Background

- Road accidents constitute a **major social problem** in modern societies, with road traffic injuries being estimated as the eighth leading cause of death globally.

- Particularly in **low and middle income countries**, road traffic injuries are twice those in high income countries and still increasing.

- **UN Decade of Action**: need to strengthen global and national efforts for casualty reduction through evidence-based approaches.
Objective

• To develop a macroscopic road safety decision making tool that will assist governments and decision makers, both in developed and developing countries, to decide on the most appropriate road safety policies and measures in order to achieve tangible results.

• Based on work carried out in the framework of the “Safe Future Inland Transport Systems (SafeFITS)” project of the United Nations Economic Commission for Europe (UNECE), financed by the International Road Union (IRU).

Available at: http://www.unece.org/?id=47239
Conceptual Framework

Based on the five pillars of WHO Global Plan of Action (WHO, 2011) and an improved version of the SUNflower pyramid (2002):

**SafeFITS layers**
1. Economy and Management
2. Transport Demand and Exposure
3. Road Safety Measures
4. Road Safety Performance Indicators
5. Fatalities and Injuries

**SafeFITS pillars**
1. Road Safety Management
2. Road Infrastructure
3. Vehicle
4. User
5. Post-Crash Services

K. Folla, The SafeFITS Model
Overview of the SafeFITS Model

1. Intervention analysis
   - testing specific interventions

2. Forecasting
   - testing of policy scenarios

3. Benchmarking
   - benchmark a country against other countries
Architecture of the Database

• Data from the five layers and the five pillars

• **International databases** explored: WHO, UN, IRF, OECD, etc.

• Data for **130 countries** with population higher than 2,8 million inhabitants

• Data refer to **2013** or latest available year
Data Analysis Methodology

• Two-step approach of statistical modeling:
  • Estimation of composite variables (factor analysis) in order to take into account as many indicators as possible of each layer
  • Correlating road safety outcomes with indicators through composite variables by developing a regression model with explicit consideration of the time dimension

• Model specification

\[
\log(\text{Fatalities per Population})_{ti} = A_i + \log(\text{Fatalities per Population})_{(t-\tau)} + B_i \cdot \text{GDP}_{ti} + K_i \cdot [\text{Economy & Management}]_{ti} + L_i \cdot [\text{Transport demand & Exposure}]_{ti} + M_i \cdot [\text{Road Safety Measures}]_{ti} + N_i \cdot [\text{RSPI}]_{ti} + \epsilon_i
\]

Where [Composite Variable]

K. Folla, The SafeFITS Model
Calculation of composite variables – Economy and Management

\[
[\text{Comp}_\text{EM}] = -0.250 \times (\text{EM2}_{\text{lt15yo}}) + 0.229 \times (\text{EM3}_{\text{gt65yo}}) + 0.228 \times (\text{EM4}_{\text{UrbanPop}}) + 0.224 \times (\text{EM7}_{\text{NationalStrategy}}) + 0.221 \times (\text{EM8}_{\text{NationalStrategyFunded}}) + 0.222 \times (\text{EM9}_{\text{FatalityTargets}})
\]

**Indicator loadings and coefficients** on the estimated factor (composite variable) on Economy and Management

<table>
<thead>
<tr>
<th>Component</th>
<th>Loadings</th>
<th>Score coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM1_Popdensity</td>
<td>0.091</td>
<td>0.029</td>
</tr>
<tr>
<td>EM2_Lt15yo</td>
<td>-0.778</td>
<td>-0.250</td>
</tr>
<tr>
<td>EM3_Gt65yo</td>
<td>0.714</td>
<td>0.229</td>
</tr>
<tr>
<td>EM4_UrbanPop</td>
<td>0.709</td>
<td>0.228</td>
</tr>
<tr>
<td>EM5_LeadAgency</td>
<td>0.284</td>
<td>0.091</td>
</tr>
<tr>
<td>EM6_LeadAgencyFunded</td>
<td>0.226</td>
<td>0.073</td>
</tr>
<tr>
<td>EM7_NationalStrategy</td>
<td>0.697</td>
<td>0.224</td>
</tr>
<tr>
<td>EM8_NationalStrategyFunded</td>
<td>0.626</td>
<td>0.201</td>
</tr>
<tr>
<td>EM9_FatalityTargets</td>
<td>0.692</td>
<td>0.222</td>
</tr>
</tbody>
</table>

K. Folla, The SafeFITS Model
Calculation of composite variables – Transport Demand and Exposure

\[
[\text{Comp}_\text{TE}] = 0.161 \times (\text{TE1}_\text{RoadNetworkDensity}) + 0.149 \times (\text{TE2}_\text{Motorways}) + 0.238 \times (\text{TE3}_\text{PavedRoads}) + 0.272 \times (\text{TE4}_\text{VehiclesPerPop}) + 0.267 \times (\text{TE5}_\text{PassCars}) - 0.221 \times (\text{TE7}_\text{PTW}) - 0.117 \times (\text{TE10}_\text{PassengerFreight})
\]

### Indicator loadings and coefficients on the estimated factor (composite variable) on Transport Demand and Exposure

<table>
<thead>
<tr>
<th>Component</th>
<th>Loadings</th>
<th>Score coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE1_RoadNetworkDensity</td>
<td>0.497</td>
<td>0.161</td>
</tr>
<tr>
<td>TE2_Motorways</td>
<td>0.460</td>
<td>0.149</td>
</tr>
<tr>
<td>TE3_PavedRoads</td>
<td>0.734</td>
<td>0.238</td>
</tr>
<tr>
<td>TE4_VehiclesPerPop</td>
<td>0.839</td>
<td>0.272</td>
</tr>
<tr>
<td>TE5_PassCars</td>
<td>0.825</td>
<td>0.267</td>
</tr>
<tr>
<td>TE6_VansLorries</td>
<td>-0.132</td>
<td>-0.043</td>
</tr>
<tr>
<td>TE7_PTW</td>
<td>-0.681</td>
<td>-0.221</td>
</tr>
<tr>
<td>TE8_Vehkm_Total</td>
<td>0.269</td>
<td>0.087</td>
</tr>
<tr>
<td>TE9_RailRoad</td>
<td>0.136</td>
<td>0.044</td>
</tr>
<tr>
<td>TE10_PassengerFreight</td>
<td>-0.360</td>
<td>-0.117</td>
</tr>
</tbody>
</table>
Calculation of composite variables - Measures

\[ \text{Comp}_\text{ME} = 0.069(\text{ME2}_\text{ADR}) + 0.045(\text{ME4}_\text{SpeedLimits}_\text{urban}) + 0.064(\text{ME6}_\text{SpeedLimits}_\text{motorways}) + 0.088(\text{ME7}_\text{VehStand}\_\text{seatbelts}) + 0.091(\text{ME8}_\text{VehStand}\_\text{SeatbeltAnchorages}) + 0.092(\text{ME9}_\text{VehStand}\_\text{FrontImpact}) + 0.091(\text{ME10}_\text{VehStand}\_\text{Sidimpact}) + 0.090(\text{ME11}_\text{VehStand}\_\text{ESC}) + 0.087(\text{ME12}_\text{VehStand}\_\text{PedProtection}) + 0.090(\text{ME13}_\text{VehStand}\_\text{ChildSeats}) + 0.068(\text{ME15}_\text{BAClimits}) + 0.068(\text{ME16}_\text{BAClimits}\_\text{young}) + 0.065(\text{ME17}_\text{BAClimits}\_\text{commercial}) + 0.057(\text{ME19}_\text{SeatBeltLaw}\_\text{all}) + 0.063(\text{ME20}_\text{ChildRestrainmentLaw}) + 0.034(\text{ME22}_\text{HelmetFastened}) + 0.038(\text{ME23}_\text{HelmetStand}) + 0.038(\text{ME24}_\text{MobileLaw}) + 0.035(\text{ME25}_\text{MobileLaw}\_\text{handheld}) + 0.038(\text{ME27}_\text{PenaltyPointSyst}) + 0.040(\text{ME29}_\text{EmergTrain}\_\text{nurses}) \]
Calculation of composite variables - SPIs

\[ \text{Comp}_PI = 0.144 \, (\text{PI1}_\text{SeatBeltLaw_enf}) + 0.155 \, (\text{PI2}_\text{DrinkDrivingLaw_enf}) + 0.152 \, (\text{PI3}_\text{SpeedLaw_enf}) + 0.160 \, (\text{PI4}_\text{HelmetLaw_enf}) + 0.155 \, (\text{PI5}_\text{SeatBelt_rates_front}) + 0.146 \, (\text{PI6}_\text{SeatBelt_rates_rear}) + 0.150 \, (\text{PI7}_\text{Helmet_rates_driver}) + 0.127 \, (\text{PI8}_SI_\text{ambulance}) + 0.116 \, (\text{PI9}_\text{HospitalBeds}) \]

Indicator loadings and coefficients on the estimated factor (composite variable) on SPIs

<table>
<thead>
<tr>
<th>Component</th>
<th>Loadings</th>
<th>Score coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI1 SeatBeltLaw_enf</td>
<td>0.756</td>
<td>0.144</td>
</tr>
<tr>
<td>PI2 DrinkDrivingLaw_enf</td>
<td>0.812</td>
<td>0.155</td>
</tr>
<tr>
<td>PI3 SpeedLaw_enf</td>
<td>0.795</td>
<td>0.152</td>
</tr>
<tr>
<td>PI4 HelmetLaw_enf</td>
<td>0.837</td>
<td>0.160</td>
</tr>
<tr>
<td>PI5 SeatBelt_rates_front</td>
<td>0.811</td>
<td>0.155</td>
</tr>
<tr>
<td>PI6 SeatBelt_rates_rear</td>
<td>0.766</td>
<td>0.146</td>
</tr>
<tr>
<td>PI7 Helmet_rates_driver</td>
<td>0.784</td>
<td>0.150</td>
</tr>
<tr>
<td>PI8 SI_ambulance</td>
<td>0.667</td>
<td>0.127</td>
</tr>
<tr>
<td>PI9 HospitalBeds</td>
<td>0.607</td>
<td>0.116</td>
</tr>
</tbody>
</table>

K. Folla, The SafeFITS Model
The **optimal performing model** for the purposes of SafeFITS

- **Dependent variable** is the logarithm of the fatality rate per population for 2013
- The main **explanatory variables** are the respective logarithm of fatality rate in 2010 and the respective logarithm of GNI per capita for 2013
- Four **composite** variables: the economy & management, the transport demand and exposure, the measures, and the SPIs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B</th>
<th>Std. Error</th>
<th>95% Confidence Interval</th>
<th>Hypothesis Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>1.694</td>
<td>.2737</td>
<td>1.157, 2.230</td>
<td>38.291 (df 1)</td>
</tr>
<tr>
<td>Comp_ME</td>
<td>-0.135</td>
<td>.0646</td>
<td>0.261, 0.008</td>
<td>4.358 (df 1)</td>
</tr>
<tr>
<td>Comp_TE</td>
<td>-0.007</td>
<td>.0028</td>
<td>0.013, 0.002</td>
<td>0.007 (df 1)</td>
</tr>
<tr>
<td>Comp_PI</td>
<td>-0.007</td>
<td>.0030</td>
<td>0.013, 0.001</td>
<td>0.017 (df 1)</td>
</tr>
<tr>
<td>Comp_EM</td>
<td>0.007</td>
<td>.0051</td>
<td>-0.003, 0.017</td>
<td>0.156 (df 1)</td>
</tr>
<tr>
<td>LNFestim_2010</td>
<td>0.769</td>
<td>.0462</td>
<td>0.678, 0.859</td>
<td>276.322 (df 1)</td>
</tr>
<tr>
<td>LNGNI_2013</td>
<td>-0.091</td>
<td>.0314</td>
<td>-0.153, -0.030</td>
<td>8.402 (df 1)</td>
</tr>
<tr>
<td>(Scale)</td>
<td>0.038</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>1379.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>&lt;.001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Statistical Model Assessment and Validation

- Validation on 30% of the sample
- Validation on 20% of the sample
SafeFITS Model Demonstration

The overall model implementation includes 3 distinct steps:

- **Step 1** – *Countries Benchmark*

- **Step 2** – *Forecast with no new interventions*

- **Step 3** – *Forecast with interventions*

Access the SafeFITS model at: [https://unecetrans.shinyapps.io/safefits/](https://unecetrans.shinyapps.io/safefits/)
User input:
The user has the option to select a country, the category of indicators to be displayed and benchmark type.

Analysis:
The outputs are based only on the database and no statistical modeling implementation is taking place.

Benchmarking results:
• Reactive diagrams presenting a benchmark of the base year situation for a selected category
• Benchmarking takes place on a global and regional scale
Step 2: Forecast with no new interventions

User input:
The user selects the intervention year and the benchmark type

Analysis:
The SafeFITS model is implemented for the year of reference on the basis of GNI and demographic indicators projection

Forecasting results:
The trend for the variable fatalities per population through the years (2013-2031), alongside with the confidence intervals

Benchmarking results:
• Overall ranking
• Regional ranking
Step 3: Forecast with interventions

User input:
The user selects the intervention year and then 3 different sets of interventions

Analysis:
The SafeFITS model is implemented for the forecasting year on the basis of the intervention set selected

Forecasting results:
The trend for the variable fatalities per population through the years (2013-2031), on which the forecast for the intervention year is also identifiable.

Benchmarking results:
- Overall ranking
- Regional ranking

K. Folla, The SafeFITS Model
Model limitations and future improvements

- The SafeFITS model was developed on the basis of **the most recent and good quality data available internationally**, and by means of rigorous statistical methods. However, data and analysis methods always have some limitations.

- Data are primarily **directed at vehicle occupants** and thus, effects on road safety outcomes of VRUs may not be captured.

- The effects of interventions may not reflect the unique contribution of each separate intervention. It is strongly recommended to **test combinations of “similar” interventions** (e.g. several vehicle standards, several types of enforcement or safety equipment use rates etc.)

- The factor analysis procedure **does not assume or indicate that a direct causal relationship exists**.

- The **calibration with new data** will be the ultimate way to fully assess the performance of the model.
Benefits for the Policy Makers

• The first global road safety model to be used for policy support
  • Global assessments (i.e. monitoring the global progress towards the UN road safety targets)
  • Individual country assessments of various policy scenarios

• A framework which enhances the understanding of road safety causalities, as well as of the related difficulties.

• Full exploitation of the currently available global data, and use of rigorous analysis techniques, to serve key purposes in road safety policy analysis: benchmarking, forecasting.

• An important step for monitoring, evidence-base and systems approach to be integrated in decision-making.

K. Folla, The SafeFITS Model
National Road Safety Policy development
trends and challenges
13-14 November 2018

The SafeFITS Model

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Tbilisi, 14 November 2018