Evaluating the Safety Impacts of a High-Tension Cable Median Barrier Installation Program

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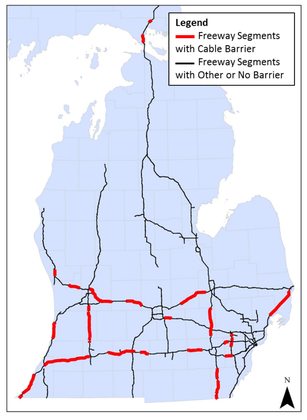
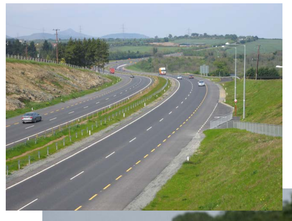
Overview

- Cross-median crashes on freeways tend to result in severe injuries as compared with other crash types:
  - In Michigan, there were 683 head on crashes in interstates from 2008-2012, resulting in 33 fatalities and 78 incapacitating injuries.
  - Nationally, in one year alone there were 821 median crossover crashes that resulted in fatalities.
- The Primary countermeasure to reduce cross-median crashes is installation of a median barrier.
- Cable median barrier has several advantages compared with other barrier types:
  - Deflects laterally to absorb collision force
  - Can be installed on up to 4:1 cross slopes
  - Relatively easy to repair
  - Cheaper installation costs than concrete or beam guardrail
- Starting in 2008, The Michigan Department of Transportation (MDOT) installed cable median barrier on freeway segments with a recent history of cross-median crashes and median width less than 100 feet. Approximately 317 miles of cable median barrier have been installed as of 2013.
- The main objective of this study is to determine the safety and economic impacts of Michigan's Cable Median Barrier Installation Program.





Data Description

- Cable median barrier installation data were obtained from MDOT, including:
  - Installation locations (beginning and ending mile points)
  - Installation completion dates
  - Engineering, construction, and repair costs
- Traffic and geometric data were obtained using MDOT's sufficiency file, with supplementary data collected from Google Earth and Google Maps Street View including:
  - Annual Average Daily Traffic (AADT)
  - Median and shoulder widths
  - Horizontal curvature (including radius measurement)
  - Lateral Clearance of cable barrier from edge of travel lane
- Weather data were obtained from the National Oceanic and Atmospheric Administration (NOAA) from weather stations closest to segment midpoints.
- All crash reports were obtained for 2004-2013. A manual review of all crashes was conducted to identify 'target' crashes (i.e. any median-related crash).
- Control segments were identified as those with no median barrier and median widths of 100 feet or less, and similar data were obtained.

Methodology

Development of Safety Performance Functions

Safety Performance Functions (SPFs) were developed using negative binomial (NB) regression modeling. The NB model is a generalized form of Poisson model:

$$\lambda_i = X_{Li} EXP(\beta_0 + \beta_1 X_1 + \beta_i X_i)$$

Where:
λ_i = Predicted number of crashes/yr per segment
X_{Li} = Length of segment in miles
β_0 = Intercept term
β_i = Estimable parameters
X_i = Explanatory variables (AADT, median width, etc..)

Empirical Bayes (EB) Before-After Crash Analysis

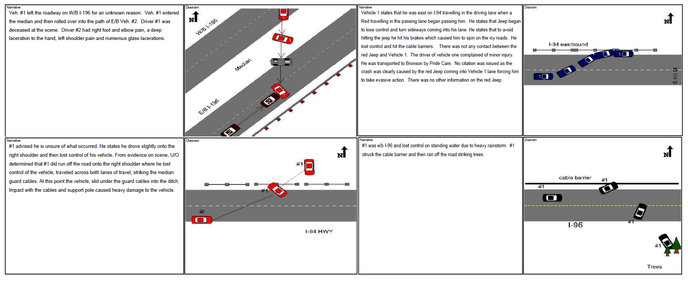
The EB method can account for selectivity bias and regression to the mean effects. It utilizes both observed crash frequency from cable barrier segments and SPF estimated crash frequency from control segments to determine the expected crashes had no barrier been installed:

$$B = [(k + x_b)/(k/P_b + y_b)] \frac{P_a}{P_b} y_a$$

Where:
B = Expected annual number of crashes had no barrier been installed
k = SPF regression estimated overdispersion parameter
x_b= Observed count of crashes during the before period
P_b & P_a= SPF regression estimate of crashes per year during the before and after periods
y_b & y_a = Length of the before and after periods in years

SPFs for Control (No Barrier) Segments

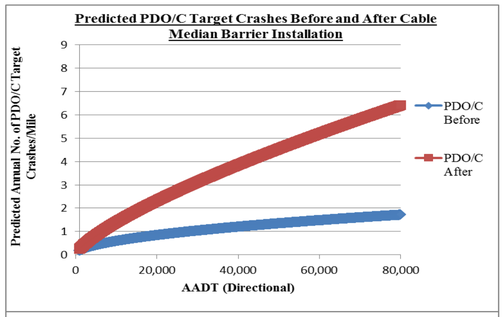
Crash Frequency Model	Parameter	No Barrier Segment SPFs		
		Estimate (β)	Std. Error	P-Value
PDO/C Injury Target Crashes per mile	Intercept	-4.543	0.566	<0.001
	lnAADT	0.533	0.053	<0.001
	Median Width	-0.018	0.002	<0.002
	Dispersion parameter	0.333		
	Log-Likelihood	-2,320.22		
	AIC	4,648.43		
B Injury Target Crashes per mile	Intercept	-6.273	1.461	<0.001
	lnAADT	0.401	0.136	0.003
	Median Width	-0.006	0.005	0.226
	Dispersion parameter	0.499		
	Log-Likelihood	-638.31		
	AIC	1,284.61		
K/A Injury Target Crashes per mile	Intercept	-8.883	1.980	<0.001
	lnAADT	0.667	0.183	<0.001
	Median Width	-0.012	0.006	0.049
	Dispersion parameter	1.015		
	Log-Likelihood	-416.39		
	AIC	840.78		

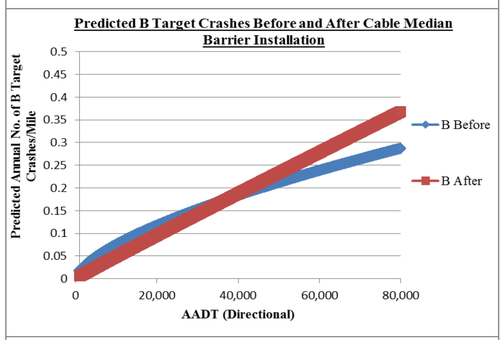


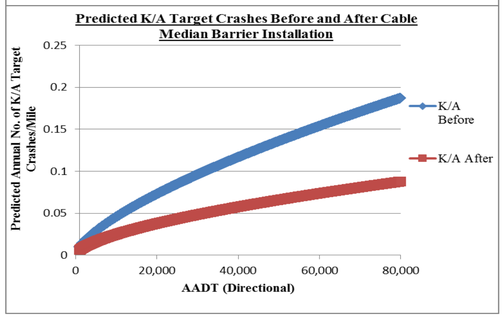
Sample Crash Report Narratives and Diagrams

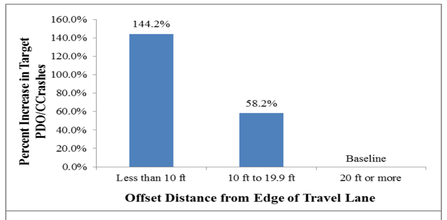
Results and Conclusions

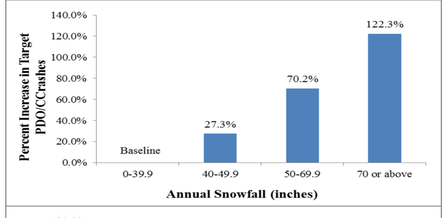
SPF Predictions for Cable Barrier Segments

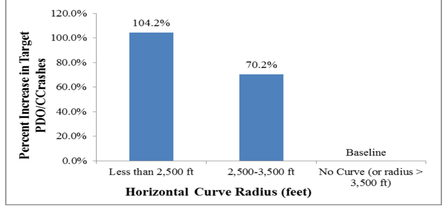












Change in Crash Rates

Crash Severity/Type	Average Annual Crash Rate (crashes per 100 MVMT)		
	Before Period	After Period	Percent Change
All Target Crashes	15.60	34.88	123.6%
Target PDO & C Crashes	12.90	32.85	154.7%
Target B Crashes	1.85	1.33	-28.1%
Target K & A Crashes	1.15	0.58	-49.6%
Median Crossover Crashes	2.66	0.35	-86.8%
Target Rollover Crashes	4.88	2.42	-50.4%

Cable Barrier Crash Performance

Cable Barrier Crash Outcome Scenario		Cable Barrier Strikes by Type and Severity						Percent of Total Cable Barrier Crashes
		PDO	C	B	A	K	TOTAL	
Contained by cable barrier in median	No.	2,861	291	101	21	6	3,280	89.3%
	%	87.2	8.9	3.1	0.6	0.2	100.0	
Struck cable barrier and re-directed back onto travel lanes	No.	222	36	16	4	2	280	7.6%
	%	79.3	12.9	5.7	1.4	0.7	100.0	
Total cable barrier strikes which did not penetrate cable barrier	**No.**	**3,083**	**327**	**117**	**25**	**8**	**3,560**	**96.9%**
	%	**86.6**	**9.2**	**3.3**	**0.7**	**0.2**	**100.0**	
Penetrated cable barrier but contained in median	No.	55	16	11	4	0	86	2.3%
	%	64.0	18.6	12.8	4.7	0.0	100.0	
Penetrated cable barrier and entered opposing lanes	No.	10	7	5	2	4	28	0.8%
	%	35.7	25.0	17.9	7.1	14.3	100.0	
Total Cable Barrier Crashes	No.	3,148	350	133	31	12	3,674	100.0%
	%	85.7	9.5	3.6	0.8	0.3	100.0	

Crash Modification Factors (EB Analysis)

- PDO/C Crashes: CMF = 2.55 (155 percent increase after installation)
- B Crashes: CMF = 1.01 (1 percent increase after installation)
- K/A Crashes: CMF = 0.67 (33 percent decrease installation)

Economic Analysis

- Cable Median Barrier Costs:
  - Installation (Engineering & Const.): $155,622 per mile
  - Maintenance/Repair: $849 per repair (crash)
- Blended Crash Costs (benefits from reduction):
  - PDO/C/B crash: $9,100 per crash
  - K or A injury: $258,300 per injured or killed person
- Benefit/Cost Ratio: 3.1, Time of Return (TOR): 13.36 years

Conclusions

- Cable median barriers were 96.7% effective in preventing penetrations.
- Cross-median crash rate was reduced 86.8% after cable barrier installation.
- Rollover crash rate was reduced by 50.4% after cable barrier installation.
- EB analysis showed K/A crashes reduced by 33 percent.
- Cable barrier is a cost effective solution to reducing cross-median crashes.