Transferability Assessment of Collision Prediction Models for Rural Highways in British Columbia

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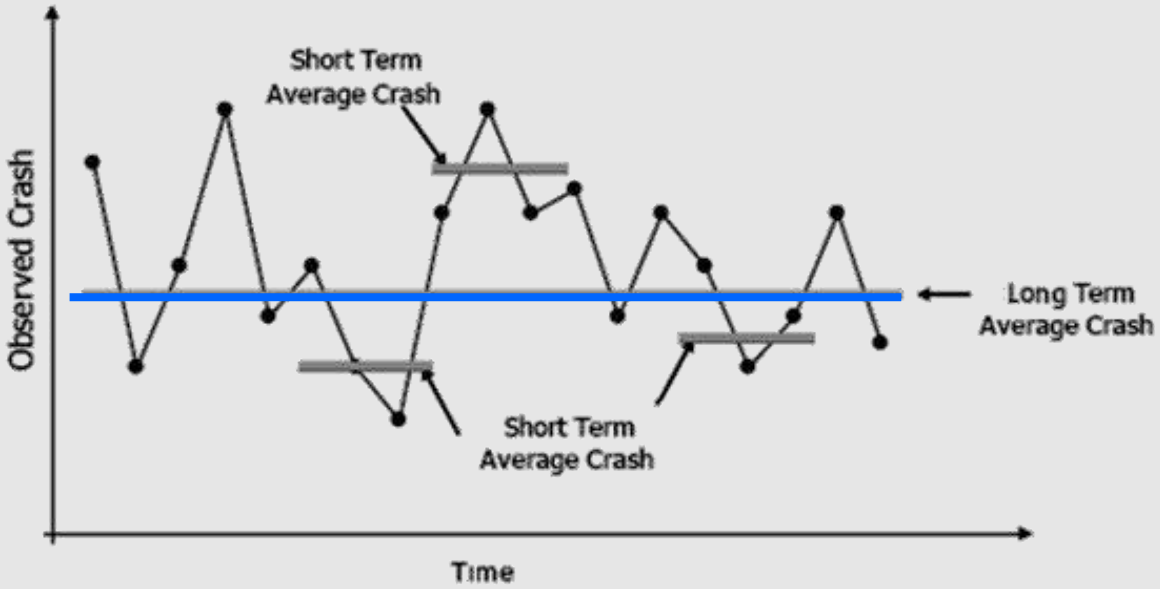
Introduction

- **Traditionally, descriptive methods based on crash rate were used in safety analysis of highways**

- **In the last two decades research has focused on the development of more statistically-rigorous predictive methods**

- **The new Highway Safety Manual (HSM) is providing guidance, based on the best available factual knowledge, to professional engineers for quantitative crash analysis**

Accident Phenomena



Estimate of Road Safety =

Estimate of long-term average crash frequency of a road site, under a given set of geometric design and traffic volumes in a given time period (in years) (Hauer, 1997)

Road Safety Modeling

CRASH = rare / non negative / discrete / random in a statistical sense (spatial and temporal context) EVENT → long term average E(Y)=λ can be described by a Poisson distribution

Negative Binomial (NB) distribution provides better fit for accident count; models obtained are called Crash prediction Models (CPMs)

Mathematical form of CPMs:

- intersections
- road segments

traffic exposure

$$E(Y) = e^{a_0} \cdot V_1^{a_1} \cdot V_2^{a_2} \cdot e^{\sum_{j=1}^{m} b_j x_j}$$

$$E(Y) = e^{a_0} \cdot L^{a_1} \cdot V_1^{a_2} \cdot e^{\sum_{j=1}^{m} b_j x_j}$$

coefficients to be estimated through regression analysis

HSM Crash Prediction Algorithm

Calibration factor → *for applying a model from a different jurisdiction and/or time period*

$$N_{predicted} = C_x \times N_b \times CMF_1 \times CMF_2 \times \ldots \times CMF_n$$

CPM for "base" conditions

Crash Modification Factors

i.e.: for 1mi of 2-lane rural highways

$$N_b = AADT \times 365 \times 10^{-6} \times e^{(-0.312)}$$

- *shoulder width = 6 ft*
- *lane width = 12 ft*
- *horizontal curvature = none*
- *vertical curvature = none*
- *grade =0%*

$$\frac{n°acc.\ (effectiveness\ of\ one\ condition)}{n°acc\ (base\ conditions)}$$

Transferability Methodology

- **The need to transfer a CPM, for a certain facility, from a jurisdiction to another arises when data availability is limited for estimating new models (CPMs can be transferred also in another time period)**

- **Two main alternatives for transferring a CPM**

  - ❑ Using a calibration factor
  - ❑ Recalibrating only the constant of the model equation and transferring unaltered the existing coefficient exponents (through a new regression) – METHOD DEVELOPED AT UBC

- **Goodness-of-fit measures are used to assess performance of transferred models to different time-space frames**

Transferability of CPMs in BC

- **Interest in updating the existing (2001-2005) CPMs to reflect current safety levels on BC highways**
- **Investigation of several options for BC CPMs calibration**

  - ✓ calibration and updating of existing models using a set of recent collision and traffic volume data
  - ✓ calibration and transferability of the HSM models to be used in BC
  - ✓ development of new models for BC conditions

The Data

2-lane 2-way rural highways

- collision and traffic volume data (2007-2011)

Summary Statistics of Sample Data

N sites = 441	Length (km)	AADT	SEVERE	PDO	TOTAL
				(crashes/5 years)	
MIN value	0.90	108	0	0	0
MAX value	83.40	34,947	127	194	321
AVRG value	17.85	5,732	20.22	24.92	45.14

Transferability of CPMs in BC

- ❑ **Task 1: Review and assemble existing CPMs**
- ❑ **Task 2: Collect data and develop new CPMs**
- ❑ **Task 3: Calibration of existing CPMs**
- ❑ **Task 4: Goodness-of-fit evaluation among current and new models**

TASK 1 and 2

$$E(Y) = a_0 \cdot V^{a_1} \cdot L^{a_2}$$

HSM models →

Crash severity model	a_0	a_1	a_2	Conversion coefficient for L [km]
PDO	$1.814 \cdot 10^{-4}$	1	1	0.62
SEVERE	$8.576 \cdot 10^{-5}$	1	1	0.62
TOTAL (PDO plus SEVERE)	$2.672 \cdot 10^{-4}$	1	1	0.62

Existing models →

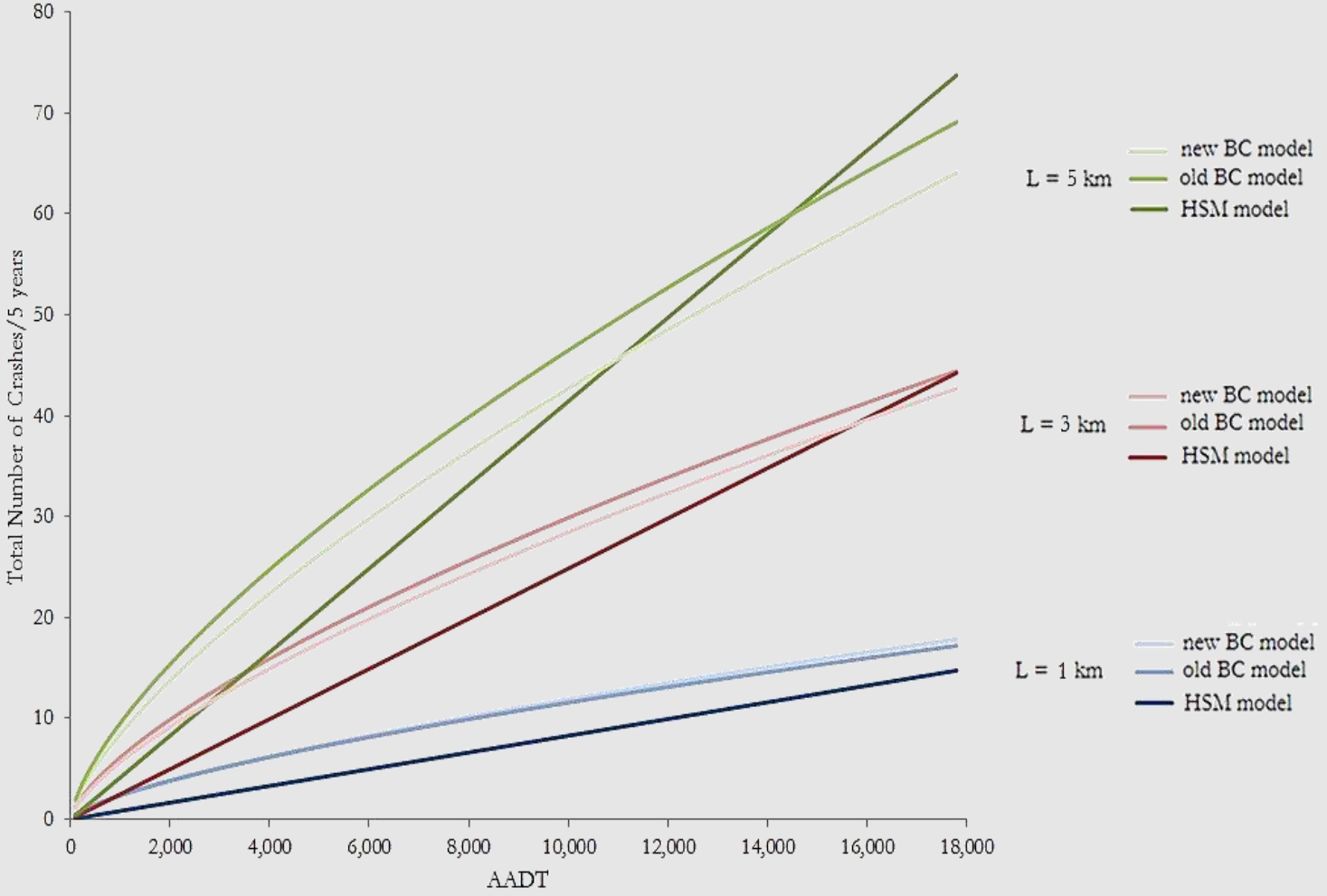
Crash severity model	a_0	a_1	a_2
PDO	0.005706	0.7523	0.9222
SEVERE	0.005242	0.7279	0.9403
TOTAL (PDO plus SEVERE)	0.02053	0.6877	0.8641

New models →

Crash severity model	a_0	a_1	a_2
a) PDO	0.011035	0.6986	0.7754
b) SEVERE	0.006335	0.7249	0.8234
c) TOTAL	0.018184	0.7038	0.7945

TASK 1 and 2

Example for total number of collisions:



Transferability of the Highway Safety Manual

TASK 3

$$\text{Calibration factor (CF)} = \frac{\Sigma\, n°acc_{observed}}{\Sigma\, n°acc_{predicted}}$$

	C.F.
PDO	0.8212
SEVERE	1.4091
TOTAL	1.2381

Transferability of current CPMs for BC

TASK 3

Recalibrating only the constant of the model equation and transferring unaltered the existing coefficient exponents (*)

Crash severity model	a_0	a_1	a_2
PDO	0.004681	0.7523*	0.9222*
SEVERE	0.004702	0.7279*	0.9403*
TOTAL (PDO plus SEVERE)	0.017780	0.6877*	0.8641*

existing coefficient exponents

Using a calibration factor

Origin of model	Existing for BC (2001-2005)
PDO	0.7966
SEVERE	0.8040
TOTAL	0.8157

Goodness-of-fit evaluation among current and new models

Z score $$z = \frac{\chi^2 - E(\chi^2)}{\sigma(\chi^2)}$$

Crash severity model	New BC model (2007-2011)	Existing BC model recalibrated transferring the coefficients	Existing BC model recalibrated using calibration factor	HSM model recalibrated using calibration factor
PDO	0.283	2.579	12.748	20.376
SEVERE	0.229	1.669	11.834	15.630
TOTAL	-0.090	0.911	11.194	12.561

Conclusions

- ✓ **Developing new CPMs was a necessary task in order to update the existing BC models**

  over-prediction of the number of collisions by about 20% for the new time frame 2007-2011

- ✓ **The existing BC models can still be transferred if no data is available. Otherwise new models should be developed**

- ✓ **The HSM transferability method is less reliable compared to the one developed at UBC**

- ✓ **The choice to use the HSM CPMs should be avoided for BC highways**

Questions