APM/CMF modelling: data need, modelling methods and results of PRACT CMF development

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Presentation Structure

1. Modeling methods and data need
2. CMF needs
3. New PRACT CMFs
4. Conclusion
General Overview:

CMF Development

Before-After Studies
- Review of road safety before and after countermeasure implementation (with/without treatment)
- Before-after data needed
- Comparison of two cases (e.g. lane width before = 5 m, after = 7 m)

Cross-Sectional Studies
- Useful if no before-after data are available
- Comparison of road safety on sites with different design features
- Provide CMFs as a function of a countermeasure (e.g. lane width 5 m till 7 m)
Method Overview:

CMF Development

Before-After Studies
- Before-After without comparison group (Naïve Before-After Comparison)
- Before-After with comparison group
- Empirical Bayes Before-After
- Full Bayes Before-After

Cross-Sectional Studies
- Simple cross-sectional comparison
- Multivariate cross-sectional regression model
Before-After without comparison group (Naïve Before-After Comparison):

• Very simple comparison of accident rates before and after a measure
• Other effects on accidents are not considered (e.g. time trends)

Before-After with comparison group \(\rightarrow\) **Empirical Bayes** \(\rightarrow\) Full Bayes

• Onward improved comparisons of accident occurrence at treatment sites and reference sites
• General problems:
  – Measures at accident black spots often are composition of several measures (effects for one measure not deducible)
  – Reference sites have to be similar to treatment sites (unlikely to find)
  – Methods depends on the choice of reference sites
Simple cross-sectional comparison:

- Simple calculation and safety evaluation of different design features with accident parameters (e.g. accident rates, accident density)

Multivariate cross-sectional regression models (accident prediction model):

- Statistical multidimensional regression model
- Model describe significant coherences between accidents and road design
- Accident occurrence modelled as function of several explanatory variables

\[ AF = k \times L \times AADT^\beta \times e^{\sum \gamma_i \times X_i} \]
Multivariate cross-sectional regression models:

- General Problems:
  - Correlating variables (confounding factors)
  - Choice of modeling approach (several innovations available)

[Mannering/Bhat 2014]*:

- Poisson regression model
- Negative binomial/Poisson–gamma models
- Duration models
- Bivariate/multivariate models
- Zero-inflated Poisson and negative binomial models
- Random effects models, spatial and temporal correlation models
- Generalized estimating equation models
- Neural network, Bayesian Neural network, and vector machine models
- Hierarchical/multilevel models
- Negative multinomial model

- Poisson-lognormal and Poisson–Weibull models
- Gamma model
- Conway–Maxwell–Poisson model
- Censored regression models
- Generalized additive models
- Random parameters count models
- Finite-mixture/latent-class and Markov switching models
- Negative binomial-Lindley model
- Count model recast as a generalized ordered response system

Motivation:

- There is a lack of CMF estimates based on European data
- A questionnaire survey of worldwide National Road Agencies and a comprehensive review of existing literature on CMFs for 92 countermeasures/road features helped identify CMF needs
- Within PRACT, new CMFs were estimated to fill some of these needs
- Estimation of new CMFs was somewhat constrained by data availability

Developed CMFs:

- which were identified as highly desirable and often lacking based on questionnaire survey & literature review
- for which suitable data for estimation were available
New PRACT CMFs

Italy, rural motorways
- Work zones
- Speed enforcement (section control)
- High friction wearing course

Germany, two-way two-lane rural roads
- Traffic composition (% HGV)
- Road width
- Horizontal curvature
- Vertical gradient

England, two-way two-lane rural roads
- Traffic composition (% HGV, % two-wheel traffic)
- Horizontal curvature
- Vertical gradient

Empirical-Bayes Before-After
Negative Binomial Models
New PRACT CMFs

Italy, rural motorways

- Work zone layouts
- Crash severity (Fatal+Injury crashes, PDO crashes)
- Crash types (single/multi vehicle crashes, run-of-road crashes)
## New PRACT CMFs

| Presence of a work zone | • Presence of a work zone increases accidents by 33%
| | • Some work zone layouts are more dangerous than others: A partial diversion of flow in 2-lane carriageways, with a single lane not diverted, increases accidents more than threefold (compared to no works at all).
| | • Some work zone layouts appear not to affect accidents (e.g. closure of emergency or slow lane in 3-lane carriageways)
| Speed enforcement (section control) | • 0.52 - 1.55 depending on injury/crash type and traffic flow
| | • In the range 0.81 - 0.92 in most cases
| | • Larger effect when traffic flow is high (0.5 - 0.6 for multi-vehicle crashes when AADT ≥ 55,000 veh/day)
| | • No effect in some cases - most importantly no effect on single vehicle fatal and injury crashes irrespective of AADT
| | • No effect on multi-vehicle PDO crashes & low AADT (< 25,500 veh/day)
| High friction wearing course | • CMF = 0.27 for fatal and injury run-off-road crashes on wet pavements
England, two-way two-lane rural roads

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Standard error</th>
<th>p-value (5% sig. level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-10.68</td>
<td>1.35</td>
<td>0.000</td>
</tr>
<tr>
<td>AADT (logarithm)</td>
<td>0.46</td>
<td>0.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Horizontal curvature</td>
<td>-0.0001</td>
<td>0.00015</td>
<td>0.595</td>
</tr>
<tr>
<td>Vertical gradient</td>
<td>0.09</td>
<td>0.044</td>
<td>0.044</td>
</tr>
<tr>
<td>% HGV</td>
<td>-7.58</td>
<td>1.96</td>
<td>0.000</td>
</tr>
<tr>
<td>% two-wheel traffic</td>
<td>4.05</td>
<td>14.70</td>
<td>0.783</td>
</tr>
<tr>
<td>Year 2013</td>
<td>-0.06</td>
<td>0.13</td>
<td>0.637</td>
</tr>
<tr>
<td>Year 2012</td>
<td>0.13</td>
<td>0.13</td>
<td>0.297</td>
</tr>
<tr>
<td>Year 2011</td>
<td>-0.09</td>
<td>0.13</td>
<td>0.503</td>
</tr>
</tbody>
</table>
New PRACT CMFs

England, two-way two-lane rural roads

$$AF = L \times AADT^{0.46} \times e^{-10.68} \times e^{0.09 \times VC} \times e^{-7.58 \times HGV}$$
New PRACT CMFs

Germany, two-way two-lane rural roads

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</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-5.15</td>
<td>0.47</td>
<td>0.000</td>
</tr>
<tr>
<td>AADT</td>
<td>0.61</td>
<td>0.07</td>
<td>0.000</td>
</tr>
<tr>
<td>Road Width</td>
<td>-0.17</td>
<td>0.09</td>
<td>0.050</td>
</tr>
<tr>
<td>Horizontal curvature</td>
<td>0.00</td>
<td>0.00</td>
<td>0.064</td>
</tr>
<tr>
<td>Vertical gradient</td>
<td>insignifiant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% HGV</td>
<td>insignifiant</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New PRACT CMFs

Germany, two-way two-lane rural roads

\[ AF = L \times AADT^{0.607} \times e^{-5.146} \times e^{-0.171 \times RW} \times e^{0.003 \times CU} \]
Comparison Germany - England

<table>
<thead>
<tr>
<th>Variable</th>
<th>Germany</th>
<th>England</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road width (RW) - metres</td>
<td>$e^{-0.17\Delta RW}$</td>
<td>-</td>
</tr>
<tr>
<td>Horizontal curvature (HC)</td>
<td>$e^{0.003\Delta HC}$</td>
<td>insignificant</td>
</tr>
<tr>
<td>Vertical gradient (V) - %</td>
<td>insignificant</td>
<td>$e^{0.09\Delta V}$</td>
</tr>
<tr>
<td>% HGV (HGV)</td>
<td>insignificant</td>
<td>$e^{-7.6\Delta HGV}$</td>
</tr>
<tr>
<td>% two wheel traffic</td>
<td>-</td>
<td>insignificant</td>
</tr>
</tbody>
</table>

Results obtained from the two models are not comparable. Could be due to:

- CMFs not being transferable between countries
- Slight differences in variable definition (e.g. horizontal curvature)
- Data used in estimation (e.g. German dataset includes relatively flat roads – not much variability in vertical gradient in the sample could lead to insignificant result)
• Gaps exist in the CMF literature. There is a lack of European estimates.
• Gaps are difficult to fill due to a lack of suitable data for estimation.
• Within PRACT, CMFs for 8 countermeasures/road features were estimated to fill some of these gaps. CMF development was constrained by data availability.
• Increased data availability could allow the use of advanced causal methods to estimate CMFs.
• More information on PRACT activities can be found at www.practproject.eu
Thank you .......

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