Development of an online Repository of Accident Prediction Models and Crash Modification Factors

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Leeds, 18-20 October 2016
1. The PRACT project
2. Review of existing APM/CMF Databases and Road Safety Toolkits
3. Development of PRACT Repository
4. Repository Operation and Features
5. Conclusions
The PRACT Project

Predicting road accidents - A transferable methodology across Europe

http://www.pRACTproject.eu/

funded by the National Road Authorities of Germany, Ireland, UK and the Netherlands within the Conference of European Directors of Roads (CEDR) 2013 Transnational Research Programme - Safety.

With the support of:

Project Manager: Elizabeth Mathie, Highways England - UK
The PRACT project **aimed** at **developing** a **practical guideline** and a **user friendly tool** that will allow the different road administrations to:

- adapt the basic Accident Prediction Model (APM) functions to local conditions based on historical data;
- identify the Crash Modification Factors (CMFs) that could be relevant for the specific application;
- verify if the selected CMFs are transferable to the specific conditions;
- apply the calibrated model to the specific location to be analysed.
PRACT workplan

WP1 – Overview of existing APMs and data sources
   *George Yannis (NTUA)*
   - TK 1.1 Inventory and critical review of existing APMs (NTUA)
   - TK 1.2 Inventory of existing Data Sources (TUB)

WP2 – Identification and prioritisation of CMF needs
   *Daniel Graham (ICL)*
   - TK 2.1 Inventory and critical review of available CMFs (TUB)
   - TK 2.2 Identification of CMF needs (UNIFI)
   - TK 2.3 Development of key missing CMFs (ICL)

WP3 – Development of the Guidance Document
   *Francesca La Torre (UNIFI)*
   - TK 3.1 Analysis of the transferability of selected APMs and CMFs (ICL)
   - TK 3.2 Production of the Guidance Document (UNIFI)

WP4 – Implementation of an APMs and CMFs Repository
   *George Yannis (NTUA)*

WP5 – Dissemination management and organization
   *Thomas Richter (TUB)*
Accident Prediction Model (APM) = a full model that allows an evaluation of the predicted number of crashes in a given condition.

- In the inquiry phase both were investigated and the results were collected in the web repository.
- The PRACT Model is based on the second approach.
Web-based CMF databases and Road Safety Toolkits

- FHWA CMF Clearinghouse (http://www.cmfclearinghouse.org)
- iRAP Road Safety Toolkit (http://toolkit.irap.org/)
- SPF Clearinghouse (http://spfclearinghouse.org/)
• Stand-alone Regression Equation
APMs are not available in any of
the above web databases.
• SPF are available only in SPF
Clearinghouse (to subscribers
only), without however providing
adequate background
information.
• Existing Databases include mostly
data from USA and Australia.
Results from European studies are
rare.

www.pract-repository.eu
In PRACT Repository:

• All types of data required in accident prediction are available:
  - CMFs,
  - SPFs, and
  - Regression Equation APMs.

• The quality of included CMFs has been verified through an evaluation process.

• User is provided with additional information to verify the quality and the transferability of CMFs and APMs.

• Data from European studies are included.

www.pract-repository.eu
The repository has **two parts**: the CMF part and the APM part.

Both parts are based on the respective inventories developed within PRACT review process.

**All reviewed APMs** were included in the repository.

Only **high quality CMFs** were included in the repository, on the basis of specific criteria.
Criteria for CMF inclusion

- Quality criteria refer to:
  - statistical design,
  - testing for statistical significance, and
  - sample size.

- CMFs originating from the Highway Safety Manual were considered “a priori” of adequate quality and were included in the repository.

- All other CMFs were assessed prior to inclusion in the repository, on the basis of fulfilling all of the quality criteria.
CMF Criterion 1: Statistical Design

- **Naive B-A analysis** (no comparison group): **not accepted**
- **Simple cross-sectional analysis**: **not accepted**
- **B-A with comparison group**: **accepted**, provided that:
  - the comparison group (CG) is comparable to the treated group,
  - CG is properly selected to address most common biases, and
  - there are sufficient controls to deal with time trends in accidents.
- **Empirical Bayes B-A analysis**: **accepted**, provided that:
  - there are no evident problems in the choice of the reference group.
- **Poisson / Negative Binomial / Quasi-Poisson Regression modelling**: **accepted** only for treatments with random treatment allocation (e.g. blanket treatments), **not accepted** for treatments applied to high risk sites.
CMF Criterion 2: Testing for Statistical Significance

- Statistically significant at 10% level as a minimum.
- 95% interval does not include 1.
- If 95% interval includes 1 and all other criteria are met, the CMF was included in the repository with the code "not significant" instead of the CMF value, as an indication that the treatment has no significant impact to accidents.
CMF Criterion 3: Sample Size (sites and years)

- **B-A analysis studies:** at least 10 treated sites and at least 3 years of data, both for the before and the after period.

- **Multivariate cross-sectional models**
  Inclusion criteria depended on the number of explanatory variables (EV) and on whether observations for each year are treated as separate observations in the model e.g.:
  1. If observations for each year are treated as separate observations:
      - For 5 or less EV, the criterion is: $\text{sites} \times \text{years} > \text{number of EVs} + 50$
      - For 6 or more EV, the criterion is: $\text{sites} \times \text{years} > \text{number of EVs} \times 10$
  2. If average / mean values of variables over all years are used in the model:
      - For 5 or less EV, the criterion is: $\text{sites} \times \text{years} > \text{number of EVs} + 50$
      - For 6 or more EV, the criterion is: $\text{number of sites} > \text{number of EVs} \times 10$
Results of Criteria Application

- The quality criteria were applied to the CMFs (1,526 Factors and Functions) gathered during the review process.

- **889 CMFs** were found to satisfy the quality criteria and were included in the repository.
Main Features of PRACT Repository

- Link to website: www.pract-repository.eu

- Five basic sections:
  - HOME: About PRACT project & Repository
  - SEARCH FOR APMs: search the database for APMs with specific characteristics,
  - SEARCH FOR CMFs: search the database for CMFs with specific characteristics,
  - GLOSSARY: definitions of the most commonly used terms
  - CONTACT: for contacting PRACT partners website.
ABOUT PRACT – PREDICTING ROAD ACCIDENTS – A TRANSFERABLE METHODOLOGY ACROSS EUROPE

This Repository contains the most recent Accident Prediction Models and Crash Modification Factors, highlighting effectiveness of road safety measures worldwide, for use by road safety decision makers and practitioners worldwide.

This Repository has been developed within the framework of the project PRACT, (Predicting Road ACCidents–a Transferable methodology across Europe) carried out by the University of Florence, the National Technical University of Athens, the Technical University of Berlin and the Imperial College London, commissioned by the Conference of European Directors of Roads.

The basic assumption on which the PRACT Repository is built is that Accident Prediction Models (APM) and Crash Modification Factors (CMF) can be transferred to conditions different from the ones for which they have been developed, if selected based on scientifically valid criteria and adapted to local conditions based on historical crash data.
**GLOSSARY**

**Accident Prediction Model (APM)** or **Safety Performance Function (SPF)**: an equation used to estimate or predict the expected average accident frequency at a location, as a function of traffic volume and road infrastructure characteristics (e.g., number of lanes, type of median, traffic control). In PRACT repository, APMs are divided into two types: Regression Equation Models and SPF & CMFs Models (see also respective definitions in the glossary).

**Average Annual Daily Traffic (AADT)**: the counted (or estimated) total traffic volume in one year divided by 365 days/year.

**Before – After Study**: the evaluation of implemented safety measures in terms of crash reduction, by comparing frequency or severity of crashes before and after implementation, that often result in the development of CMFs. There are several different types of before – after studies – see also: Naive Before-After Study, Before-After with Comparison Group Study, Empirical Bayes Before-After Study, and Full Bayes Before-After Study.

**Before-After with Comparison Group Study**: a type of before-after study, in which a group of untreated sites that are similar in nature to the treated sites is used to control for changes in crash frequency not influenced by the treatment. For the approach to give unbiased estimates, treatment implementation must be random (e.g., a blanket treatment applied to all sites) rather than related to accident rates and reference sites must have similar characteristics to the treatment sites, including accident rates in the before period.

**Crash Modification Factor (CMF) or Function, or Accident Modification Factor**: the relative change in accident frequency due to a change in one specific condition (when all other conditions and site characteristics remain constant). CMF is the ratio of the expected accident frequency after a modification or measure is implemented to the estimated
CONTACT section

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The search page allows the user to search the database for APMs by providing any of the characteristics displayed in the figure to the right.

If one or more of the above search criteria are left blank (or the blank field is selected at the drop-down list), the criterion is ignored. Thus, a search with all fields blank will return **all the 273 entries of the APM database**.
The search leads to a **results page** with a list of the APMs in the database that meet the search criteria and their most basic characteristics.

Further clicking on any specific ID number from this list provides the user with all the available data related to this specific APM.
**APM ID: 1-029**

<table>
<thead>
<tr>
<th>Type of APM</th>
<th>Regression Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is applicable to Motorways Segments?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable Motorway Speed Change Lanes?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable to Interchange Ramps?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable to 2-way 2-lane Rural Road Segments?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable to Rural Road Intersections?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**For Regression Equation**

- **APM variable 1**: Traffic Volume of Major Road AADT1 (veh/day)
- **APM variable 2**: Traffic Volume of Minor Road AADT2 (veh/day)
- **APM variable 3**: Major Road median width MEDWm (ft/cr)
- **APM variable 4**: Number of driveways on major road within 250ft. of intersection centerline (ND)

**APM equation**: \( A1 = \exp(-15.4660) \times AADT1^{-1.433} \times AADT2^{0.265} \times \exp(-0.0612 \times MEDWm) \times \exp(-0.0560 \times ND) \)

**APM development information**

<table>
<thead>
<tr>
<th>Study Design</th>
<th>Negative Binomial Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size – No of sites</td>
<td></td>
</tr>
<tr>
<td>Sample Size – No of years</td>
<td></td>
</tr>
<tr>
<td>Sample Size – No of crashes</td>
<td></td>
</tr>
</tbody>
</table>

**Study information**

- **Study name**: Crash models for rural intersections: four-lane by two-lane stop-controlled and two-lane by two-lane signalized. Report FHWA-RD-99-128
- **Year published**: Year study published: 1999
- **Authors**: Vogt, A.

**Information of considered road elements**

- **Geographic Data Origin**: USA - California & Michigan
- **Road element**: Intersection
- **Road type**: Two-lane two-way rural road
- **Sampling Criteria**: -
- **No. of lanes per direction**: -
- **Inside Tunnel**: -
- **Minimum Traffic Volume AADT (veh/day)**: Minimum Traffic Volume: -
- **Maximum Traffic Volume AADT (veh/day)**: Maximum Traffic Volume: -
- **Intersection / Interchange type**: 3-leg at-grade intersection
- **Traffic control at intersection**: Stop signs to minor road

**Information of considered accidents**

- **Period of crash data – start**: 1993
- **Period of crash data – end**: 1995
- **Crash severity**: All
- **Crash types**: At intersection
- **No of vehicles**: -
- **Other accident parameters**: Not specified
- **Road user types**: Not specified

**Comments**
The search page allows the user to search the database for APMs by providing any of the characteristics displayed in the figure to the right.

If one or more of the above search criteria are left blank (or the blank field is selected at the drop-down list), the criterion is ignored. Thus, a search with all fields blank will return all the 889 entries of the CMF database.
The search leads to a **results page** with a list of the CMFs in the database that meet the search criteria and their most basic characteristics.

Further clicking on any specific ID number from this list provides the user with all the available data related to this specific CMF.


**CMF ID: 1170**

<table>
<thead>
<tr>
<th>Type of CMF</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMF Value Function</td>
<td>0.560</td>
</tr>
<tr>
<td>CMF variable 1 (within the study)</td>
<td>-</td>
</tr>
<tr>
<td>CMF variable 2 (within the study)</td>
<td>-</td>
</tr>
<tr>
<td>CMF variable 3 (within the study)</td>
<td>-</td>
</tr>
<tr>
<td>CMF Type</td>
<td>Intersection - Traffic control</td>
</tr>
<tr>
<td>Is applicable to Motorway Segments?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable to Motorway Speed Change Lanes?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable to Interchange Ramps?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable to Interchange Ramp Terminals?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable to 2-way 2-lane Rural Road Segments?</td>
<td>No</td>
</tr>
<tr>
<td>Is applicable to Rural Road Intersections?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**CMF development information**

- **Study Design**: Empirical Bayesian Before-After
- **Standard error**: 0.030
- **Were results tested for statistical significance?**: Yes
- **Sample size: No of sites**: 84
- **Sample size: No of years**: 10
- **Sample size: No of crashes**: Not specified
- **Explanatory variables included in the safety performance function** (if applicable, e.g., EB before-after):
  - Not specified
- **Explanatory variables included in the model** (for multivariate cross-sectional studies):
  - Not specified
- **Model form for multivariate cross-sectional models** (e.g., Negative Binomial model):
  - Not specified
- **Was the potential for crash migration taken into account?** (Yes, how? (for countermeasures where crash migration could be an issue))
  - Not specified
- **Any other sources of potential bias that you identified?**

**Study information**

- **Study name**: Accident Modification Factors for Traffic Engineering and ITS Improvements, NCHRP Report 617
- **Year**: 2008

**Information of considered road elements**

- **Geographic Data Origin**: USA (States of California & Minnesota)
- **Road network length**: Intersection
- **Road type**: Two-lane two-way rural road
- **Sampling Criteria**: Not specified
- **Comparison Group Selection Criteria**: Not specified
- **No. of lanes per direction**: Not specified
- **Minimum Traffic Volume AADT (veh/day)**: Not applicable
- **Maximum Traffic Volume AADT (veh/day)**: Not applicable
- **Ramp terminal type**: Not specified

**Information of considered accidents**

- **Period of crash data - start**: 1992
- **Period of crash data - end**: 2001
- **Crash severity**: All
- **Crash types**: At intersection - all
- **No of vehicles**: Not specified
- **Other accident parameters**: Not specified
- **Road user types**: Not specified

**Countermeasure information**

- **Safety deficiency**: Inadequate Intersection Traffic Control
- **Countermeasure category**: Intersection Traffic Control and Operational Elements

**Comments**
The PRACT Repository is **a valuable road safety decision support system** because:

- it organizes current knowledge on accident prediction (both APMs and CMFs) in a user-friendly and easily accessible by all road safety practitioners website,
- it is a complementary database to the PRACT Tool & Guideline,
- it provides all the available background information on the APM or CMF development, to assist in the assessment of the suitability of the provided data.
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