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RESEARCH ARTICLE

Reducing Vehicle Submersions and Consequent Fatalities on Highway I-75 in Florida (*Alligator Alley*): Effectiveness of a Cable Safety Barrier System

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Abstract:

Objective:

We evaluated the effectiveness of a Cable Safety Barrier (CSB) system in preventing Run-Off-Road (ROR) Vehicle Immersions (VIs) and fatalities in canals along the I-75 freeway (*Alligator Alley*) in Collier County, Florida. The CSB system, which runs along both sides of the 80-km stretch of freeway and was installed between 2003 and 2004.

Methods:

Data from the Fatal Analysis Reporting System (FARS) were used to compare annual VIs and VI fatalities between pre-installation of the CSB system (1995-2002) to post-installation (2005-2012). As well, post-installation data from the Florida Department of Transport (FDOT) (2007-2011) and police reports were reviewed to determine the number of, and manner in which, vehicles were either contained by, or crossed, the CSB by either penetrating or overriding the barriers.

Results:

Pre- to post-installation, total accidents increased from 81.4/y to 106.2/y, accidents resulting in VIs decreased from 13.8% to 2.4%, and accidents resulting in VI fatalities decreased from 3.4% to 0.4% (FDOT). Fatal vehicle immersions decreased from 2.4/y to 0.9/y ($P<0.01$) and vehicle immersion fatalities decreased from 3.3/y to 1.4/y ($P<0.05$) (FARS). Post-installation, 531 accidents occurred with 110 ROR vehicles travelling towards the canals; 91 vehicles contacted the CSB with only 14 vehicles (15.4%) penetrating the barrier, and 7 (7.7%) overriding the barrier (FDOT).

Conclusion:

The CSB system along I-75 in Collier County dramatically decreased ROR vehicles from reaching the parallel canals, and consequent vehicle immersion fatalities. Results support the installation of lateral CSB systems on other high-risk roadways to reduce ROR crashes into water, or with other secondary hazards.

Keywords: Vehicle immersion fatalities, Accident prevention, Barrier penetration, Barrier override, Safety performance evaluation, Vehicle submersion.

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1. INTRODUCTION

Traffic-related fatalities are a growing global problem reaching epidemic levels [1]. Safety interventions are required to help reduce traffic accidents worldwide; however limited evidence exists to support the efficacy of many novel interventions in use [2]. Run-off-road (ROR) crashes are a major contributor to traffic fatalities and injuries. An ROR crash occurs when a vehicle leaves the roadway and collides with natural and/or artificial surroundings. This type of crash often involves a single motor vehicle and the crash is typically attributed to driver behaviour [3] or condition [4]. Specifically, an ROR crash into water has a high fatality rate as occupants

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have only about one minute to self-rescue (exit) before drowning is imminent [5].

In order to reduce the rate of any road traffic accident, there may be multiple strategies and countermeasures that can be utilized independently or in combination. In the case of vehicle submersions (also referred to as immersions), there are four general approaches: public education [6], warning systems [7 - 9], road and vehicle design [2], and spatial or physical barriers [7] to reduce accidents, injuries, and fatalities.

In Florida, in the early 1990s approximately 45 motor vehicle occupant drownings occurred annually. This was double the national average per 100 million vehicle miles travelled [10]. In the late 1990s and early 2000s, the Florida Department of Transportation (FDOT) identified a section of Interstate 75 (I-75) in southern Florida (known as *Alligator Alley)* as an area where increased vehicle immersions and occupant drownings were occurring. In 2003-2004, a novel cable safety barrier (CSB) system was installed along the canals to prevent vehicle submersions [11]; this was the first highway in Florida to have such an installation.

To our knowledge, the effectiveness of this installation has not been determined in the scientific literature. Therefore, the objective of the present study was to 1) compare pre- and post-installation accident data to determine the effectiveness of the new CSB system in decreasing vehicle immersions and deaths in canals along *Alligator Alley*; and 2) to analyse post-installation data to determine the effectiveness of the CSB system in capturing vehicles that left the roadway and hit the cable barrier. The objective of this study was not to create a methodology to evaluate safety systems in general; rather it is to retroactively test the effectiveness of the I-75 CSB system. If this system is demonstrated to be effective, this could justify installation of CSB systems on other roadways, and a robust methodology could then be developed for future prospective analyses of the effectiveness of these installations.

2. REVIEW OF LITERATURE

2.1. The Problem of Vehicle Submersion Fatalities

Each year in Canada and the United States, there are approximately 400 fatalities attributed to vehicle submersions [7, 12] and, moreover, these fatalities account for up to 10% of all accidental drownings [5]. It is especially tragic that most of these fatalities are due to the drowning of occupants who had minimal, or no, trauma [12, 13] and could have survived if they had performed a simple self-rescue. Although many knowledge translation measures are being introduced to inform occupants of what to do in a sinking vehicle, prevention of vehicles reaching water is the best strategy [5].

The mortality rate of crashes into water (7.6%) is about eight times higher than for all types of crashes combined (0.9%); 82% of these deaths were due to drowning [14]. A review of vehicle immersion deaths revealed that the most common cause of vehicles entering water was the loss of control (just under 47%), the fatality rate is much higher in deep water (44%) than in shallow water (5%), and 17% of fatalities occurred in water bodies running alongside the road [5]. In one dangerous canal area in Canada, 19 people drowned over a 52-year period [5]. The Netherlands is the most well known area where canals run beside roadways, and vehicle immersion drownings are prevalent [14]. Thus, the *Alligator Alley* highway is of particular interest because deep canals run continuously along both sides of the roadway (Fig. **1**). One additional risk factor is that the road is long and straight and this might contribute to inattentiveness and fatigue [2], thus increasing the risk of ROR crashes.

2.2. Mitigation of ROR Vehicle Submersions

Multiple strategies and countermeasures have been utilized independently or in combination to decrease the frequency and severity of ROR vehicle crashes.

First, public education on the dangers of vehicle submersion, the promotion of safe driving practices, and the instructions for a proper self-rescue protocol would be valuable [6]. However, a recent study indicated that public understanding regarding vehicle submersion accidents is low, and it was proposed that the simple awareness of the SWOC self-rescue protocol [*e.g.*, SEATBELTS off, WINDOWS open or broken, OUT immediately, CHILDREN first (oldest to youngest)] could help decrease the high fatality rate [15].

Second, warning systems can alert drivers about dangers near or alongside roadways such as: roadway signage (*e.g.*, bridge/curve ahead and potential for flooding); and other warning methods (*e.g.*, rumble strips, markings/reflectors, and weather warnings) in areas of increased risk [7 - 9]. Third, road and vehicle designs (*e.g.*, road curvature, lighting, speed limits, skid resistant pavement, electronic stability control, lane departure technologies, and anti-lock braking) help decrease the potential for an ROR accident [2].

Finally, spatial or physical barriers are used to either prevent vehicles from leaving the roadway, or impacting secondary structures after leaving the roadway. Spatial barriers simply provide a large space between the road and secondary objects (*e.g.*, structures or water bodies) [16]. Physical barriers can also prevent, or minimize the effect of secondary impact. They are classified as either rigid (*e.g.*, concrete barricades) [7, 17] or pliant (*e.g.*, sand or water-filled barrels, metal guardrails and cable barriers) [18].

2.3. Effectiveness of Crash Mitigation Efforts

Effectiveness of many mitigation systems have been analysed. For example, in one study, automated speed enforcement cameras and chevron signs have been shown to decrease traffic crashes, while delineator posts and rumble strips have not [19]. Other studies have shown positive results with rumble strips [20 - 22] and other systems such as transition road safety barrier systems (*e.g.*, metal guard rails) [17].

Rigid (concrete) and pliant (metal and cable) barriers have been installed in medians to prevent crossover crashes, and along the roadside to prevent ROR crashes. Pliant barriers, especially cable systems, have the advantage of absorbing more kinetic energy and preventing vehicles from crossing into oncoming traffic, or rebounding back into the roadway from which they left [18, 23].

In general, barriers have been shown to reduce the percentage of total crashes that result in casualties by 40-70% [24 - 26]. Metal and cable barriers installed in medians have been shown to reduce or eliminate crossover crashes and decrease injury crashes by 29-35% [27]. Specifically, median CSB systems have been shown to decrease head-on crashes by 96%, fatal crashes by 82% and incapacitation injury crashes by 76% [28].

The use and evaluation of CSB systems installed lateral to the roadway is limited. Although roadside barriers have decreased general injury crashes by 32-48% [27], we are unaware of research on the effects of CSB systems in the prevention of ROR vehicle submersion deaths. Thus, the current analysis was conducted for *Alligator Alley*, a highway section that had an extremely high rate of vehicle submersion deaths.

3. METHODS

Data were collected from various sources for before and after CSB installation. Two main sources that were used did not provide all the same variables, and one of the sources (FDOT) no longer had yearly reports for the pre-installation period, rather only aggregate data were available for this 5-year period. Thus, each data set was used to address some unique questions relating to effectiveness in preventing ROR vehicle immersion fatalities.

3.1. Data Collection

Data from before and after the installation period (2003-2004) were collected from four sources: 1) FDOT (and police reports when available); 2) the Fatal Analysis Reporting System (FARS); 3) media reports supplied by FDOT; 4) and media reports from on-line searches.

In the State of Florida, law enforcement agencies complete crash reports for traffic crashes which are housed by Florida Highway Safety and Motor Vehicles (FLHSMV). Crash data for all traffic crashes are provided to the FDOT Crash Analysis Reporting database [29]. As well, data for all fatal traffic crashes on public roadways are provided by FLHSMV to the National Highway Traffic Safety Administration (NHTSA) for inclusion in the FARS national database [30].

First, pre-installation data from FDOT was limited for the following reasons. The FDOT converted to a digital data collection system in 2007 and pre-2007 data were not digitized. These pre-2007 paper files were lost through a storage accident and were no longer available. However, the summary data used by FDOT for their pre-installation study had been extracted and stored elsewhere. Therefore, limited mean data were available for the 1995-1999 period. Post-installation data were analysed from a similar 5-yr period from 2007-2011; this data included police reports. Thus, the limited pre-installation data includes total accidents, the number of vehicles reaching the water, and vehicle immersion fatalities. Post-installation data also included direction of travel for ROR vehicles and vehicles hitting the cable system; police reports added information as to whether vehicles penetrated or overrode the fence, and the final vehicle position.

Second, more complete data were available from the FARS database; thus data were collected for 8-yr periods before (1995-2002), and after (2005-2012) the CSB installation. The FARS database was searched to target ROR vehicle immersions on I-75 in Collier County. The variables and search criteria were as follows (code): State, Florida (3); County, Collier (021); First Harmful Event, Any (All); Number of Fatalities, Any (All); and Most Harmful Event, Vehicle Immersion (3). In the FARS system, all vehicle immersions are classified with the most harmful event being Vehicle Immersion (VI). All resultant cases were then manually evaluated and were only included when the accident occurred on I-75 (based on the traffic identifier in the FARS system). This provided confirmation on the number of yearly fatalities in ROR vehicle immersions on *Alligator Alley* in Collier County and also provided the first harmful event for all of these cases.

Third, upon request, the FDOT provided a copy of all reports and media they had on hand regarding the CSB system on *Alligator Alley*. Finally, an online search was conducted for any media coverage for accidents on *Alligator Alley* between 1995 and 2014. Media sources were compiled by years and if possible, paired to the corresponding FARS case reports. This was done to match and capture any additional information regarding crashes occurring in this timeframe.

3.2. Data Analysis

Only descriptive statistics are presented for FDOT data since they were only available as single mean values for the 5-yr pre-installation period (1995-1999) and accident descriptions were only available the post-installation period (2007-2011).

Since yearly FARS data were available, unpaired t-tests were used to compare mean values for the number of vehicle immersions and vehicle immersion fatalities, for the 8-yr pre-installation (1995-2002) and post-installation (2005-2012) periods. Data were analyzed with the SigmaStat package within SigmaPlot 14. Significance for all analyses was set at $P \leq 0.05$. For each pre-and post-installation period, a linear regression analysis was conducted for each variable (from FARS). If a significant correlation was detected in the pre-installation period, the trend could be used to predict values for the post-installation period if the CSB system had not been installed.

4. CABLE SAFETY BARRIER SYSTEM ON FLORIDA INTERSTATE 75 (*Alligator Alley*)

4.1. History of *Alligator Alley*

Alligator Alley was originally designed as a 2-lane undivided roadway. It opened in 1968 as a straight east-west toll-way connecting southern Florida through the everglade wetlands between Naples and Fort Lauderdale. It traverses Collier (80 km) and Broward (40 km) counties. This roadway quickly became well known for high-speed accidents, including head-on collisions and collisions with wildlife [11].

To increase safety and address growing traffic volumes, several upgrades were made. By 1992 *Alligator Alley* was a 4-lane divided highway. Notably, drainage canals (up to 12 m deep) ran parallel to both sides of the highway. A minimum clear zone of 18.3 m formed a spatial barrier between the road and canals to decrease the likelihood of vehicles reaching and entering the water [31] (Fig. **1**). Additionally, chain-link wildlife fencing (FDOT Standard Type A and B) along the canals restricted animal access to the roads.

Fig. (1). Aerial view of long, straight, 4-lane divided highway with canals running parallel on both sides.

The evaluation indicated that, due to high speeds on the straight roadways, many ROR vehicles still traversed the spatial barriers and entered the canals. Importantly, the wildlife fencing did not act as a barrier for ROR vehicles, but instead actually increased the difficulty in, and response time for locating the crash sites since the fencing could return to its original position after the vehicle passed under or over the fencing. The FDOT suspected many of the occupants in ROR vehicles that reached the canals would have survived their crash-related injuries, and may not have drowned in the canal had they been found and rescued sooner [32].

In 2002, the FDOT began a process to implement a new safety intervention after 26 vehicle submersions occurred in a single year in the canals along *Alligator Alley,* resulting in six drowning fatalities. A novel cable safety barrier system was selected by the FDOT to be integrated with the existing wildlife fencing along *Alligator Alley* in Collier County. This unique system was proposed to 1) minimize the effects of an ROR accident (*i.e.*, injury, fatality and property damage); 2) prevent ROR vehicles from reaching and entering the canals; 3) facilitate faster detection and response times for emergency services for ROR crashes; and 4) maintain and protect the natural beauty of the Florida Everglades [32].

4.2. Description of Cable Safety Barrier System

The system was constructed from 2003-2004 at a total cost of 4.2 million dollars USD. This was the first installation of a CSB system in Florida. It used two 19 mm diameter galvanized steel cables installed 53 cm and 69 cm above the ground. The existing wildlife fence posts support these cables. Sections of the cable fencing are contiguous except for areas where culverts cross under the highway. Guardrails are installed over these culvert areas close to the road shoulder. The CSB extends well past the beginning of the guardrail but does not start again until after the guardrail ends. CSB sections are anchored by foundation systems spaced no more than 610 m apart. Terminal foundation systems anchor the terminal sections of the CSB system (*e.g.*, at the beginning and end of guardrails). The remaining non-terminal foundation systems anchor any two adjoining CSB sections (Fig. **2**). Each cable section attaches to an underground anchor (concrete Jersey barrier) within the foundation system via heavy-duty springs providing 907 kg of tension (Figs. **2** and **3**), with a breakaway switch (Fig. **4**) attached to the top cable. Therefore, cable impact stretches the spring and triggers the breakaway switch; this activates a strobe light and signals a regional traffic management centre to indicate the approximate location of the collision. As well, on impact, the slack in the cable system is taken up to safely decelerate and capture errant vehicles. This system not only prevents vehicles from entering the canals, but also reduces injury severity that might occur if a solid (*e.g.*, concrete) barrier was used.

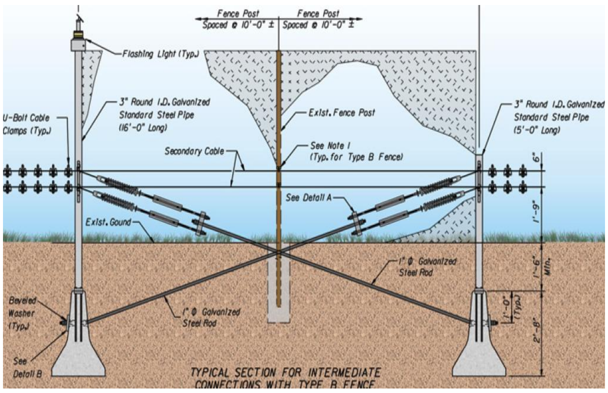

Fig. (2). Dual foundation zones, which anchor contiguous sections of the cable barrier safety system (used with permission, American Consulting Professionals).

Fig. (3). Heavy-duty springs that anchor cables at the end of the cable barrier segment (used with permission, American Consulting Professionals).

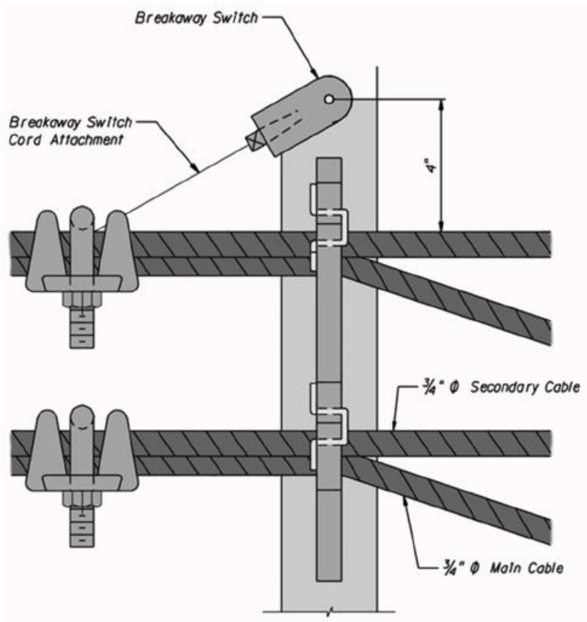

Fig. (4). Breakaway switch attachment at anchor ends of the cable barrier safety segment (used with permission, American Consulting Professionals).

5. RESULTS

5.1. Performance by Rates of Vehicle Immersions and Fatalities

Table **1** provides annual accident and fatality rates for *Alligator Alley* in Collier County as determined from the FDOT and FARS data.

As stated above, FDOT data for the pre-installation period (1995-99) were only available in aggregate form; therefore statistical analysis could not be performed; this data is still instructive, however. There was a rise in overall accident rates from pre- to post-installation of the CSB system [annual total accidents increased from 81.4/y (for 1995-99) to 106.2/y (for 2007-11)]; this corresponds to increased traffic volumes from 1995-2011 [29] and is consistent with predictions such as the surrogate safety assessment model [33]. Comparing the pre- to post-installation periods, the percentage of all accidents resulting in ROR vehicle immersions decreased from 13.8% to 2.4%, and the percentage of all accidents that resulted in vehicle immersion fatalities decreased from 3.4% to 0.4% (FDOT data) (Table **1**).

Regression analysis for the FARS data determined that there were no significant correlations or trends for vehicle immersions or vehicle immersion fatalities in either period. Therefore, pre-installation data could not predict what would have occurred post-installation if a CSB system had not been installed. Therefore, the best indicator of the effectiveness of the CSB system was to compare mean data for the pre- and post-installation periods. Statistical analysis of the FARS data indicates that the installation of the CSB system corresponded to a significant decrease for fatal crashes, in both the number of vehicles (from 2.4/y to 0.9/y; $P < 0.01$), and fatalities (from 3.3 to 1.4/y; $P < 0.05$) in fatal accidents where vehicle immersion was the most harmful event (MHE) (Table **1**). Prior to installation of the CSB system, for fatal vehicle immersions, 84.2% involved vehicles that first experienced a collision with the wildlife fencing. After installation of the CSB system, only 14.3% of fatal vehicle immersions involved vehicles that first experienced a collision with the CSB system ($P < 0.01$). Notably, total vehicle immersions and vehicle immersion fatalities for the State of Florida were unchanged from the pre- to post-installation periods (Table **A1**). Therefore, vehicle immersion fatalities on *Alligator Alley*, as a percentage of total state fatalities, decreased from 7.2% pre-installation to 3.2% post-installation.

5.2. Performance for Barrier Crossing Prevention

Further analysis of post-installation data from FDOT and police records indicates that from 2007 to 2011, there were a total of 531 accidents with 110 ROR vehicles travelling towards the canals (Table **2** mean data, Table **A2** yearly data). Ninety-one vehicles contacted the CSB system, with only 14 vehicles (15.4%) penetrating the barrier, and 7 (7.7%) overriding the barrier.

Table 1. Accident data from two data sources (Florida Department of Transportation, and Fatal Analysis Reporting System) for two time periods (pre- and post-installation of CSB system) for I-75 (*Alligator Alley*) in Collier County, FL.

Florida Department of Transportation				Fatal Analysis Reporting System			
Time period	**Total accidents per year**	**VI vehicles per year [% of total]**	**VI fatalities per year [% of total]**	**Time period**	**VI is MHE vehicles per year**	**VI is MHE fatalities per year [number/vehicle]**	**% of fatal VIs that hit fence/barrier first**
1995-99 Wildlife fencing	81.4	11.2 [13.8%]	2.8 [3.4%]	1995-2002 Wildlife fencing	2.4 (1.3)	3.3 (2.4) [1.4/vehicle]	84.2 (24)
2003-04 Installation of CSB system				2003-04 Installation of CSB system			
2007-11 CSB system	106.2	2.6 [2.4%]	0.4 [0.4%]	2005-12 CSB system	0.9 (0.8)**	1.4 (1.5)* [1.6/vehicle]	14.3 (18)**

VI (vehicle immersion); MHE (most harmful event); CSB (Cable Safety Barrier). Mean (SD); *, $P < 0.05$; **, $P < 0.01$.

Table 2. Accident descriptions post-installation of cable safety barrier system, for I-75 (*Alligator Alley*) in Collier County, FL, for 2007-2011.

Traffic Accident Classification	Number of Accidents (Total)	Number of Vehicles/y	Occupants Injured/y	Occupants Killed/y
Total Traffic Accidents	531	106.2 (20)	51.6 (10)	5.0 (2)
Run-Off-Road	215	43.0 (10)	22.6 (5)	1.6 (2)
Run-Off-Road Toward Median	105	21.0 (4)	11.4 (2)	0.6 (1)
Run-Off-Road Toward Canal	110	22.0 (6)	NA	NA
- Did not hit fence	19	3.8 (3)	NA	NA
- Hitting the Fence	91	18.2 (7)	17.6 (8)	0.6 (1)
- Penetrating the Fence and Cables*	14	2.8 (1)	2.4 (1)	0.4 (1)
- Overriding the Cables**	7	1.4 (1)	1 (1)	0 (0)

Source, Florida Department of Transportation. Mean (SD), *, Police report indicates that vehicle drove directly through the fence without overturning or becoming airborne. **, Police report indicates that the vehicle overturned while traversing the fence. NA, data not available.

5.3. Summary of Results

Following the installation of the CSB system, there was a decrease in the proportion of total accidents that resulted in vehicle immersions (from 13.8% to 2.4%) and vehicle immersion fatalities (3.4% to 0.4%) (FDOT). This positive outcome is consistent with the decrease in the rate of fatal vehicle immersions occurring after hitting the wildlife fences (84.2%) compared to hitting the cable barrier (14.3%) (FARS).

6. LIMITATIONS

One limitation is that this study is a retrospective analysis using two different data sets. Each data set covered different parameters and periods (*e.g.*, FDOT, 1995-99 and 2007-11; FARS, 1995-2002 and 2005-12). However, each data set included lengthy periods before and after the CSB system was installed, thus providing enough data to determine if there was an effect of the CSB system. As well, the FDOT data did not include information regarding hitting the wildlife fence during the pre-CSB period, however, this data was available both pre- and post-CSB installation from FARS.

One other limitation is that statistical analysis was not possible with the FDOT data since yearly data were no longer available, rather only the composite values for the pre-installation period were available. Nevertheless, it is clear that the number of vehicle immersions and fatalities decreased following the installation of the CSB system.

7. DISCUSSION

To our knowledge, this is the first evaluation of a roadside cable safety barrier system that was installed to prevent vehicle immersion accidents. There were dramatic decreases in the rates of both vehicle immersions and vehicle immersion fatalities after the CSB system was installed on I-75 in Collier County, FL (*Alligator Alley*). These improvements occurred despite the increased traffic rates and the fact that VI fatality rates remained unchanged for the State of Florida as a whole [30].

Results indicate that the cable system was strong enough, and designed well enough, to prevent vehicle immersions in all but the most exceptional circumstances (see below). The post-installation rate of vehicles reaching the canals, either through (2.8/year) or over (1.4/year) the cables, is very low. These vehicles reached the canals due to either: 1) very high speed leading to cartwheeling or rolling over the cables and through the wildlife fence, riding up on the guardrail and overriding the cables, or breaking through the guardrail and entering the canal between CSB sections; or 2) sharp change in direction (*e.g.*, side-swiping a stationary vehicle near the end of a guardrail and veering toward the canal and hitting the wildlife fence just before the next section of CSB starts again) [29].

There are only a few potential improvements that could be made to the CSB system to prevent these remaining vehicle immersions. One or more cables could be added above the current cables to prevent vehicles from overriding the barrier. Stronger cables could also be used to prevent vehicle penetration. Finally, the gaps between the end of guardrails and the start of the next CSB segments could be closed (*e.g.*, by starting the new segment earlier). The low rate of VIs in the canals is unlikely to be improved further by increasing the number of speed limit signs or rumble strips (which already run the length of the roadway). Some benefit might be gained by adding info-graphic road signs that are specific to the dangers of canal immersions and or how to self-rescue if one occurs.

Public education on safe driving (to prevent ROR incidents) and specifically what to do if you end up in a vehicle immersion (to increase survival rates for VIs) would help to further decrease vehicle immersion fatalities. Specifically, the SWOC self-rescue strategy (SEATBELTS off, WINDOWS open, OUT, CHILDREN first) should be widely shared [*e.g.*, by expanding education in elementary schools, inclusion in driver education handbooks (just under half of states currently include this information; unpublished review of state handbooks) and other public education initiatives]. Other strategies to decrease the number of, and fatalities related to, vehicle immersions could include vehicle technologies that reduce lane departures, and water-triggered automatic window opening systems [34]. Based on the documented success of the CSB system on I-75 in Collier County, expansion to other areas with high incidence of ROR incidents on roadways close to water or other hazards, seems warranted.

FARS data provided slightly higher values for VIs and fatalities than FDOT data. First, pre-installation data for FARS included 2002, which had a very high fatality rate, thus inflating the averages. Second, there are coding inconsistencies between the two data sets. In general, with FARS all fatalities involving a VI were classified with VI as the most harmful event. However, FDOT coding systems allow classification for VI fatalities that involved fatal-injuries that were likely sustained before immersion occurred (*e.g.*, a roll over); in these cases, the fatality would not be classified as a ROR VI fatality.

CONCLUSION

Following the installation of the CSB system on *Alligator Alley*, there was an increase in traffic flow and the annual number of traffic accidents. However, after the CSB system was installed, there was a decrease in the rate of accidents resulting in vehicle immersions (from 13.8% to 2.4%) and vehicle immersion fatalities (3.4% to 0.4%). This positive outcome is consistent with the decrease in the rate of fatal vehicle submersions occurring after hitting the wildlife fences (84.2%) compared to hitting the cable barrier (14.3%).

In conclusion, the installation of a cable safety barrier system along I-75 in Collier County (*Alligator Alley*) has dramatically decreased ROR vehicles from reaching the parallel canals, and consequent vehicle immersion fatalities. CSB systems are common on roadway medians and are now used laterally more frequently (*e.g.*, on cliffs, near forests and other structures). The current data support the installation of lateral CSB systems on other high-risk roadways to reduce ROR crashes into water or with other secondary hazards.

Future studies could include similar analyses of other existing lateral CSB systems to prevent contact with water or other roadside hazards. Studies could also identify other roadway segments that have exceptionally high rates of ROR contact with roadside hazards, and consideration could be given to installing CSB systems in these areas as well.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

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CONFLICT OF INTEREST

None.

ACKNOWLEDGEMENETS

Declared none.

APPENDIX

Table A1. Yearly vehicle immersion data for the State of Florida, Collier County, and I-75 (*Alligator Alley*) in Collier County, FL, for pre- and post-installation of cable safety barrier system.

Year	Florida VI's	Florida VI Fatalities	Collier County VI's	I-75 Collier County VI's	I-75 Collier County VI Fatalities
Wildlife Fencing					
1995	34	37	3	3	4
1996	24	33	3	2	2
1997	42	50	3	2	4
1998	37	42	3	1	1
1999	41	54	1	1	1
2000	38	44	6	5	5
2001	37	40	4	2	2
2002	55	69	4	3	7
Mean (SD)	**38.5 (9)**	**46.1 (11)**	**3.4 (1)**	**2.4 (1)**	**3.3 (2)**
Cable Safety Barrier System Installation 2003-2004					
2005	56	67	5	2	2
2006	36	42	0	0	0
2007	46	53	3	2	3
2008	44	50	1	1	1
2009	27	35	2	0	0
2010	39	40	5	1	1
2011	27	39	2	1	4
2012	23	28	0	0	0
Mean (SD)	**37.3 (11)**	**44.3 (12)**	**2.3 (2)**	**0.9 (1)****	**1.4 (2)***

Source, Fatal Analysis Reporting System. VI, vehicle immersion. Difference between two periods, * ($P < 0.05$); ** ($P < 0.01$).

Table A2. Accident descriptions post-installation of cable safety barrier system, for I-75 (*Alligator Alley*) in Collier County, FL for 2007-2011.

Year	Traffic accident classification	Number of vehicles	Occupants injured	Occupants killed
2007	Total Traffic Accidents	139	66	8
	Run-off-road	58	31	2
	Run-off-road toward median	27	14	1
	Run-off-road toward canal	31	NA	NA
	Did not hit fence	1	NA	NA
	Hitting the fence	30	30	0
	Penetrating the fence and cables*	3	3	0
	Overriding the cables**	3	3	0
2008	Total Traffic Accidents	102	51	6
	Run-off-road	43	21	0
	Run-off-road toward median	19	9	0
	Run-off-road toward canal	24	NA	NA
	Did not hit fence	8	NA	NA
	Hitting the fence	16	16	0
	Penetrating the fence and cables*	4	4	0
	Overriding the cables**	2	2	0
2009	Total Traffic Accidents	107	55	3
	Run-off-road	45	23	1
	Run-off-road toward median	24	13	0
	Run-off-road toward canal	21	NA	NA
	Did not hit fence	5	NA	NA
	Hitting the fence	16	14	2
	Penetrating the fence and cables*	2	2	0
	Overriding the cables**	0	0	0
2010	Total Traffic Accidents	99	44	3
	Run-off-road	38	22	1
	Run-off-road toward median	19	12	0
	Run-off-road toward canal	19	NA	NA
	Did not hit fence	0	NA	NA
	Hitting the fence	19	19	0
	Penetrating the fence and cables*	3	2	**1**
	Overriding the cables**	0	0	**0**
2011	Total Traffic Accidents	84	42	5
	Run-off-road	31	16	4
	Run-off-road toward median	16	9	2
	Run-off-road toward canal	15	NA	NA
	Did not hit fence	5	NA	NA
	Hitting the fence	10	9	1
	Penetrating the fence and cables*	2	1	**1**
	Overriding the cables**	2	0	**0**
Mean (SD) 2007-2011	Total Traffic Accidents	106.2 (20)	51.6 (10)	5.0 (2)
	Run-off-road	43.0 (10)	22.6 (5)	1.6 (2)
	Run-off-road toward median	21.0 (4)	11.4 (2)	0.6 (1)
	Run-off-road toward canal	22.0 (6)	NA	NA
	- Did not hit fence	3.8 (3)	NA	NA
	- Hitting the fence	18.2 (7)	17.6 (8)	0.6 (1)
	- Penetrating the fence and cables*	2.8 (1)	2.4 (1)	0.4 (1)
	- Overriding the cables**	1.4 (1)	1 (1)	0 (0)

Source, Florida Department of Transportation. Mean (SD), *, Police report indicates that vehicle drove directly through the fence without overturning or becoming airborne. **, Police report indicates that the vehicle overturned while traversing the fence. NA, data not available.

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