Highway Safety Improvement Program (HSIP)

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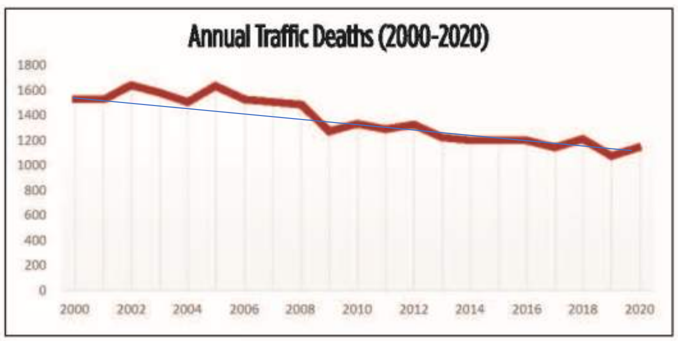
Working Toward Zero Deaths

Toward Zero Deaths (TZD) is a national highway safety movement supporting the elimination of fatalities and serious injuries on our nation's roadways, conceptualized by safety practitioners, researchers, and advocates from a variety of disciplines. TZD calls for all stakeholders to champion the idea that one death is too many, and we must all work together to bring the annual number of roadway deaths down to zero. Pennsylvania's SHSP sets the groundwork for progressing TZD in the commonwealth by incorporating the following themes:

- Highway Safety: strategies for key focus areas to reduce crash frequency and severity and achieve measurable success.
- Active Transportation: mobility options powered primarily by human energy, including bicycling and walking.
- Safe System Approach: roadway design that emphasizes minimizing the risk of injury to all road users, considers the possibility of human error, and accommodates human injury tolerance by considering likely accident types and resulting impact forces.
- Transportation Equity: reducing inequities in our transportation network, building resilience against future disruptions, improving safety, and supporting both environmental and financial sustainability.
- Data & Technology: using cost-effective, data-driven methods, and incorporating safety technologies into infrastructure, vehicles & other modes of travel.

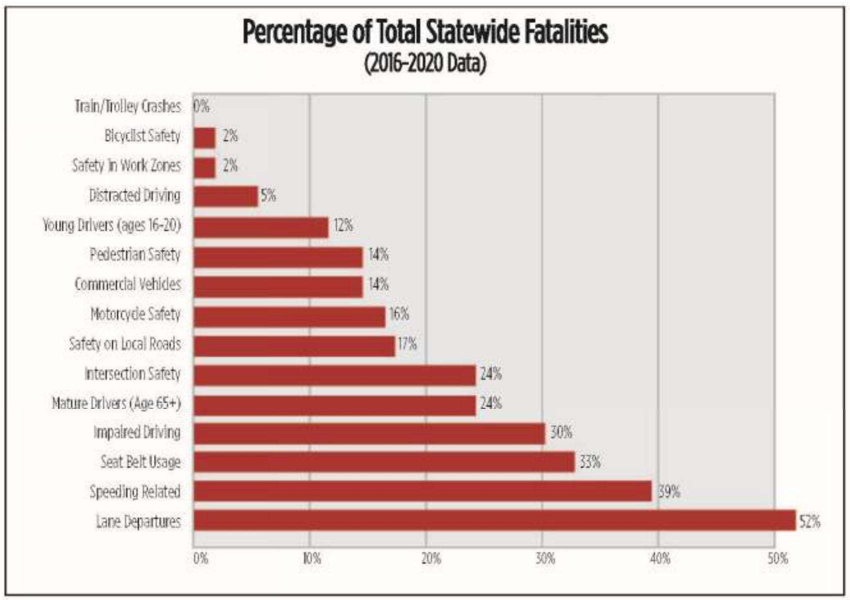


This graph shows highway fatalities in Pennsylvania since the turn of the century. The trend indicates a steady decline from 2000 to 2020. These two decades include the 12 lowest fatality years on record (stats have been kept since 1928). Despite these substantial improvements, there were still 1,129 highway fatalities in Pennsylvania in 2020. It is the responsibility of traffic safety professionals and stakeholders to continue engaging and innovating to work TZD. Collaboration and commitment will be essential to make TZD progress. More information on the national TZD initiative can be found at: https://www.towardzerodeaths.org/

- Progress in 20 years; but we have a long way to go.
- 1,129 Fatalities in PA in 2020

2022 Strategic Highway Safety Plan

Safety Focus Areas



This chart represents the percentage of statewide fatalities associated with each SFA (not including Traffic Records Data, TSMO, or EMS). Note that the percentages in this chart do not add up to 100% because there is often more than just one contributing factor for any given fatal crash.

- Lane Departure Majority Fatal Crash Type in PA
- 2/3rd of Lane Departure Fatal Crashes result in collisions with Trees, Utility Poles, Embankments & Guiderail. Roadside Environment is “Open for Scrutiny”.
- Defending Drivers also need forgiving roadside environment.

2022 Strategic Highway Safety Plan

Using the HSM predictive method can yield both a predicted number of crashes from the SPF equation and an expected number of crashes. The expected number of crashes is a statistical adjustment or 'correction' of the observed number of crashes at the location to adjust for the unpredictable nature of actual crash occurrences (due to such things as driver behavior, etc.). The potential for safety improvement for a particular location (or network) will be reflected in the difference between these two outcomes. This is graphically represented in Figure 1-2. The greater the difference between the expected number of crashes and the predicted number of crashes, the greater the potential for safety improvement. If the expected number of crashes is fewer than the predicted number of crashes, then it is assumed there is little room for safety improvement.

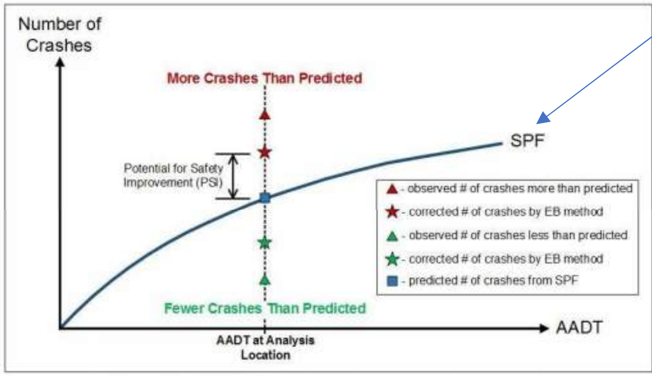


Figure 1-2: HSM Method – Potential for Safety Improvement

More detailed explanations of these concepts and their applicability in project development and alternatives analysis are provided in PennDOT Publication 638, *District Highway Safety Guidance Manual* Chapter 5, the AASHTO HSM, and FHWA's "*Scale and Scope of Safety Assessment Methods in the Project Development Process*" FHWA-SA-16-106

Table 2.2-2 (Continued): Regionalized SPFs for Two-lane Rural Roadway Segments

	Regionalized SPF Predictive Equations	Over-dispersion Factor
District 9		
Total Predicted	$N_{total} = e^{-6.039} \times L \times AADT^{0.734} \times e^{0.206 \times RHR567} \times e^{-0.167 \times PZ} \times e^{-0.118 \times SRS} \times e^{0.007 \times AD} \times e^{0.038 \times HCD} \times e^{0.002 \times DCPM}$	$k = 0.426$
Fatal Inj Predicted	$N_{fatal\_inj} = e^{-6.510} \times L \times AADT^{0.728} \times e^{0.163 \times RHR567} \times e^{-0.212 \times PZ} \times e^{-0.182 \times SRS} \times e^{0.006 \times AD} \times e^{0.041 \times HCD} \times e^{0.001 \times DCPM}$	$k = 0.495$

Location

Roadway Attributes

Crash Experience

District	County	Road Name	SR	Beginning Segment	Beginning Offset	Ending Segment	Ending Offset
9	Bedford	Brumbaugh Rd	0869	0360	0598	0370	2050
9	Bedford	Raystown Rd	0026	0680	0804	0690	2533
9	Bedford	Allegheny St	0056	0130	1747	0150	2924
9	Bedford	Lincoln Hw	0030	0020	0750	0020	2060
9	Bedford	Allegheny Rd	0031	0030	0941	0040	1473
9	Bedford	Clear Ridge Rd	0026	0450	0789	0450	3161
9	Bedford	Quaker Valley Rd	0056	0030	0200	0040	0566
9	Bedford	Raystown Rd	0026	0750	0147	0750	3009
9	Bedford	Lincoln Hw	0030	0560	2764	0570	2976
9	Bedford	Raystown Rd	0026	0700	0848	0700	2728
9	Bedford	Sproul Mountain Rd	1042	0010	1103	0020	2198
9	Bedford	Quaker Valley Rd	0056	0260	2479	0270	2126
9	Bedford	Main St	1036	0050	0023	0060	0349
9	Bedford	Lincoln Hw	0030	0630	0272	0650	1308
9	Bedford	Sarah Furnace Rd	4034	0070	0897	0070	1468
9	Bedford	Bedford Valley Rd	0220	0090	2840	0100	2007
9	Bedford	Woodcock Valley Rd	1019	0040	2684	0040	2795
9	Bedford	Quaker Valley Rd	0056	0010	1759	0020	0085
9	Bedford	Black Valley Rd	2015	0260	1488	0260	2544

Road Name	Number of Lanes (Multi-lane = 4 or more lanes)	Length (Feet)	AADT	Roadside Hazard Rating	Passing Zone	Shoulder Rumble Strips	Total Driveways & Intersections	Number of Curves	Total Degree of Curvature	Presence of Median Barrier	Speed Limit	Centerline Rumble Strips
Brumbaugh Rd	2-lane	3498	932	6	No	No	1	6	380	N/A	N/A	N/A
Raystown Rd	2-lane	4278	1850	5	No	No	21	4	188	N/A	N/A	N/A
Allegheny St	2-lane	4469	4215	3	No	No	40	1	22	N/A	N/A	N/A
Lincoln Hw	2-lane	1310	1416	5	No	No	1	4	122	N/A	N/A	N/A
Allegheny Rd	2-lane	4040	1126	5	No	Yes	1	4	67	N/A	N/A	N/A
Clear Ridge Rd	2-lane	2372	1554	6	No	No	7	2	44	N/A	N/A	N/A
Quaker Valley Rd	2-lane	2129	4101	5	No	Yes	3	2	221	N/A	N/A	N/A
Raystown Rd	2-lane	1862	1863	5	No	No	5	4	123	N/A	N/A	N/A
Lincoln Hw	Multi-lane	4202	12278	4	N/A	Yes	12	N/A	0	No	55 MPH	Yes
Raystown Rd	2-lane	1880	1850	4	No	No	8	1	50	N/A	N/A	N/A
Sproul Mountain Rd	2-lane	3411	2102	5	No	No	4	6	242	N/A	N/A	N/A
Quaker Valley Rd	2-lane	2525	6462	2	No	No	18	1	37	N/A	N/A	N/A
Main St	2-lane	2125	1195	3	No	No	18	3	87	N/A	N/A	N/A
Lincoln Hw	Multi-lane	8481	11938	5	N/A	Yes	19	N/A	227	Yes	45 MPH	No
Sarah Furnace Rd	2-lane	571	1339	5	No	No	1	1	55	N/A	N/A	N/A
Bedford Valley Rd	2-lane	2480	4611	3	No	Yes	9	2	35	N/A	N/A	N/A
Woodcock Valley Rd	2-lane	711	1056	2	No	No	3	2	194	N/A	N/A	N/A
Quaker Valley Rd	2-lane	1868	4101	7	Yes	Yes	0	3	132	N/A	N/A	N/A
Black Valley Rd	2-lane	3046	827	5	No	No	8	1	30	N/A	N/A	N/A

Road Name	Observed Crashes				Fatal & Injury Crashes						Total Crashes						Excess Cost
	No. Years of Analysis	Fatal & Injury	PDO	Total	Observed Crashes / Year	Predicted Crashes / Year	Overdispersion	W	Expected Crashes / Year	Excess	Observed Crashes / Year	Predicted Crashes / Year	Overdispersion	W	Expected Crashes / Year	Excess	
Brumbaugh Rd	5	12	21	33	2.40	0.27	0.495	0.50	1.34	1.07	6.60	0.47	0.426	0.40	4.15	3.68	$474,300
Raystown Rd	5	11	15	26	2.20	0.54	0.495	0.38	1.57	1.03	5.20	0.96	0.426	0.28	4.01	3.05	$450,400
Allegheny St	5	11	8	19	2.20	0.84	0.495	0.29	1.81	0.97	3.80	1.48	0.426	0.23	3.31	1.82	$411,000
Lincoln Hw	5	7	10	17	1.40	0.19	0.495	0.35	0.98	0.79	3.40	0.32	0.426	0.27	2.57	2.25	$344,300
Allegheny Rd	5	10	8	18	2.00	0.26	0.495	0.54	1.06	0.80	3.60	0.47	0.426	0.43	2.25	1.78	$342,400
Clear Ridge Rd	5	8	3	11	1.60	0.24	0.495	0.43	1.02	0.78	2.20	0.43	0.426	0.32	1.62	1.19	$327,000
Quaker Valley Rd	5	7	6	13	1.40	0.36	0.495	0.30	1.08	0.72	2.60	0.67	0.426	0.22	2.18	1.51	$307,000
Raystown Rd	5	7	1	8	1.40	0.28	0.495	0.34	1.02	0.74	1.60	0.49	0.426	0.25	1.32	0.83	$306,500
Lincoln Hw	5	8	8	16	1.60	0.72	0.929	0.19	1.43	0.71	3.20	1.66	0.790	0.11	3.03	1.37	$301,300
Raystown Rd	5	7	3	10	1.40	0.18	0.495	0.44	0.86	0.68	2.00	0.31	0.426	0.35	1.41	1.10	$285,900
Sproul Mountain Rd	5	7	6	13	1.40	0.50	0.495	0.34	1.09	0.59	2.60	0.86	0.426	0.26	2.15	1.29	$252,300
Quaker Valley Rd	5	7	5	12	1.40	0.64	0.495	0.25	1.23	0.59	2.40	1.12	0.426	0.17	2.18	1.06	$249,400
Main St	5	6	7	13	1.20	0.20	0.495	0.45	0.75	0.55	2.60	0.36	0.426	0.35	1.81	1.46	$238,400
Lincoln Hw	5	17	17	34	3.40	2.86	0.929	0.11	3.34	0.48	6.80	6.30	0.790	0.06	6.77	0.47	$198,000
Sarah Furnace Rd	5	4	3	7	0.80	0.06	0.495	0.42	0.49	0.43	1.40	0.11	0.426	0.32	0.99	0.88	$183,300
Bedford Valley Rd	5	5	6	11	1.00	0.40	0.495	0.32	0.81	0.41	2.20	0.73	0.426	0.25	1.86	1.13	$178,200
Woodcock Valley Rd	5	4	4	8	0.80	0.07	0.495	0.44	0.48	0.41	1.60	0.12	0.426	0.35	1.08	0.96	$176,100
Quaker Valley Rd	5	4	7	11	0.80	0.28	0.495	0.34	0.62	0.34	2.20	0.54	0.426	0.24	1.80	1.26	$151,900
Black Valley Rd	5	4	1	5	0.80	0.08	0.495	0.50	0.44	0.36	1.00	0.14	0.426	0.40	0.66	0.52	$150,600

Output of Safety Performance Function & Empirical Bayes Method – Screened locations with Excess “Expected Crashes” greater than the “Predicted Crashes” crash/year rate. Ranking based on crash cost/year relative to the Excess.

This method of priority takes in account; value of crashes (severity), attributes increasing risk, and crashes/year in a short distance of roadway.

Cluster Lists are still good measures – Indicating a specific number and crash type, in a short distance and within a 5-year period. The bias vs. screening list, attributes aren’t always accounted for; and the crash cost/severity isn’t accounted for.

Rating = 5

- Clear zone between 5 to 10 ft from pavement edge line.
- Side slope about 1V:3H.
- May have guiderail 0 to 5 ft from pavement edge line.
- May have rigid obstacles or embankment within 6.5 to 10 ft of pavement edge line.
- Virtually non-recoverable.

Figure A-5: Typical Roadway with Roadside Hazard Rating Equal to 5

Rating = 6

- Clear zone less than or equal to 5 ft.
- Side slope about 1V:2H.
- No guiderail.
- Exposed rigid obstacles within 0 to 6.5 ft of the pavement edge line.
- Non-recoverable.

Figure A-6: Typical Roadway with Roadside Hazard Rating Equal to 6

Rating = 7

- Clear zone less than or equal to 5 ft.
- Side slope 1:2 or steeper.
- Cliff or vertical rock cut.
- No guiderail.
- Non-recoverable with high likelihood of severe injuries from roadside collision.

Figure A-7: Roadway with Roadside Hazard Rating Equal to 7

Example:

Consider State Route 3009 in Bedford County as an example. In this example, as in most segments, the RHR will be different for the two directions of travel within the segment limits. As such, data collectors should estimate the average of the RHR within the segment (i.e., produce only a single RHR measure per segment). Figure A-8, Figure A-9 and
Table A-2 show the process used to determine that SR 3009, Segment 0010 is category 6.

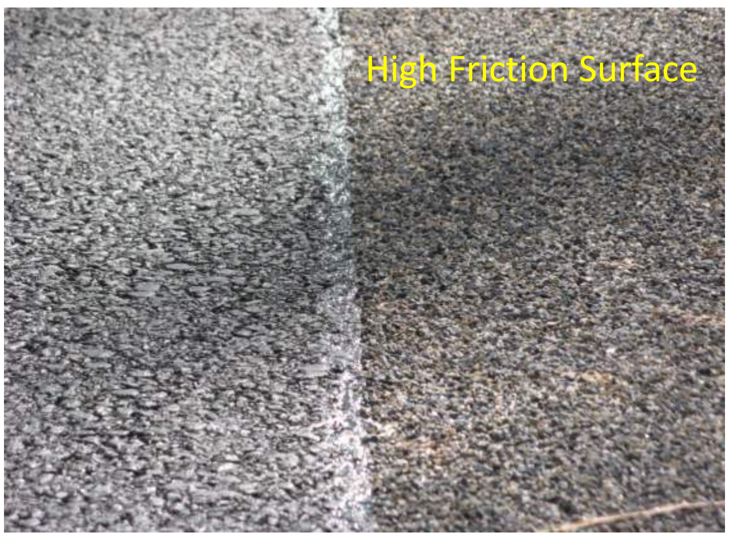
Figure A-8: Video Log for SR 3009, Segment 0010

- Rating System Roadside Environment
- Rating/Scaling; allows a means of quantifying risk.

Pub 638a

Integrated Advance Warning


Lane Diet at Intersection


High Friction Surface

Value of Countermeasures?

CRASH MODIFICATION FACTORS CLEARINGHOUSE

CMF / CRF Details

CMF ID: 10327

Install high friction surface treatment (HFST)

Description:

Prior Condition: Curves without High Friction Surface Treatment

Category: Roadway

Study: ***Developing Crash-Modification Factors for High-Friction Surface Treatments*, Merrit et al., 2020**

Star Quality Rating:	★★★★★ [View score details]

Crash Modification Factor (CMF)	
Value:	0.37
Adjusted Standard Error:	
Unadjusted Standard Error:	0.033

Crash Reduction Factor (CRF)	
Value:	63 *(This value indicates a **decrease** in crashes)*
Adjusted Standard Error:	

Same Countermeasure;
Different Outcome

CRASH MODIFICATION FACTORS CLEARINGHOUSE

CMF / CRF Details

CMF ID: 10335

Install high friction surface treatment (HFST)

Description:

Prior Condition: Curves without High Friction Surface Treatment

Category: Roadway

Study: ***Developing Crash-Modification Factors for High-Friction Surface Treatments*, Merrit et al., 2020**

Star Quality Rating:	★★★★★ [View score details]

Crash Modification Factor (CMF)	
Value:	0.168
Adjusted Standard Error:	
Unadjusted Standard Error:	0.02

Crash Reduction Factor (CRF)	
Value:	83.2 *(This value indicates a **decrease** in crashes)*
Adjusted Standard Error:	

Crash Cost Applications

- Economic burden of crashes
- Calculating safety benefits

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Project Benefits}}{\text{Project Costs}}$$

$$\text{Safety Benefits} \approx (\text{Crash Cost}) \times (\text{Exist Crash Freq.}) \times (1-\text{CMF})$$

The cost of crashes saved by the deployed countermeasure; Annualized through Project Life Cycle

The cost of the project; Annualized Through life cycle.

* BCR = 1 or Greater for a spot specific HSIP funded project.


• Traffic Safety Engineering
• Assess th s
• Apply countermeasures proven successful.
• Monitor the benefit yield