

Prediction of long-term consequences from crash serious injuries – Findings from the Horizon Europe IMPROVA project

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42nd Meeting of the International Road Traffic Safety
Analysis and Data (IRTAD) Group

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International Traffic Safety
Data and Analysis Group

Background

- Every year, **20 to 50 million people** around the world **suffer life-altering injuries** due to road traffic accidents (WHO)
- These are **more than just numbers** as they represent lives forever changed, families disrupted, and communities impacted
- It is time we include in our focus **long-lasting consequences of injuries** in addition to survival
- We must tackle the long-term consequences (LTC) of road traffic injuries to **truly protect and support all road users**



The IMPROVA project

➤ IMPROVA:

- “Injury Mitigation to Promote Vision-Zero Achievement”
- improva-roadsafety.eu



➤ Project partners:

- 13 partners across 7 EU countries, involving: National Technical University of Athens

➤ Duration of the project:

- 48 months (June 2024 – May 2028)

➤ Framework Program:

- Funded by the European Union
- This project has received funding from the Horizon Europe programme under grant agreement No GAP-101146652



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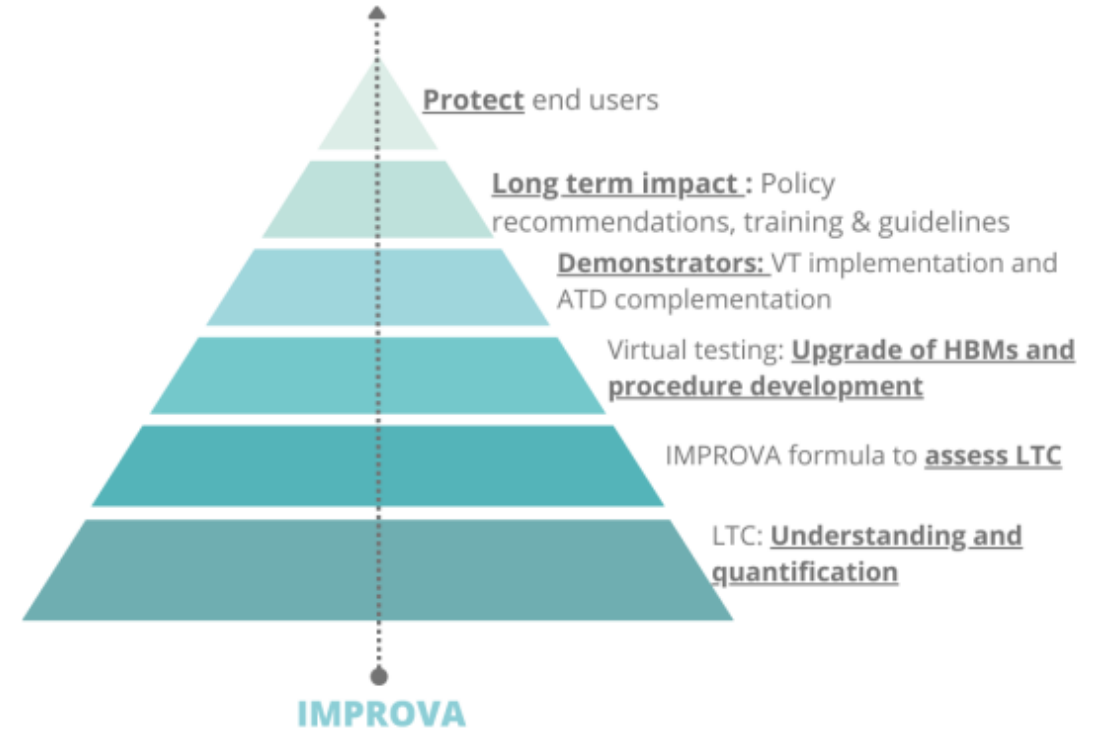
IMPROVA objectives

- Understand and **quantify the long-term consequences** of serious road traffic injuries
- Develop **LTC assessment scales** and a predictive IMPROVA formula
- Improve **human body models** and virtual safety assessment procedures
- Support prevention, psychological care and **road safety policy**

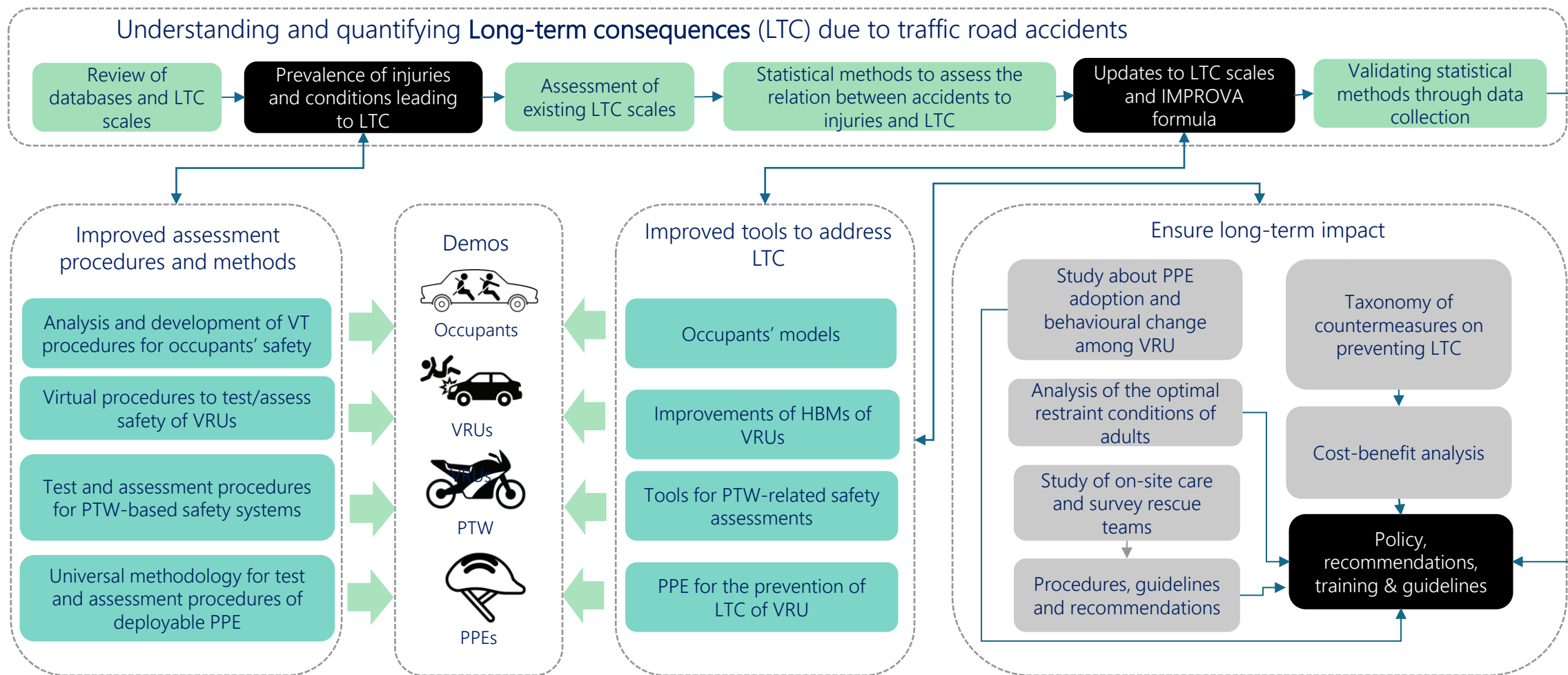


IMPROVA overall concept

- **Five interconnected pillars** form the IMPROVA framework, addressing long-term consequences of serious road traffic injuries
- **Stepwise approach:** from quantifying long-term consequences → assessment formula → advanced Human Body Models & virtual testing → demonstrators
- **Final outputs:** policy recommendations, training, and guidelines to ensure long-term impact
- **Ultimate goal:** protect end users by translating research & innovation into tangible road safety improvements



IMPROVA methodological approach



Evidence for LTC assessment

- **Review databases**, injury prevalence and existing LTC scales
- **Estimate the European burden** of serious injuries and LTC
- **Model relationships** between crash characteristics and injury-based LTC indicators
- Support the **IMPROVA formula** and casualty follow-up data collection

Country	In-depth crash data
France	VOIESUR
Germany	GIDAS
Great Britain	RAIDS



Serious injuries and LTC indicators

- **pFCI and Disability Weights** are injury-based proxies for long-term outcomes
- **Current models** do not directly measure individual recovery or psychological LTC

Indicator	Definition used in the models
MAIS3+	Maximum Abbreviated Injury Scale score ≥ 3
pFCI < 5	Predicted Functional Capacity Index: functional impairment
DWmax > 0.1	Maximum assigned Disability Weight exceeds 0.1



First estimates of the European burden

83,400

MAIS3+ persons per year
Reported uncertainty: $\pm 26\%$

68,883

Persons with LTC per year
Reported uncertainty: $\pm 10.6\%$

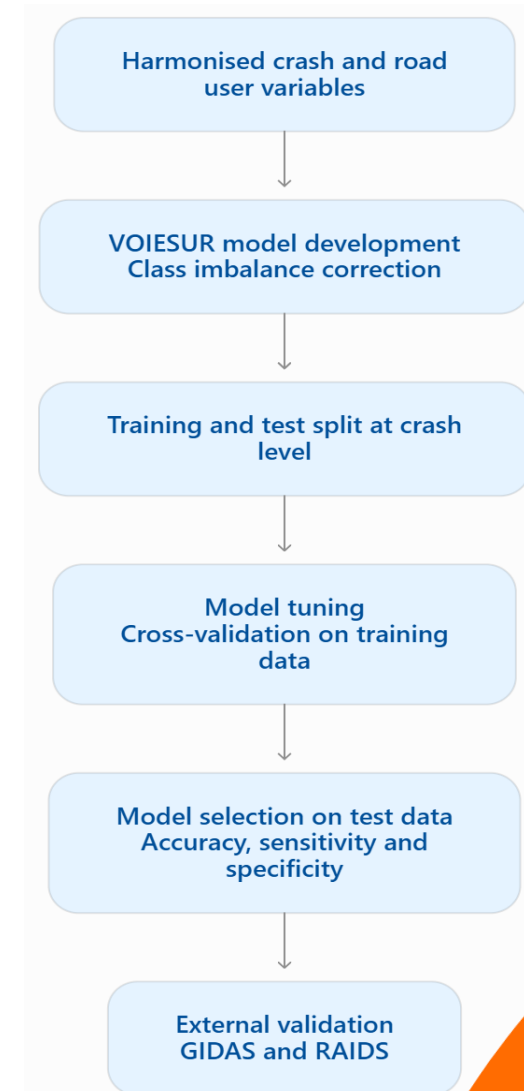
EU-27 plus Great Britain

- Initial estimates based on **in-depth data, national statistics and CARE**
- **Decision trees** estimate serious injury and LTC probabilities for application to national crash data
- Harmonised variables and **weighting factors support extrapolation** to the EU-27 plus Great Britain
- Injury **definitions, representativeness and underreporting** affect the estimates



Methodology for injury and LTC prediction

- **Harmonised crash and road user variables** predict serious injuries and LTC indicators
- Models were developed **using VOIESUR**, accounting for class imbalance
- Data were **split at user level**, with cross-validation for model tuning
- **Model selection** considered accuracy, sensitivity and specificity
- **External validation** used GIDAS and RAIDS



Prediction models results

Road user group - model	Outcome	Most influential predictors	GIDAS: Acc. / Sens. / Spec. (%)	RAIDS: Acc. / Sens. / Spec. (%)
Occupants – XGBoost	MAIS3+	EES, age, collision partner/obstacle	94 / 57 / 94	80 / 37 / 90
Occupants – XGBoost	pFCI < 5	EES, age, loss of control, collision partner/obstacle	93 / 41 / 94	79 / 46 / 86
Occupants – XGBoost	DWmax > 0.1	EES, age, crash responsibility, seat belt use	80 / 47 / 85	66 / 50 / 80
Pedestrians - Random Forest	MAIS3+	Vehicle impact speed, age, overrun, impact angle	76 / 63 / 78	73 / 82 / 66
Pedestrians - Random Forest	pFCI < 5	Age, vehicle impact speed, pedestrian manoeuvre, lighting	73 / 23 / 85	52 / 37 / 64
Pedestrians - Random Forest	DWmax > 0.1	Age, vehicle impact speed, pedestrian manoeuvre, impact angle	63 / 57 / 66	69 / 72 / 58
Cyclists/PTW - Random Forest	MAIS3+	Age, collision partner, rider impact speed and type	35 / 72 / 39	58 / 72 / 48
Cyclists/PTW - Random Forest	pFCI < 5	Age, collision partner, rider impact type and speed	63 / 47 / 64	51 / 85 / 23
Cyclists/PTW - Random Forest	DWmax > 0.1	Age, collision partner, rider impact type and speed	32 / 87 / 17	64 / 89 / 7

Acc. = accuracy, **Sens.** = sensitivity, **Spec.** = specificity. **EES** = energy equivalent speed



Conclusions

- Machine learning links **in-depth crash parameters to injury-based LTC indicators** across multiple datasets
- **LTC reflect** crash configuration, injury characteristics and individual vulnerability
- Impact severity alone cannot explain LTC, with important **differences across road user** groups
- **Interpretable classification schemes** support modelling, safety assessment and decision-making within IMPROVA
- Planned **journal publication will share these findings** with the wider road safety research community



Scientific and social impact

- **Improved understanding** of crash mechanisms and factors associated with **long-term consequences**
- **European burden estimates** supporting road safety monitoring and prevention priorities
- **Predictive models** informing safety assessment and protective technologies
- **Evidence supporting policies** addressing physical and psychological consequences
- Better quality of life and **social reintegration as long-term goals** for crash survivors



Future research

- **Collect direct evidence** on physical, functional and psychological LTC among crash casualties
- **Validate and refine predictions** currently based on proxy indicators such as pFCI and Disability Weights
- **Assess model transferability** across countries, crash configurations and road user groups
- **Extend follow-up over time** to capture recovery and improve the robustness and representativeness of future analyses



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