European/International Joint PhD
in Social Representations and Communication
International Summer School 2016

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So.Re.Com. Joint-IDP
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Funded by the European Union

Methodological input from the EU project SafetyCube: a meta-analysis from mixes different types of studies (road user, infrastructure, vehicle) and applied disciplines (from medicine to epidemiology, to transportation and environmental studies)

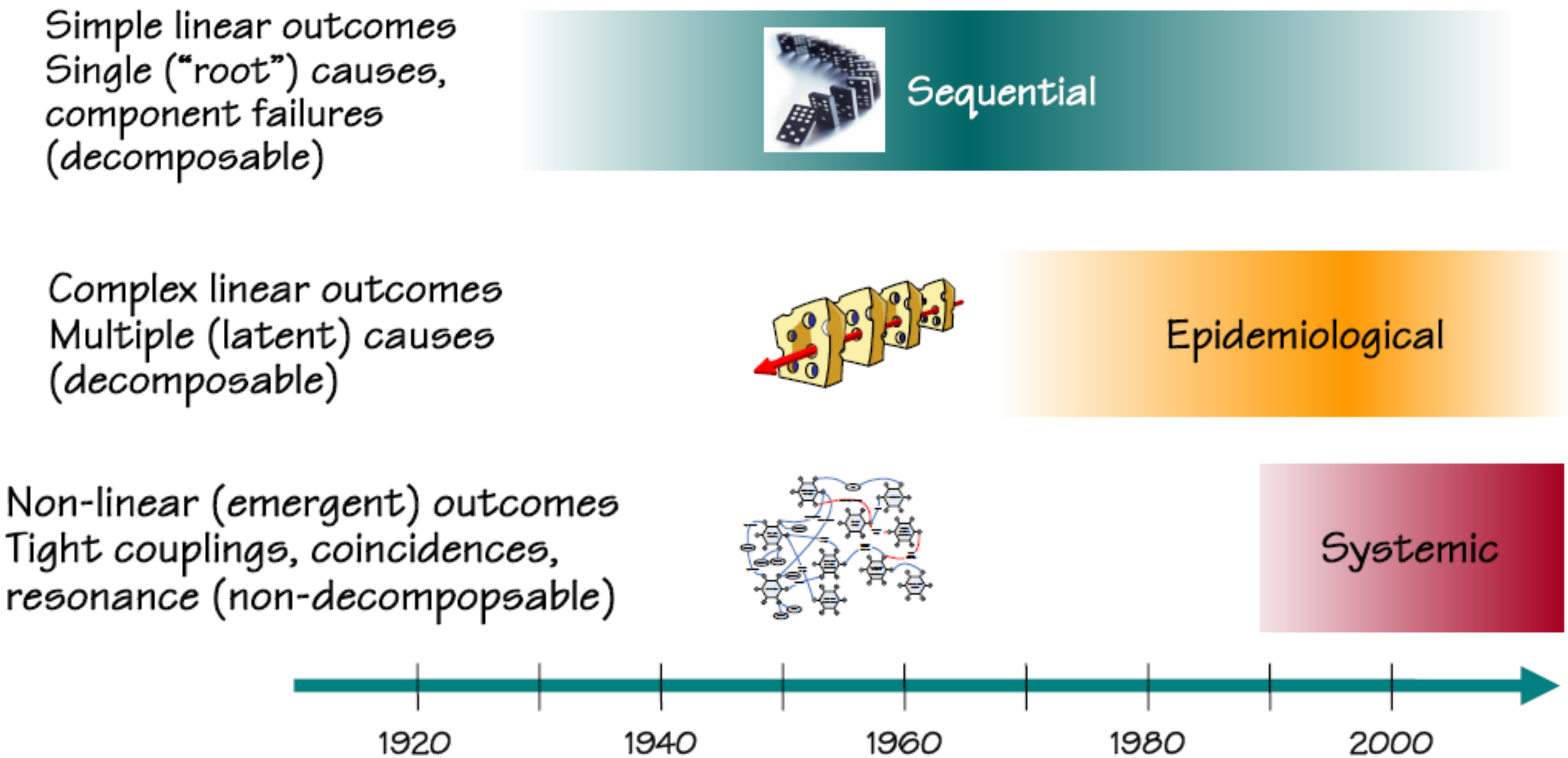
Sylvain Lassarre

GRETTIA/COSYS – IFSTTAR

http://www.safetycube-project.eu

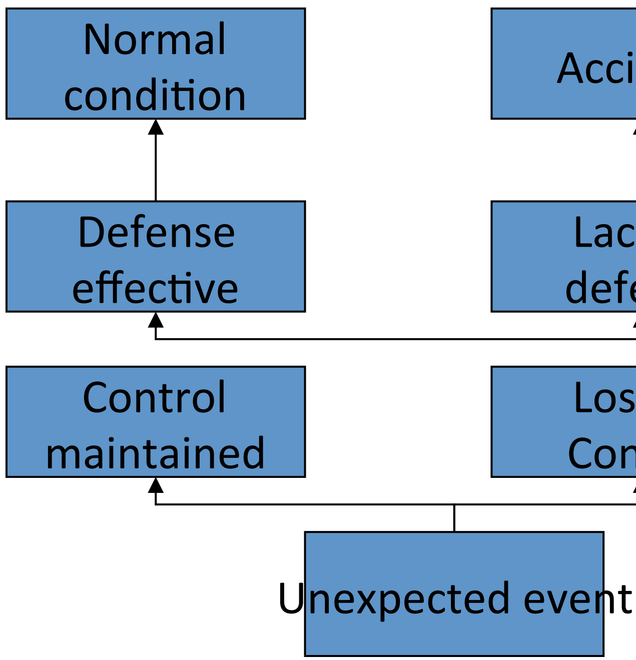
- Accident models and road safety (reminder)
- Knowledge in road safety
  - Paradigms
  - Diffusion and policy
- Science making in road safety
  - Systematic reviews and meta-analysis
    - Physical vulnerability in collision
    - Effectiveness of seat belt use
- Conclusion

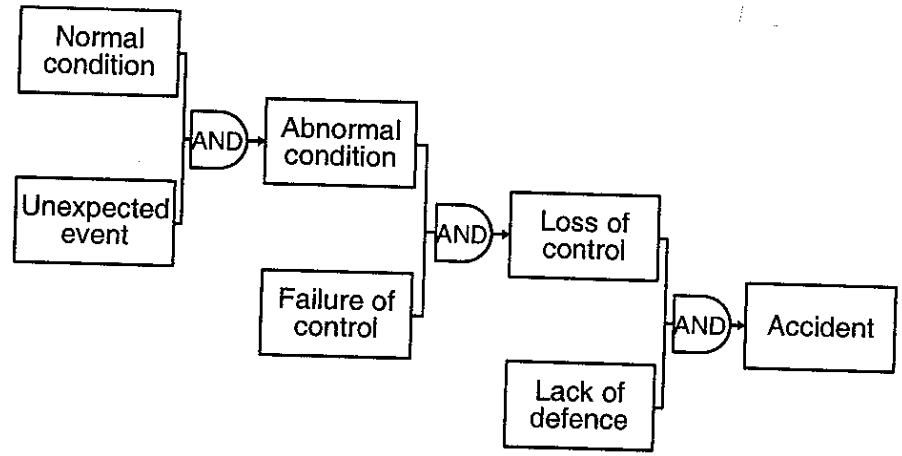
Accident models

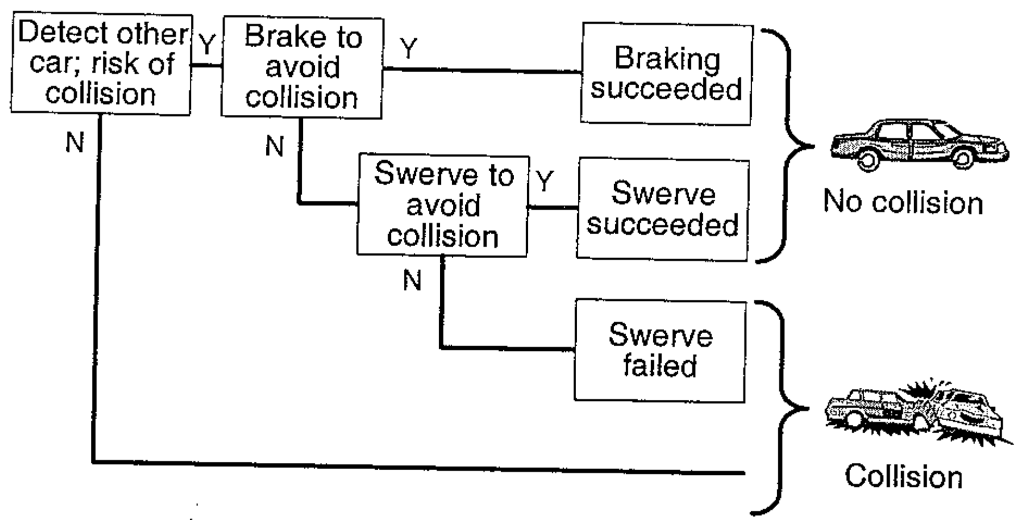


E. Hollnagel (2004) Barriers and accident prevention. Ashgate.

Accident tree: event and fault tree





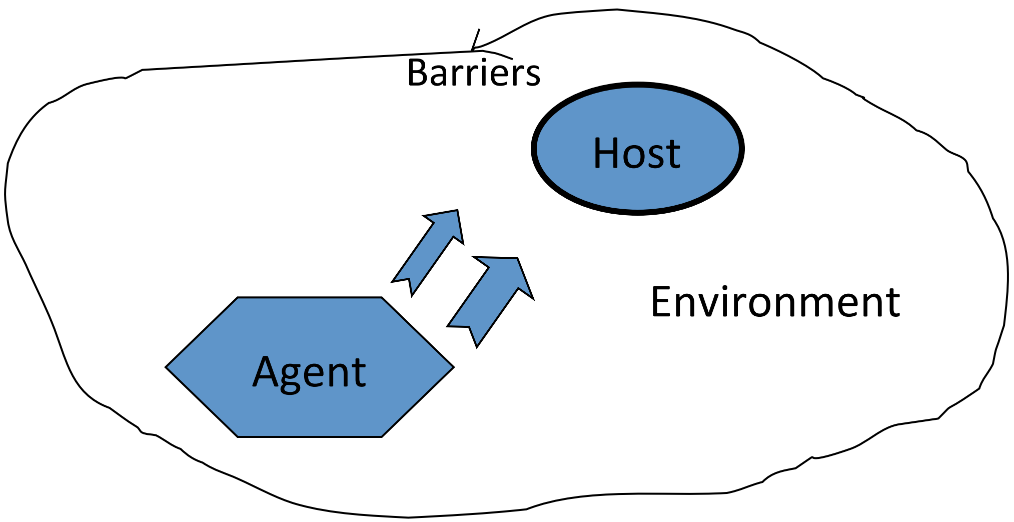


Epidemiological model

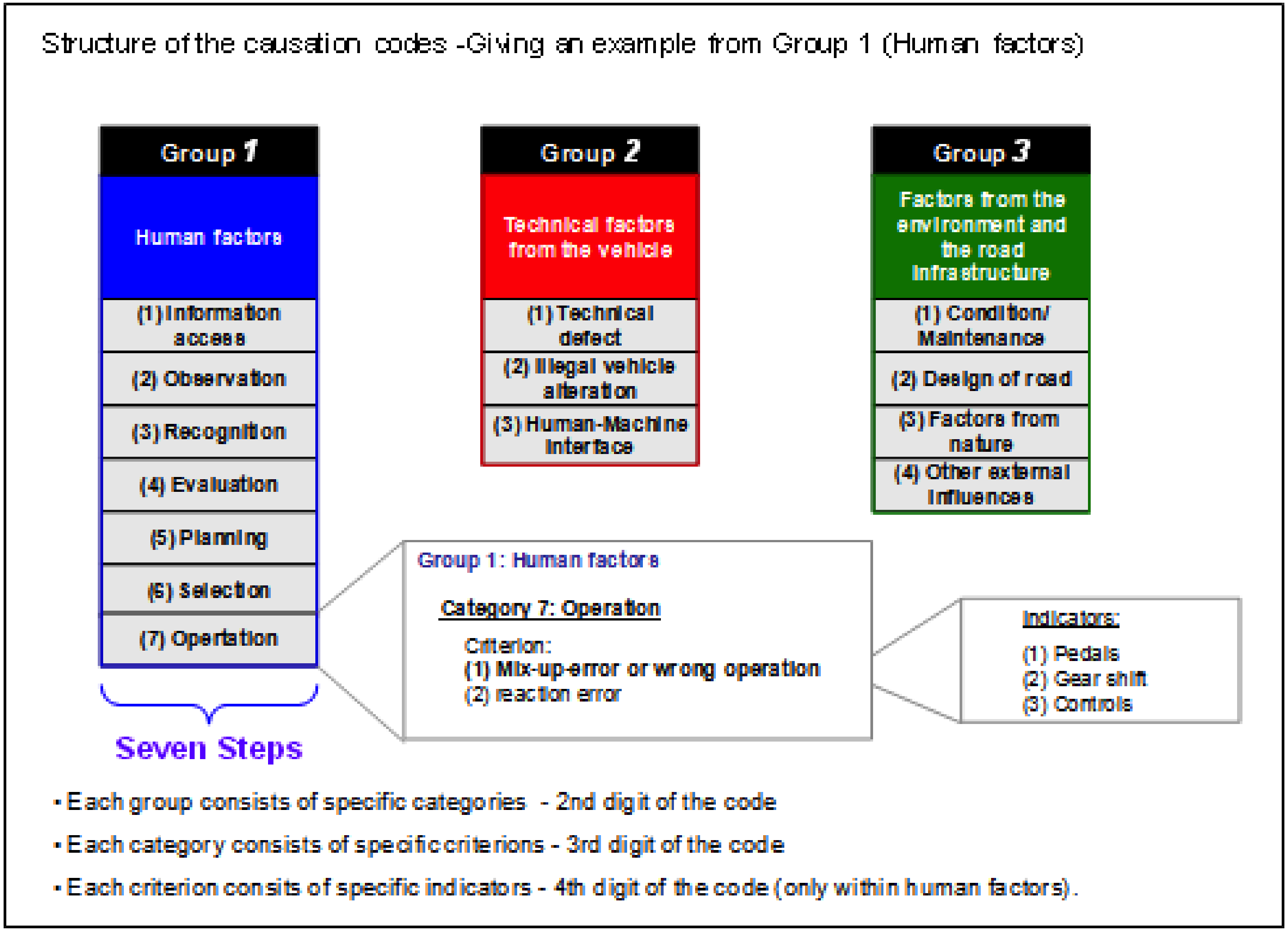
Complex linear outcomes
Multiple (latent) causes
(decomposable)

Epidemiological

Desease	Host	Agent	Vector	Interaction
Malaria	Man	Plasmadium sp.	Mosquito	Bite
Skull fracture	Man	Mechanical energy	Moto	Collision



Risk factors, failures and barriers



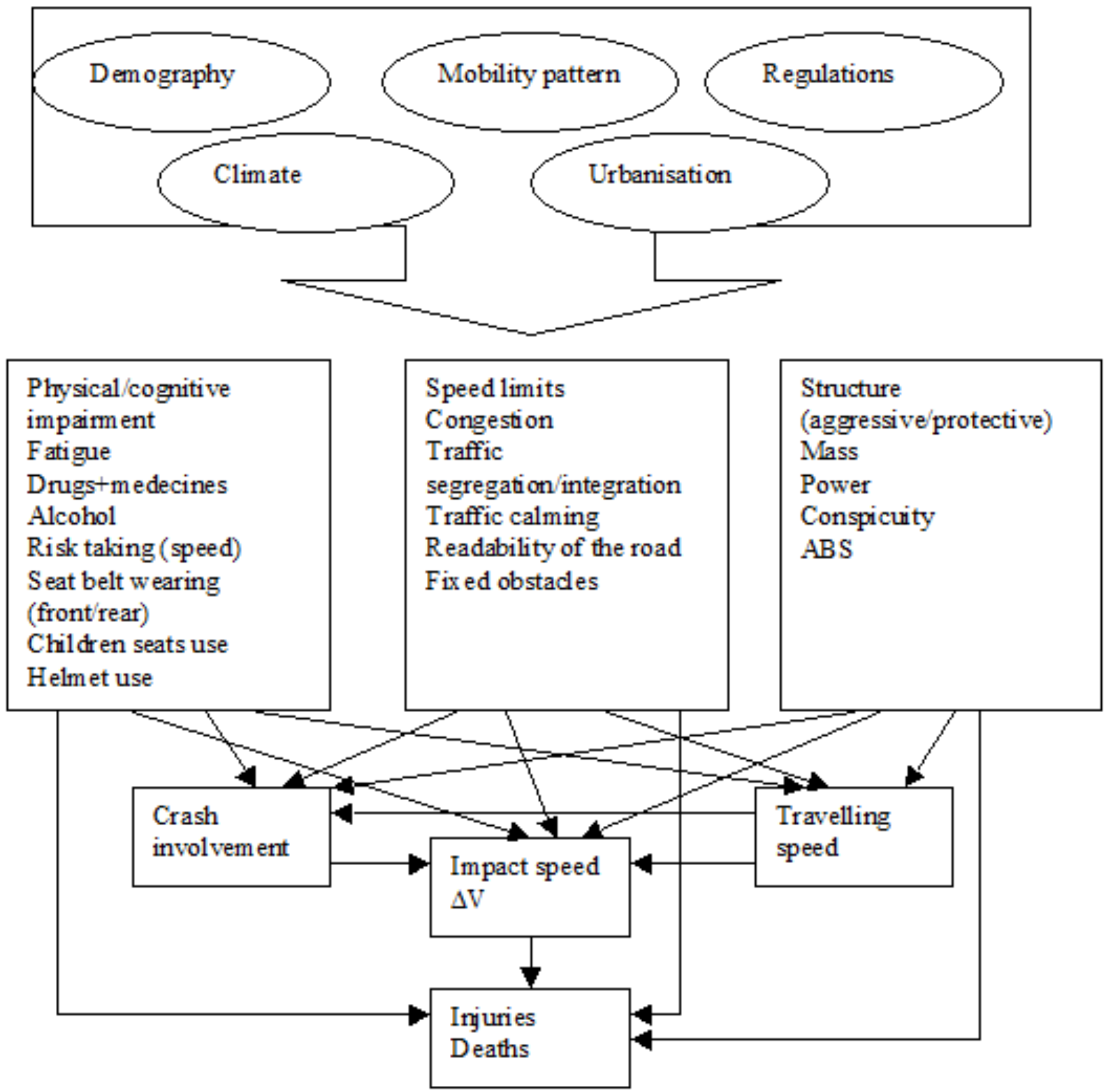
Structure of causation codes in ACASS Accident Causation Analysis with Seven Steps (Jaensch et al., 2008)

- DREAM from CREAM Cognitive Reliability and Error Analysis Method (Hollnagel, 1998)

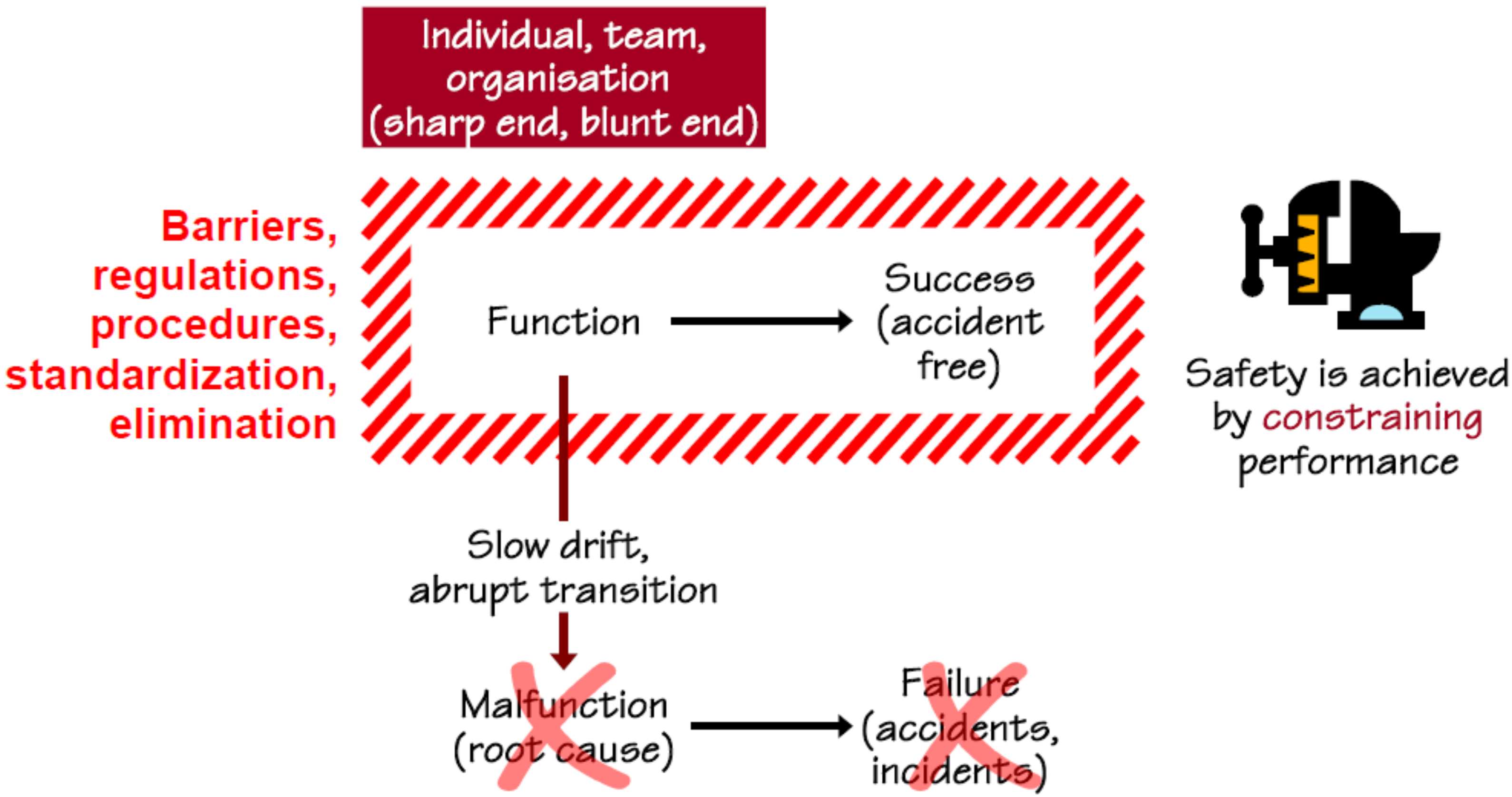
Genotypes				
Driver	Vehicle	Traffic environment	Organisation	A: Phenotypes
B: Observation	G: Temporary HMI problems	J: Weather conditions	N: Organisation	Timing
C: Interpretation	H: permanent HMI problems	K: Obstruction of view due to object	O: Maintenance	Speed
D: Planning	I: Vehicle equipment failure	L: State of road	P: Vehicle design	Distance
E: Temporary personal factors		M: Communication	Q: Road design	Direction
F: Permanent personal factors				Force
				Object

Warner, H., Ljung Aust, M., Sandin, J., Johansson, E., & Bjorklund, G., 2008. Manual for DREAM 3.0, Driving reliability and error ananlysis method. Deliverable 5.6 of the EU FP6 project SafetyNet, TREN -04-FP6TR-S12.395465/506723.

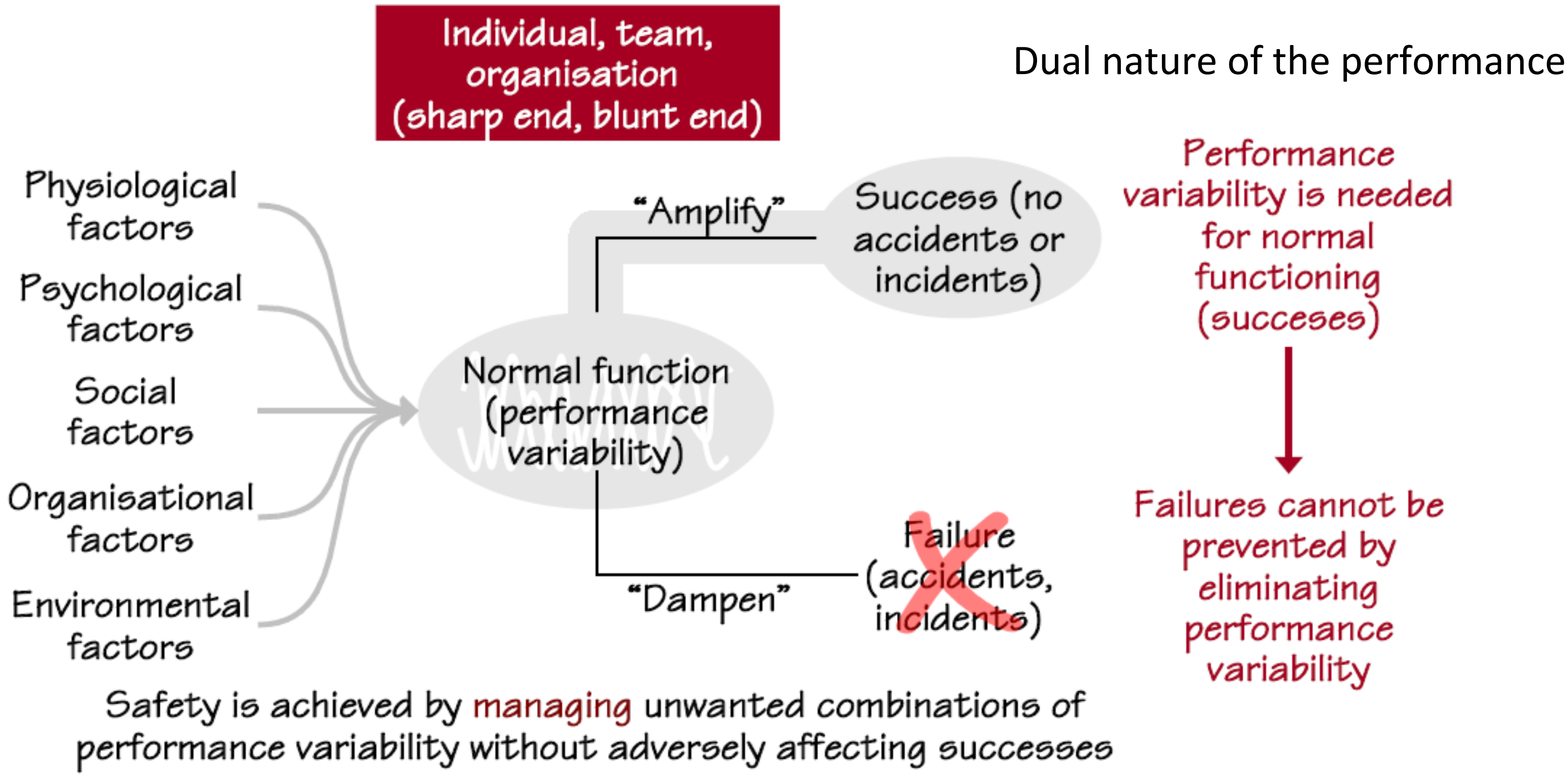
Causal web proximal/distal conditions and factors



Safety by constraint



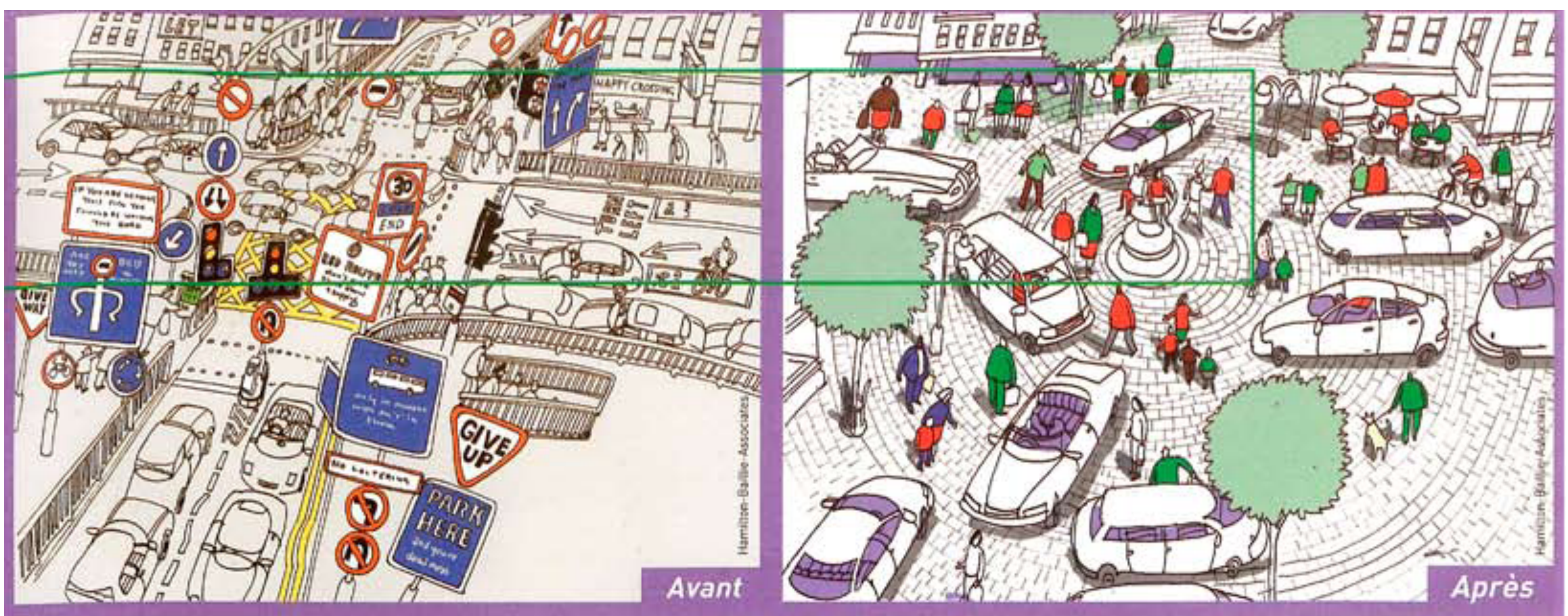
Safety by management



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

Exemple

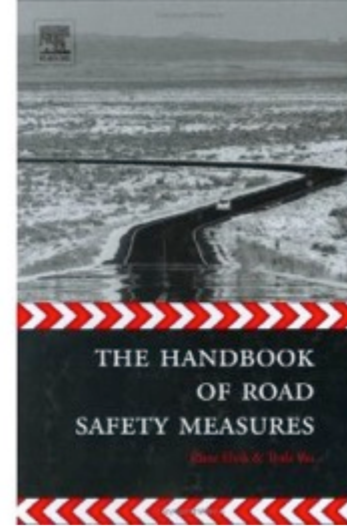
- Shared spaces
- Hans Monderman



Knowledge

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

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

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

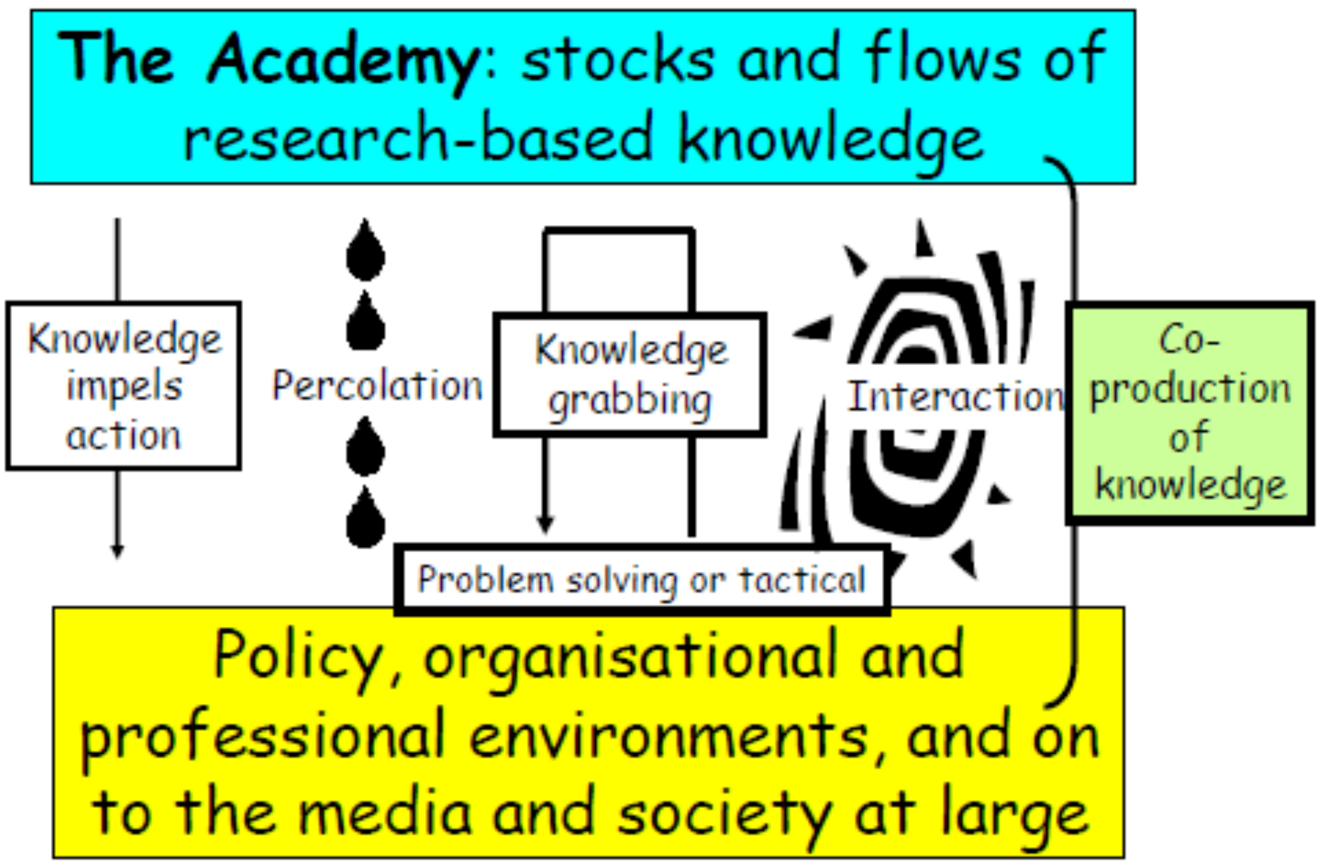
Implications on knowledge

	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

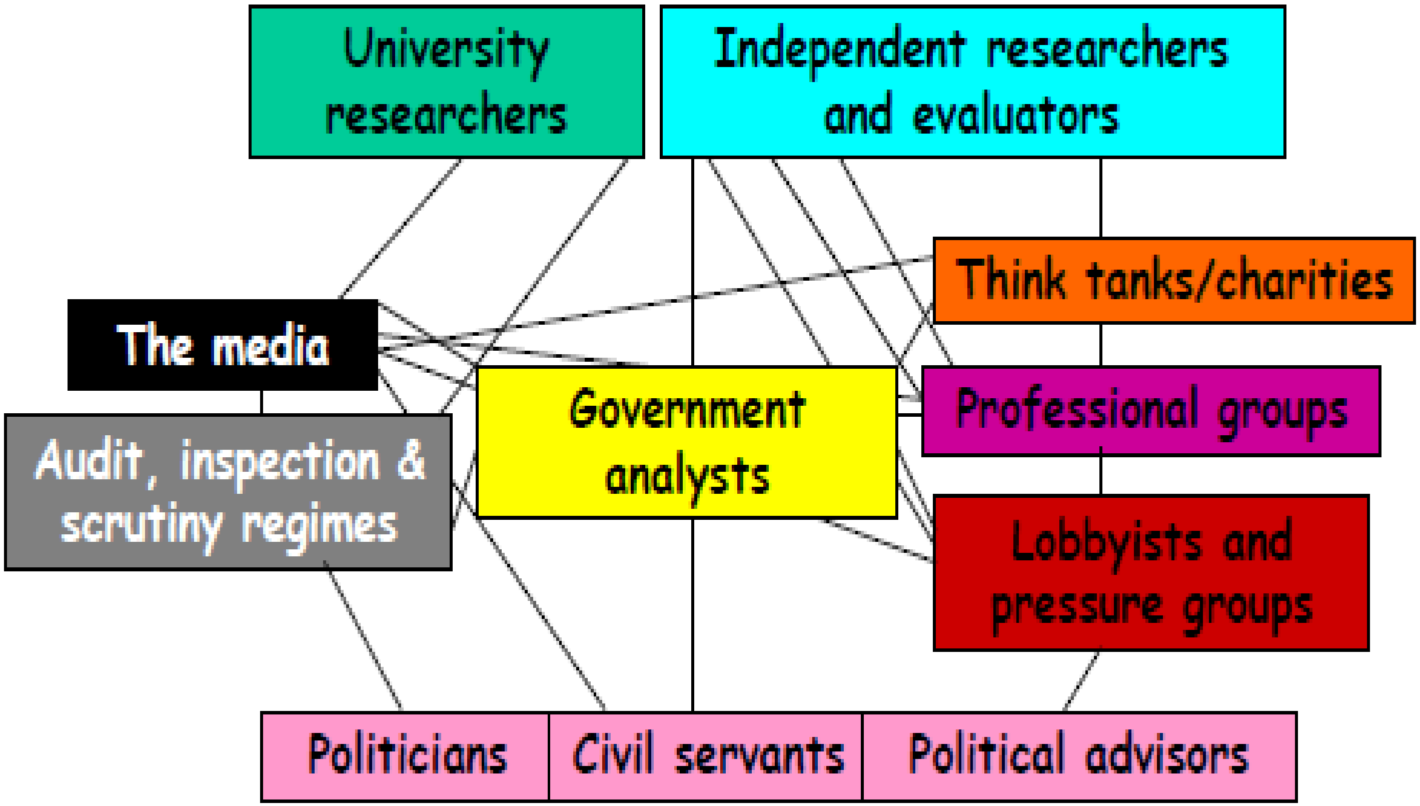
How to increase the usage of evaluations beyond CMFs Crash Modification Functions

	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**

Many different ways of ‘using’ research:



The many actors and the complexity of the policy networks



Sandra Nutley and al. Using Evidence

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

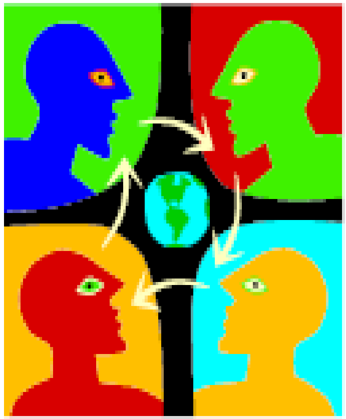
- ***Know-about (problems):*** e.g. the nature and formation of social problems.
- ***Know-why (requirements of action):*** relationship between values & policy/practice.
- ***Know-how (to put into practice):*** e.g pragmatic knowledge about implementation.
- ***Know-who (to involve):*** e.g. building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

Need research evidence and other knowledge to address these issues

Sandra Nutley

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

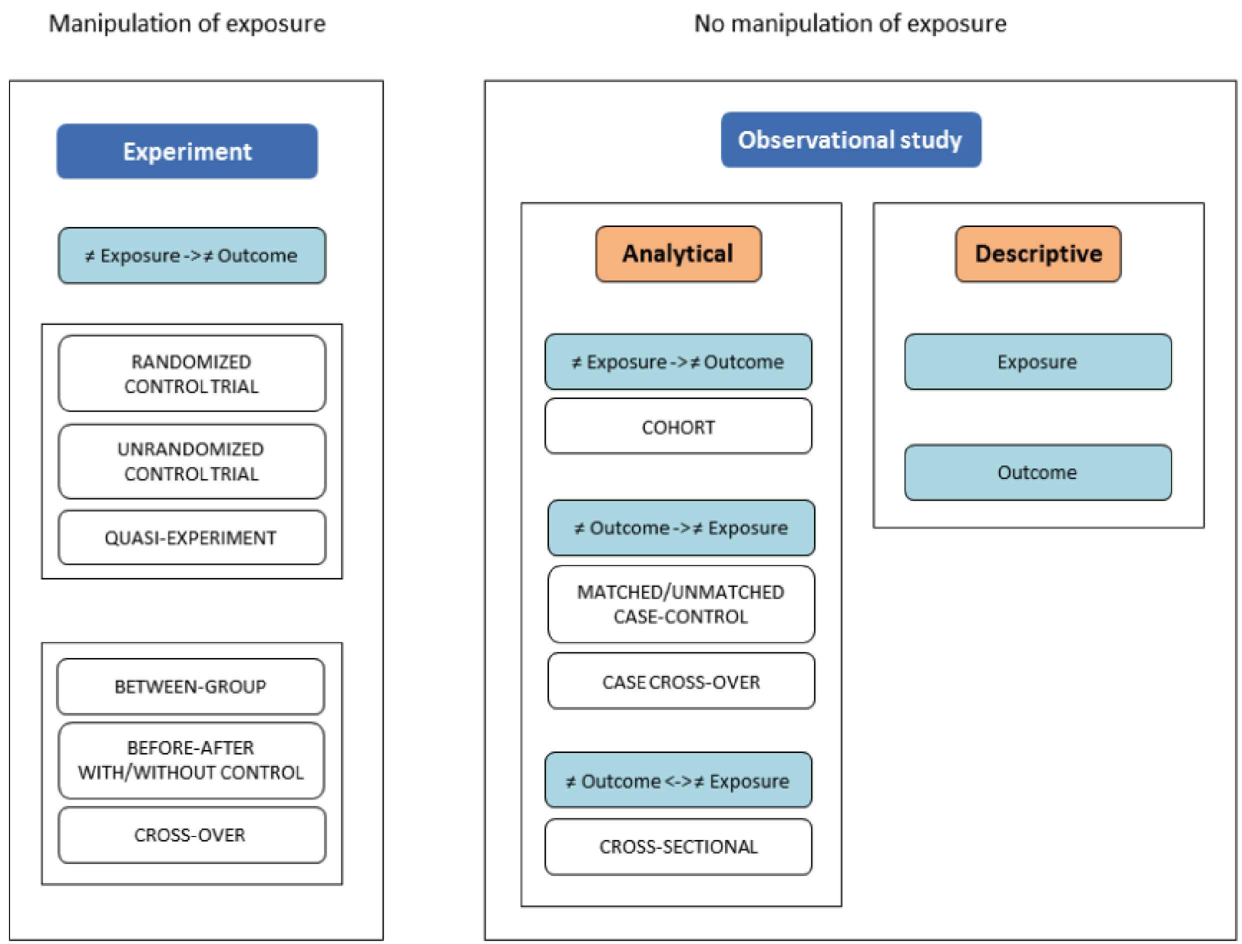
Need for systematic review and meta-analysis

- A systematic review aims to provide a complete, exhaustive summary of current literature relevant to a research question. often, but not always, use statistical techniques (meta-analysis) to combine results of eligible studies
- Not flat
  - Big Names (+ Followers (detailed) + Contradictors)
    - For seat belt effectiveness in the US : L. Evans (+ H. Joksch) in the 1980s, 90s , P. Cummings in the 2000s
  - Big Data (FARS, …)
  - Big Methods
  - Big Results

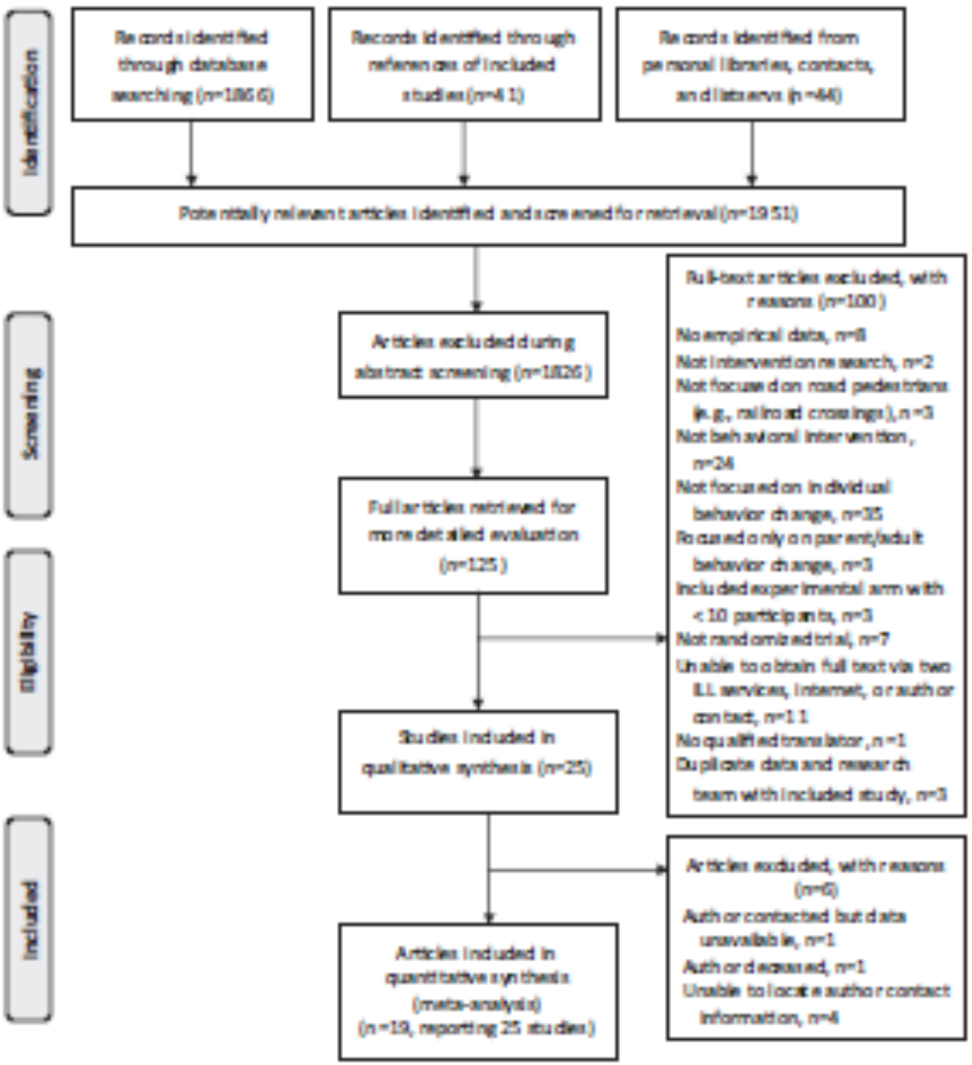
- The job of a multidisciplinary and intergenerational team

Study designs in risk analysis and evaluation of countermeasures

- Simulators
- Test tracks
- Crash tests
- Quasi-experimentations
- Observations



Processing litterature automated/manual



Text Mining

Contentmine

The rigth to read is the rigth to mine

Standardisation

Systematic Review and Meta-Analysis of Behavioral Interventions to Improve Child Pedestrian Safety

David C. Schwebel,[1] PhD, Benjamin K. Barton,[2] PhD, Jiabin Shen,[1] MEd, Hayley L. Wells,[1] BA, Ashley Bogar,[2] BS, Gretchen Heath,[2] BS, and David McCullough,[2] MS

Cochrane Collaboration

- **Intervention reviews** assess the benefits and harms of interventions used in healthcare and health policy.
- **Diagnostic test accuracy reviews** assess how well a diagnostic test performs in diagnosing and detecting a particular disease.
- **Methodology reviews** address issues relevant to how systematic reviews and clinical trials are conducted and reported.
- **Qualitative reviews** synthesize qualitative and quantitative evidence to address questions on aspects other than effectiveness.
- **Prognosis reviews** address the probable course or future outcome(s) of people with a health problem.
- **Overviews of Systematic Reviews (OoRs)** are a new type of study in order to compile multiple evidence from systematic reviews into a single document that is accessible and useful to serve as a friendly front end for the Cochrane Collaboration with regard to healthcare decision-making.

- The Cochrane Collaboration provides a handbook for systematic reviewers of interventions which "provides guidance to authors for the preparation of Cochrane Intervention reviews."The *Cochrane Handbook* outlines eight general steps for preparing a systematic review:
- Defining the review question(s) and developing criteria for including studies
- Searching for studies
- Selecting studies and collecting data
- Assessing risk of bias in included studies
- Analysing data and undertaking meta-analyses
- Addressing reporting biases
- Presenting results and "summary of findings" tables
- Interpreting results and drawing conclusions

Systematic review

- Physical vulnerability
- Injury probability function
  - Pedestrian
  - Car occupants
- Crash tests with dummies, corpses, animals
- Accidents
- Numerical simulations

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

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

- 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

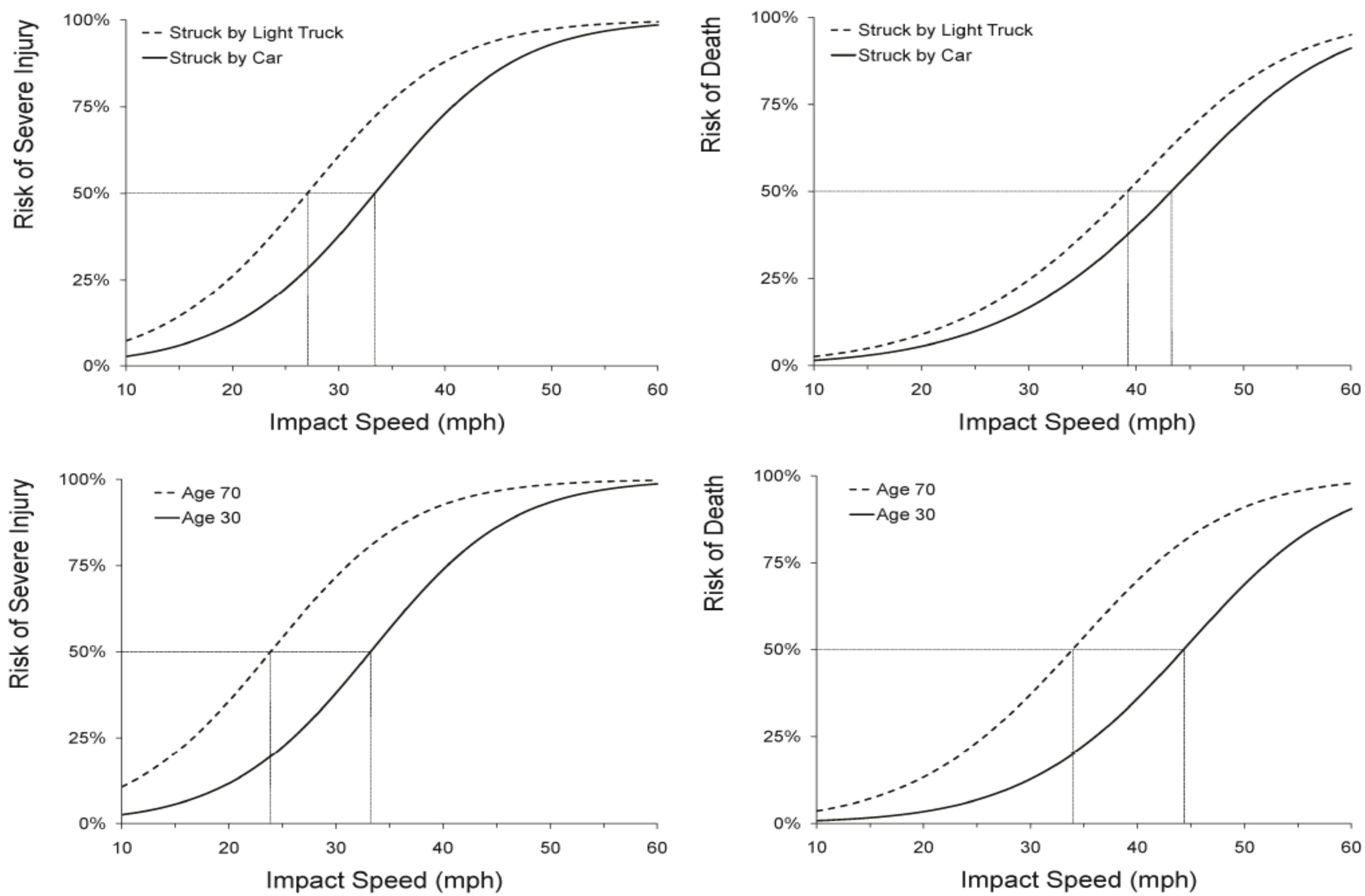


Figure 2. Risk of severe injury (left) and death (right) in relation to impact speed in a sample of 422 pedestrians aged 15+ years struck by a single forward-moving car or light truck model year 1989–1999, United States, 1994–1998. Risks are adjusted for pedestrian age, height, weight, body mass index, 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.

Table 4. Impact speed at which estimated risk of death reaches 10%, 25%, 50%, 75%, and 90%, and odds ratio for change in odds of death given 5 mph increase in impact speed, previous studies and current study.

Study	Data	Confounders adjusted	Odds Ratio (95% CI)	Risk of death (%) 10	25	50	75	90
				Impact speed (mph)				
Davis (2001)	United Kingdom, 1966-1969 & 1973-1979	None	2.78 (2.09-3.69)	33	38	43	49	54
Rosen & Sander (2009)	Germany, 1999-2007, pedestrians ages 15+ years struck by front of car	None	2.06 (1.60-2.66)	32	40	48	55	63
		Age	2.15 (1.67-2.76)	33[a]	41	48	55	63
Richards (2010)	United Kingdom, 2000-2009, pedestrians struck by front of car	None	2.41 (1.79-3.24)[b]	33	38	45	51	62
Current Study	United States, 1994-1998, pedestrians ages 15+ years struck by forward-moving car or light truck	None	1.99 (1.60-2.49)	28[c]	36	44	52	60
		Age, height, weight, BMI, vehicle type	2.18 (1.78-2.67)	30[d]	38	46	53	61
				23[e]	32	42	50	58

a. Adjusted risks for age = 45 years (mean age in sample).
b. Richards did not report standard error of odds ratio; standard error estimated using information in Table A2.2 of Richards (2010).
c. Unadjusted model, pedestrians struck by cars only, pedestrians struck by light trucks excluded.
d. Average marginal prediction for pedestrian aged 45 struck by cars, adjusted for age, height, weight, BMI, and vehicle type.
e. Average marginal predictions for pedestrians struck by cars and light trucks, standardized the distribution of age and type of striking vehicle for pedestrians struck in the United States in years 2007–2009, adjusted for age, height, weight, BMI, and vehicle type.

Tefft B. (2011) Impact speed and a pedestrian's risk of severe injury or death. AAA Foundation for Traffic Safety, Washington.

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 $[v, \infty]$
- Parametric and non parametric models and estimations
  - Proportional hazard and accelerated failure time models

Meta-analysis

- Formulation of the problem
- Search of literature
- Selection of studies ('incorporation criteria')
  - Based on quality criteria, e.g. the requirement of quasi-experimentation
  - Selection of specific studies on a well-specified subject, e.g. the use of seat belt.
  - Decide whether unpublished studies are included to avoid publication bias
- Decide which dependent variables or summary measures are allowed called the study effect size. For instance:
  - Relative risks, odds-ratios
  - Regression coefficients, elasticities
- Selection of a meta-regression statistical model: e.g. simple regression, fixed-effect meta-regression or random-effect meta-regression.

- Source : wikipedia

- Fixed-effect model

$$y_i = \beta_F + e_i,$$

where β_F is the common effect under the fixed-effects model,
and $Var(e_i) = v_i$ is the known sampling variance.
The common effect is estimated as a weighted mean by the inverse of the variances $1/v_i$

- Random-effect model

A random-effects model allows studies to have their own study-specific effect. The model for the ith study is:

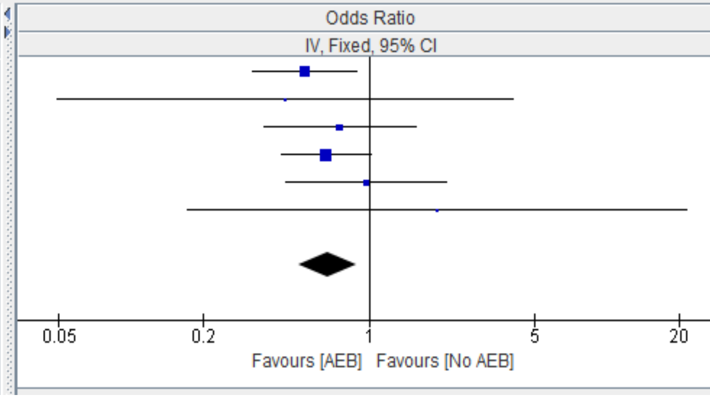
$$y_i = \beta_R + u_i + e_i,$$

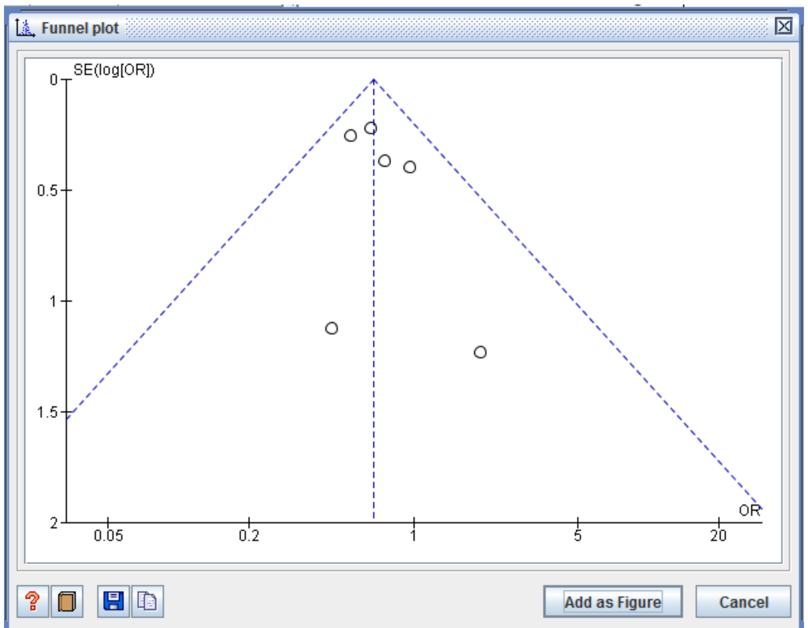
where β_R is the average population effect under the random-Effects model,and $Var(u_i) = \tau^2$ is the heterogeneity variance

Autonomous Emergency Breaking

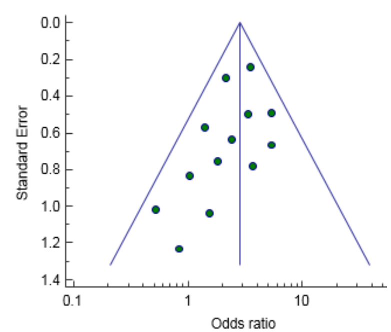
Comparison: 2 Struck or striking in head tail accident of cars with and without AEB, Outcome: 2.1 Striking car in head tail accident

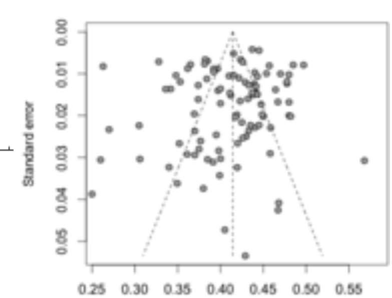
Study or Subgroup	With AEB		Without AEB		Weight	Odds Ratio
	Events	Total	Events	Total		IV, Fixed, 95% CI
Country 1	21	105	202	637	30.0%	0.54 [0.32, 0.89]
Country 2	1	5	138	384	1.6%	0.45 [0.05, 4.03]
Country 3	14	30	434	808	14.4%	0.75 [0.36, 1.57]
Country 4	35	94	404	854	39.9%	0.66 [0.43, 1.03]
Country 5	15	29	105	200	12.7%	0.97 [0.44, 2.11]
Country 6	2	3	85	167	1.3%	1.93 [0.17, 21.69]
Total (95% CI)		266		3050	100.0%	0.67 [0.51, 0.88]
Total events	88		1368			
Heterogeneity: Chi² = 2.55, df = 5 (P = 0.77); I² = 0%						
Test for overall effect: Z = 2.83 (P = 0.005)						





Manuscript	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias; all outcomes)	Incomplete outcome data (attrition bias; all outcomes)	Selective reporting (reporting bias)
Albert & Dolgin, 2010	●	○	○	○	○
Bart et al., 2008	○	○	○	○	○
Colborne, 1971	●	○	○	○	○
Cross & Pitkethly, 1991	●	○	○	○	○





Fildes, B, van Ratingen, M, Lie, A, Keall, M, Tingvall, C A (2015) new Approach to Evaluating New Vehicle Safety Technologies using Meta-Analysis Vehicle Technology ARSC conference.

Street lighting for preventing road traffic injuries
Fiona R Beyer, Katharine Ker
Motorcycle rider training for the prevention of road traffic crashes
Katina Kardamanidis, Alexandra Martiniuk, Rebecca Q Ivers*, Mark R Stevenson, Katrina Thistlethwaite
Safety education of pedestrians for injury prevention
Olivier Duperrex, Ian Roberts, Frances Bunn
Vision screening of older drivers for preventing road traffic injuries and fatalities
Ediriweera Desapriya,Rahana Harjee, Jeffrey Brubacher, Herbert Chan, D Sesath Hewapathirane, Sayed Subzwari, Ian Pike
Post-licence driver education for the prevention of road traffic crashes
Katharine Ker[1,*],Ian G Roberts[1],Timothy Collier[2], Fiona R Beyer[3], Frances Bunn[4], Chris Frost[2]
Area-wide traffic calming for preventing traffic related injuries
Frances Bunn[1,*],Timothy Collier[2], Chris Frost[2],Katharine Ker[3], Rebecca Steinbach[4], Ian Roberts[3], Reinhard Wentz[5]
Driving assessment for maintaining mobility and safety in drivers with dementia
Alan J Martin[1,*],Richard Marottoli[2], Desmond O'Neill[3]
Interventions for increasing pedestrian and cyclist visibility for the prevention of death and injuries
Irene Kwan[1,*], James Mapstone[2]
Helmets for preventing injury in motorcycle riders
Bette C Liu[1,*], Rebecca Ivers[2], Robyn Norton[3], Soufiane Boufous[2], Stephanie Blows[2], Sing Kai Lo[4]
Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries
Alison Macpherson[2], Anneliese Spinks[1,*]
The 'WHO Safe Communities' model for the prevention of injury in whole populations
Anneliese Spinks[1,*], Cathy Turner[2], Jim Nixon[3], Roderick J McClure[4]
Increased police patrols for preventing alcohol-impaired driving
Cynthia W Goss[1,*], Lisa D Van Bramer[2], Jeffrey A Gliner[3], Todd R Porter[4], Ian G Roberts[5], Carolyn DiGuiseppi[1]
School-based driver education for the prevention of traffic crashes
Ian G Roberts[1,*], Irene Kwan[2]
Graduated driver licensing for reducing motor vehicle crashes among young drivers
Kelly F Russell[1], Ben Vandermeer[2], Lisa Hartling
Interventions for promoting booster seat use in four to eight year olds travelling in motor vehicles
John E Ehiri[1,*], Henry OD Ejere[2], Lesley Magnussen[3], Donath Emusu[4], William King[5], Scott J Osberg
Helmets for preventing head and facial injuries in bicyclists
Diane C Thompson[2], Fred Rivara[1,*], Robert Thompson
Alcohol ignition interlock programmes for reducing drink driving recidivism
Charlene Willis[1,*], Sean Lybrand[2], Nicholas Bellamy
Speed cameras for the prevention of road traffic injuries and deaths (Review)
Wilson C, Willis C, Hendrikz JK, Le Brocque R, Bellamy N
Red-light cameras for the prevention of road traffic crashes (Review)
Aeron-Thomas AS, Hess S
Cycling infrastructure for reducing cycling injuries in cyclists (Started in 2014)
Caroline A Mulvaney1, Michael C Watson2, John Parkin3, Carol Coupland4, Denise Kendrick1, Philip Miller5, Sherie Smith1
Helicopter emergency medical services for adults with major trauma
Galvagno SM, Jr., Thomas S, Stephens C, et al

Effectiveness of seat belt use

Table 1
Studies of the effects of seat belt use included in meta-analysis.

	Data years	Seat belt use[a]	Contr. for crash severity	N of effect estimates	Sum of stat. weights
Studies of the effects of own seat belt use					
Angel and Hickman, 2009 (USA)	1995–2004	NA	No	3	966
Bédard et al., 2002 (USA)	1975–1998	Low	No	1	141
Braver et al., 2008 (USA)	1998–2005	Medium	Yes	1	92
Crandall et al., 2001 (USA)	1992–1997	Low	Yes	1	235
Cummings et al., 2002 (USA)	1990–2000	Medium	Yes	1	1110
Cummings et al., 2003 (USA)	1975–1983	Low	Yes	4	4357
Cummings, 2002 (USA)	1988–2000	Medium	Yes	1	82
Cummins et al., 2011 (USA)	1988–2004	Medium	No	1	672
Dissanayake and Ratnayake, 2007 (USA)	1993–2002	High	Yes	3	19
Donaldson et al., 2006 (USA)	1996–2001	Low	No	1	129
Eluru and Bhat, 2007 (USA)	2003	High	Yes	1	3
Gabauer and Gabler, 2010 (USA)	1997–2007	Medium	Yes	1	2
Jehle et al., 2012 (USA)	2000–2005	Medium	No	1	5259
Lardelli-Claret et al., 2006 (Spain)	1993–2000	High	Yes	1	26
Martin et al., 2003 (France)	1996–2000	High	Yes	5	1026
Mayrose and Priya, 2008 (USA)	2000–2003	Low	Yes	1	26
McGwin et al., 2003 (USA)	1995–2000	Medium	Yes	1	206
Meyer and Finney, 2005 (USA)	1997–2002	High	No	2	81
Rivara et al., 2000 (USA)	1993–1996	Medium	Yes	2	31
Sivak et al., 2010 (USA)	1998–2008	NA	No	1	4295
Smith and Cummings, 2006 (USA)	1990–2001	Medium	No	3	7924
Toy and Hammitt, 2003 (USA)	1993–1999	High	Yes	2	42
Yannis et al., 2010 (France, Netherlands, Italy, Finland, Sweden, UK, Germany)	2003–2004	NA	No	4	213
Zhu et al., 2007 (USA)	2000–2004	Low	No	2	972
Sum				42	27,866
Studies of the effects of others seat belt use					
Bose et al., 2013 (USA)	2001–2009	NA	Yes	1	101
Broughton, 2004 (UK)	1984–1988	NA	Yes	2	545
Cummings and Rivara, 2004 (USA)	1988–2000	Low	Yes	2	921
Ichikawa et al., 2002 (Japan)	1995–1999	NA	Yes	4	130
MacLennan et al., 2004 (USA)	1991–2002	NA	Yes	6	1381
Mayrose et al., 2005 (USA)	1995–2001	NA	Yes	1	292
Sum				15	3268

[a] Low: <50%; medium: 50–80%; high: >80%; NA: not available.

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

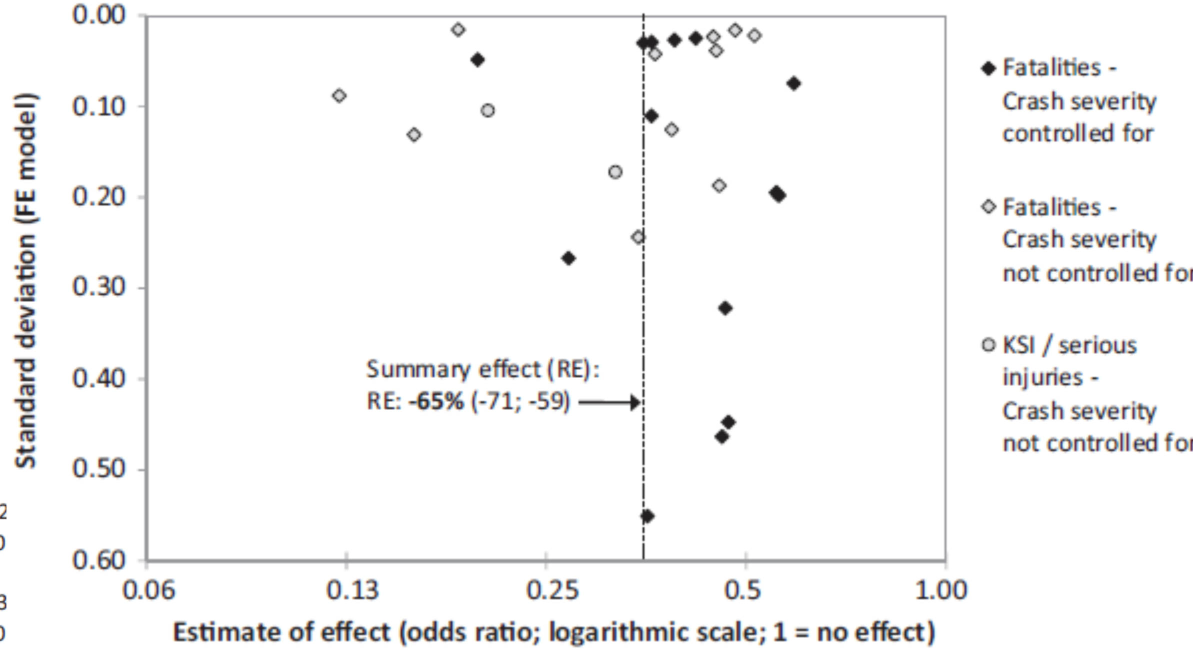


Fig. 2. Distribution of the estimates of the effect of own seat belt use on fatality risk and standard deviations, all effect estimates from all studies.

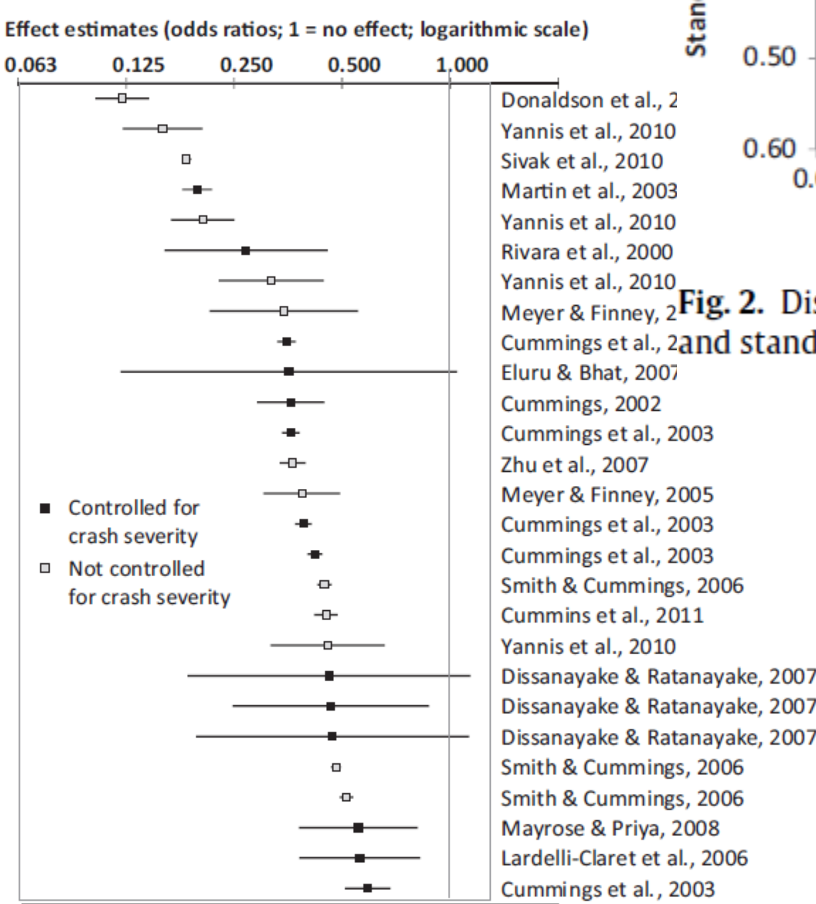


Fig. 1. Forest plot of effect estimates referring to the effect of seat belts in all crashes.

Table 3
Results from meta-analysis of the effects of seat belt use on other than fatal injuries, tests of heterogeneity, summary effects and confidence intervals (RE models unless denoted otherwise); including corresponding results for fatalities (effects at the same seating positions in the same type of crashes and with the same status of control for crash severity).

	Effect estimates		Corresponding summary effects for fatalities		
	Best est.	95% CI	df[a]	Best est.	95% CI
Effects on KSI					
Drivers (two vehicle crashes)	−63	(−80; −32)	0 (FE)	−83	(−88; −76)
All occupants (all crashes)[c]	−80	(−83; −75)	8***	−71	(−80; −56)
All front seat occupants (single vehicle crashes)[b]	−81	(−96; −6)	0 (FE)	−80	(−82; −78)
All occupants (two vehicle crashes)[c]	−88	(−89; −86)	1***	−88	(−97; −57)
Effects on serious injuries					
All occupants (all crashes)[c]	−68	(−77; −56)	8***	−71	(−80; −56)
Drivers (two vehicle crashes)[b]	−74	(−81; −65)	2**	−76	(−83; −67)
Effects on all injuries					
Drivers (two vehicle crashes)[b]	−83	(−86; −80)	2**	−76	(−83; −67)
All occupants (two vehicle crashes)[c]	−82	(−83; −81)	0 (FE)	−94	(−96; −91)
Driver/front seat passenger (frontal collisions)[b]	−53	(−59; −46)	7***	−65	(−72; −55)[d]

[a] Degrees of freedom of the test for heterogeneity; the significance of the test for heterogeneity is indicated as follows: *** if $p < .001$; ** if $p < .01$; * if $p < .05$.
[b] Crash severity controlled for.
[c] Crash severity not controlled for.
[d] Result for fatalities: all instead of frontal crashes.

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

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

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

- Conditional Odds Ratio

$$\hat{O}R_1 = \frac{b}{c}$$

Odds=p/1-p

- Marginal OR

$$\hat{O}R_2 = \frac{(a+b)(b+d)}{(a+c)(c+d)}$$

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		

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

- Still the need to synthesise by means of systematic review the results of different studies with different data sets and methods.