describing crashes.

The narratives were then categorized into several types of crashes. These types were based on consistencies between narratives of how the buggy was struck and what actions the buggy driver and motorist were committing. Those cases with ambiguous or insufficient information were placed in the “other or unknown” classification. After developing broad categories, cases were reviewed further for major sub-classifications.

Among crash characteristics, natural illumination was analyzed. Rather than relying solely on vague illumination designations from police reports (daylight, dark, dusk, dawn, etc.), the illumination was determined by identifying the sunrise and sunset time for the crash date and county location and then calculating whether or not the crash fell into a period when natural illumination was changing. In order to create a simple measure for the purpose of this study, the specified period was designated as either of the following: (1) for sunrise periods, two hours after dawn and all crashes indicated as dawn regardless of actual time; (2) for sunset periods, two hours before dusk and all crashes indicated as dusk regardless of actual time. These calculations of sunrise and sunset periods are, admittedly, rough estimates of conditions based on timing, but emerging evidence should at least provide some sense of the impact of natural conditions during these time periods.

Results

Four primary types of horse and buggy crashes were identified among the reported 76 Old Order Mennonite or Amish crashes in the PennDOT crash database. These crash types are listed in Table 1. By far, the largest category of buggy crashes for 2006 involved a motorist closing on the buggy from behind and striking it at the rear. It accounted for 31 of 76 (41%) of buggy crashes (Table 2). Only one rear-end collision that was not an attempted pass was at an intersection, the rest at midblock. This compares to 61% of 2006 rear-end crashes for all vehicles in Pennsylvania at midblock versus other locations (excluding on/off ramps and other such segments buggies would not travel). While the buggy sample is low, and therefore statistical analysis was not conducted, the difference is nevertheless apparent. Rear-end collisions are a mid-block, not intersection, problem for buggies.

Table 1: Number of Crashes by Crash Type

Crash Type	Pa. Crashes in 2006
1. Motorist rear-ended a forward-moving buggy	31
2. Motorist attempted to pass a forward-moving buggy	8
3. Buggy driver attempted to cross or enter a main road	12
4. Buggy driver attempted a left turn off the main road	9
5. Other (small categories) or unknown	16

Table 2: Motorist Rear-Ended a Forward Moving Buggy

	Count
Total crashes in category	31
Midblock (non-intersection)	30
Straight road alignment	29
Sun near horizon	14
Driving towards sun	8
Driving another direction	6
On a grade (hill)*	10
Motorist distracted*	8
Motorist impaired (drowsiness or intoxication)*	3

*Categories mutually exclusive: impairment is prioritized over distraction, which is prioritized over grade.

For exploratory purposes, sub-factors are summarized in Table 2. Nearly all rear-end crashes were on a straight road alignment, with only two at curved alignments, though a third occurred on a grade. Approximately one quarter of crashes involved a distracted motorist. The rear-end crash type contained no shortage of crashes occurring when the sun was near the horizon (14 of 31). Of those crashes that occurred during transitional periods, over half (eight of 14) were when the buggy and motorist were traveling towards the sun, whereas if randomly distributed across the four possible directions should only be 25%. Thus, of all crashes in this study, 10.5% were rear-end, midblock collisions when the motorist was driving toward the sun.

In the second scenario, eight crashes occurred when a motorist attempted to pass a forward-moving buggy on a straight road (Table 3). Seven of eight motorists struck the buggy at the six or seven o'clock position³ and one at the 11 o'clock position. Thus, the majority of crashes here occur at the beginning of the pass, where the buggy is struck in its rear or rear left side. Environmental conditions do not allude to extenuating circumstances, but the sample size is too small to conclude environmental conditions are not a reoccurring issue in such crashes.

Table 3: Motorist Attempted to Pass a Forward-Moving Buggy

	Count
Total crashes in category	8
Type of collision and angle buggy struck	
Struck (sideswiped) at the 11 o'clock position	1
Struck at the six or seven o'clock position	7
Environmental conditions	
Clear, daytime	3
Clear, transitional	1
Clear, nighttime	3
Fog, nighttime	1

In the third scenario, 12 crashes occurred when a buggy entered an intersection and an oncoming vehicle struck the buggy (Table 4). The buggy was coming from either a driveway or local road (indicated by the presence or absence of a traffic control device). The buggy driver either wanted to cross the intersection or merge into the far lane, evidenced by the position struck. No reports suggested a right turn, that is, merging into the near lane. Only once was the motorist cited for something, in that case "too fast." Complications like a grade of rain/fog existed in most crashes, affecting the buggy driver's ability to interpret oncoming traffic distance and speed. Twice as many crashes occurred in the far lane from the buggy's point of entry than the near lane, further suggesting timing misinterpretation.

Table 4: Buggy Driver Attempted to Cross or Enter a Main Road

	Count
Total categorical crashes in category	12
Nature of buggy entrance	
Buggy ran a stop sign	5
Buggy proceeded without clearance	7
Illumination and environmental conditions	
Rain and/or fog	6
Clear, on a grade or hillcrest	3
Lane in which buggy is struck	
Struck by vehicle in the far lane	6
Struck by vehicle in the near lane	3
Could not be determined	3

In the fourth scenario, nine crashes occurred when a buggy driver attempted a left turn off the main road and onto a local road or driveway (Table 5). All crashes were onto a T-oriented side road or driveway; none occurred at a four-way intersection. Two-thirds (six) of crashes occurred when a vehicle came from behind, attempting to pass just as the buggy started turning. In two crashes, the buggy turned into oncoming traffic. All crashes occurred during clear conditions and most on a level grade.

Table 5: Buggy Driver Attempted a Left Turn off the Main Road

	Count
Total categorical crashes	9
Grade	
Level grade	7
Unlevel grade	2
Illumination and environmental conditions	
Daytime, clear	5
Transitional, clear	1
Nighttime, clear	3
Buggy struck at...	
6 to 11 o'clock position (vehicle from behind)	6
12 to 5 o'clock (vehicle from front), angle impact	2
Unspecified in data	1

Any crashes that did not fit in the above four crash scenarios were either in minor categories or described too vaguely to be classifiable. Five crashes occurred when a motorist attempted to enter a travel lane on a main highway from a local road, colliding with a buggy on the main road. Four crashes occurred between a motor vehicle and a buggy traveling in opposite directions; three of these occurred during a transitional period, the fourth at night. Two were sideswipes and two were head-on collisions. Seven crashes could not be reconstructed based on available information.

Discussion

Motorist Rear-Ends a Forward-Moving Buggy

Approximately 41% of all crashes in this study occurred when a motor vehicle rear-ended a buggy, by far the largest crash scenario. There is some consistency among the cases: all but two crashes occurred on a straight road and all but one occurred at midblock. Both vehicles were moving forward on a straight road; the motor vehicle approached the buggy from behind and struck it. From these observations, the extreme speed differences between motor vehicles and the buggies emerges as a foundational variable, given that the speed disparities are optimized along straight mid-block corridors.

Large speed differences compound crash risk, but other factors, such as distracted driving, adds further risk. Of this study's four primary crash scenarios, all but one of the "distracted driver" cases (eight of nine) were in this category. Under normal conditions, glances away from the road totaling two seconds at minimum doubles the near-crash/crash risk. Engaging in complex secondary tasks at least triples the risk (Klauer, et al. 2006). Motorists may feel more confident engaging in distracted activities when there is no curvature in the road, further lending support to distracted driving as a major causative factor of rear-end collisions, which are almost exclusively on straight segments. Grades may also reduce timing. On positive grades, closing time will be quicker since buggies travel more slowly. On negative grades, the buggy is obstructed from view until the motorist crests the hill and a negative grade requires increased braking time. The three drivers who were impaired introduce obvious risk to colliding with a horse and buggy. The glare of the sun or transitional illumination evidently impacted some motorists' vision. That over half of the fourteen cases occurring during periods of illumination transition were while the motorist was driving towards the sun suggests glare as a causative factor in crashes, compounded by reduced reaction time given already large speed differences. Further, all four positive grade crashes occurred during periods of transitional illumination. While this sample is too low to generate statistical results, sun glare merits more attention in future buggy crash studies.

The major issues in rear-end crashes appear to be the speed differences of the motor vehicle and buggy, distracted driving, motorist's view of the buggy obstructed by topography, and the glare of the sun obstructing the motorist's view of the buggy. What about the conspicuity

of the buggy? Was this a cause in crashes? In seven rear-end crashes on level surfaces in which the motorist was neither distracted nor driving into the sun, conspicuity may have been a factor. While it is certainly important for the buggy to be conspicuous from the rear, other factors are also entering the equation in rear-end crashes. Remedial measures targeting rear end crashes must account for several factors that reduce response and breaking time, including obstruction of view and distracted driving.

Motorist Attempts to Pass a Forward-Moving Buggy

Whenever the crash report indicated that a motorist failed to pass a buggy, the given is that the motorist was aware of the buggy's presence and was making an action in response. Thus, these crashes are different from common rear-end crashes because of an additional, deliberate action to pass. Most attempted passes failed at the beginning of the execution, either rear-ending or sideswiping the rear left corner of the buggy. Since the road grade and illumination varied, and there was only one case of adverse weather conditions, crash causation likely rested with the motorist's action. The motorist may have miscalculated closing time. Also, the motorist may not have internalized the actual width of the buggy to include the axel and wheels that extend beyond the visually-dominant coach. In trying to pass, the motorist only allows room for the coach, not the wheel. Ironically, a buggy with extensive rear markings and lighting may draw the motorist toward the object of his fixation while attempting to pass. This so-called "moth effect" (Green 2006) is intensified by markings that draw attention to the center of the buggy, such as the S.M.V. emblem (Anderson 2014). Effective markings communicate the full width of the buggy, not just the center or cabin area, as on motor vehicle taillights. The motorist may have also attempted to pass, but then encountered an oncoming vehicle. Rather than experiencing a head-on collision, the motorist either sideswipes the buggy or fails in attempting to pull back behind the buggy.

The cases in this category did not indicate that the motorist was unaware of the buggy or did not see it in time to react appropriately, aside from the possibility of rear-end collisions on negative grades described in the previous category. Rather, the motorist made an error when attempting to pass because of misperceiving closing time or buggy width, or carelessness in passing. Conspicuity is not a critical issue in any of these crashes.

Buggy Driver Attempted to Cross or Enter a Main Road

In entering or crossing a main road, buggy drivers likely underestimated the time needed to pass through the intersection safely and the time for an approaching vehicle to reach the intersection. More buggies were struck in the far lane versus the near, suggesting timing miscalculations or obstruction of view of oncoming traffic. Supporting the case of miscalculation, a number of buggies ran a stop sign, suggesting an attempt to fit a quick maneuver in a tight time window. In addition, some buggy horses are former racehorses (Scott 1998[1981]) and may grow impatient having to stop for an extended period (Brumbaugh 1989).

This may have cajoled the buggy drivers to proceed at risky times. Alternatively, adverse conditions like fog or an incline can obstruct the buggy driver's view of oncoming traffic. Further, the coach sits farther back than a typical motor vehicle driver seat because of the horse's presence. While the fixed objects at intersection corners may not obstruct a motorist's view, they will obstruct the buggy driver's view. In a survey of select Lancaster County intersections, Dempski (1993) found that of the 46 intersection buggy crashes from 1986 to 1990, 34 (74%) occurred at locations with poor sight distance for the buggy driver.

The primary causative factors in this crash type appear to be, one, buggy drivers incorrectly calculate the time it would take to cross an intersection and the time it would take a vehicle to approach, including underestimating the motorists' reaction and response time; two, buggy drivers may take a risk and try to beat the oncoming traffic by running a stop sign or because of an impatient horse; and, three, the motor vehicle is obstructed from the buggy drivers' view. Buggy conspicuity does not appear to be a primary issue in this crash type.

Buggy Attempted a Left Turn off the Main Road

Left turns at intersections are a top concern for Old Order populations (Burkholder [n.d.]; Ohio Department of Public Safety 2000; Pathway 1993). Left turns are dangerous for traffic in general due to the multiple conflicting patterns in vehicle movement and multiple operations for the driver (Larsen and Kines 2002; Wang and Abdel-Aty 2008). For a buggy driver, executing a left turn involves steps exceeding that required for motorists, including merging into faster traffic from the right shoulder and thereby forcing motorists to match the buggy's pace, and then crossing the opposing lane while also watching the rear to make sure motorists are respecting the buggy driver's desire to turn and not attempting to pass on the left.

In seven of the nine clearly defined left-turn crash cases, the motorist approached from behind the buggy, attempted to pass on the left, and struck it at various maturities of the buggy's turn. The motorist may have either disregarded the buggy driver's intention or was not aware of it and attempted to pass, striking the buggy in mid-turn. The latter may have been the buggy driver's fault, in that he did not signal correctly or at all and made a sudden turn. In two remaining clearly defined cases, an oncoming vehicle struck the turning buggy, but the cases are too few to discuss further.

Similar to the crash types where the motorist attempted to pass, buggy conspicuity played a minimal if any role in this category's crashes, as the motorists must have been aware of the buggies to attempt a pass. The two issues at stake in these crashes were, one, the buggy driver's miscommunication or lack thereof of his intention to turn, and, two, the motorist's impatience and/or disrespect for that intention.

Major Causes of Crashes

These crash categories do not suggest that buggy conspicuity is the most critical issue in

buggy crashes but rather one variable among many. The data suggest three general issues. The first are factors limiting the motorist's or buggy driver's calculation of the drastic speed differences between motor vehicles and buggies. Two subcategories are:

1a. Buggy speed differences were undetected: A motorist did not see the buggy because he was distracted or the buggy was obscured from sight by a grade or the sun's glare, or it was not well illuminated because of dawn/dusk, and conspicuous markings like lighting or reflective strips had not yet become effective. All three visibility types—conspicuity, illumination, and obstruction of view—contribute to non-detection of speed differences.

1b. Speed differences were miscalculated: A motorist, aware of the buggy, miscalculated closing time when coming from behind, or the buggy driver miscalculated a motor vehicle's speed when crossing an intersection

The second major issue was carelessness and risky behavior. Four subcategories are:

2a. Motorist made a careless pass: A motorist, already aware of the buggy, attempted to risky pass, such as under conditions of poor sight distance or at the moment the buggy driver attempted a left turn.

2b. Motorist was distracted: A motorist engaged in distracting behaviors (e.g. cell phones, food, or rubber necking) and was thereby ill prepared to see a buggy.

2c. Motorist was impaired: While the total crashes involving an intoxicated or fatigued motorist were low, it was nevertheless an independent causative factor.

2d. Buggy driver risks: The buggy driver may risk passing in front of oncoming traffic, such as when crossing an intersection or turning left off the main road.

The third major issue was miscommunication. Two subcategories are:

3a. A buggy turned left: A buggy driver wanted to turn left, and the motorist did not understand this from either the buggy driver not signaling or the motorist not understanding the signal.

3b. Motorist miscomprehends buggy dimensions: A motorist did not comprehend the actual size and dimensions of the buggy when passing, especially width (wheel to wheel).

Implications

The findings in this study have broader implications for slow-moving vehicle safety in general. North America will witness increasing conflict between slow-moving vehicles and higher speed automobiles as urban areas continue to deconcentrate into suburbs and exurbs, and rural roads with slow-moving farm equipment become increasingly congested with automobiles as each share this public resource (Costello, Schulmanb, and Mitchell 2009). Slow-moving

vehicle crashes may also increase as people look to alternative modes of motorized transportation, such as golf carts and motorized and non-motorized two-wheel vehicles, as travel costs rise and as land use development patterns increasingly favor the non-use of automobiles in some areas (Taylor 2006; Zhang 2004). There are some similarities between horse-drawn vehicle crashes in this study and other slow-moving vehicle crashes in other studies, such as farm vehicles (Gkritza, et al. 2010; Kinzenbaw 2008). Further research may investigate crashes for other slow-moving vehicles to see if there are similar categories across vehicle types.

Limitations, Constraints, and Conclusion

While this study identified at least four major types of buggy crashes from a sample of 76, in an extended study, a greater sample size would better investigate these crash types' nuances; this study could only suggest nuances. Further, greater precision in measuring the sun's glare during transitional periods is worth investigating further given the prevalence of the sun's impact. Expanding the study to include multiple states with large horse and buggy populations, such as Indiana, Ohio, Missouri, and Wisconsin, would benefit the broader applicability of this study to other Amish and Old Order Mennonite settlements; yet, focusing in on a local setting, such as Lancaster County, PA, with an increased sample size would allow for more precise understandings of crashes because of controlling for environmental and geographic variables.

The PennDOT dataset was unable to account for crashes caused by an unruly horse because police reports do not include this variable in a check box. While training materials provide plain people with a detailed approach in training horses for the road, even a well-trained horse can spook without warning (Brumbaugh 1989; Brumbaugh 1998). Indeed, horse misbehavior in general is one of the highest causes of fatalities among Old Order groups (Jones and Field 2003). From her examination of Amish-reported crashes in the Amish newspaper *The Diary*, Piacentini (2003) found 33.5% of crashes were caused by an unruly horse, 43.9% a careless motorist, and 8.7% a careless buggy driver. These, however, are reports of all buggy crashes, not just those involving a motor vehicle. Using a different period of *The Diary* reports, Dewalt and Bradley (2013) found only 5% of buggy crashes with a motor vehicle were attributed to an unruly horse. Whatever the extent to which an unruly horse causes a crash, it is a factor, and one unaccounted for in PennDOT data.

In conclusion, this study analyzed 76 buggy crashes from 2006 and categorized them into four primary crash types based on the existing data. This study then analyzed each crash type for readily evident and probable causative factors in each crash. This study then reviewed the extent to which certain variables such as glare, conspicuity, obstruction of view, risk-taking behaviors, and motorist impairment are a primary causative factor in buggy crashes. This study suggests that external and internal factors limiting the realization of speed differences, careless behavior, and miscommunication are common generalized issues in buggy crashes. Conspicuity of the buggy, while a variable, was not the foremost cause of crashes.

Endnotes

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²The data used herein was supplied by the Pennsylvania Department of Transportation. The Pennsylvania Department of Transportation specifically disclaims responsibility for any analyses, interpretations, or conclusions drawn in this publication or release.

³Police reports identify position struck by superimposing the hand positions of a clock over a vehicle. For example, six o'clock would be a rear-end crash while 12 o'clock would be head-on.

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Appendix A: Amish Buggy Styles

Buggies vary by shape, style, and markings depending on settlement, affiliation, purpose, and personal expressiveness, as demonstrated here. All photos are by the author.

Figure 3: Buggy (Rear) in LaGrange County, Indiana



Figure 4: Pony Cart in LaGrange County, Indiana



Figure 5: A Gig in Lancaster County, PA



Figure 6: Horse-Drawn Farm Equipment in Holmes County, Ohio



Figure 7: Buggy (Rear) in Holmes County, Ohio



Figure 8: Open Buggies (Typical of Swiss Amish) in Daviess County, Indiana



Figure 9: Closed Buggy in Daviess County, Indiana

