Macro-Level Models for Quantitative Safety Planning
In Partnership with the Federal Highway Administration

Modeling Task Force Meeting
July 28, 2021
Background: Project Origins

- SCAG played a big role in NCHRP 17-81 agency outreach.
- Outreach helped inform the form and function of planning-level crash prediction models (CPMs).
- FHWA technical assistance to help implement the NCHRP 17-81 research at SCAG.
Background: Existing HSM Crash Prediction Models (CPMs)

- Fundamental analysis unit of the HSM processes, procedures, and methods is a “site” (e.g., a specific segment, intersection, ramp, or ramp terminal).

- An HSM user can combine analyses of multiple sites into a facility-level analysis (e.g., freeway facility with multiple interchanges).
• Predict average crash frequency, by crash type and severity, for a defined area, such as a census tract, traffic analysis zone, or county.

• Predictor variables for macro-level models characterize the broader area for which the models apply:
  o Area Type Classifications and Geography
  o Socioeconomics
  o Land Use
  o Presence/type/extent of Multimodal Transportation Infrastructure

• Intended to supplement the transportation planning process, not replace it (or create a whole new dimension).
Background: Potential Role of Macro-Level Crash Prediction Models

- Setting safety targets or performance measures (e.g., estimating #s of crashes in the future given population growth, land use changes, economy, & other related factors).
- Estimating how much investment in safety may be needed to meet future safety targets given growth and other changes.
- Assessing the safety impacts of large-scale projects.
- Comparing alternative growth scenarios (e.g., scenario planning).
Background: Project Overview

• FHWA Safety Data and Analysis Technical Assistance Program.
• Develop series of predictive models for safety planning and target setting.
• Safety Target Setting Models (3, county-level)
  o Fatalities
  o Serious injuries
  o Non-motorized fatalities and serious injuries
• Community Models
  o Predict traffic crashes at TAZ-level
  o Contributing to federal effort to produce macro-level crash prediction models & guidance for AASHTO Highway Safety Manual
Safety Target Setting Models
Background: Annual Safety Target Setting

- MAP-21 requirement
- Establish annual targets for:
  - Number of fatalities
  - Rate of fatalities per 100 million VMT
  - Number of serious injuries
  - Rate of serious injuries per 100 million VMT
  - Number of active transportation fatalities & serious injuries
Safety Target Setting Models - Data

• Natural events
  o Average precipitation
  o Fire coverage

• Vehicle miles traveled – annual estimates
  o By county
  o By functional classification (urban areas only)

• Demographic/Socioeconomic
  o Population
  o Employment
  o Age
  o Household income
  o Unemployment rate
  o Commuters by mode

• Project funding
  o Local Highway Safety Improvement Program (HSIP)
  o State Highway Operation and Protection Program (SHOPP)

• Behavioral indicators
  o Alcohol consumption – statewide by category
Safety Target Setting Models - Process

- Negative binomial regression.
  - County-Month as the unit of observation.
  - Common approach to safety modeling – lends itself to modeling over-dispersed count outcomes.
  - Lower threshold of statistical significance.
    - Avoid unobserved variable bias.

- Preliminary investigation of project-related effects.
  - Difficult to assess the influence of SHOPP funded projects; some potential for HSIP projects as an indicator.
  - Better data with respect to project location and construction dates.
  - Still weak relative to other variables.

- Training and testing datasets used for model validation.
  - Model trained with 70% of data and tested on the remaining 30%.
  - Cumulative residual (CURE) plots used to assess model fit.
Safety Target Setting Models - Process

Testing Dataset

Predicted non-motorized fatal and serious injuries

Full Dataset

Predicted Non Mot Fatal Serious Injuries

CumRes  L95  U95
## Safety Target Setting Models - Process

<table>
<thead>
<tr>
<th>Data Input</th>
<th>Total Fatality Model</th>
<th>Total Serious Injury Model</th>
<th>Total Non-Motorized Fatality and Serious Injury Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual VMT, Natural logarithm (LN)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Proportion of VMT on urban interstates</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Proportion of VMT on urban major collectors</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Proportion of VMT on urban local roads</td>
<td></td>
<td></td>
<td>✓</td>
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<tr>
<td>Proportion of population aged 65+</td>
<td>✓</td>
<td></td>
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<tr>
<td>Proportion of population aged 15-24*</td>
<td>✓</td>
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<tr>
<td>Proportion of population aged 18-24*</td>
<td>✓</td>
<td></td>
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<tr>
<td>Median household income (2011$; divided by 1,000)</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Total population</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Total employment</td>
<td></td>
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<tr>
<td>Proportion of the population that commutes by transit, bicycle, or walks</td>
<td>✓</td>
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<tr>
<td>Unemployment rate (Not seasonally adjusted)</td>
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<tr>
<td>Distilled spirit consumption per capita</td>
<td></td>
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<td>✓</td>
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<tr>
<td>Regular gas prices (2019$)</td>
<td>✓</td>
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</tr>
</tbody>
</table>

![Cumulative Residuals](chart.png)

- Predicted Non Mot Fatal Serious Injuries
  - CumRes
  - L95
  - U95
Safety Target Setting Models - Results

- Highly intuitive results with strong connection to existing research.
- Identifies tangible safety indicators that could inform policy:
  - Traffic trends on facility types
  - Older and younger drivers
  - Alcohol consumption
  - Changes in employment and population trends

- These are baseline projections – can be affected by changed inputs. Possible to develop “what-if” scenarios – What could we expect?

![Graph showing predicted serious injuries from 2016 to 2025 with observed values.](image-url)
Community Models
Community Modeling - Data

• Data obtained and processed
  o TAZ boundaries
  o Crash location, type, and severity
  o VMT
  o Centerline mileage (including NHS)
  o Total population
  o Total employment
  o Median household income
  o Urban area
  o Transit stops
  o Intersections
  o Total commuting age population
    ▪ Commute trips by mode

• Additional data
  • California Public Health Assessment Model
  • Disadvantaged Communities data
Community Modeling - Process

• Methods consistent with NCHRP 17-81.
  o Negative binomial regression.
  o Boundary data allocation – avoid duplication.
  o Outcomes compared with expectations based on NCHRP 17-81.

• CURE plots used to assess model fit.
  o No training/testing datasets – NCHRP research provides confidence that inputs are relevant.
  o Developing SCAG-specific models better than calibrating NCHRP models to SCAG’s data (Census block group vs. TAZ).
• Strong results highly consistent with the recent NCHRP research.

• Good model fit and predictive performance – limited over- and under-estimation while not overfitting the model.

• Inputs derived from SCAG’s existing transportation models can support safety projections – complement the current planning process.

<table>
<thead>
<tr>
<th>Data Input</th>
<th>Total Crash K</th>
<th>Total Crash KA</th>
<th>Total Crash KABC</th>
<th>Pedestrian/Bicycle KA</th>
<th>Pedestrian/Bicycle KABC</th>
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</thead>
<tbody>
<tr>
<td>Annual VMT (LN)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Median household income (2011$; divided by 1,000)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Total population</td>
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<tr>
<td>Total employment</td>
<td></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Commuting age population (aged 16 – 64)</td>
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<td>TAZ boundaries (Inverse Area Variable)</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Total intersections</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Total centerline mileage</td>
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<td>Total NHS centerline mileage</td>
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<td>Transit stop locations by mode</td>
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Community Modeling - Results
• 3 Sample Scenarios: What if by 2025?
  • Significant increase in predicted pedestrian crashes (Hesperia, CA).
    • Population to more than double.
    • Associated increase in traffic.
    • Household income expected to decline.
• 3 Sample Scenarios: What if by 2025?

• No major change in predicted pedestrian crashes (Hesperia, CA).
  • Population to slightly increase (~10%).
  • No change in employment.
  • Minor anticipated change in traffic volumes as a result.
  • Major increase in household income.
Community Modeling – Spatial Visualization & Examples

• 3 Sample Scenarios: What if by 2025?

• Decline in predicted fatal and serious injury crashes (Los Angeles, CA).
  • Very minor increase in population.
  • Notable decline in employment (greater than increase in population).
  • Potentially lower VMT.
  • Significant increase in median household income.
Future Considerations

• Models represent the baseline, business as usual path.

• Inputs can be adjusted or projected based on possible future outcomes.

• New information or changes to the transportation system can affect projections.
  o Local road safety initiatives
  o Increased investment and data-driven project programming
  o Speed management or implementation of a safe system approach
  o Improved vehicle safety features
  o Vehicle and infrastructure connectivity and other operational improvements
  o Development trends and personal travel choices

• Models are most effective when relative trends are used.

• Community models are most effective in places where people (will) live, work, and play.
Next Steps

• Share draft Technical Assistance Memo with stakeholders.
• Meet to discuss final work.
• Finalize technical assistance memo.
• Stakeholder feedback.
• Future phase: visualization tool – display scenario model results, interactive view of safety conditions within a community.
Questions? Comments?
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