NCHRP 17-62
Improved Prediction Models for Crash Types and Crash Severities

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Project Objectives

- Develop crash severity and crash type SPF's for the facility types in the HSM to replace fixed proportions to predict crash type and severity
- Recommendations for incorporating results into the HSM and associated tools
- Describe statistical and practical pros and cons of the methodology and potential barriers to implementation

Crash Type Definitions (Most facilities)

Same Direction (SD)	Intersecting Direction (ID)	Opposite Direction (OD)	Single Vehicle (SV)
• Rear End (RE) • Sideswipe Same Direction (SSD) • Turning Same Direction (TSD)	• Angle (ANG) • Turning Intersecting Direction (TID)	• Head On (HO) • Sideswipe Opposite Direction (SOD) • Turning Opposite Direction (TOD)	• Overturn or Roll Over (RO) • Fixed Object (FO) • Moving Object (MO)

Crash Type Definitions (Urban/Suburban Segments)

Rear End (RE)	Sideswipe Same Direction (SSD)	Multivehicle Driveway (MVD)	Multivehicle Nondriveway (MVN)
Multivehicle Nondriveway Other (MVN OTHER)	Head On and Sideswipe Opposite Direction (HO+SOD)	Single Vehicle (SV)	Nighttime (NIGHT)

Severity Prediction

KA

KAB

KABC

KABCO

- We considered probabilistic severity models (crash based) (i.e., predict severity given a crash)
- With only AADT and crash type, these models were not effective
- Instead we estimated crash severity count models – most by crash type as well (i.e., crash type AND severity) (negative binomial regression)
- K and A combined due to small number of K crashes
- PDO crashes = predicted KABCO minus KABC (etc.)

Models Estimated by Facility Type

Urban/Suburban Segments

KABCO all types	KABC all types	KAB all types
KA all types	Rear End (RE)	Sideswipe Same Direction (SSD)
Multivehicle Driveway (MVD)	Multivehicle Nondriveway (MVN)	Multivehicle Nondriveway Other (MVN OTHER)
Head On and Sideswipe Opposite Direction (HO+SOD)	Single Vehicle (SV)	Nighttime (NIGHT)

All other Facilities

Total Crashes	Same Direction Crashes	Intersecting Direction Crashes	Opposite Direction Crashes	Single Vehicle Crashes
KABCO	KABCO	KABCO	KABCO	KABCO
KABC	KABC	KABC	KABC	KABC
KAB	KAB	KAB	KAB	KAB
KA	KA	KA	KA	KA

Model Formulation (Rural Segments)

$$N = exp[b_0 + b_1 \times \ln(AADT) + \ln(L)]$$

N = expected average crash frequency per year

AADT = annual average daily traffic (vehicles per day)

L = length of roadway segment (miles)

b_0, b_1 = regression coefficients

Overdispersion Parameter: $k = {}^{1}/_{exp[c+\ln(L)]}$

c = estimated parameter

Model Formulation (Rural Intersections)

$$N = exp\left[b_0 + b_1 \times \ln(AADT_{maj}) + b_2 \times \ln(AADT_{min})\right]$$

Or $N = exp[b_0 + b_3 \times \ln(AADT_{total})]$

N = base expected average crash frequency per year

$AADT_{maj}$ = AADT (vehicles per day) for major-road approaches

$AADT_{min}$ = AADT (vehicles per day) for minor-road approaches

$AADT_{total}$ = AADT (vehicles per day) for minor- and major-road approaches combined

b_0, b_1, b_2, b_3 = regression coefficients.

Model Formulation (Urban/Suburban Segments)

Crashes/year = (length)exp$^{(Alpha1+Ohio)}$AADT$^{(Beta1)}$ exp$^{(Beta3*dwydens+ +Beta4*fodensity+Beta5*medwid)}$

Length = segment length (miles)

dwydens = aggregate driveway density of all types (per mile)

fodensity = fixed objects per mile

medwidth = width of median (ft) (for divided facility types)

Dispersion parameter = exp$^{(Alpha2)}$(length)$^{(Beta2)}$

Model Function (Urban/Suburban Intersections)

$$Y = \exp\left[a + b \times \left(\frac{MajorAADT}{10000}\right) + c \times \ln(MajorAADT) + d \times \left(\frac{MinorAADT}{10000}\right) + e \times \ln(MinorAADT)\right]$$

$$Y = \exp\left[a + b \times \left(\frac{TotalAADT}{10000}\right) + c \times \ln(TotalAADT) + d \times \left(\frac{MinorAADT}{TotalAADT}\right) + e \times \ln\left(\frac{MinorAADT}{TotalAADT}\right)\right]$$

Two options considered

Y is the predicted number of crashes in one year

a, b, c, d, and e are parameters to be estimated

Data Used for Estimation and Validation

Facility Type	Segments Estimation	Segments Validation	Intersections Estimation	Intersections Validation
Two-lane rural highways	Washington	Ohio	3ST: Minnesota 4ST: Minnesota 4SG: Ohio	3ST: Ohio 4ST: Ohio 4SG: Minnesota
Multilane rural highways	4U: Texas (2009-11) 4D: California	4U: Texas (2012) 4D: Illinois & Washington	3ST: Minnesota 4ST: Minnesota 4SG: Ohio	3ST: Ohio 4ST: Ohio 4SG: Minnesota
Urban/suburban arterials	Ohio	Minnesota	Ohio	North Carolina

Two-lane Rural Segments Base Conditions

Base condition	HSM Base	17-62 Base
Lane width	12 feet	Same
Shoulder width	6 feet	4 to 7 feet
Shoulder type	Paved	Same
Roadside hazard rating	3	Same
Driveway density	5/mile	Unknown
Horizontal curvature	None	Same
Vertical curvature	None	Unknown
Centerline rumble strips	None	Same
Passing lanes	None	Same
Two-way left-turn lanes	None	Same
Lighting	None	Assumed none
Automated speed enforcement	None	Assumed none
Grade level	0%	Same

Two-lane Rural Intersection Base Conditions

Base Condition	HSM Base	17-62 3ST & 4ST	17-62 4SG
Intersection skew angle (excludes 4SG)	0 degrees	Same	NA
Intersection left-turn lanes	None	Same	Same
Intersection right-turn lanes	None	Same	Same
Lighting	None	Same	With

Multilane Rural Highway Segment Base Conditions

Variable	HSM Base	17-62 Base
Lane width	12 feet	Same
Shoulder width	6 feet	≥ 6 ft
Shoulder type	Paved	Same
Side slopes	1V:7H or flatter	Unknown
Lighting	None	Unknown
Automated speed enforcement	None	Same

Multilane Rural Intersection Base Conditions

Base Condition	HSM (3ST & 4ST)	17-62 (3ST & 4ST)	17-62 (4SG)
Intersection skew angle	0°–5°	Same	Same
Intersection left-turn lanes	None	Same	Same
Intersection right-turn lanes	None	Same	Same
Lighting	None	Same	WITH

Urban/Suburban Arterial Segment Base Conditions

HSM Base Condition	17-62 Base Condition
No on-street parking	Same
No roadside fixed objects	Same
A 15-foot median width for divided roads	Same
No lighting	Same
No automated speed enforcement	Same

Urban/Suburban Intersections
Stop Controlled Base Conditions

HSM Base	17-62 Base
No left-turn lanes	Same
No right-turn lanes	Same
No lighting	Same
No schools within 1,000 feet	Same
No bus stops within 1,000 feet	Same
No alcohol sales establishments within 1,000 feet	Same

Urban/Suburban Intersections Signalized Base Conditions

HSM Base	17-62 Base
No left-turn lanes	Same
No right-turn lanes	Same
No right-turn-on-red prohibition	Same
No red light cameras	Same
Lighting is not present	Lighting is present

Re-visit of calibration approach

- Key issues we addressed:
  - Required sample size for calibration data
  - How to capture variation of calibration factor with site characteristics
- Evaluated different options:
  - Estimating a single calibration factor (current HSM method)
  - Estimating a calibration function
  - Directly estimating a model using the calibration data

Calibration Recommendations

1. When CMFs are available to apply the HSM algorithm, perform the calibration by applying CMFs to the base models. Otherwise, perform the calibration on the base models.
2. Start with an available sample that is desirably random and at least as large as that recommended in the HSM.
3. Perform the calibration first with a constant calibration factor, and assess the success of the calibration using CURE plots and CV of calibration factor (FHWA Calibrator is suggested).
4. Consider the Calibration Function if a constant calibration factor does not provide useful results. Determine if the calibration function provides useful results.
5. If the sample is insufficient, then incrementally assemble additional data for additional sites and adjust the method until a successful calibration is achieved.

Recommended Changes to Predictive Method

CURRENT HSM

1. Predict total base crashes (all types and severities)
2. Modify with CMFs
3. Apply calibration factor
4. Apply aggregate proportions to get crash counts by type and/or severity level

PROPOSED FROM 17-62

1. Identify crash type and severity needed
2. Predict base crashes for that crash type and severity
3. Modify with CMFs (applying to that crash type and severity)
4. Apply calibration factor

Advances to HSM Predictive Methods

- Base crash count prediction models are estimated based on newer crash data from more states than the existing HSM
- Allocation of predicted crash count among crash types and severity accounts for varying effect of traffic exposure
- Models were validated using data from more states than the existing HSM
- Recommended update to calibration procedure provides more guidance regarding selection of sample size and includes alternative approaches

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QUESTIONS?