Decision, knowledge and science in road safety

Sylvain Lassarre

GRETTIA/COSYS IFSTTAR

- Road safety policy seen as a Road risk regulation regime
  - discussion about the concept of safe systems and the role of a vision like Zero vision,

- Relationships between knowledge (scientific and professional) and policy through the actor-network model applied to road safety field
  - discussion about universal laws in road safety, and transferability

- Possibilities of a systemic review of risk models in road safety
  - application to physical vulnerability in cars and effectiveness of seat belt use.

- Conclusion, the necessity to take into account the history and the dynamics of progress about the four pillars : vehicle, infrastructure, road-user and organisation, separately and systemically.

Traffic accident and Road safety

- Traffic accident is a socio-technical risk that has to be regulated by state authorities
- The road safety policies can be seen as a means of regulating relations between the automotive industry and other sectors
- Road safety is
  - a public good (non excludable and non rivalrous commodity)
  - in competition with the efficiency in term of mobility of the transportation sytem
- Implies
  - A road safety policy, institutions and capacity
  - RS performance indicators
  - A governance process (public policy) or/and a management process (institutions)

How to control risk in general?

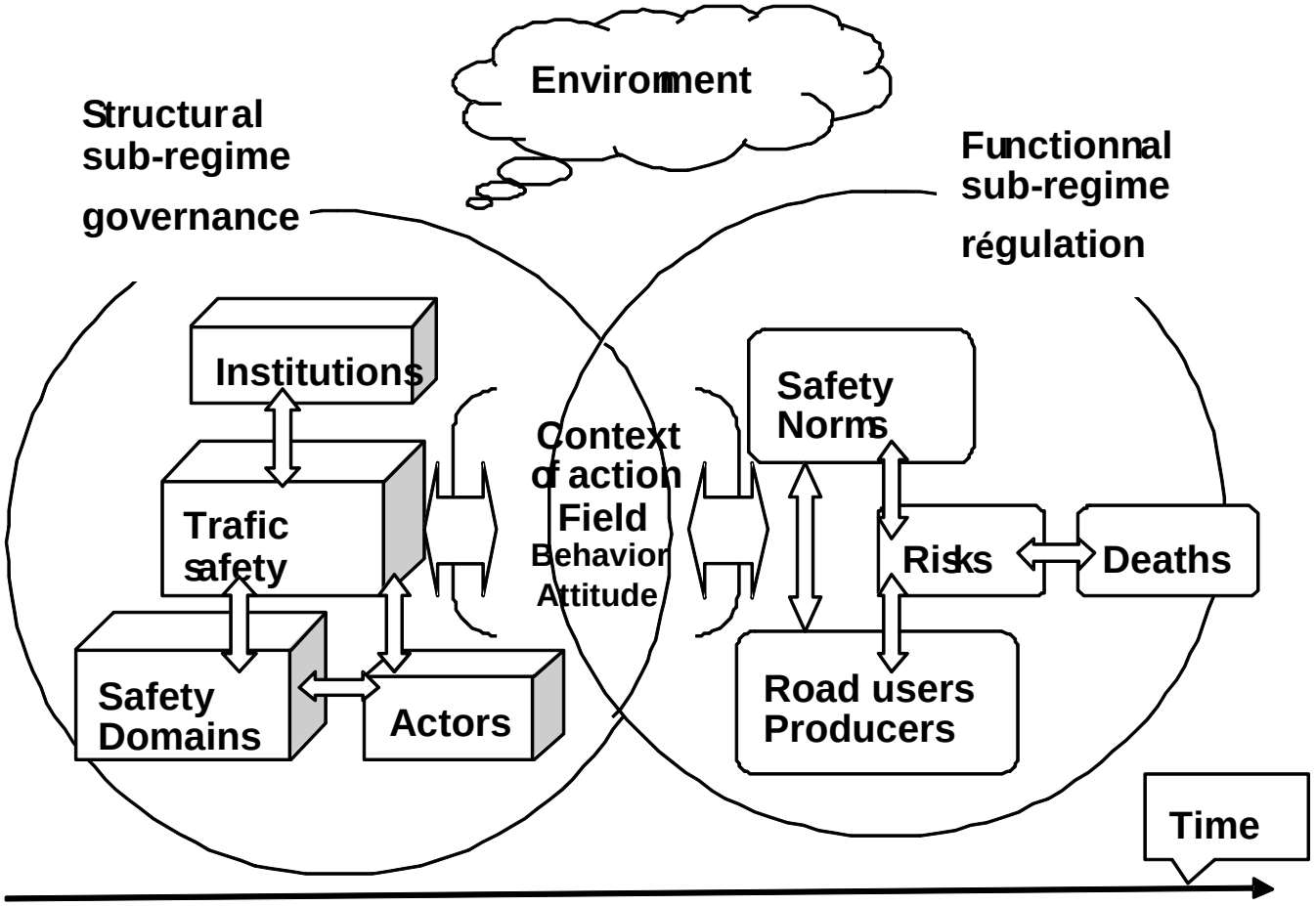
- The regulation can be characterized as a combination of the three components of risk control that are:
  - **collection of information** on risks for the monitoring of system status and action,
  - **setting goals and standards** through a process cost / efficiency, for example,
  - **individual and organisational behavior change** of users and managers by preventive (compliance) or repressive (deterrence) activities.

Risk regulation regimes

- Three shapers (Hood and al.)
  - **Market and civil law process-failure pressures**. In a perfect liberal market, risk is factored through prices (product, contract, insurance)
  - **Opinion responsive pressures** . Democracy and media
  - **Interest-driven pressures**. Corporatism. Lobbies.

Hood, C., Rothstein,H., Baldwin, R., 2001.The Government of Risk. Oxford, Oxford U.P.

Road Risk Regulation Regime



A new theory of complexity for safety research. The case of the long-lasting gap in road safety outcomes between France and Great Britain

by Robert Delorme, Sylvain Lassarre Safety science (2014), 70, 488-503

Content and Context of R4

- Policy settings
- Configuration of State and insitutions engaged directly in regulation
- Attitudes and representations of the regulators

- Types and levels of risk
- Public attitudes and preferences over risk
- Network of actors who produce and are affected by risk

Safe system as an international normative approach

Safe System – the new frontier

An unequivocal long term goal to eliminate death and serious injury with time-limited outcome and output targets driving and made possible by:

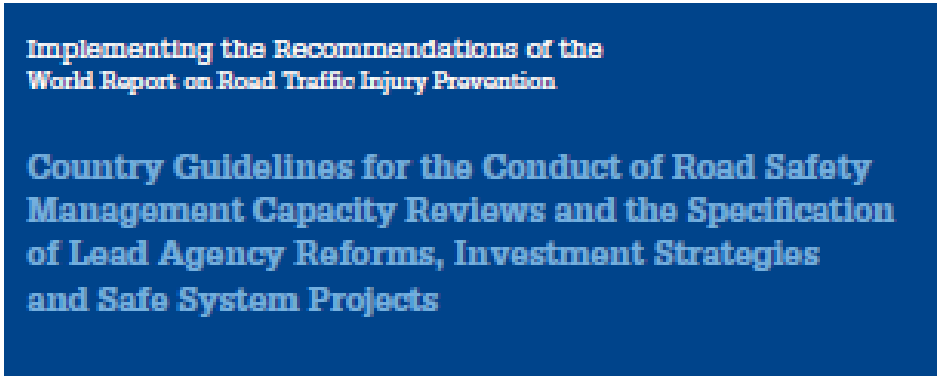
An exacting strategy for system-wide, multi-sectoral intervention based on known safety principles to address human limitations made possible by:

Strengthened, accountable institutional management

requiring best practice & continuous innovation across all elements of the road safety management system.

OECD (2008) Towards Zero : Ambitious road safety targets through a safe system approch

Tony Bliss
Jean Breen
WB GRSP

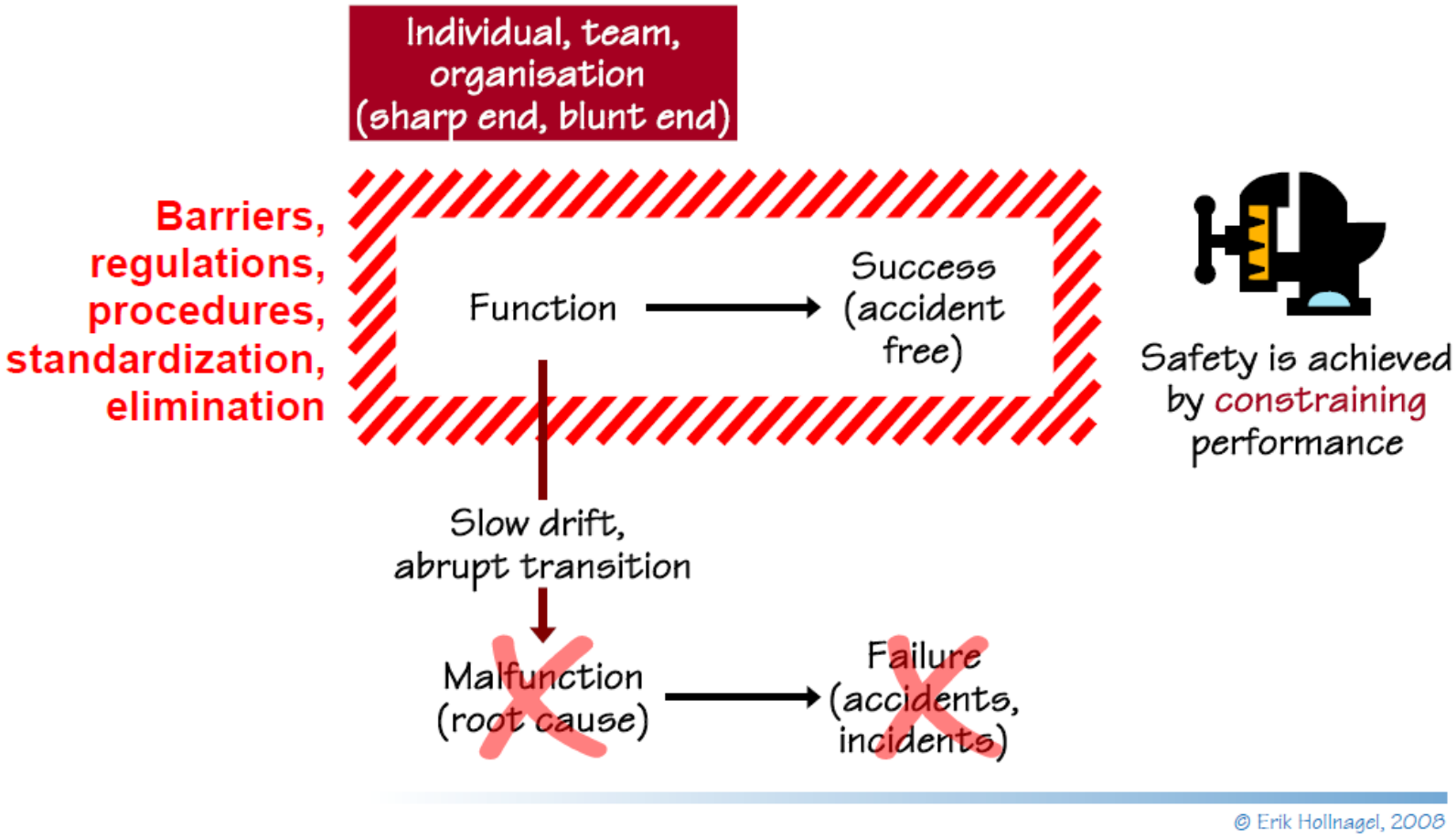


The underlying principles of Safe Systems = an old representation of risk

- human beings can make mistakes that can lead to road crashes; (human factors/organisational)
- the human body by nature has a limited ability to sustain crash forces;
- all road users, road managers, vehicle manufacturers have a shared responsibility to take appropriate actions to ensure that road crashes do not lead to fatal or serious injuries.
- all parts of the system need to be strengthened - roads and roadsides, speeds, vehicles, and road use - so that if one part fails, other parts will still protect all the people involved.

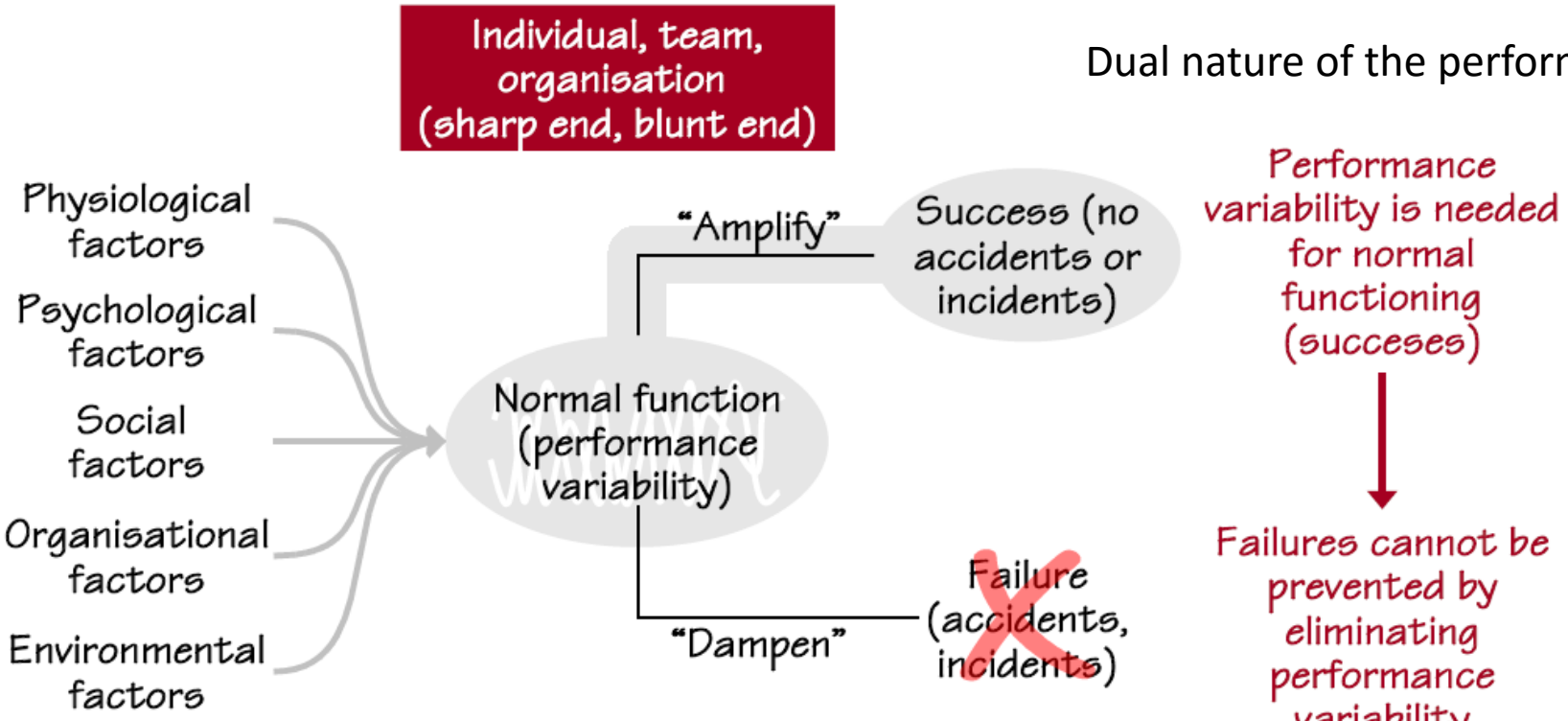
OECD report Safe systems (2016)

Safety by constraint



Hollnagel, E. (2014). *Safety*-I and *Safety-II*: The Past and Future of *Safety* Management. Farnham, UK: Ashgate

Safety by management



Dual nature of the performance

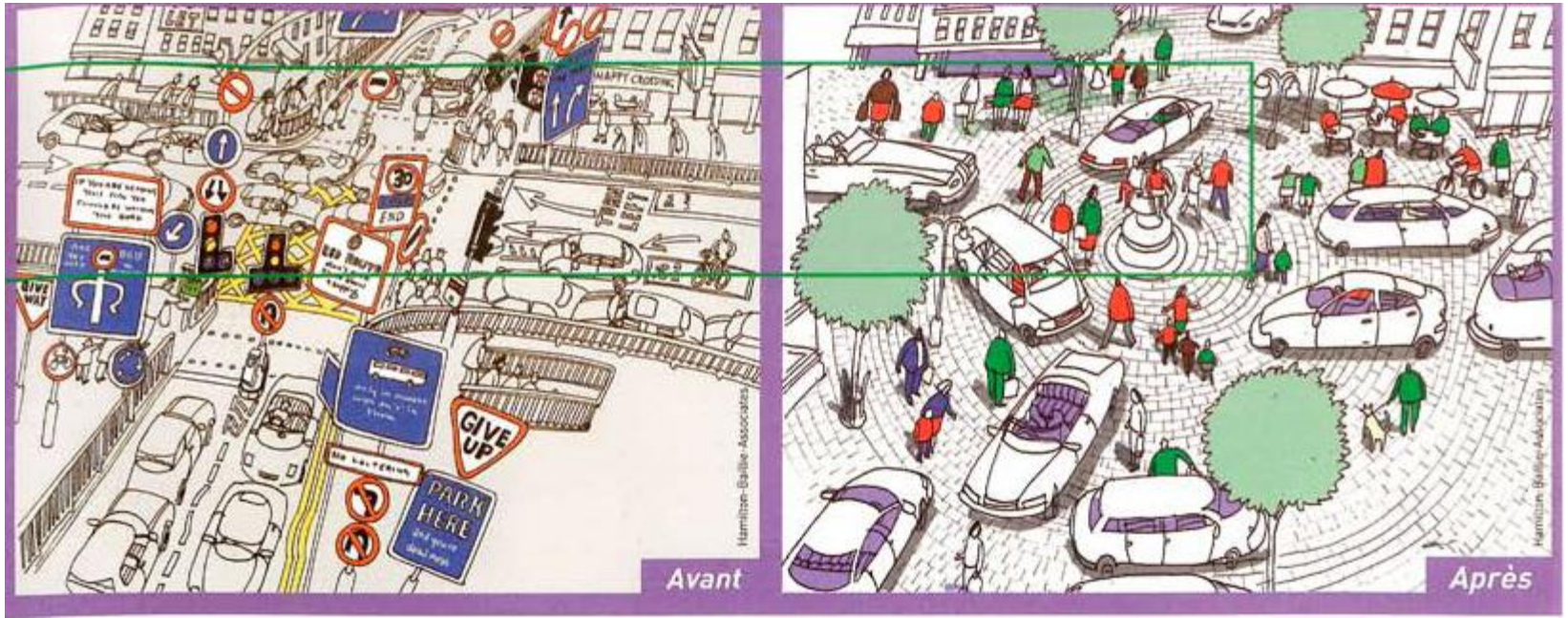
Performance variability is needed for normal functioning (succeses)

Failures cannot be prevented by eliminating performance variability

Monitoring **Detection** **Dispersion** **Correction**

Exemple

- Shared spaces
- Hans Monderman



Vision zero = When Ethics governs politics

Vision Zero is based on the ethical imperative that (Tingvall and Haworth, 1999):

"It can never be ethically acceptable that people are killed or seriously injured when moving within the road system."

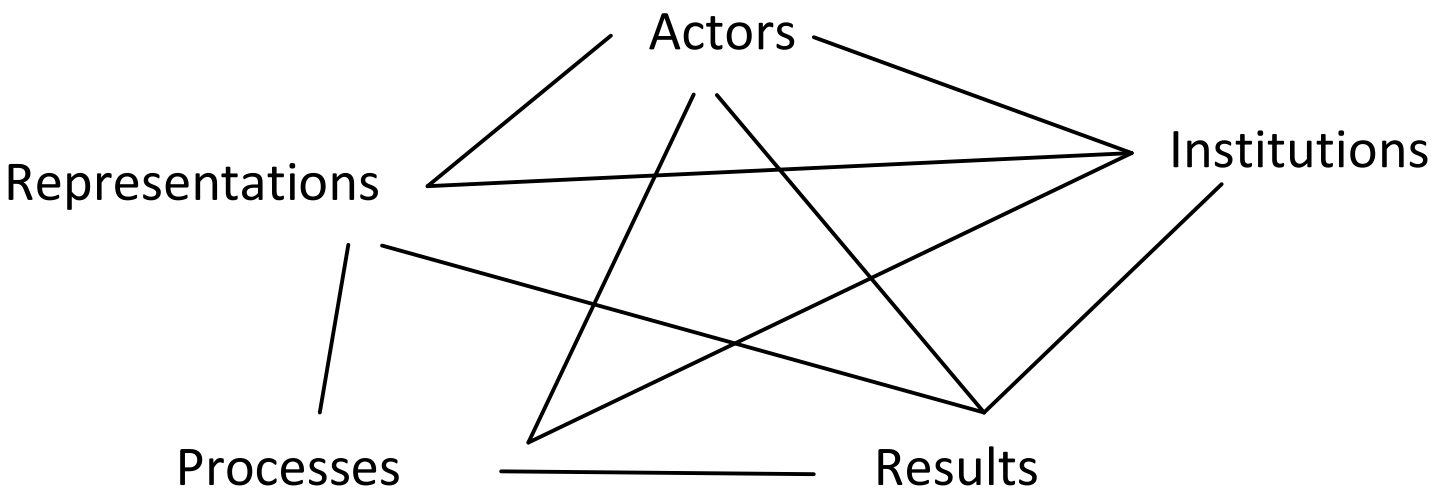
- Sweden was the original pioneer of the Safe Systems Approach adopting their 'Vision Zero' strategy by a Parliamentary decision in 1997.
- "the transport system's design, function and use should be aligned so that no one is killed or seriously injured".
- This ethical imperative and the chain of responsibility constitute two important cornerstones of Sweden's application of the Safe System's approach.

Representations relative to cognitive and normative framework of the strategy with a vision

- This dimension is interesting to understand the coordination of actors by global representations, which may take the form of referentials or paradigms.
- The referential is the representation of the global / sectoral relationships which is built by a group of actors to be determined, qualified as mediators who may be professionals (engineers), administrative elites or politicians.

Public policy

- consists of five elements interacting according to Lascoumes and Le Gales (2007).



Pierre Lascoumes, Patrick Le Galès, ***Sociologie de l'action publique. (2e édition)***, Armand Colin, coll. « 128 », 2012

Evolution in public policy

- Public Administration (traditionnal policy)
- New Public Management
- New Public Governance

	Public adminsitration	New Public Management	New public governance
Focus	Policy system (Vertical)	Intra_organisational management	Inter_organisational management (Horizontal)
Emphasis	Policy implementation	Service inputs and outputs	Service processes and outcomes
Mechanism	Hierarchy	Market or neo-classical contracts	Trust or relational contracts

S. Osborne (2006) The new public governance. Public management, 8 (3), 377-387

Knowledge

- Positivist Vision of science
- The Truth and the paradigms
- The network of researchers with experimental and data bases

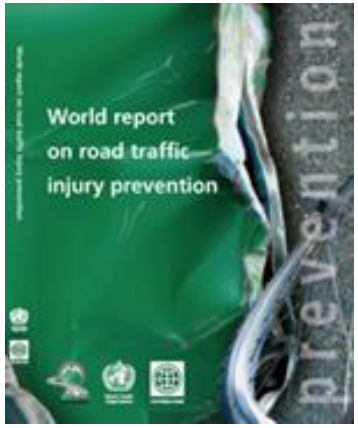
Paradigms in (road safety) research

- Paradigm=basic belief systems based on ontological, epistemological and methodological assumptions (Guba and Lincoln, 1994)

	Positivism	Postpositivism	Constructivism
Ontology	Naive realism « real »	Critical realism	Relativism « constructed »
Epistemology	Dualist/objectivist Findings true	Modified Probably true	Subjectivist created
Methodology	Experimental/manipulative Verification quantitative	Modified Quasi-experimental Falsification +qualitative	Hermeunetical/ dialectical

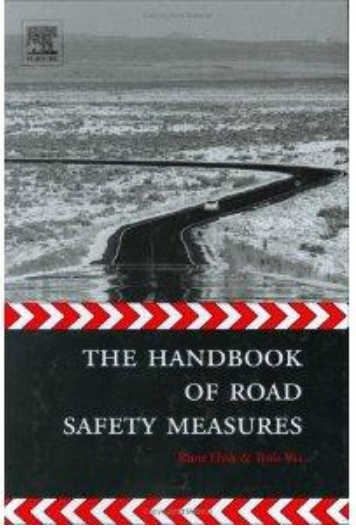
Implications on knowledge

	Positivism	Postpositivism	constructivism
Inquiry aim	explanation	Prediction control	understanding
Nature of knowledge	Verified hypothesis established as facts or laws	Falsified hypothesis established as probable facts or laws	Individual reconstructions + consensus
accumulation	Generalizations and cause-effect linkages		Informed reconstructions, experience
Goodness criteria	rigor		trustworthiness authenticity
values	excluded		included
voice	Desinterested scientists experts	Informer of decision makers	Passionate participant
training	technical	quantitative	qualitative
hegemony	In control	dominant	recognition



What works ?

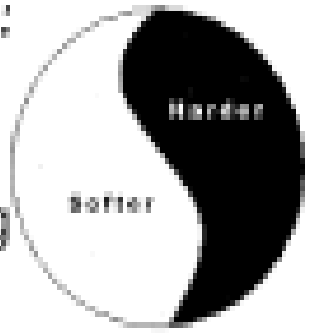
- Feasability
- **Effectiveness**
- **Efficiency**
- **Acceptability**
- Equity
- Sustainability



- Rune Elvik, Truls Vaa The handbook of
- road safety measures
- World report on injury prevention (WHO)
- Sharing road safety (CMF), OECD

But knowledge required for effective services is *much* broader than simply "what works"

- ***Know-about (problems):*** e.g. the nature and formation of social problems.
- ***Know-why (requirements of action):*** relationship between values & policy/practice.
- ***Know-how (to put into practice):*** e.g. pragmatic knowledge about implementation.
- ***Know-who (to involve):*** e.g. building alliances for action.



Need research evidence and other knowledge to address these issues

Sandra Nutley

How to increase the usage of evaluations beyond CMFs

	Positivist CMF	Constructivist CMF
Ontology	road Engineering only	**System approach**
Methodology	Purely quantitative Quasi-experiment Analytic	Quantitative +Qualitative History Holistic
Models and theories	Black-box outcomes	Outcomes + implementation process
Evaluation findings	Manipulable solutions Instrumental and universal (generazlizable probability)	Transferable explanations
Knowledge Transfer	Information to practitioners and decision makers	**Safety culture** Co-elaboration with practitionners and public
Policy	Cost-benefit	**Integration** **Profesionalisation**

Recommandations

- Have multiple evaluations of the same kind of programs/projects/elements using different quantitative and qualitative techniques respecting the goodness criteria
- Specialization of evaluators in road safety able to co-construct a theory of change with the stakeholders and actors of the program
- Measure activities as outcomes at a multi-level
- Carry out critical reviews of evaluations
- Complete meta-analysis (quantitative evidence) by looking at evidence about the mechanisms and the contexts of change inside (inter)national committees
- Form translators between practitionners and researchers

Adressing non-technical issues about CMF

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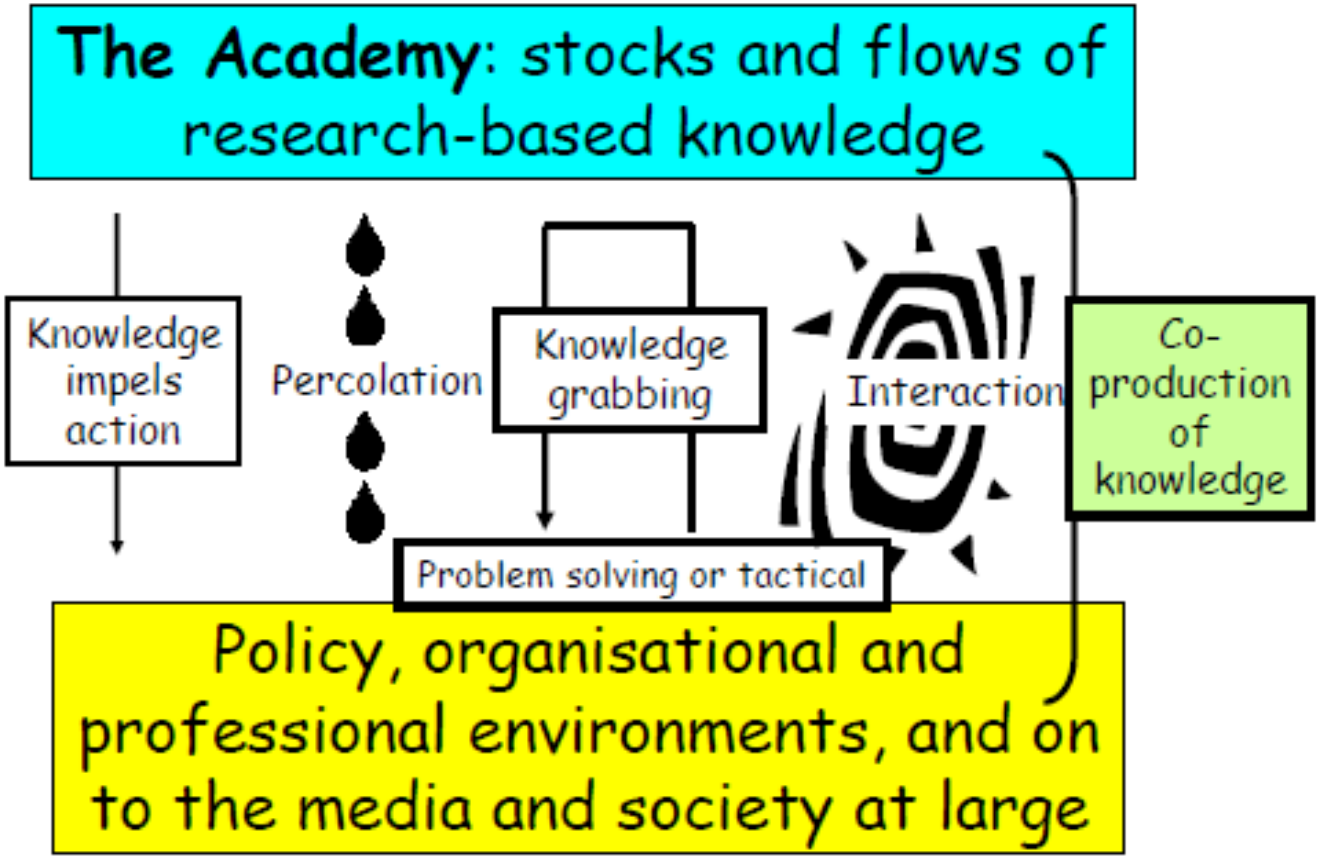
IFSTTAR-GRETIA

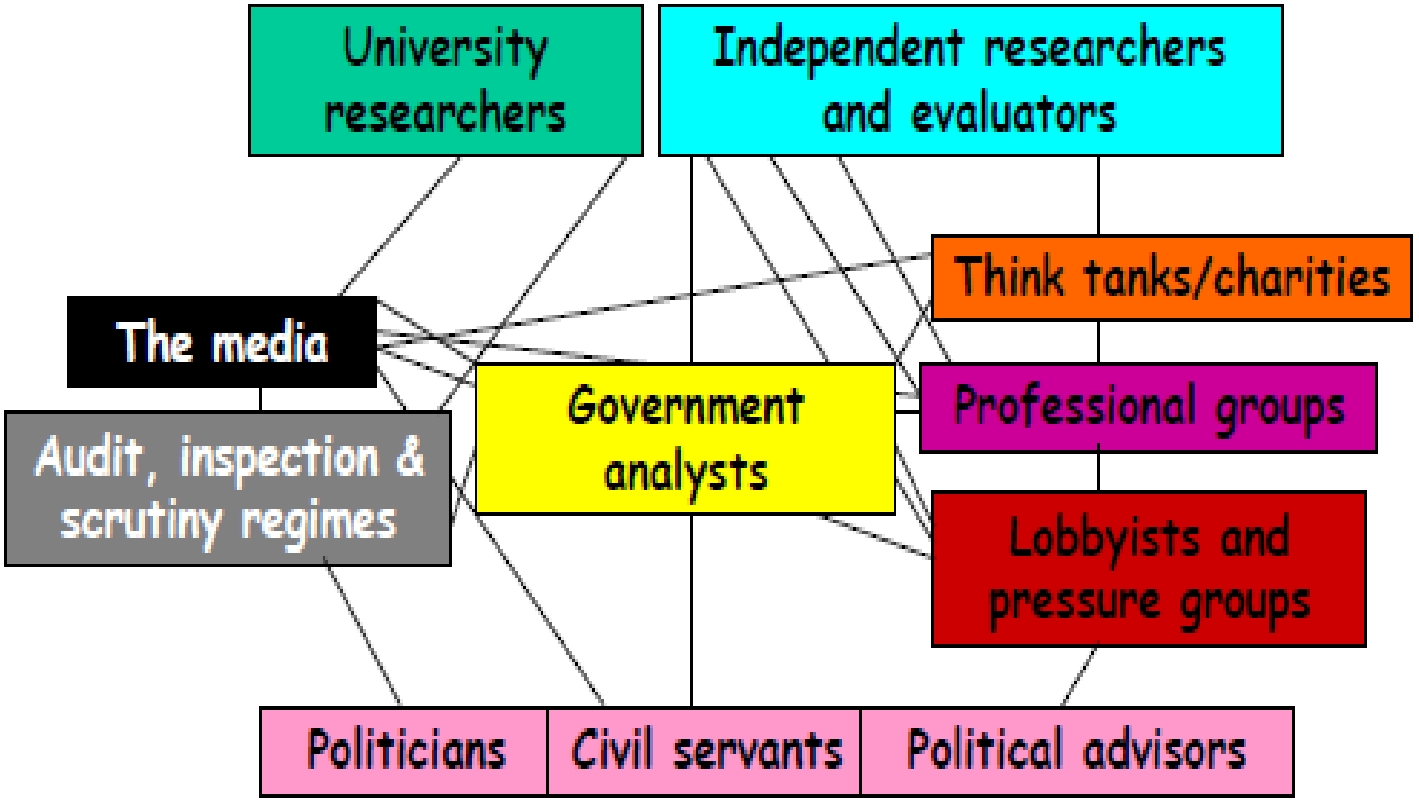
2011 TRB Annual Meeting

International Workshop on Transferability of Crash Modification Factors (CMFs)

Many different ways of 'using' research:



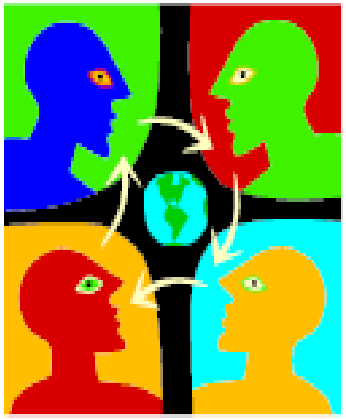
The many actors and the complexity of the policy networks



Sandra Nutley and al. Using Evidence

Evidence-informed practice

Moving away from ideas of 'packaging' knowledge and enabling knowledge transfer - recognising instead:



- The importance of ***context***;
- ***Interaction*** with other types of knowledge (tacit; experiential);
- Multi-voiced ***iterative dialogue***;
- 'Use' as a ***process*** not an event.

Science making

- Network of laboratories, institutes
- Data bases on accidents and victims
- Conferences and international institutions

Physical vulnerability

- The vulnerability which can be measured by a probability function of the chance, when involved in a crash, to be injured more or less severely from no injury to death will depend on
  - The characteristics of the person, mainly the age (physical conditions),
  - The effectiveness of the barriers, according to the position inside the car related to the forces of the impact and and the position after the crash in case of ejection ,due to:
    - The level of protection by the use of safety devices such as seat belt,
    - The crashworthiness of the car, or the protection offered by the structure and the mass of the car, according to the types of collision (frontal, lateral, rear-end, …),
  - The amount of mechanical energy released during the collision, measured by ΔV or other measurements of the severity of the crash.

Multinomial models

- The probability of sustaining an injury in a crash is modeled by an ordered probit or logistic or Gumbel distribution, with y* an unobserved continuous variable such as

$$y = \begin{cases} 0 & \text{if } y^* \leq 0, \\ 1 & \text{if } 0 < y^* \leq \mu_1, \\ 2 & \text{if } \mu_1 < y^* \leq \mu_2 \\ \vdots & \\ N & \text{if } \mu_{N-1} < y^*. \end{cases}$$

- y* can be linked to a measure of the severity of the collision, usually ΔV, but also other crash automatic recorder data

$$y^*_{ik} = \alpha + \beta_{(k)} \Delta V_i + \varepsilon_{ik}$$

$$G(E(y_{ik})) = G(P_{ik}) = \alpha + \beta_{(k)} \Delta V_i$$

- Ordered logit model = proportional odds model

  Death/SI +LI= SI/LI
- If not, stereotype logit model or nested logit model

- No rating, then multinomial model with Gumbel distribution, multinomial probit or logistic model

$$y^*_{ik} = \alpha + \beta_k \Delta V_i + \varepsilon_{ik}$$

$$G(E(y_{ik})) = G(P_{ik}) = \alpha + \beta_k \Delta V_i$$

- Weighting to correct different sample sizes according to ΔV
- Non zero injury probability at zero severity

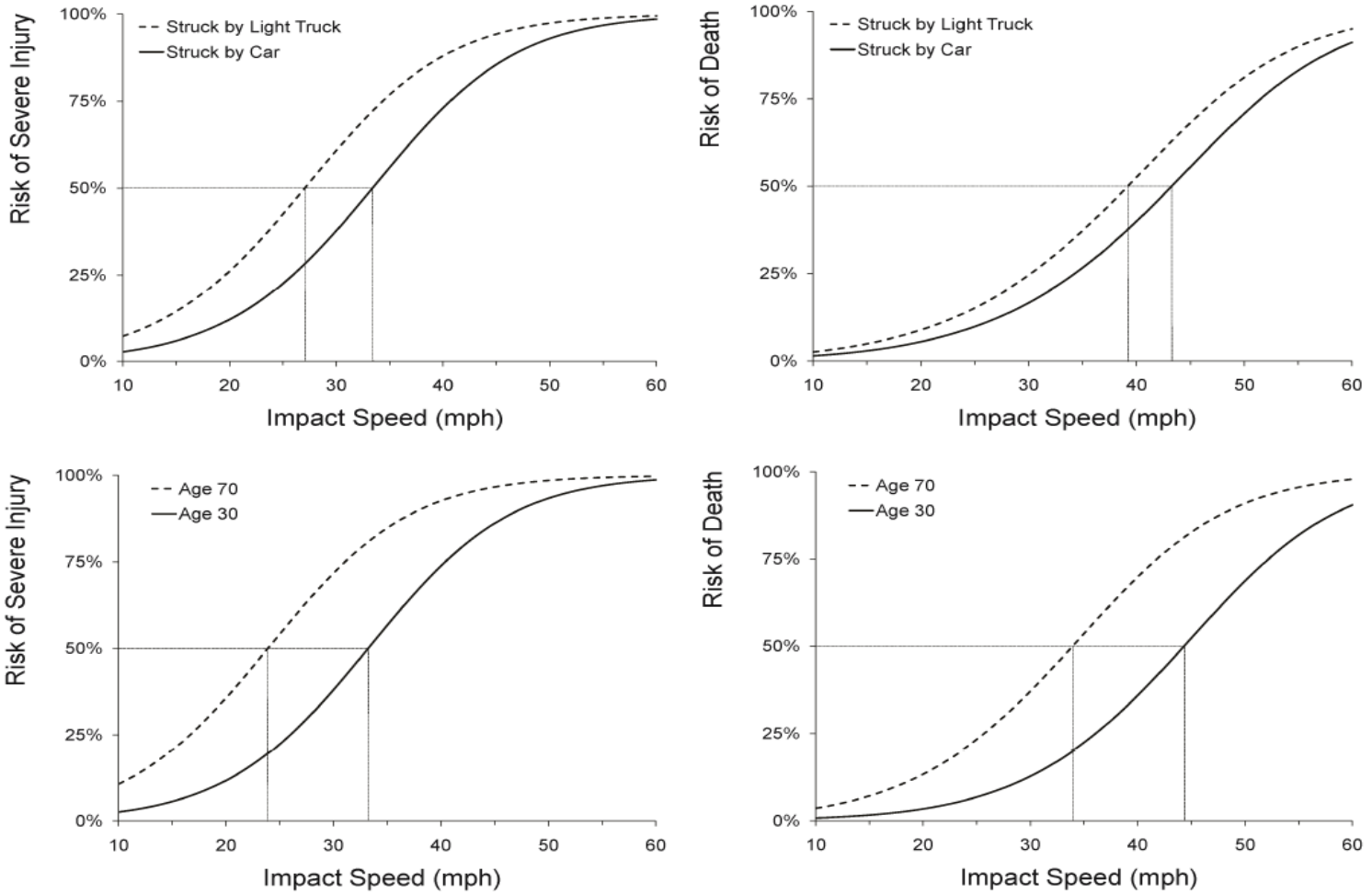


Figure 2. Risk of severe injury (left) and death (right) in relation to impact speed in a sample of 422 pedestrians aged 15+ years struck by a single forward-moving car or light truck model year 1989–1999, United States, 1994–1998. Risks are adjusted for pedestrian age, height, weight, body mass index, and type of striking vehicle. Top panel shows average risk for pedestrians struck by cars vs. light trucks, standardized to the age distribution of pedestrians struck in the United States in years 2007–2009. Bottom panel shows average risk for pedestrians ages 30 vs. 70, standardized to the distribution of type of striking vehicle for pedestrians struck in the United States in years 2007–2009. Serious injury is defined as AIS score of 4 or greater and includes death irrespective of AIS score.

Multiple Survival models

- Death or injury occurs if $\Delta V_i > v$
- Hazard function h(v) and survival function S(v)
- Censored data
  - Left censored for injury point if injury treshhold lies in [0, v]
  - Rigth censored for non injury point if injury treshhold lies in [v, ∞]
- Parametric and non parametric models and estimations
  - Proportional hazard and accelerated failure time models

Effectiveness of seat belt use

- Two main kinds of studies
  - Cohort studies or exposed/non exposed studies

	Exposed Belted occcupant	Non exposed Unbelted occupant
Died		
Injured or survived		

  - Case/control studies

	Died (Injured) in collision	In traffic
Exposed Belted occcupant		
Non exposed Unbelted occupant		

Exposed/non exposed studies

- The usage of the system is not randomly distributed among the population (of drivers by exemple)
  - Unbelted drivers are more prone to traffic violations, high speed, agressive driving, …
  - Protected road users as belted drivers are either more safer or on the contrary are going to take risk because of an increased protection (The problem of risk compensation or adapatative behavior).
- Solution to the problem of endogoneous selection
  - To model both the choice of the safety device (helmet, seat belt, ..) and the risk of injury by correlated bivariate models.
  - A joint econometric analysis of seat belt use and crash related injury severity. N Eluru, C. Bhat, AAP 39 (2007) 1037-1049 (car drivers GES 2004)
  - M. de Lapparent Willingness to use safety belt and levels of injury in car accidents . AAP 40 (2008) 1023-1032. BAAC 2003 Car driver, front-seat and back-seat passenger

Matched pair cohort studies

- In the same vehicle : matching of driver and passenger belted/unbelted

Number of pairs

	Driver or passenger	unbelted	
Diriver or passenger		died	lived
belted	died	a	b
	lived	c	d

- In the same two-vehicles accident : matching of two drivers belted/unbelted

Same accident severity (ΔV)

	Driver 1 or 2	unbelted	
Diriver 1 or 2		died	lived
belted	died	a	b
	lived	c	d

- Relative risk

$$\hat{RR} = \frac{a+b}{a+c}$$

Just based on the counts of **dead** drivers and passengers

- Conditional Odds Ratio

$$\hat{OR}_1 = \frac{b}{c}$$

Odds=p/1-p

- Marginal OR

$$\hat{OR}_2 = \frac{(a+b)(b+d)}{(a+c)(c+d)}$$

Conditional logistic regression

- C. Crandall, L. Olson, D. Sklar Mortality reduction with air bag and seat belt use in head-on passenger car collisions . American journal of epidemiology, 153,3, 219-224 (2000). FARS 1992-1997 head_on pairs of passenger cars and drivers. Conditional ORs and conditional logistic models.
- Used only two discordant pairs. Problem : In 15 to 20 % of fatal crashes, the two drivers died. So OR is biaised further to 1.

Double pair comparison

- L. Evans Double pair comparison A new method to determine how occupant characteristics affect fatality risk in traffic crashes. AAP 18, 3, 217-227 (1986)
- Ratio of RRs between two tables of pairs to correct the confounding of seat position:
  - belted driver/unbelted passenger (front seat)
  - unbelted driver/unbelted passenger
- Source : FARS Fatality analysis reporting system in the US

Conditional Poisson regression

- P. Cummings, B. McKnight, N. Weiss. Matched-pair cohort methods in traffic crash research. AAP 35 (2003) 131-141. FARS 1986-1998, model years 1974-1987. Driver/passenger in the same car. With and without roll-over accidents.
- L. Ratnayake. Development and testing of methodologies to estimate benefits associated with seat belt usage in Kansas. PHD dissertation, Kansas State University (2007).

Sample selection

- S. Levitt, J. Porter Sample selection in the estimation of air bag and seat belt effectiveness. The review of economics and statistics, 83(4), 603-615 (2001). FARS 1994-1997. Children, one-vehicle crash, three or more , involving fatalities among vulnerable road users excluded. Information incomplete on air bag and seat belt use dropped from sample
- Correction of sample selection by restricting the the data set to occupants of vehicles in which anyone of the other vehicle dies in the crash.

$$Y_{jvc} = \alpha + \beta_1 seatbelt_{jvc} + \beta_2 airbag_{jvc} + X_{jvc}\Gamma + V_{vc}\Theta + Z_c\Lambda + \varepsilon_{jvc}$$

  - Frontal, partial frontal, non-frontal crashes,
  - Automobiles/utility vehicles, vans

Case-control studies

- We can use a with/without the safety device approach by comparing the fatality rate per registered cars. This method can be used in the first phases of diffusion of the safety device among the fleet.
- *Braver* ER, *Ferguson* SA, *Greene* MA, *Lund* AK (1997) Reductions in deaths in *frontal crashes* among right front passengers in vehicles *JAMA* 278:17 (1997), 1437–1439.
- If the percentage of front-seat occupants wearing a seat belt is estimated with a sample survey on the road, we could estimate by an odds ratio the relative risk.

	Died (Injured) in collision	**In traffic**
Exposed Belted occcupant		
Non exposed Unbelted occupant		

- We could use a third approach (**induced exposure**) which compares the consequences of crashes according to their types divided in two classes: crashes where the devices play a role and other crashes without any impact. For air bag, we could compare injury status of occupants of cars involved **in frontal and non frontal crashes**.
- We suppose that the proportion of dead occupants in no frontal collisions, that is to say in car struck from the side or the rear is an estimate of the safety device exposure in the traffic, under the hypothesis that there is no influence of the safety device on the mortality in non frontal crashes. This appears to be false as “safe” drivers are found more among equipped cars and are more likely to be hit by another vehicle and are under-represented in frontal crashes; or in case of an induced protection of the safety device in non frontal crashes

Conclusion

- Necessity to take into account the **history** and the dynamics of progress about the four pillars : vehicle, infrastructure, road-user and organisation, separately and **systemically**.
- Risk regulation regime
  - traditional public Management (vertical) + NMP
  - Governance (horizontal)
- Knowledge
  - Network of researchers+laboratories+data bases+conferences

Conclusion

- A long way from data to scientific facts and knowledge about physical vulnerability and seat belt effectiveness in real crashes.
  - Non linear effect of speed impact on the probability of injuries
  - Seat belt use is effective in reducing fatal and serious injuries

- Some methods are better than others :
  - Matched pair cohort studies to control for impact speed
  - Bivariate binary regressions to control from selection biases

- Next step : synthesise by means odf systematic review the results of different studies with different data sets and methods.

Hoye A. (2016) How would increasing seat belt use affect the number of killed or seriously injured light vehicle occupants ? Accid. Anal. & Prev 88, 175-186