
Estimating Numbers and Costs of Crashes Using FARS Data

Kathleen Hancock, PE, PhD
Virginia Polytechnic Institute and State University
hancockk@vt.edu

Improving Data-Driven Safety Decisions

- Roadway crashes result in direct losses to the people involved and indirect losses to society.
- Assessing economic damage caused by roadway crashes is an important step in establishing a data-driven approach to systematically improving safety at strategic locations.
- The publicly available and most commonly used source of crash data is the Fatality Analysis Reporting System (FARS)

<http://www.nhtsa.gov/FARS>

Methodology

- Identify relationship between number of regional crashes in different severity categories using historic data
- Estimate number of non-fatal crashes in different severity categories based on number of fatal crashes in the same region for period to be predicted
- Estimate number of KABCO injuries per crash severity
- Validate estimated numbers against actual numbers of regional crashes
- Calculate economic losses caused by roadway crashes using representative KABCO cost data from authoritative sources such as NSC or NHTSA
- Estimate economic losses due to roadway crashes in each Virginia DOT district and compare with VDOT's total annual budget to illustrate magnitude of crash costs

Methodology: Crash Prediction

Regression Analysis:

$$N_{sev\ i} = \beta_{Ni} N_k + \epsilon_{Ni}$$

Where: N = number of crashes

sev *i* = crash severity level where *i* is

A or SI – Severe Injury crash

B or I – Injury crash

C or PI – Possible Injury crash

O or NI – No injury (PDO) crash

K or *FC* = fatal injury crash

β and ϵ = regression constants from historical data

Average Ratio:

$$r_{sev\ i} = avg \sum_{years} \left(\frac{N_{sev\ i}}{N_K} \right)$$

$$N_{sev\ i} = r_{sev\ i} N_K$$

Methodology: Injuries

Regression Analysis:

$$n_{sev\ i} = a_{sev\ i} n_K$$

Where: n = number of injuries

$sev\ i$ = crash severity level where i is

A or SI – Severe Injury crash

B or I – Injury crash

C or PI – Possible Injury crash

O or NI – No injury (PDO) crash

K or FC = fatal injury crash

a = regression constant from historical data

Methodology: Injuries

Injuries by severity type per crash severity

$$n_{sevi} = a_{sevi} N_{sevi}$$

Total Injuries

$$\bar{n} = \begin{bmatrix} a_{FC_K} \bar{N}_{FC} & a_{FC_A} \bar{N}_{FC} & a_{FC_{BC}} \bar{N}_{FC} & a_{FC_{kNI}} \bar{N}_{FC} \\ & a_{SIC_A} \bar{N}_{SIC} & a_{SIC_{BC}} \bar{N}_{SIC} & a_{SIC_{NI}} \bar{N}_{SIC} \\ & & a_{IC_{BC}} \bar{N}_{IC} & a_{IC_{NI}} \bar{N}_{IC} \\ & & & a_{NI_{NI}} \bar{N}_{NI} \end{bmatrix}$$

Methodology: Injuries

Injuries by severity type per crash severity

$$n_{sevi} = a_{sevi} s_{sevi} N_K$$

Total Injuries

$$\bar{n} = \begin{bmatrix} a_{FC_K} \bar{N}_K & a_{FC_A} \bar{N}_K & a_{FC_{BC}} \bar{N}_K & a_{FC_{NI}} \bar{N}_K \\ & a_{SIC_A} s_A \bar{N}_K & a_{SIC_{BC}} s_A \bar{N}_K & a_{SIC_{NI}} s_A \bar{N}_K \\ & & a_{IC_{BC}} s_{BC} \bar{N}_K & a_{IC_{NI}} s_{BC} \bar{N}_K \\ & & & a_{NI_{NI}} s_{NI} \bar{N}_K \end{bmatrix}$$

Methodology: Costs

$$\bar{C} = \begin{bmatrix} a_{FC_K} \bar{N}_K & a_{FC_A} \bar{N}_K & a_{FC_{BC}} \bar{N}_K & a_{FC_{NI}} \bar{N}_K \\ & a_{SIC_A} s_A \bar{N}_K & a_{SIC_{BC}} s_A \bar{N}_K & a_{SIC_{NI}} s_A \bar{N}_K \\ & & a_{IC_{BC}} s_{BC} \bar{N}_K & a_{IC_{NI}} s_{BC} \bar{N}_K \\ & & & a_{NI_{NI}} s_{NI} \bar{N}_K \end{bmatrix} * \begin{bmatrix} \bar{C}_K \\ \bar{C}_A \\ \bar{C}_{BC} \\ \bar{C}_O \end{bmatrix}$$

Average Comprehensive Cost by Injury Severity

(National Safety Council)

Injury Severity	2012 Costs per Injury
Death	\$4,538,000
Incapacitating Injury	\$230,000
Non incapacitating evident injury	\$58,700
Possible injury	\$28,000
No Injury	\$2,500

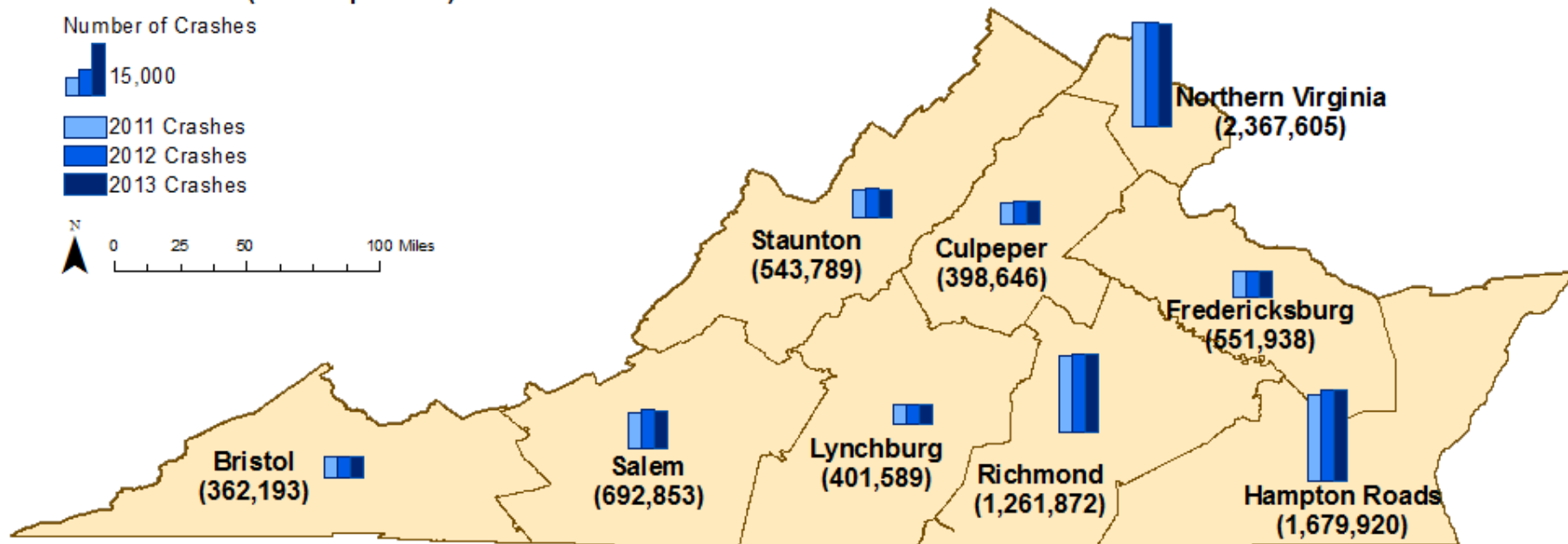
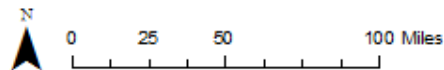
Source:

http://www.nsc.org/NSCDocuments_Corporate/Estimating-the-Costs-of-Unintentional-Injuries-2014.pdf

Virginia: Historic Crashes

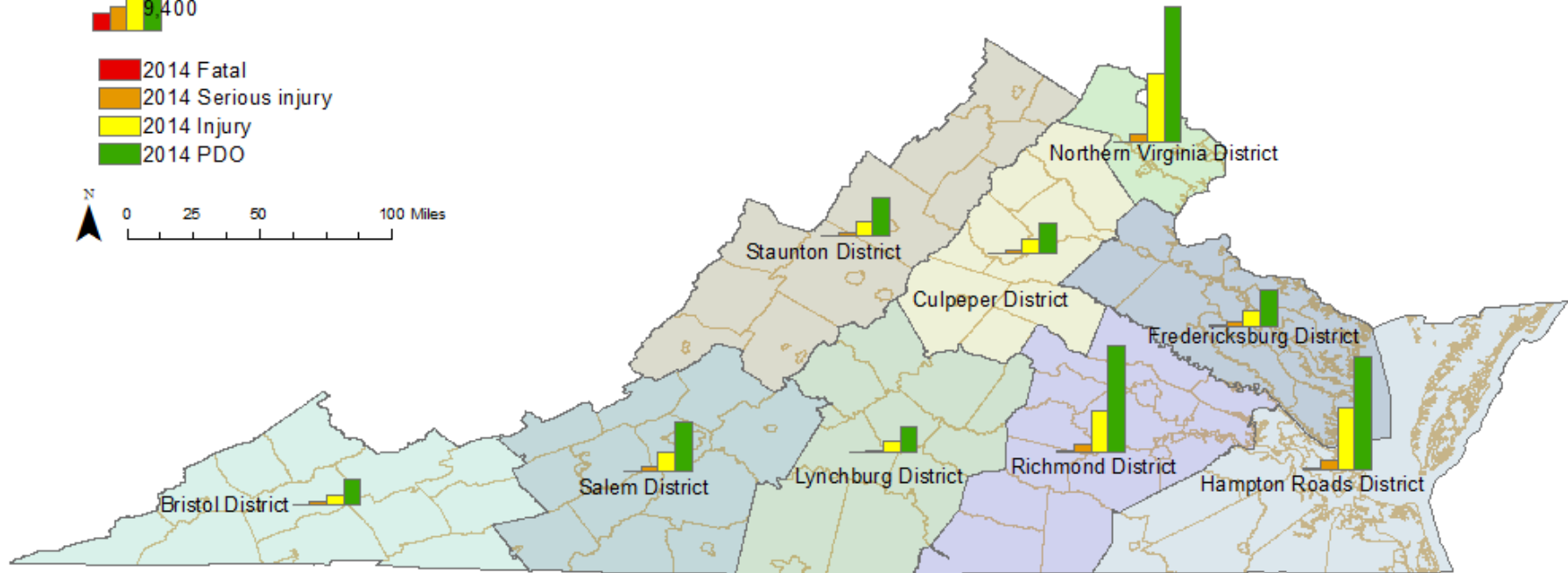
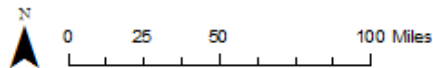
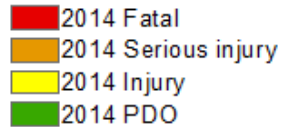
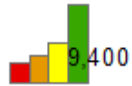
VDOT Districts (2013 Population)

Number of Crashes



Virginia: 2014 Crashes

VDOT Districts



2014 Crashes	Fatal	Ser Injury	Injury	PDO	Total
Virginia Crashes	656	6,145	35,448	78,033	120,282
Estimated Cost (\$B)*	\$3.24	\$1.81	\$2.23	\$0.35	\$7.64

* National Safety Council: http://www.nsc.org/NSCDocuments_Corporate/Estimating-the-Costs-of-Unintentional-Injuries-2014.pdf

Virginia: Statewide Costs

$$N_{K_{2014}} = 656 \text{ Fatal Crashes}$$

$$\bar{c} = \begin{bmatrix} 1.1 * NK & 0.4 * NK & 0.4 * NK & 0.4 * NK \\ 1.2 * 11.3 * NK & 0.4 * 11.3 * NK & 0.5 * 11.3 * NK & \\ 1.4 * 51.6 * NK & 0.8 * 51.6 * NK & & \\ & 1.8 * 110.3 * NK & & \end{bmatrix} * \begin{bmatrix} 4,538,000 \\ 230,000 \\ 43,350 \\ 2,500 \end{bmatrix}$$

$$C_{2014 \text{ predicted}} = \$ 7.68 \text{ B}$$

Virginia: District Costs

VDOT District	Cost from 2014 Crash & Injury Numbers (\$M)	Predicted Costs (\$M)	Difference
Bristol	\$ 410	\$ 402	-2.0%
Culpeper	\$ 456	\$ 476	4.2%
Fredericksburg	\$ 546	\$ 549	0.6%
Hampton Roads (U)	\$ 1,685	\$ 1,853	9.1%
Lynchburg	\$ 544	\$ 597	8.8%
Northern Virginia (U)	\$ 1,350	\$ 1,244	-8.5%
Richmond (U)	\$ 1,332	\$ 1,354	1.6%
Salem	\$ 727	\$ 752	3.2%
Staunton	\$ 589	\$ 653	9.8%

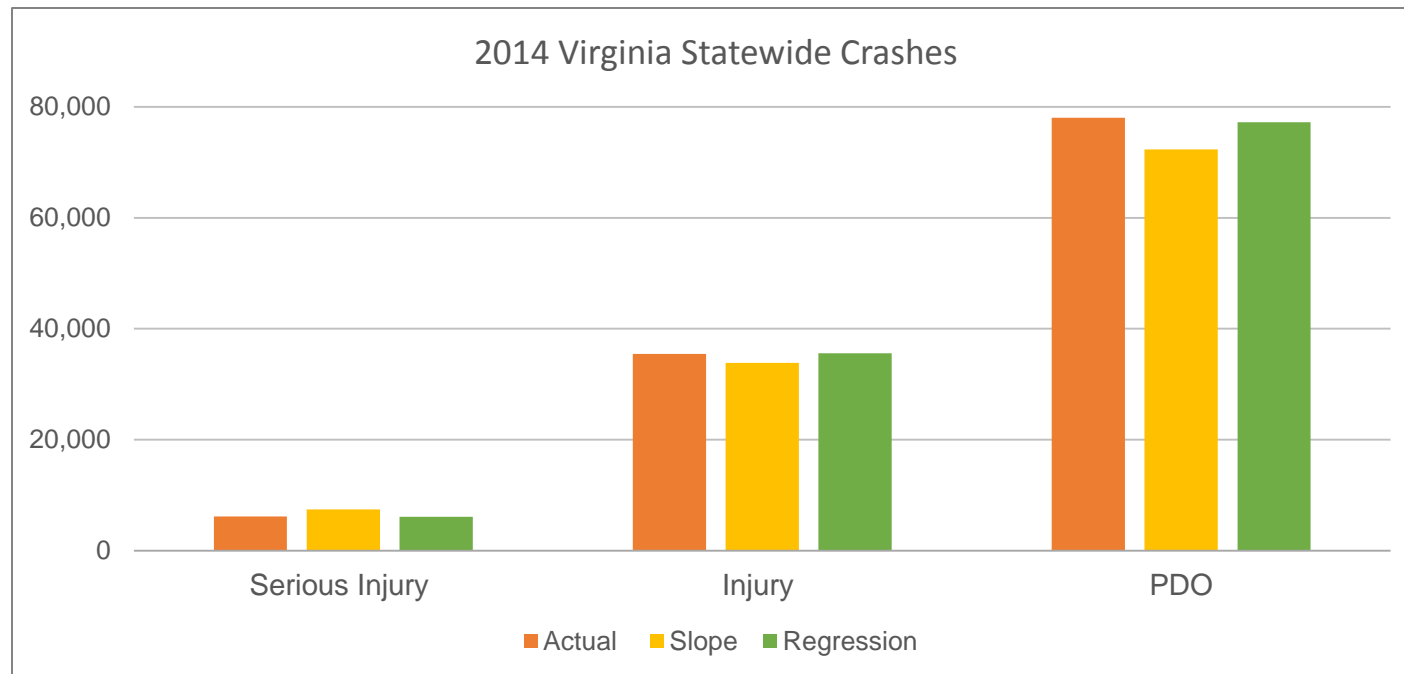
2014 Predicted Crashes

	Fatal Crashes	Serious Injury Crashes			Injury Crashes			No Injury Crashes		
	Actual	Actual	Slope	Regres	Actual	Slope	Regres	Actual	Slope	Regres
VIRGINIA	656	6,145	7,428	6,133	35,448	33,859	35,590	78,033	72,343	77,262
Bristol	38	425	458	475	1,375	1,015	1,535	3,591	2,475	3,700
Culpeper	47	266	414	514	1,821	1,687	1,862	4,210	3,780	3,628
Fredericksburg	51	366	520	610	2,011	1,809	2,011	4,936	4,192	4,786
Hampton Roads (U)	135	1,632	1,864	1,738	8,548	9,202	8,555	15,673	16,395	15,180
Lynchburg	63	555	521	483	1,547	1,721	1,586	3,671	4,064	3,771
Northern Virginia (U)	69	1,097	1,157	1,308	9,534	8,206	9,249	18,861	16,025	18,331
Richmond (U)	113	974	1,111	1,275	5,776	5,867	6,320	14,663	13,301	14,265
Salem	74	481	682	799	2,648	2,234	2,510	6,831	6,153	7,131
Staunton	66	431	602	601	2,000	1,965	1,996	5,376	5,109	5,200

U – primarily urban district

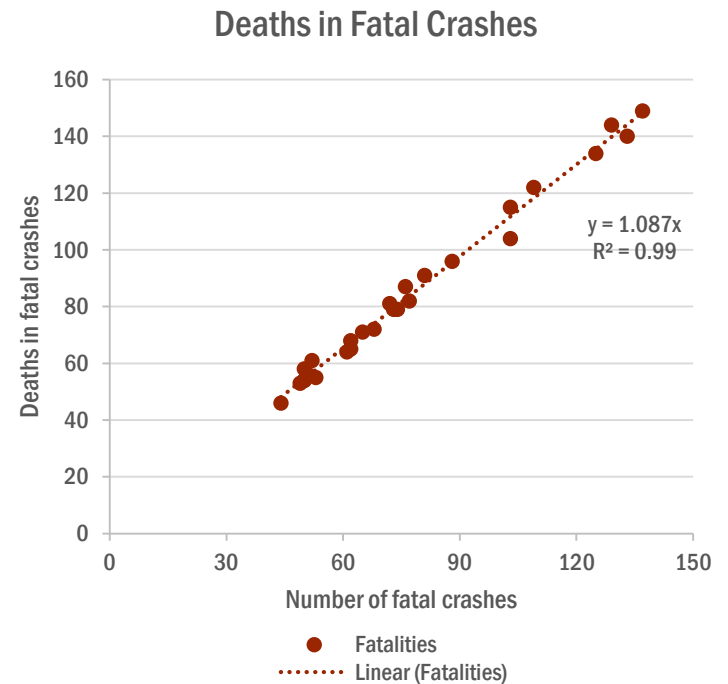
Virginia Predicted Crashes

	Actual	Slope	Regression
Serious Injury	6,145	7,428	6,133
Injury	35,447	33,859	35,590
PDO	78,027	72,343	77,262
Total	119,619	113,629	118,985



Example Number of Injuries

Fatalities in Fatal Crashes						
	2013		2012		2011	
	Crashes	Deaths	Crashes	Deaths	Crashes	Deaths
VIRGINIA	683	741	714	775	700	764
Bristol	49	53	50	58	68	72
Culpeper	51	56	53	55	50	54
Fredericksburg	61	64	62	65	52	61
Hampton Roads	133	140	103	104	137	149
Lynchburg	44	46	72	81	50	54
Northern Virginia	73	79	88	96	77	82
Richmond	129	144	109	122	125	134
Salem	81	91	103	115	76	87
Staunton	62	68	74	79	65	71



Virginia: Statewide Costs

$$N_{K_{2014}} = 656 \text{ Fatal Crashes}$$

$$\bar{c} = \begin{bmatrix} 1.1 * NK & 0.4 * 11.3 * NK & 0.4 * 51.6 * NK & 0.4 * 110.3 * NK \\ & 1.2 * 11.3 * NK & 0.4 * 51.6 * NK & 0.5 * 110.3 * NK \\ & & 1.4 * 51.6 * NK & 0.8 * 110.3 * NK \\ & & & 1.8 * 110.3 * NK \end{bmatrix} * \begin{bmatrix} 4,538,000 \\ 230,000 \\ 43,350 \\ 2,500 \end{bmatrix}$$

$$C_{2014 \text{ predicted}} = \$ 7.68 \text{ B}$$

FY 2015 Virginia DOT Budget

- **Total Transportation Budget:** **\$4.35 B**
- **Section 603 budget:** **\$1.07 B**
- **Safety budget:** **\$51.8 M**

- **2014 Crash Costs**
- **Predicted Statewide cost:** **\$7.68 B**
- **District costs:** **\$400 M to \$1.7 B**

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Questions



Kathleen Hancock, PE, PhD
Associate Professor
Virginia Polytechnic Institute and State University
(703) 538-3760
hancockk@vt.edu