

Article

Are Safety Corridors Effective in Mitigating Safety? An Ohio-Based Case Study Evaluating Their Effectiveness

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Abstract: Distracted driving remains a major concern on highways, with it contributing to severe and fatal crashes, particularly on high-speed routes, prompting numerous states to implement targeted initiatives aimed at combating traffic violations that significantly contribute to fatal and injury-inducing crashes. Among these initiatives is the highway safety corridor program, a collaborative endeavor between the state departments of transportation and law enforcement agencies. Highway safety corridors employ a combination of engineering interventions and heightened law enforcement presence to address risky driver behavior and mitigate the occurrence of crashes. Despite the longstanding existence of safety corridors, research on their effectiveness remains relatively limited, with existing studies indicating only moderate success rates. This study is dedicated to evaluating the effectiveness of ten highway safety corridors in Ohio, where the state recently launched its inaugural highway safety corridor program targeting distracted driving. Utilizing 2023 crash data, this Empirical Bayes' before-and-after study seeks to gauge the impact of these safety corridors on enhancing roadway transportation safety. Upon assessing all crash types within Ohio's distracted driving safety corridors that provided sufficient data for a before–after study, it was determined that the adoption of safety corridors generally led to a reduction in crashes ranging from 2% to 49%. The significance and magnitude of crash reduction may vary if specific crash types or severity levels are considered.

Keywords: safety corridor program; empirical bayes; before-and-after study; distracted driving



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1. Introduction

Unsafe and distracted driving behavior is a common cause of crashes along high-speed roadways, in addition to speed-related crashes [1]. In order to counter unsafe and distracted driving, many states have developed a program to specifically target traffic offenses that cause a significant portion of fatal and injury-inducing crashes along segments of roadways with high or comparatively high crash rates. This program is known as a highway safety corridor program, and it is a collaboration between the state departments of transportation (state DOTs) and law enforcement officials.

Highway safety corridors are meant to utilize engineering measures and law enforcement presence to reduce the amount of risky behavior exhibited by drivers and in turn reduce the number of crashes [2]. While the concept of safety corridors is not necessarily new, specific research into the effectiveness of adopting highway safety corridors is somewhat lacking—in that, (i) the limited research depicts that these corridors are moderately

effective [3]; any research to date is limited in the amount of available crash data, and, subsequently, there are no specific crash modification factors developed to this effect.

The state of Ohio has implemented both distracted driving safety corridors as well as distracted driving and speeding-related safety corridors. Distracted driving safety corridors are those that have strict prohibitions against distracted driving, with enhanced patrols in problem areas. The objective of these safety corridors is to encourage drivers to adopt safe driving behaviors, such as refraining from the use of electronic devices while driving [4]. Similarly, speeding-related safety corridors encourage drivers to adhere to posted speed limits. As such, the necessary crash data to conduct a before–after study that can provide statistically significant results of the effectiveness of these safety corridors in Ohio is only now becoming available [5].

2. Literature Review

Several studies have shown increasing speed to be linked to a higher number of crashes. Some researchers in Australia studied speed-related data to find that drivers who drove at a high speed had reported more crashes in the past five years compared to those that drove at a lower speed [6]. A rise in the number of crashes with an increased speed was also observed by Maycock et al. [7,8]. Another study revealed that the increase in the number of crashes with a rise in speed was greater on urban roads compared to that on rural roads [9].

Similarly to speed-related crashes, the impact of distracted driving on the number of crashes has also garnered significant research attention. Lym et al. [10] showed that distracted driving due to tasks such as dialing, texting, looking at a roadside object, and eating resulted in an increased number of crashes. In another study, various aspects of crashes related to distracted driving were examined, such as injury severity and their urban or rural setting, and demonstrated that high-severity injury is less likely at roundabouts and urban areas, where speeds are lower and distraction is limited [5]. On the other hand, crashes are likely to be more severe when distracted driving is coupled with speeding and when the crash sites are intersections and curved roads [10].

Highway safety corridors are used as a cost-effective method to decrease the number of crashes occurring along a roadway segment [11]. The selected segment typically has a comparatively high number of crashes or many crashes that involve severe injuries or fatalities [11]. Safety corridors use some combination of increased law enforcement presence, higher fines, and enhanced signage to reduce the number or severity of crashes along a roadway segment [11]. For example, in April 1996, a photo radar program was implemented along the safety corridor on Pat Bay Highway in British Columbia in Australia, where the photo radar technology was used to control speed [12]. Photo radars would take photographs when the speed of the vehicles exceeded the limit by a minimum of 11 km/h. Violators were initially warned and later issued tickets amounting to a fine of AUD 100 to AUD 150. Photo radars were deployed at locations that historically reported high collisions. The outcome of this measure was an increase in adherence to the speed limit and enhanced traffic safety. Similarly, in France, the French Automated Speed Enforcement Program (FASEP) was implemented to curtail speed-related traffic violations [13]. As part of this program, photo radars were installed along the routes with a history of high crashes or speed limit infringement. Subsequently, new devices were introduced to capture the images of the front and rear of a vehicle as two-wheelers were easier to miss, as they lacked a front plate. These devices also helped to distinguish trucks from other vehicles as the speed limits were different for trucks [13]. This program helped reduce crashes.

Within the US, many states including Virginia, California, Oregon, New Mexico, and Pennsylvania have already implemented highway safety corridors, the first of which was Pennsylvania [11]. These states have shown that there has been a decrease in the number of crashes along designated safety corridors; however, many also believe more data are needed before conclusively stating how effective the safety corridors are at reducing crashes and crash severity [11]. Jernigan [8] studied highway safety corridor programs in Virginia,

California, and Pennsylvania. In each of the programs, it was reported that there was a reduction in the number and severity of crashes [14]. In many cases, the programs were considered successful at increasing safety before crash data had been collected and analyzed [14].

Before–after studies have since shown that the safety corridors appear to be successful at reducing the number or severity of crashes, but some programs are more successful than others. Jernigan [8] found that successful programs tended to be associated with corridors that have a much higher crash rate than other corridors, high public interest in the programs, a high level of experience in program leaders, and the ability of the group to recommend effective solutions for utilization in safety corridors. Jones et al. [9] studied the public perception of risk when associated with speeding along safety corridors in Oregon, as well as in work zones and school zones. It was found that most drivers did not find speeding in a designated safety corridor to be inherently riskier than speeding on other rural and urban routes that had similar roadway geometry and traffic [15]. However, it was noted that drivers did find it riskier to speed in a designated safety corridor when fines for such driving behavior were doubled [15]. Therefore, having a designated safety corridor with increased fines would have at least somewhat of an effect on the public perception of risk, which may cause a reduction in speeding along safety corridors [15]. Fontaine et al. [11] conducted an Empirical Bayes (EB) before–after study on the I-81 and I-95 corridors in Virginia, showing that there were no significant changes in either crashes or traffic speeds [6]. However, there was evidence that over time, the type and severity of crashes changed after the implementation of the safety corridor, indicating that drivers were exhibiting safer driving behaviors, a trend which might eventually cause a significant reduction in the number of crashes [11]. This study focused solely on speeding-related safety corridors.

The existing literature also provides insight into the effectiveness of safety corridor programs in 13 states across the US [16]. According to this research, the effectiveness of any safety corridor is indicated by reliable “before” and “after” data [3]. However, this study observed that there was insufficient data available after the implementation of the corridors. In addition, this study identified certain factors that were integral to the success of safety corridors. These factors are the selection of the corridors after examination of crash history; the composition of the team managing the project; the identification of the decision makers; public support; multidisciplinary countermeasures; funding; and benefit assessment.

Within the state of Ohio, adopting safety corridors is a relatively new concept, the first having been implemented in 2018 along I-76 and I-80 in Mahoning and Trumbull Counties. It was only in 2020 that the Ohio Traffic Safety Council was formed to focus on changing driver behavior, with distracted driving as one of the priority areas [17]. The safety corridors in Ohio utilize increased signage along the roadside to indicate to the drivers that they are in an area where unsafe, distracted driving and speeding behaviors are not tolerated, as shown in Figures 1 and 2 below [18]. It also indicates, although not explicitly, that there will be an increased law enforcement presence along these corridors to distribute citations for unsafe driving behaviors [18]. In Ohio, distracted driving is a primary offense, meaning a driver can be pulled over for it [18].

It has been claimed that the safety corridors in Ohio have reduced the number of crashes in locations where they have been implemented, but there is a lack of any statistical-based approach—empirical before–after data evaluations—to confirm this conclusion [11]. Additionally, given how recently the first corridor was implemented, the data to statistically evaluate the effectiveness of these corridors in Ohio has not been readily available previously. With Ohio distracted driving- and speeding-related safety corridor data now becoming available, this study aims to fill the gap in terms of systematically exploring the effectiveness of these projects across the state. This study is also different in its scope as it focuses on the before–after evaluation of speeding as well as distracted driving safety corridors, unlike ones that have focused solely on speeding-related safety corridors [9,11,15].



Figure 1. Increased signage at a distracted driving safety corridor in Ohio [19].



Figure 2. Increased signage at a distracted driving and speeding safety corridor in Ohio [20].

3. Methodology

For this study, ten in-service safety corridors which had the necessary data (i.e., crash data from at least 3 years before and also after treatment) were used. The before and after crash data were analyzed using the Empirical Bayes (EB) approach as described in AASHTO's Highway Safety Manual (HSM) [21]. Table 1 provides a listing of the corridors that were evaluated (i.e., study sites), and also includes characteristics of the study sites pertinent to the analysis, such as the location of the route within Ohio (by Ohio DOT District # and Ohio County), the classification of the route (by Route Prefix), the length of the safety corridor (by Length), and a date that the section was officially designated as a safety corridor.

Table 1. Listing of selected in-service Ohio safety corridors and their characteristics.

Study Site	Ohio DOT District #	Ohio County	Route Prefix	Length (Miles)	Date Corridor Was Designated as Safety Corridor
1	11	Belmont	IR	20	4 July 2020
2	11	Belmont	IR	7	4 July 2020
3	5	Licking	SR	12	7 August 2021
4	10	Athens	US	17	11 October 2021
5	4	Stark/Summit	IR	14	24 April 2020
6	6	Delaware/Morrow	IR	22	1 June 2018
7	3	Medina	SR	5	5 August 2018
8	7	Montgomery	IR	11	8 April 2021
9	1	Allan/Hancock	IR	20	1 May 2020
10	3	Lorraine	SR	8	7 July 2020

Note: Sites 7 and 10 are distracted driving- and speeding-related safety corridors. IR, US, and SR, are defined as interstate Route, US Route, and State Route, respectively.

Estimates of the Annual Average Daily Traffic (AADT) for the analyzed years before and after the implementation of the distracted driving safety corridors at the different sites

are given in Table 2. These estimated AADT values were obtained from the Ohio DOT Traffic Monitoring Management System [13]. The AADT data in Table 2 show that the AADT for site 1 reduced after establishing it as a safety corridor, whereas for the remaining sites, the AADT was fluctuating—reduced in some years and increased in others.

Table 2. AADT data for the studied safety corridors during the analysis period.

Study Site	Annual Average Daily Traffic (AADT)						
	Years						
	2017	2018	2019	2020	2021	2022	2023
1	19,855	18,957	23,790	14,263	16,203	16,219	19,513
2	41,088	38,923	33,382	27,340	35,446	33,972	34,957
3	36,631	36,455	37,330	31,656	38,735	36,420	37,331
4	14,609	13,949	14,088	11,989	15,004	15,244	15,534
5	103,843	104,881	105,196	86,156	97,873	77,199	79,230
6	64,314	65,295	65,295	51,137	62,290	62,539	68,150
7 *	23,013	23,128	25,865	22,709	25,389	20,344	21,015
8	109,478	110,718	107,759	89,398	101,556	102,753	105,733
9	30,240	30,465	29,929	24,512	29,015	30,016	31,898
10 *	54,004	54,760	56,074	48,962	54,740	54,740	60,930

Note: * Sites 7 and 10 are distracted driving- and speeding-related safety corridor.

Observed crash data for the ten analyzed sites before and after the implementation of the distracted driving safety corridors were obtained from the Ohio DOT's GIS Crash Analysis Tool (GCAT) [13]. GCAT “provides great on-demand analysis for performing data analysis on roadways to determine crash patterns and issues” [22]. All crash data for the analyzed years were included; however, it should be noted that the first two months after the implementation of a specific safety corridor were excluded due to the possibility of higher or lower than average crashes caused by motorists acclimatizing to the new safety measure. It should also be noted that, at the time this before–after analysis was being conducted, crash data for December of 2021 had not yet been released. The observational crash data for the analyzed distracted driving safety corridors is given in Table 3. At first glance, the overall crash data show a reduction in crashes after the implementation of the safety corridor for all the sites, except at sites 5, 6, 7, 9, and 10.

Table 3. Observed crash data at the study locations before and after treatment was implemented.

Site	Observed Crashes Before						Observed Crashes After						
	2017	2018	2019	2020	2021	SUM	2018	2019	2020	2021	2022	2023	SUM
1	270	258	279	91	-	898	-	-	63	189	248	215	715
2	51	63	57	25	-	196	-	-	17	45	47	74	183
3	70	62	63	68	35	298	-	-	-	16	62	57	135
4	110	95	95	87	66	453	-	-	-	19	81	74	174
5	519	522	514	129	-	1684	-	-	285	495	440	466	1686
6	230	108	-	-	-	338	152	300	200	247	261	272	1432
7	100	35	-	-	-	135	16	70	58	56	88	64	352
8	829	687	840	674	242	3272	-	-	-	676	894	1067	2637
9	109	136	162	50	-	457	-	-	101	132	171	193	597
10	114	106	96	62	-	378	-	-	42	142	117	136	437

In order to apply the EB method to evaluate countermeasures, we need to establish safety performance functions (SPFs) and crash modification factors (CMFs) for the facility type that is being evaluated. For this work, specific CMFs and SPFs for interstate freeways and rural multilane divided highways were adopted from Report No. FHWA/OH 2021-20 [14] and the HSM [21], respectively. Note that there were some divided highways that have two independent roadways with different features and have a central median which

is wide. In such cases, the SPF for divided highways was applied two times—separately for each road feature. The traffic volume is, however, totaled, and the mean of the predicted crash frequencies is considered [12].

Therefore, the SPF utilized for rural multilane highway sections is presented in Equation (1). This equation was used for sites 3, 4, 7, and 10.

$$N_{SPF,rd} = e^{(a+b \times \ln(AADT) + \ln(L))} \quad (1)$$

where $N_{SPF,rd}$ is the base number of total crashes for a roadway segment in crashes per years, L is the length of the segment in miles, $AADT$ is the traffic volume, and a and b are regression coefficients.

Similarly, the SPF utilized for urban interstate freeway sections—sites 1, 2, 5, 6, 8, and 9—is presented in Equation (2).

$$N_{SPF,rd} = L \times AADT^{\beta_1} \times e^{(\alpha + D_i)} \quad (2)$$

where D_i is district information, β and α are regression coefficients, and other variables as defined previously.

Specific segment characteristics such as lane width, shoulder width, median width, etc., were determined based on aerial imagery, and values of the associated CMFs were determined based on the CMF Clearinghouse [23]. Shoulder and median width values available in the HSM are predetermined [21]. For lane width and presence (or absence) of lighting, Equations (3) and (4), respectively, were adopted.

$$CMF_{lrd} = (CMF_{RA} - 1.0) \times p_{RA} + 1.0 \quad (3)$$

$$CMF_{4rd} = 1 - [(1 - 0.72 \times p_{inr} - 0.83 \times p_{nr}) \times p_{nr}] \quad (4)$$

where CMF_{RA} is the crash modification factor for related crashes (run-off-the-road, head-on, and sideswipe), p_{RA} is the proportion of total crashes constituted by related crashes, p_{inr} is the proportion of total night-time crashes for unlighted roadway segments that involve a fatality or injury, p_{pnr} is the proportion of total night-time crashes for unlighted roadway segments that involve property damage only, and p_{nr} is the proportion of total crashes for unlighted roadway segments that occur at night.

Overall, the combined CMF was calculated by multiplying the individual CMFs. The combined CMF thus obtained will be for a section of a particular safety corridor. The CMF for the entire safety corridor under consideration is calculated as shown in Equation (5).

$$CMF_{segment} = CMF_{lane\ width} \times CMF_{right\ shoulder\ width} \times CMF_{median\ width} \times CMF_{lighting\ for\ one\ segment} \quad (5)$$

$$CMF_{combined} = CMF_{segment} \times CMF_{segment\ for\ each\ segment\ within\ the\ safety\ of\ corridor} \quad (6)$$

The predicted number of crashes before the implementation of the safety corridor ($N_{pred,B}$) was determined using Equation (7).

$$N_{pred,B} = N_{spf} * CMF_{combined} * CF \quad (7)$$

where CF is a calibration factor, which is defined as a factor that accounts for the difference between crash frequency estimates from a predictive model and the observed conditions at the state, regional, or local level [21].

The expected number of crashes before the implementation of the safety corridors ($N_{exp,B}$) was determined using Equation (8).

$$N_{exp,B} = w \times N_{pred,B} + (1 - w) \times N_{obs} \quad (8)$$

where w is a weighted adjustment factor placed on the SPF prediction, as shown in Equation (9), N_{obs} is the observed crash frequency at the site, and $N_{pred,B}$ is the predicted average crash frequency predicted using SPF.

$$w = \frac{1}{1 + k \left(\sum \text{all study years } N_{pred} \right)} \quad (9)$$

where k is the overdispersion factor from the associated SPF, represented by Equation (10) for rural multilane highways and Equation (11) for interstate freeways.

$$\text{For multilane highways } k = \frac{1}{e^{1.549 + LN(L(\text{miles}))}} \quad (10)$$

$$\text{For interstate freeways } k = \text{constant} * L^{\beta_3} \quad (11)$$

The expected number of crashes after the implementation of the safety corridors was determined from Equation (12).

$$N_{exp,A} = N_{exp,B} \times r \quad (12)$$

where r is the adjustment factor, which is the difference between the before and after periods in duration and traffic volume at each site.

An estimate of the safety effectiveness of the treatment at each site i is calculated in the form of an odds ratio, OR_i , as follows.

$$\text{Odds Ratio } (OR_i) = \frac{N_{observed,A}}{N_{expected,A}} \quad (13)$$

$N_{observed,A}$ = observed crash frequency at site i for the entire after period.

Next, the safety effectiveness specific to a countermeasure of interest—which, in the case of this paper is conversion to a safety corridor—that is, $CMF_{safety\ corridor}$, was computed using Equation (14). Additionally, the statistical significance associated with the effectiveness value was computed.

$$CMF_{safety\ corridor} = 100 (1 - OddsRatio_i) \quad (14)$$

4. Results and Discussion

The base number of total crashes ($N_{SPF,rd}$) for each corridor (based on the SPF) and their combined CMF values before a safety corridor was established at each study site are given in Table 4.

Table 4. Results from SPF and combined CMF calculations for each of the sites before the distracted driving and speeding-related safety corridor were implemented.

Study Site	Base Number of Total Crashes, $N_{spf,B}$					CMF_{comb}	CF
	2017	2018	2019	2020	2021		
1	62	61	65	56	-	0.77	1
2	26	26	25	24	-	0.91	1
3	89	88	90	76	94	0.77	1
4	48	46	46	39	49	0.7	1
5	83	83	84	79	-	0.76	1
6	104	105	-	-	-	0.91	1
7	23	23	-	-	-	0.23	1
8	66	67	66	63	65	0.94	1
9	84	84	84	79	-	0.87	1
10	89	90	92	80	-	0.86	1

The predicted number of crashes ($N_{pred,B}$) for each of the sites before the treatment (safety corridor) was implemented are shown in Table 5. At all the sites, both types of crashes were considered—distracted driving as well as speeding-related. Thereafter, the treatment was implemented. Then, crashes at the sites were split into distracted driving and speed-related. Table 6 shows the expected number of crashes after the treatment was implemented for distracted driving safety corridors. Table 7 shows the expected number of crashes after the treatment was implemented for speeding-related safety corridors.

Table 5. Predicted number of crashes for each of the sites before the distracted driving and speeding-related safety corridor was implemented.

Study Site	$N_{pred,B}$						k	w
	2017	2018	2019	2020	2021	SUM		
1	47	47	50	43	-	186	0.009	0.364
2	24	24	23	22	-	92	0.022	0.329
3	68	68	69	58	72	335	0.018	0.144
4	33	32	32	27	34	159	0.012	0.334
5	63	63	63	60	-	249	0.013	0.243
6	95	95	-	-	-	190	0.007	0.445
7	5	5	-	-	-	10	0.042	0.697
8	62	62	62	59	-	245	0.015	0.211
9	73	73	73	69	-	288	0.009	0.27
10	76	77	79	69	-	301	0.027	0.111

k = overdispersion parameter; w = weighted adjustment.

Table 6. Expected number of crashes for each of the sites before the distracted driving safety corridor was implemented.

Study Site	$N_{exp,B}$						SUM
	2017	2018	2019	2020	2021		
1	25	28	22	16	-		91
2	11	13	9	8	-		40
3	15	11	13	11	12		63
4	19	13	12	12	14		71
5	37	39	27	21	-		125
6	53	55	-	-	-		108
7	8	5	-	-	-		13
8	50	44	41	29	-		164
9	24	26	23	23	-		96
10	13	13	11	12	-		49

Table 7. Expected number of crashes for each of the sites before the speeding-related safety corridor was implemented.

Study Site	$N_{exp,B}$						SUM
	2017	2018	2019	2020	2021		
1	57	79	68	43	-		247
2	18	23	18	12	-		71
3	20	20	16	21	22		99
4	29	39	26	24	31		150
5	69	77	70	74	-		291
6	77	81	-	-	-		158
7	4	5	-	-	-		9
8	150	124	157	150	-		580
9	37	53	53	49	-		191
10	32	26	32	25	-		115

Table 5 depicts that study sites 3 and 7 had the highest (>300) number of predicted crashes before the implementation of the safety corridor, whereas study site 7 had the lowest (≤ 10) number of predicted crashes. The expected distracted driving crashes were the lowest at site 7 before the implementation of the safety corridor, whereas they were the highest at site 8.

For speeding-related crashes, the expected number of crashes was highest at site 8 and the lowest at site 7 with only nine expected crashes. The results of the SPF, CMF, predicted, and expected number of crashes for each of the sites after the distracted driving safety corridor was implemented are given in Table 8.

Table 8. SPF, CMF, predicted number of crashes, and expected number of crashes for each of the sites after the implementation of the distracted driving safety corridor.

Study Site	2019	2020	$N_{spf,A}$		2023	SUM	CMF_{comb}	CF	2019	2020	$N_{pred,A}$		2023	SUM	r	$N_{exp,A}$
			2021	2022							2021	2022				
1	-	-	58	58	61	177	0.77	1	-	-	45	45	47	136	0.73	66
2	-	-	25	25	25	76	0.91	1	-	-	23	23	23	69	0.749	30
3	-	-	-	88	90	178	0.77	1	-	-	-	68	69	137	0.408	26
4	-	-	-	50	51	101	0.7	1	-	-	-	35	36	71	0.444	32
5	-	-	82	77	77	235	0.76	1	-	-	62	58	58	178	0.715	89
6	105	98	103	103	106	515	0.91	1	95	89	94	94	97	469	2.466	267
7	26	22	25	20	21	114	0.23	1	6	5	6	4	5	26	2.5	33
8	-	-	-	65	66	131	0.94	1	-	-	-	61	62	123	0.5	82
9	-	-	83	84	85	252	0.87	1	-	-	72	73	74	219	0.761	73
10	-	-	90	90	101	281	0.86	1	-	-	77	77	86	241	0.799	40

CF = calibration factor that is used to align the predicted number of crashes with the observed number of crashes based on the results of the SPF calculations.

The CMF of the predicted and expected number of crashes showed that site 7 resulted in the highest reduction in the number of distracted driving crashes after the implementation of the safety corridor for 77%. The CMF for site 8 indicated the least reduction in distracted driving crashes after the implementation of the safety corridor at 6%. Based on their r values, site 10 showed that the expected number of crashes was 79.9% of the predicted values, indicating the highest effectiveness of the intervention, whereas site 3 showed that the expected number of crashes were only 40.5% of the predicted crashes. This was also the observation in the case of speeding-related crashes shown in Table 9. For speeding-related safety corridors, site 7 showed the highest reduction in the number of speeding-related crashes after the implementation of the safety corridor at about 77%, whereas site 8 showed the least reduction at about 6%. Based on the r values, similar to the distracted driving safety corridors, site 10 showed that the expected number of crashes was 79.9% of the predicted values, showing that the effectiveness of the intervention was the most for this site, whereas at site 3, the intervention was the least effective, with the expected crashes at 40% of the predicted value. All the CMF calculations were based on the HSM procedures. The r values were similar to those for Table 8.

Finally, the results of the EB statistical analysis are given in Table 10. This was used to determine if the implementation of distracted driving safety corridors had any impact on the number of total crashes along the corridor. This table has the odds ratio calculated for each site, measuring the odds of crashes occurring after the implementation of the safety corridor at that particular site. Thereafter, the standard error corresponding to each odds ratio helped determine the accuracy of the odds ratio estimate. The odds ratio was adjusted to account for the factors that could impact the outcome. The variance, standard error of the odds ratio, safety effect, and statistical significance are presented in the form of a combined value. Statistical significance was calculated at a 95% confidence interval. At 2.36, which is greater than 1.96, the results proved statistically significant at the 95% confidence interval. Table 10 shows that the implementation of safety corridors was effective in reducing distracted driving-related crashes. On the other hand, Table 11 shows that the impact of speeding-related safety corridors was not statistically significant

at confidence intervals of both 95% and 90%, indicating that it was not effective in reducing speeding-related crashes because -0.49 is lower than both 1.96 and 1.645.

Table 9. SPF, CMF, predicted number of crashes, and expected number of crashes for each of the sites after the implementation of the speed driving safety corridor.

Study Site	N _{spf,A}						CMF _{comb}	CF	N _{pred,A}						r	N _{exp,A}
	2019	2020	2021	2022	2023	SUM			2019	2020	2021	2022	2023	SUM		
1	-	-	58	58	61	177	0.77	1	-	-	45	45	47	136	0.73	180
2	-	-	25	25	25	76	0.91	1	-	-	23	23	23	69	0.749	53
3	-	-	-	88	90	178	0.77	1	-	-	-	68	69	137	0.408	40
4	-	-	-	50	51	101	0.7	1	-	-	-	35	36	71	0.444	67
5	-	-	82	77	77	235	0.76	1	-	-	62	58	58	178	0.715	208
6	105	98	103	103	106	515	0.91	1	95	89	94	94	97	469	2.466	390
7	26	22	25	20	21	114	0.23	1	6	5	6	4	5	26	2.5	22
8	-	-	-	65	66	131	0.94	1	-	-	-	61	62	123	0.5	290
9	-	-	83	84	85	252	0.87	1	-	-	72	73	74	219	0.761	145
10	-	-	90	90	101	281	0.86	1	-	-	77	77	86	241	0.799	92

Table 10. Analysis of treatment effectiveness for distracted driving safety corridor.

Study Site	OR	SE	OR'	Var.	Adj. OR	Unbiased SE	Var (OR)	SE (OR)	SE (Safety Effect)	Statistical Significance
1	0.257	74.345		30.77						
2	0.168	83.194		14.96						
3	0.195	80.524		8.97						
4	0.284	71.550		9.35						
5	0.482	51.813		48.36						
6	0.248	75.240	0.387	364.48	0.386	61.36	0.068	0.260	26.0	2.36
7	0.819	18.071		24.95						
8	0.977	2.298		32.33						
9	0.205	79.497		40.65						
10	0.455	54.484		28.10						
	SUM			602.92						

Table 11. Analysis of treatment effectiveness for speeding-related safety corridor.

Study Site	OR	SE	OR'	Var.	Adj. OR	Unbiased SE	Var (OR)	SE (OR)	SE (Safety Effect)	Statistical Significance
1	1.261	-26.085		83.61						
2	1.217	-21.747		26.85						
3	1.140	-14.015		14.10						
4	1.428	-42.821		19.66						
5	1.472	-47.174		112.68						
6	1.214	-21.400	1.465	532.74	1.464	-46.43	0.897	0.947	94.7	-0.49
7	1.700	-69.966		16.92						
8	2.249	-124.901		114.64						
9	1.162	-16.244		80.77						
10	1.172	-17.225		65.47						
	SUM			1067.43						

The safety effectiveness, when calculated for each of the sites, showed that the implementation of the distracted driving safety corridors had a positive effect on the number of crashes occurring within the corridors. However, the safety effectiveness of the safety corridors for speeding-related crashes showed negative results for all the sites, indicating that the safety corridor could not reduce the number of speeding-related crashes. In general, based on the unbiased safety effectiveness, the distracted driving safety corridors reduced the number of total crashes. Its impact was statistically significant at the 95% confidence interval. The impact of speeding-related safety corridors was not statistically significant at the 95% and 90% confidence intervals.

It should be noted that all crash types were used in determining the effectiveness of the distracted driving safety corridor, and that the effectiveness and significance may change if only crashes involving distracted drivers or speeding are utilized. Calculating individual site-specific SPFs and CMFs may also provide a more accurate view of the impact of distracted driving safety corridors. Crash severity and change in crash severity before and after the implementation of the distracted driving safety corridor was also not investigated, but it is possible that even if the number of crashes did not significantly reduce the severity of potential crashes.

5. Conclusions

When considering all crash types along in-service distracted driving safety corridors in Ohio that had enough data available to conduct a before–after study, the safety corridors did, in general, reduce the total number of crashes to 2273, and the reduction of total crashes was statistically significant at the 95% confidence level. However, the reduction in speeding-related crashes was shown to be statistically insignificant at the 90% confidence level. However, this finding (i.e., not significant) is likely to change—positively or negatively—if only specific types of crashes are considered, or if crash severity is considered. The findings related to speed-related safety corridors as part of this study corroborate a before-and-after evaluation of the highway safety corridors in Virginia with comparison sites [7]. The Virginia-based study showed no major changes in the speed but brought forth behavioral changes, evident from the changes in crashes [7].

Additionally, having several more years of crash data after the implementation of the safety corridors or using comparison sites from states that have implemented similar programs may provide a more accurate estimation in the effectiveness of the safety corridors in Ohio; however, this may be difficult as highway safety corridor programs tend to differ between states. One of the limitations of this paper is that it does not adopt site-specific SPFs. The differences between the traffic, road geometry, and the overall environment between the states have been accounted for by adopting SPFs developed specifically for interstate freeways in Ohio. For the rural multilane divided highways (i.e., sites #3, 7, and 10) the SPFs in the HSM were adopted. Not having used site-specific SPFs is a limitation of the paper that future research can consider exploring.

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