CMFs for High-Friction Surface Treatment (HFST) and High-Tension Cable Median Barriers (HTCMB) in Pennsylvania

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CMFs in Real Life

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Goal of these two projects was to estimate CMFs for HFST and HTCMBs in Pennsylvania

- High friction surface treatment (HFST)
  - Applied on horizontal curves of two-lane undivided roadways
  - Intersections
- High tension cable median barriers (HTCMBs)
  - Divided limited-access highways

HFST

High friction surface treatment

- Application of a high-friction aggregate material to the pavement surface
- Aims to increase the friction between vehicle tires and the road surface
- Applied at locations where vehicles are more likely to lose control, especially under wet conditions

Source: FHWA

Safety effectiveness of HFST applied to horizontal curves in the literature suggests significant benefit

Road Type	Crash Type	CMF Range
Curves	Total	0.370-0.529
	Injury	0.490-0.885
	Run-out road	0.226-0.569
	Wet-road	0.125-0.385
	head-on plus opposite direction sideswipe	0.416-0.926

(Merritt et al., 2015, Merritt et al., 2020)

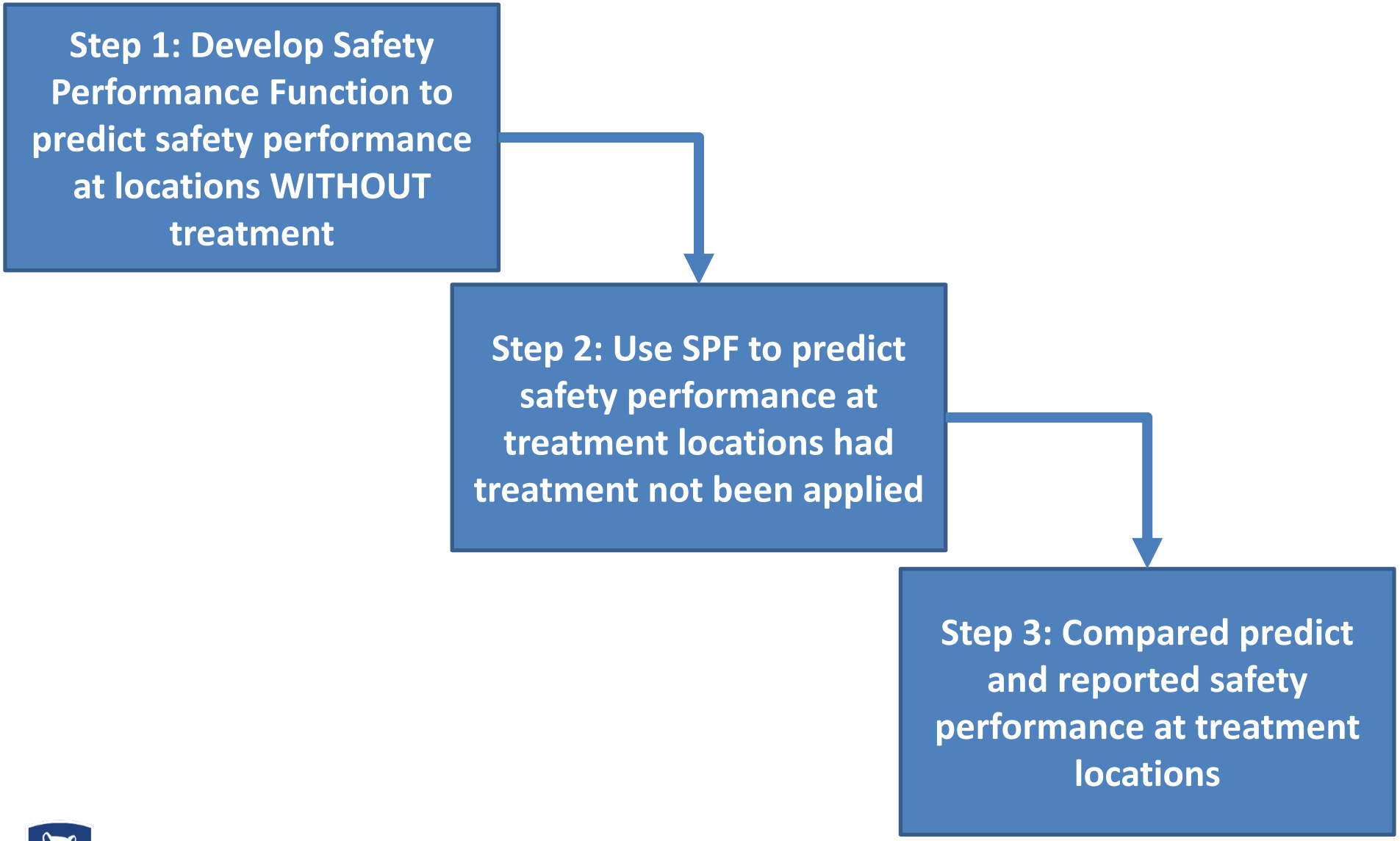
HFST installation in Pennsylvania

- Curves

PennDOT District	Number of curves with HFST	Total length (miles)
1	5	0.465
2	27	5.392
3	0	0.000
4	19	1.609
5	108	8.339
6	219	13.274
8	113	7.988
9	98	7.578
10	58	6.758
11	18	1.578
12	35	4.364
Total	700	57.35

- Intersections
  - 33 intersections with sufficient traffic volumes available for analysis

Applied Empirical Bayes before-after method



SPF development for horizontal curves considered the following explanatory variables…

- Traffic volume
- Curve length
- Degree of horizontal curvature
- Number of adjacent horizontal curves
- Speed limit
- Indicator for year
- Indicator for PennDOT engineering district
- Presence of horizontal curve warning signs


W1-1


W1-6


W1-8


W1-10c

Source: MUTCD

CMFs for HFST applied to horizontal curves of two-lane undivided roadways (including adjacent tangent sections)

Crash type	Number of curves	Total length (miles)	Reported crashes in after period	EB estimate in after period	Unbiased CMF	CMF standard error
Total	530	90.51	1,266	2,853.05	0.444*	0.014
FI			568	1136.38	0.500*	0.023
PDO			698	1533.78	0.455*	0.019
ROR			847	1848.06	0.458*	0.018
HFO			767	1630.07	0.470*	0.019
WR			416	1687.41	0.246*	0.013
HO			65	132.32	0.490*	0.066
SS			42	89.68	0.467*	0.077
ROR FI			360	616.07	0.584*	0.034
HFO FI			312	519.34	0.600*	0.037
WR FI			160	536.21	0.298*	0.025
HO FI			47	87.01	0.539*	0.083
SS FI			27	39.89	0.673*	0.138

* statistically significant at the 95% confidence level

CMFs disaggregated for rural and urban locations tell the same story

Crash type	Number of curves	Total length (miles)	Reported crashes in after period	EB estimate in after period	Unbiased CMF	CMF standard error
Curves on urban roadways						
Total	252	16.04	349	899.40	0.388*	0.023
FI			173	348.09	0.496*	0.042
PDO			176	479.67	0.366*	0.031
ROR			228	498.14	0.457*	0.034
HFO			205	443.22	0.462*	0.036
WR			118	530.80	0.222*	0.022
HO			27	50.19	0.534*	0.112
SS			23	34.14	0.667*	0.153
ROR FI			105	151.33	0.692*	0.075
HFO FI			91	126.95	0.715*	0.083
WR FI			52	160.11	0.324*	0.048
Curves on rural roadways						
Total	278	24.29	261	545.73	0.478*	0.033
FI			124	220.05	0.563*	0.055
PDO			137	270.22	0.506*	0.048
ROR			195	426.04	0.457*	0.036
HFO			174	350.57	0.496*	0.041
WR			88	314.53	0.279*	0.032
HO			8	19.36	0.409*	0.150
SS			10	12.67	0.776	0.264
ROR FI			89	147.21	0.603*	0.069
HFO FI			76	121.17	0.626*	0.077
WR FI			35	106.54	0.327*	0.058

* statistically significant at the 95% confidence level

HFST CMFs also developed for intersections

- SPFs from existing PennDOT projects used
  - 3-leg minor stop-controlled intersection on urban-suburban collectors
  - 3-leg all-way stop-controlled intersection on urban-suburban collectors
  - 4-leg minor stop-controlled intersection on urban-suburban collectors
  - 3-leg minor stop-controlled intersection on urban-suburban arterials
  - 4-leg signalized intersection on urban-suburban arterials
  - 3-leg minor stop-controlled intersection on two-lane rural roads
  - 4-leg signalized intersection on two-lane rural roads

HFST CMFs also developed for intersections

Crash type	Number of intersections	Reported crashes in after period	EB estimate in after period	Unbiased CMF	CMF standard error
Total	33	81	241.747	0.334*	0.042
FI		28	118.742	0.234*	0.048

* statistically significant at the 95% confidence level

HTCMB

High tension cable median barriers

- Median barrier designed to prevent cross-median crashes
- These barriers consist of
  - Tensioned steel cables
  - Posts (support the cables)
- Benefits:
  - Cost-effectiveness
  - Minimal disruption to sightlines
  - Ability to contain vehicles

Source: FHWA

Literature suggests that HTCMB reduces frequency of most severe crashes but increases frequency of least severe crashes

Study Location	Method	Crash Type	CMF Range
Tennessee	Naïve before-after	Fatal	0.04
		Incapacitating Injury	0.09
		Fatal and Incapacitating	0.07
		Non-Incapacitating Injury	0.15
		Incapacitating and Non-Incapacitating	0.12
Michigan	EB before-after and naive before-after	PDO and possible injury	2.48-2.75
		Minor injury	0.60-1.02
		Serious injury + fatal injury	0.40-0.76

(Chimba , 2017, Russo et al., 2016)

HTCMB installation in Pennsylvania

PennDOT District	HTCMB installed on entire segment		HTCMB installed on a portion of a segment	
	# of segments	Total length (miles)	# of segments	Total length (miles)
1	106	52.99	10	4.74
2	8	3.44	70	35.68
3	225	98.38	36	16.97
4	90	44.78	28	14.17
5	166	82.22	64	31.27
6	144	67.46	12	6.17
7	0	0.00	0	0.00
8	390	202.40	36	18.37
9	200	95.11	46	22.63
10	0	0.00	0	0.00
11	232	115.62	63	29.86
12	2	0.75	2	0.74
Total	1,563	763.16	367	180.61

HTCMB type	Number of segments	Total length (miles)
Shoulder (one side)	903	433.23
Single-run (center of median)	498	253.74
Shoulder (both sides)	162	76.19
Total	1,563	763.16

SPF development for divided freeways considered the following explanatory variables…

- Traffic volume
- Segment length
- Degree of horizontal curvature per mile
- Presence of inside and outside shoulder rumble strips
- Presence of on- and off-ramps
- Presence of outside barrier
- Posted speed limit
- Indicator for year
- Indicator for PennDOT engineering district

CMFs for HTCMBs for all freeway sections

Crash type	Number of segments	Total length (miles)	Reported crashes in after period	EB estimate in after period	Unbiased CMF	CMF standard error
Total	1563	763.16	11,424	10,081.46	1.133*	0.019
FI			3,736	3,624.00	1.031	0.025
PDO			7,688	6,393.08	1.202*	0.023
HB			1,213	426.57	2.835*	0.178
CM			78	371.82	0.209*	0.025
KA			308	467.25	0.658*	0.044
KA CM			7	68.30	0.101*	0.039

* statistically significant at the 95% confidence level

CMFs disaggregated for urban and rural sections

Crash type	Number of segments	Total length (miles)	Reported crashes in after period	EB estimate in after period	Unbiased CMF	CMF standard error
Urban sections						
Total	808	398.74	8,609	7,745.48	1.111*	0.023
FI			2,868	2,805.51	1.022	0.030
PDO			5,741	4,836.72	1.187*	0.028
HB			948	349.92	2.698*	0.192
CM			48	268.61	0.178*	0.027
KA			219	358.46	0.610*	0.049
KACM			7	49.43	0.139*	0.055
Rural sections						
Total	755	364.42	2,815	2,335.98	1.205*	0.030
FI			868	818.49	1.060	0.044
PDO			1,947	1,556.37	1.251*	0.036
HB			265	76.65	3.416*	0.426
CM			30	103.22	0.290*	0.055
KA			89	108.79	0.817*	0.092
KACM			0	18.87	0.000	N/A

* statistically significant at the 95% confidence level

Thank you!

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