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Ben-Gurion University of the Negev

The Study of Crash Causation:
from Clinical Analysis to Broad-Band Transmission*

*Everything you always wanted to know but could not afford to ask

David Shinar
Ben Gurion University of the Negev

Presentation for
SHRP2 7th Safety Symposium,
Washington DC, July 12, 2012

What I plan to talk about

- Crashes, accidents and their definition
- Causes and their definitions
- The evolvement of crash causation study methods and analysis
- Culminating in the NDS approach: it's hopes, promises, and pitfalls.
- Its embodiment in SHRP2 - Safety

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What is an Accident?

An Act of God?

American Heritage Dictionary:

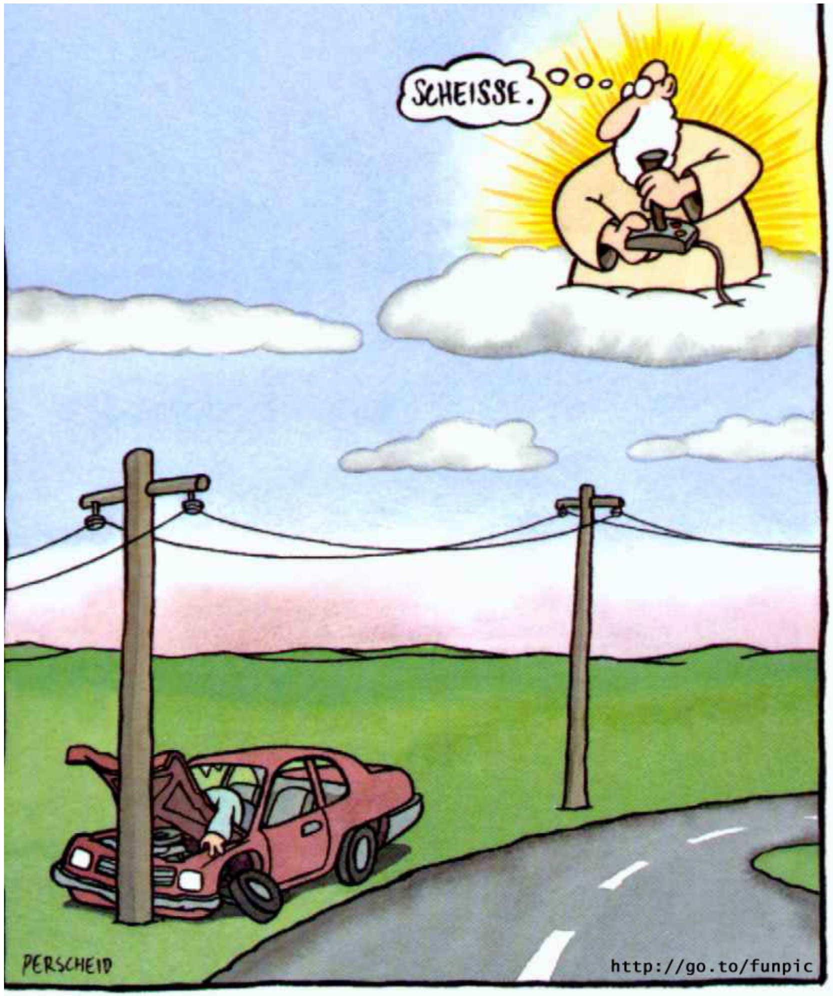
An unexpected and undesirable event, especially one resulting in damage or harm: (such as) *car accidents on icy roads…* **an unforeseen incident… (involving) lack of intention; chance"**

Oxford online dictionary:

An unfortunate incident that happens unexpectedly and unintentionally; 2. an incident that happens by chance or without apparent cause. 3 chance."

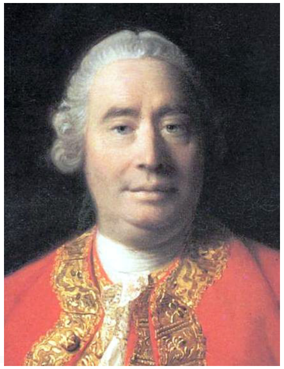
Dictionary.com

an undesirable or unfortunate happening that occurs unintentionally and usually results in harm, injury, damage, or loss;…unexpectedly, without a deliberate plan or cause… chance.



Why is a Crash ≠ Accident?

- Evans 1993 – "The word *crash indicates in a simple factual way what is observed*, while accident seems to suggest in addition a general explanation of why it occurred without any evidence to support such an explanation."
- NHTSA 1996 - "accidents imply random activity beyond human influence and control" while *crashes are "predictable results of specific actions".*
- BMJ 2001- "Accidents are not unpredictable… we are banning the inappropriate use of 'accident' in our pages… in favor of the descriptive and *more neutral terms 'crash' and 'collision'"*



What is a Cause? David Hume

(An Inquiry Concerning Human Understanding, 1748).

- We cannot deny the concept of causation, but we cannot prove it sufficiently. This is because basing causation on induction, assumes that the future will resemble the past. We have no proof for this. Inductions – unlike deductions – can at best prove probability.
  - Example; Unemployment is a good predictor of crashes (Partyke, 1984) or not (Partyke, 1991).

What is a 'cause'? John Stuart Mill. Logical contingencies for causation (1843)

1. **Method of agreement**: if a single common factor (e.g. DWI) exists in all cases where a phenomenon occurs (e.g. crash), then we can attribute the phenomenon to that factor (*necessary condition*).
2. **Method of difference**: if one set of circumstances (e.g. DWI) leads to a given phenomenon (e.g. crash) and another set of circumstances (e.g. driving sober) does not (e.g., no crash), and the sets differ only in a single factor (alcohol) that is present in the first set and not in the second set, then the phenomenon (crash) can be attributed to that factor (*sufficient condition*).

What's a 'cause'? John Stuart Mill. Logical contingencies for causation (1843)

3. **Joint method of agreement and difference**: when both conditions exist
4. **Method of residue**:–if several factors account for several phenomena and there is one phenomenon left and one factor left, then it causes it (e.g. fatigue-related fatal crashes).
5. **Method of concomitant variations**: if a set of phenomena vary in accordance with a set of factors then the latter causes it (*Dose-response relationship*).

How strong is causality in crashes?

In highway Safety Research Support for crash causation is based on:

- shaky-theory, and
- statistically-based causality.

What's a highway traffic crash Cause?

- Pat Waller's baseball umpires analogy
- Highway Safety Research Approach to crash causation depends on:
  - Who you ask: crash investigator vs. data base analyst
  - The tools you have: objective observable case details vs. interviews vs. statistical controls
  - The orientation: focus on 'why' vs. prevention

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Cause is in the Eye of the Beholder: The Oxfordshire crash data - Police

An INVESTIGATION and REPORT on FOUR YEARS' FATAL ACCIDENTS IN OXFRODSHIRE

- Study analyzed the causes of 148 fatal accidents in Oxfordshire over a 4-year period
- Definition: a contributory factor is one that had it been removed the accident would have been prevented
- Study background: according to the police "fewer than 1% of accidents are primarily due to road defects and that in only 3% of cases are road defects contributory to any degree"

Cause is in the Eye of the Beholder: The Oxfordshire crash data - Approach

- It is probably correct to say that personal error is a contributory cause in every accident other than those due entirely to "Act of God".
- Unless we are to assume that the behavior of road users is capable of being perfected, there is little significance in this statement.
- There were 146 accidents with personal error but that does not mean that the error was in the nature of gross carelessness or misbehavior.
- In many, indeed the error was such that any normal person might commit under the stress of circumstances or owing to momentary lack of attention.

Cause is in the Eye of the Beholder: The Oxfordshire crash data - Engineering

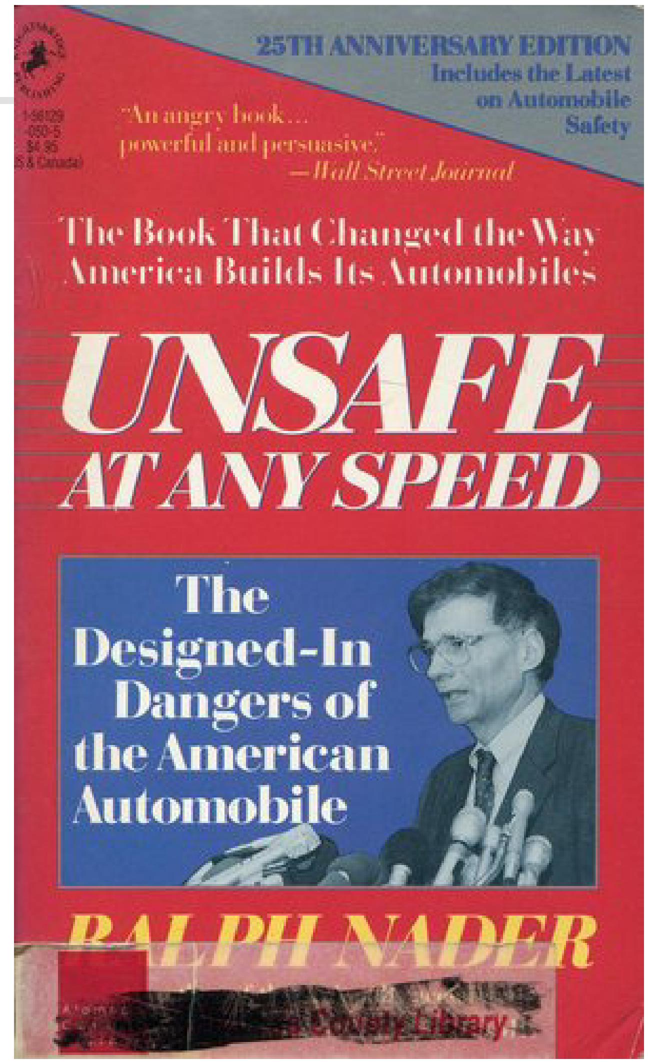
- In this analysis of 148 fatal accidents:
- ‘Ordinary’ road defects were contributory to 36% of the accidents.
- ‘Major’ road defects were contributory to another 17% of the accidents.
- ‘Major and ordinary’ road defects were contributory to 23% of the accidents.
- ‘Ordinary and/or major’ road defects were contributory to 76% of the accidents.
- *Source: M.S. Gilutz, Oxford, The Vincent Works, 1937*.

Approaches to cause attribution and causal analysis

- Theory-based clinical case analysis
- Statistical ‘theory-free’ data-base analysis and over-involvement
- Prospective in-vehicle monitoring of driver behavior.

Some background to the IU study and clinical analysis

- Unsafe at Any Speed (1965)
- Highway Safety Act - 1966: Creation of NHTSA 1970
- Naturally, the first large-scale stud
y on causes of traffic accidents focused on the safety defects of the American automobile



How the Indiana University study started

PIs: John R. Treat and Kent B. Joscelyn

DOT HS-800 850

STUDY TO DETERMINE THE RELATIONSHIP BETWEEN VEHICLE DEFECTS AND FAILURES, AND VEHICLE CRASHES
Volume 1

Contract No. DOT-HS-034-2-263
May 1973
Final Report

PREPARED FOR:
U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

Document is available to the public through
the National Technical Information Service,
Springfield, Virgina 22151

Indiana University Study: What they looking for?

Abstract:

- PROCEDURES AND TECHNIQUES DEVELOPED IN CONJUNCTION WITH A TRI-LEVEL ACCIDENT INVESTIGATION PROGRAM ARE REPORTED. INCLUDED ARE PRINCIPAL DATA COLLECTED FORMS, CRITERIA, AND INSTRUCTIONS.
- THE TRI-LEVEL INVESTIGATION PROGRAM HAS AS ITS OBJECTIVE THE IDENTIFICATION OF ALL PRE-CRASH ACCIDENT-CAUSATIVE FACTORS.
- PARTICULAR INTEREST IS *FOCUSED ON ACCURATELY IDENTIFYING THE ROLE PLAYED BY VEHICULAR FACTORS*.
- Treat, J.R. and Joscelyn, K.B.
- Contract No DOT-HS-034-2-263, 348 p. 1971-11-1

Indiana University Study: What they looking for? What did they find?

- "Human factors were implicated by far the most frequently."
- "Vehicular factors were implicated the least frequently."
- "Environmental factors were implicated to an intermediate extent."

THE IU study: Tri-Level Study of the Causes of Traffic Accidents

TRI-LEVEL STUDY OF THE CAUSES OF TRAFFIC ACCIDENTS: FINAL REPORT

VOLUME I: Causal Factor Tabulations and Assessments

Institute for Research in Public Safety
School of Public and Environmental Affairs
Indiana University
Poplars Research and Conference Center
400 East Seventh Street
Bloomington, Indiana 47401

March 31, 1977

Prepared for:
United States Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20591

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA •

Final Report
Report No. DOT-HS-034-3-535-77-TAC

Availability is unlimited. Documents may be released to the public through the National Technical Information Service, Springfield, Virginia 22151.

DOT HS-805 085

TRI-LEVEL STUDY OF THE CAUSES OF TRAFFIC ACCIDENTS: FINAL REPORT

Volume I: Casual Factor Tabulations and Assessments

J.R. Treat, N.S. Tumbas, S.T. McDonald, D. Shinar, R.D. Hume, R.E. Mayer, R.L. Stansifer, N.J. Castellan

Institute for Research in Public Safety
Indiana University
400 East Seventh Street
Bloomington, Indiana 47401

Contract No. DOT HS-034-3-535
Contract Amt. $1,531,466

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA •

PRINTED MAY 1979
FINAL REPORT

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Prepared For
U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
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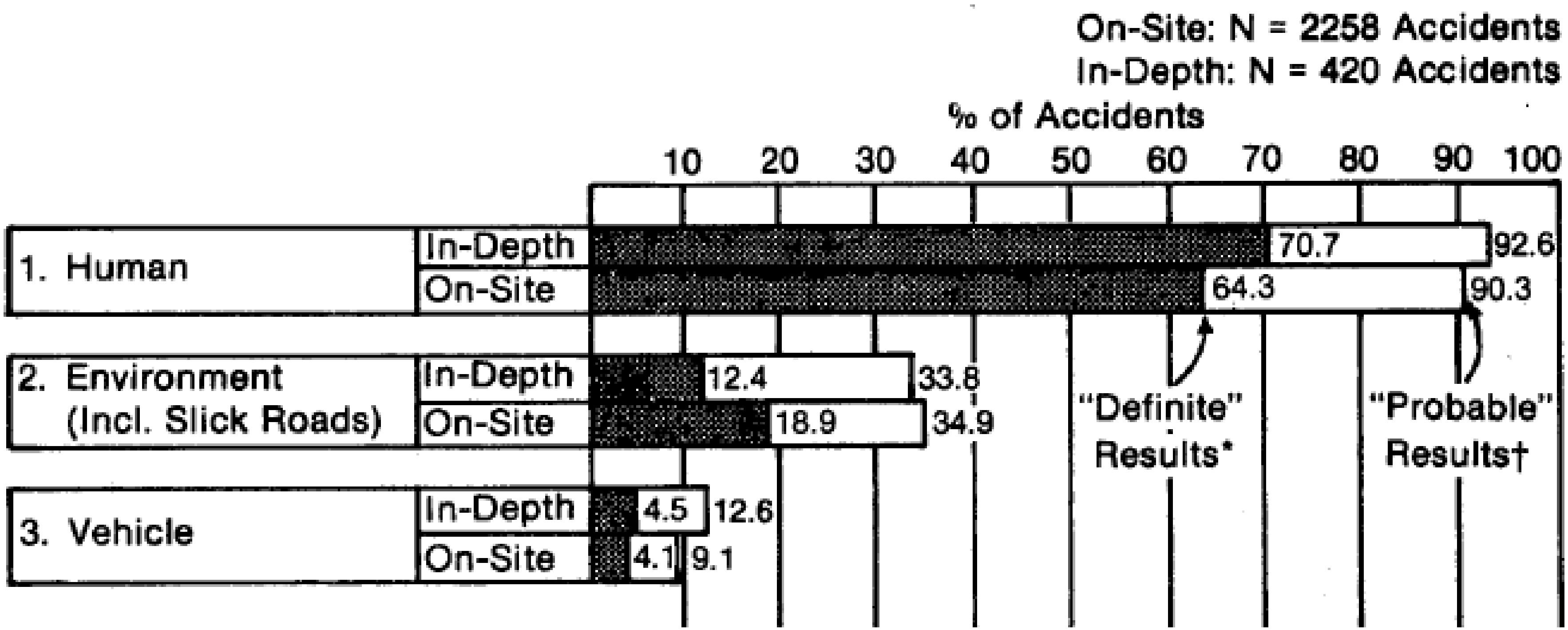
IU Study – subjective but very structured.

- Inclusion criteria: time of arrival, cooperation
- Evaluation of H E V contributions by experts
- Group decision on
  - Probability of Presence: p(p)
  - Probability o Causation given presence: p(c|p)
  - Causal attribution: p(c,p)= p(c|p)*p(p)
- Categorization
  - Definite p(c, p) = $\geq$.95
  - Probable p(c, p) = .80-.94
  - Possible p(c, p) = .20-.79

Percentage of Combined Phase II, III, IV, & V Accidents Caused by Human, Vehicular, and Environmental Factors



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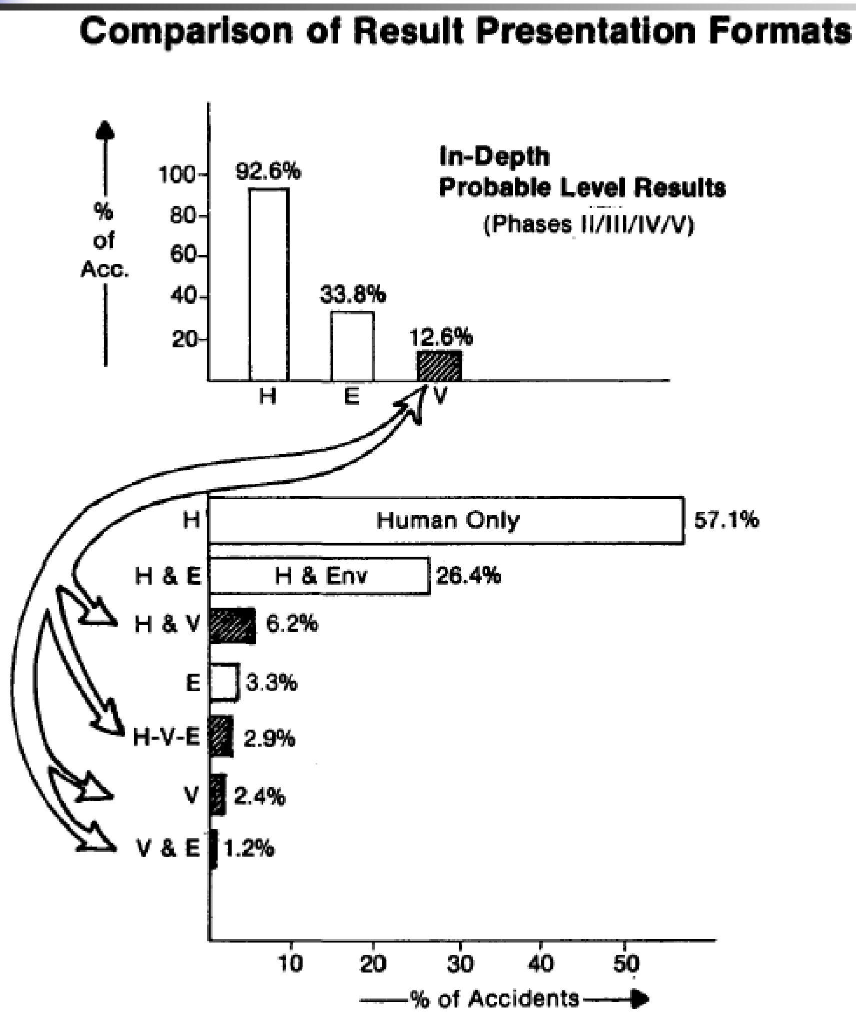
Why there are >100% of causes



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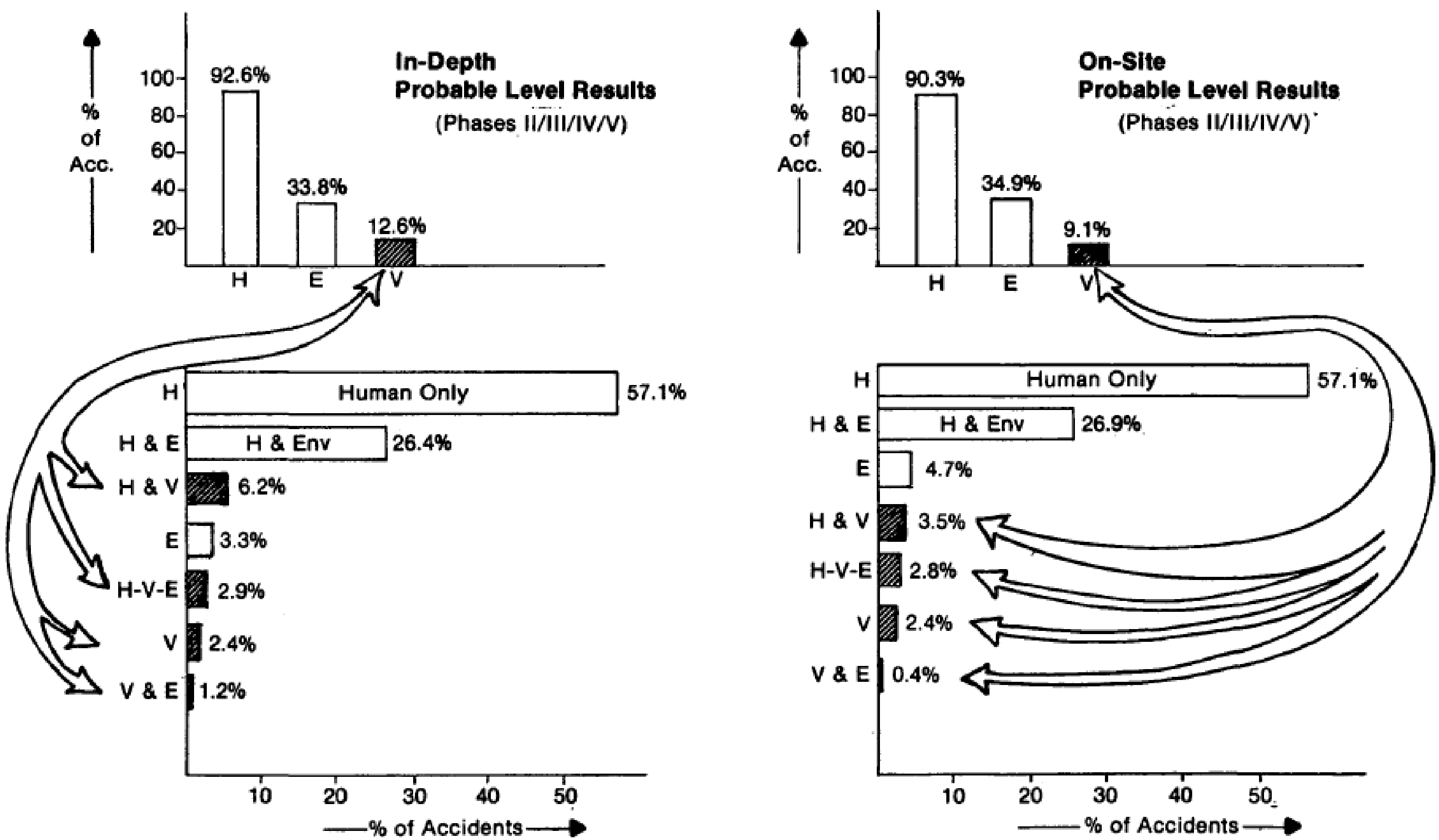
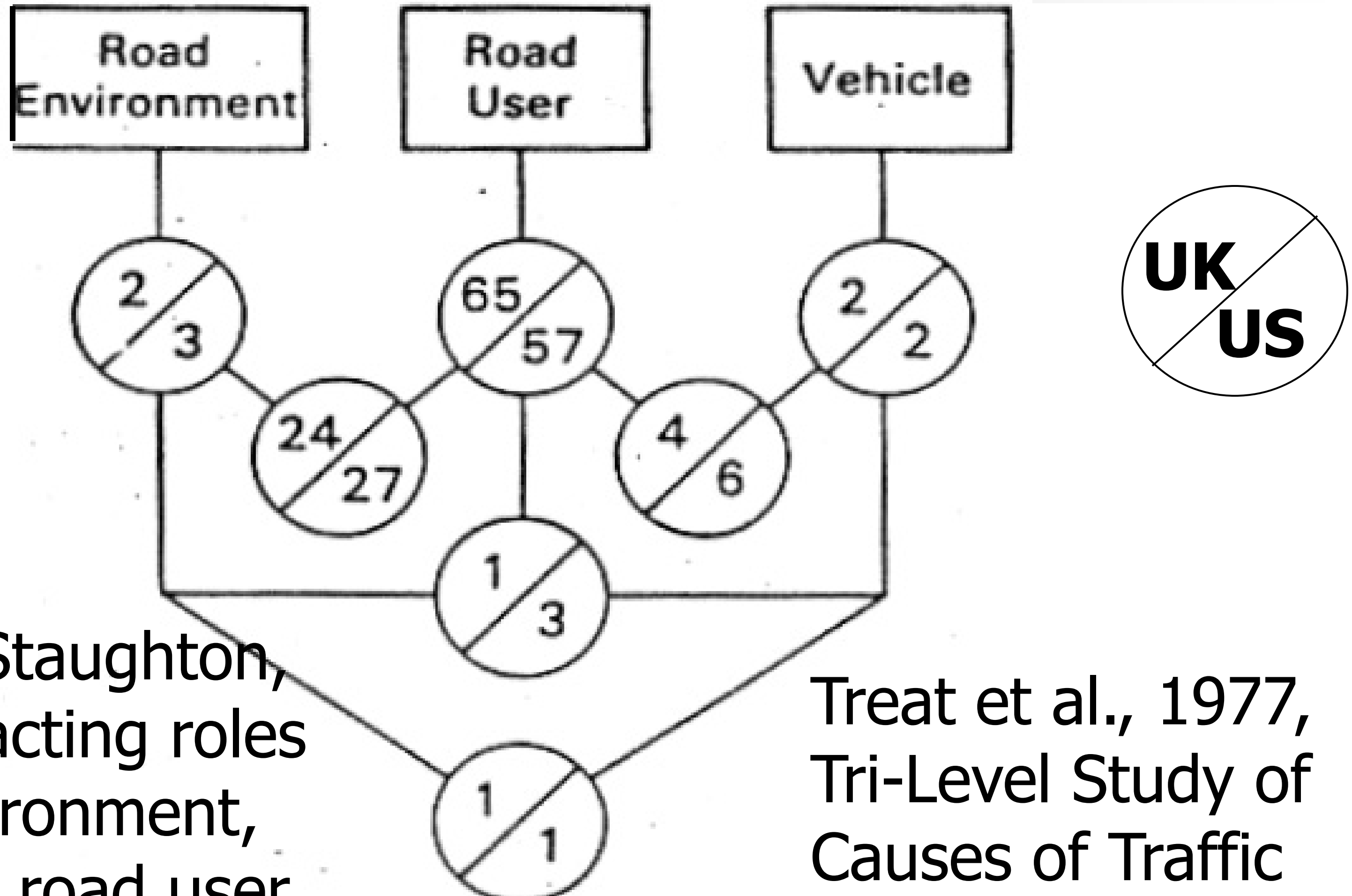
Why there are >100% of causes

Comparison of Result Presentation Formats



In-Depth Analysis: UK vs. US

(Rumar, 1985)



Sabey and Staughton, 1975, Interacting roles of road environment, vehicle, and road user in accidents.

Treat et al., 1977, Tri-Level Study of Causes of Traffic Accidents

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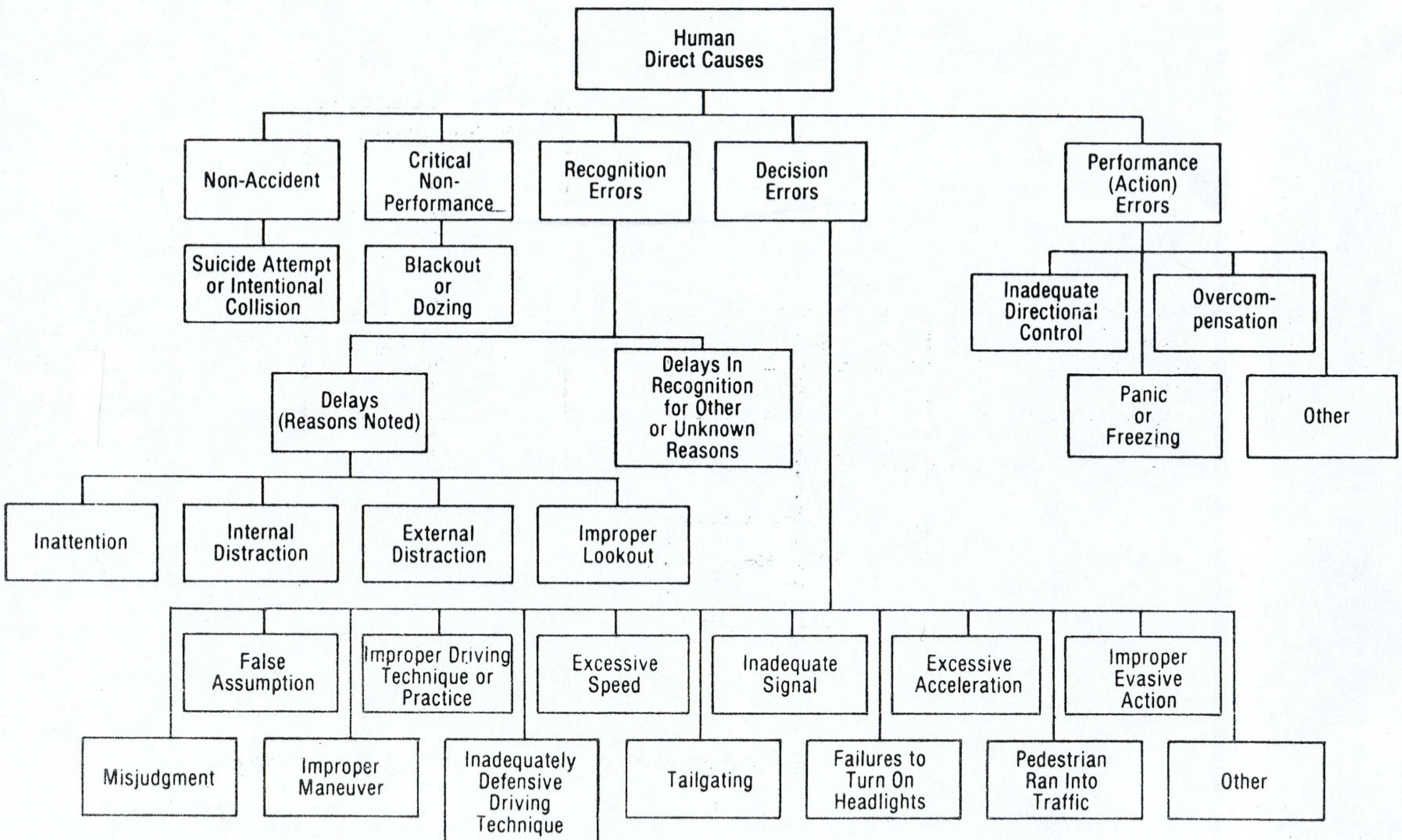
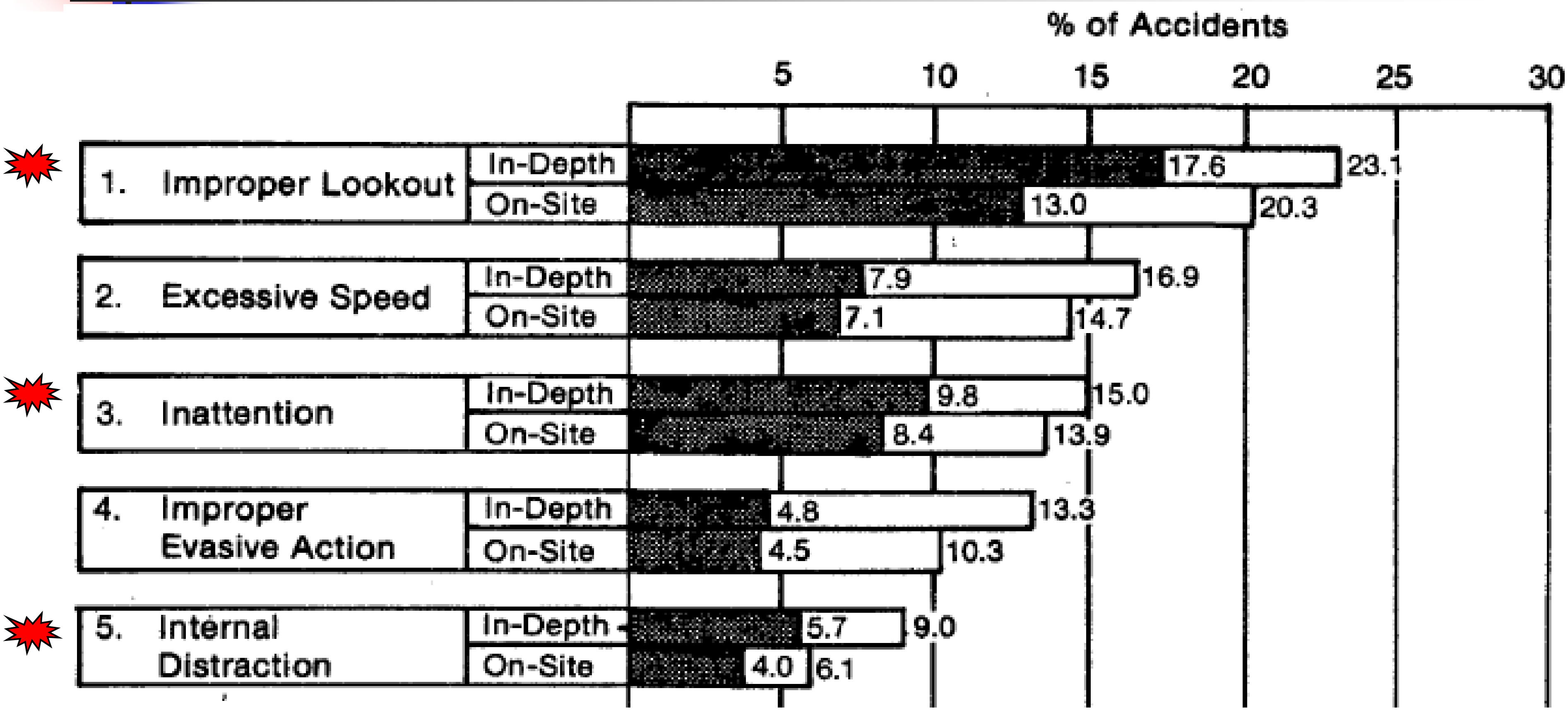
The IU Tri-Level Study Model

(Treat, Tumbas, McDonald, Shinar, Hume, Meyer, Stansifer, and Castellan, 1977)

Causal Factor Tree for Human Direct Causes



IU Study: Top 5 Specific Direct Human Causes (Phases II-V)



Total crashes caused by inattention (including 4.3% external distraction) = 51.4%

Human Direct Causes – Top 10: Definitions

Category	Definition
Improper Lookout	Delayed recognition due to failure to perform an adequate visual search in a situation that requires a distinct visual surveillance (e.g., in intersections and pulling out of a parking space)
Excessive Speed	Speed that is excessive relative to the traffic, roadway, and ambience conditions – regardless of the legal speed limit
Inattention	Delayed recognition due to preoccupation with irrelevant thoughts r wandering of the mind
Improper Evasive Action	Failing to take an emergency action that is apparent and within the capabilities of an adequately trained and alert driver (e.g., locking the brakes and as a result loosing control of the car, in a situation where steering could have prevented the accident)
Internal Distraction	Delayed recognition due to an attentional shift to an event, activity, object, or person within the vehicle
Improper Driving Technique	Engaging in an improper control of vehicle path or speed, in an habitual maneuver (e.g., cresting hills while driving in the center of the road)
Inadequately Defensive Driving Technique	Unnecessarily placing the vehicle in a position where there is a foreseeable and substantial risk of collision if another driver performs contrary to normal expectorations, or failing to check that another driver is not engaged in such an unexpected action
False Assumption	Taking action on the basis of an assumption that is not valid – even if it is based on the traffic system rules (e.g., pulling in front of a driver who is signaling a turn but dos not in fact turn)
Improper Maneuver	Willfully choosing a vehicle path that is wrong, since it increases the chance of a collision (e.g., turning from the wrong lane, driving the wrong way in a one-way street)
Overcompensation	Improper reactions to emergency situations that cause loss of control, such as overbraking or oversteering (e.g., oversteering back into the highway after going off into the road shoulder)

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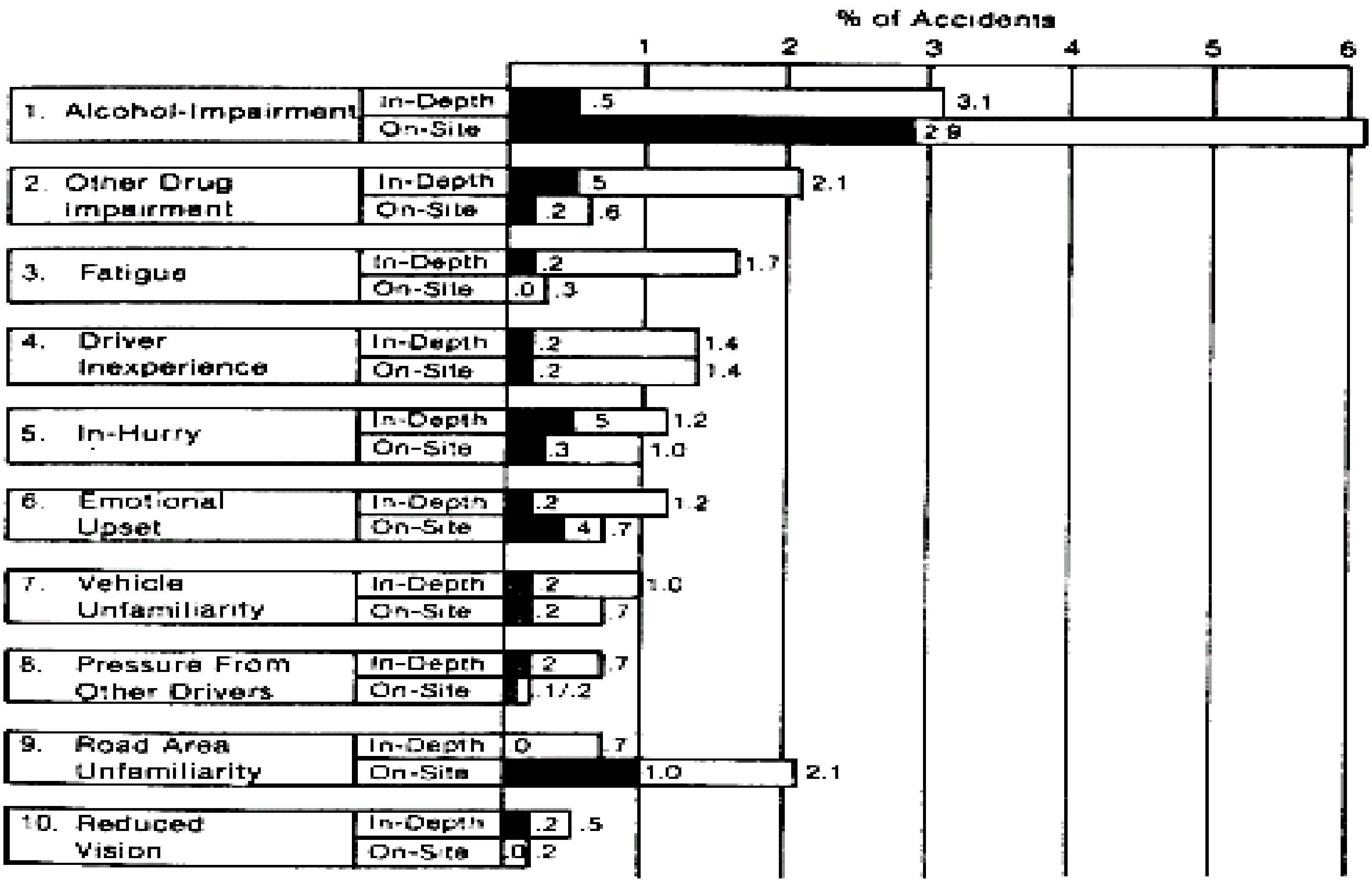
IU Study: Human Conditions and States in Percent of Accidents



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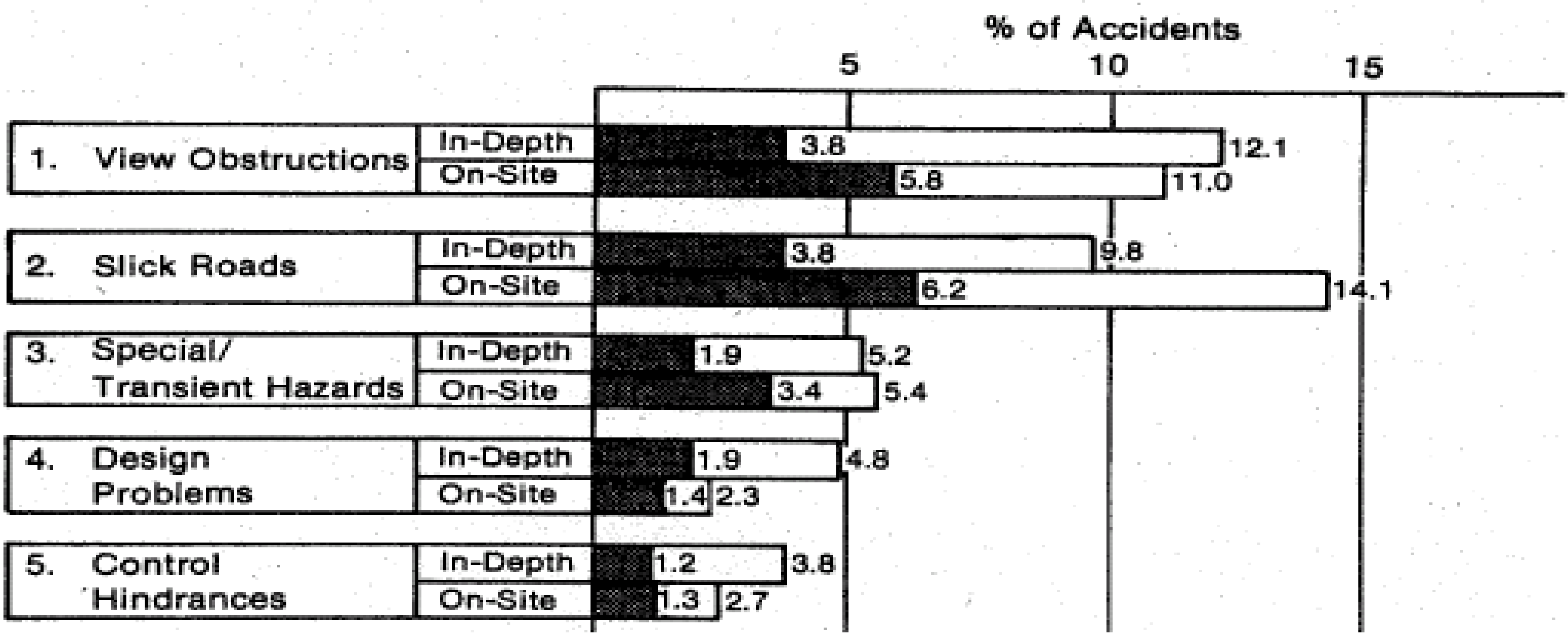
IU Study: Environmental Causes

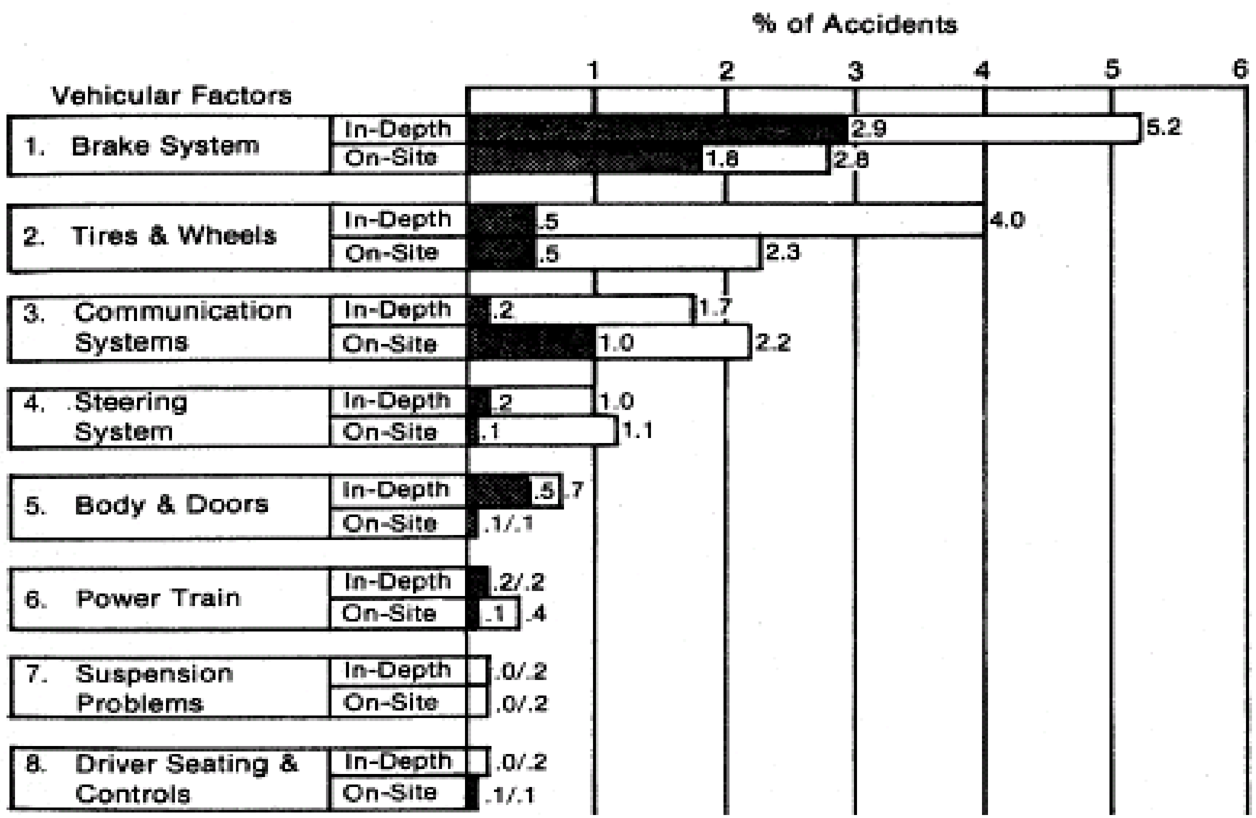
Percentage of Combined Phase II, III, IV, & V Accidents Caused by Specific Environmental Causal Factors



IU Study: Vehicular Causes

Figure 3-9

Percentage of Combined Phase II, III, IV, & V Accidents Caused by Deficiencies in Major Vehicular Systems



What has been done since the IU study?

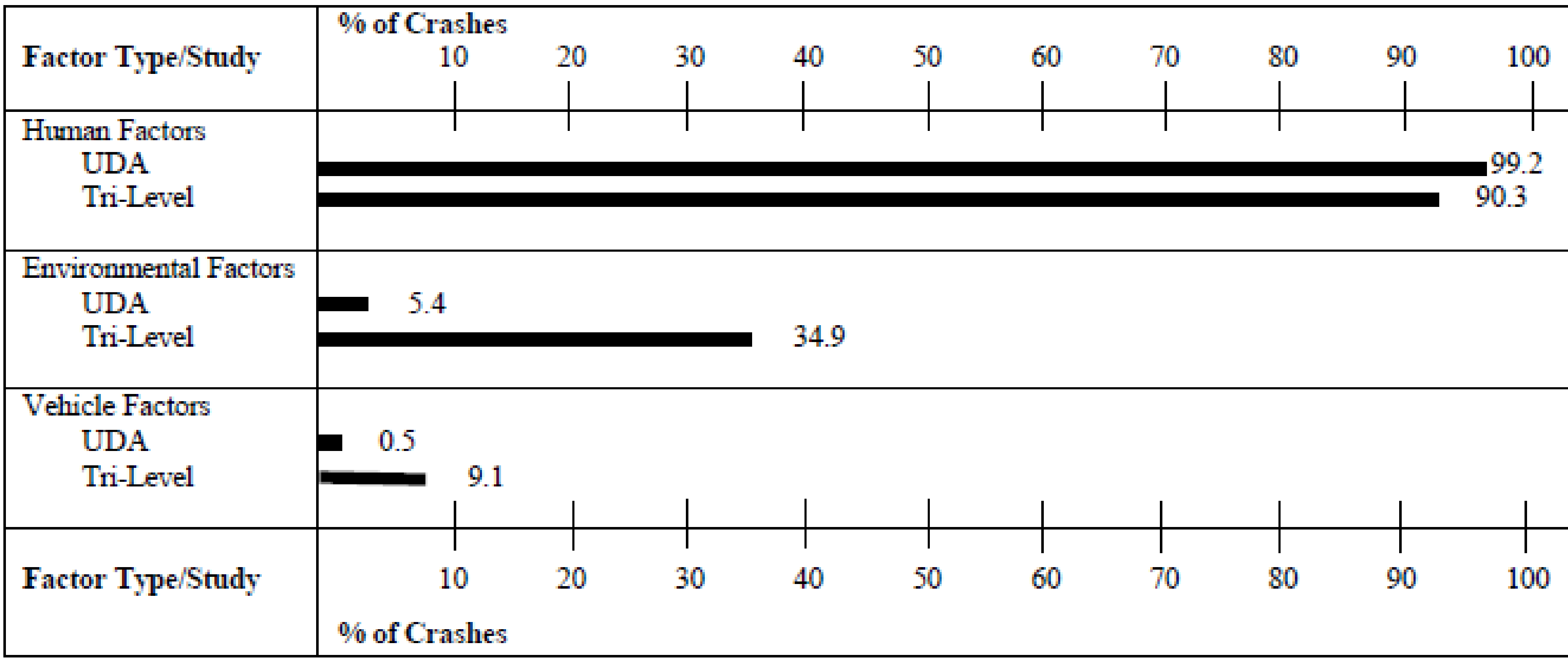
- The Unsafe Driving Acts (UDA) study - 1999
- The National Motor Vehicle Crash Causation Study (NMVCCS) - 2008

Unsafe Driving Acts (UDA) Study

(Freedman, Fell, and Hendricks, 1999)

- NASS Special Study
- 12-Months data: April 1996- March 1997
- 1284 Drivers involved in 723 Crashes
- Special Study form added to on-site investigation included 78 Unsafe Driving Acts
- Research Team added 13 more.

Unsafe Driving Acts Study vs. Tri-Level Study (Hendricks, Freedman, Zador, Fell, 2001)



UDA Study: Most Frequent Causes

23%

15%

Causal Category	Assignment Level	% of Drivers Contributing To Causation (10 / 20 / 30)
DRIVER INATTENTION	Primary (Sole Factor)	16.7
	Primary (In Combination)	5.2
	Contributory	0.8
Total		**22.7**
VEHICLE SPEED	Primary (Sole Factor)	6.8
	Primary (In Combination)	3.8
	Contributory	8.1
Total		**18.7**
ALCOHOL IMPAIRMENT	Primary (Sole Factor)	6.0
	Primary (In Combination)	11.1
	Contributory	1.1
Total		**18.2**
PERCEPTUAL ERRORS (Looked, Did Not See)	Primary (Sole Factor)	8.9
	Primary (In Combination)	0.1
	Contributory	0.1
(Accepted Inadequate Gap)	Primary (Sole Factor)	6.0
Total		**15.1**
DECISION ERRORS (Turn/Cross With Obstructed View)	Primary (Sole Factor)	4.7
(Violated Red Signal)	Primary (Sole Factor)	2.6
(Attempted To Beat Phasing Signal)	Primary (Sole Factor)	2.1
(Violated Stop Sign)	Primary (Sole Factor)	0.7
Total		**10.1**

UDA vs. IU: Most Common Causes

Causal Factor Study	
Four Common Factors	
Driver Inattention: UDA	23.0
Driver Inattention/Distraction: Tri-Level	20.3
Excessive Speed: UDA	18.9
Excessive Speed: Tri-Level	14.7
Perceptual Errors: UDA	15.3
Improper Lookout: Tri-Level	20.3
Decision Errors: UDA	10.2
False Assumption: Tri-Level	11.8
Total Assignment Frequency	**UDA - 67.4%** **Tri-Level - 66.8%**
Two of Six Most Frequent UDA Factors	
Alcohol Impairment: UDA	18.4
Alcohol Impairment: Tri-Level	6.1
Incapacitated: UDA	6.5
Critical Non-Performance: Tri-Level	1.4
Total Assignment Frequency	**UDA - 29.4%** **Tri-Level - 7.5%**

NMVCCS: National Motor Vehicle Crash Causation Survey, 2008

- Rationale: "nearly 30 years have passed since the last on-scene crash causation study was conducted (the Indiana University Tri-Level Study in 1979)."
- IU study was not nationally representative
- Vehicle fleet and vehicle technologies have changed
- Driver behavior has changed due to a variety of telematics.

The NMVCCS Method (1)

- Qualifying crashes
  - Moving vehicle involved
  - One of 1^{st} 3 vehicles is light passenger car
  - Tow-away with injury
  - Police-reported
  - EMS called and police present at arrival of investigator

The NMVCCS Method (2)

- Nationally representative sample, based on NASS PSUs
- 6,950 crashes, July 3, 2005 – December 31, 2007
- On-scene investigation by trained investigators includes, interviews, vehicle + scene inspection + official records
- Over 600 variables + photos + narratives relating to driver, vehicle, environment

The NMVCCS Method (3)

- Identified pre-crash:
  - Movement - straight, negotiating curve, stopped in traffic, etc.
  - critical event – that makes the collision unavoidable
  - critical reason for that event.
- Critical Reason ≠ Cause: Only one per crash. May not reflect the cause of the crash

The NMVCCS - Results

Critical Reason	Weighted % Factors/reasons	Primarily	Followed by
Driver Errors	97%		
- Recognition	41	Inadequate surveillance	Internal Distraction
- Decision	34	Too fast for conditions	Too fast for curve
- Performance	10	Over-compensation	Poor direction control
Environmental conditions	23%	Roadway	Atmosphere
Vehicle	12%	Tires	Brakes

Summary of 4 post-hoc clinical studies of crash causation

	UK 1975	**IU 1977**	**UDA 1999**	**NMVCCS 2008**
Human	94	93	99	97
Environment	28	34	5	33
Vehicle	8	13	1	12
Total %	130	140	105	132

Causation based on ‘theory free’ statistical associations

- Rely only on observable, objectively measurable, data elements.
- Draw conclusions based on logistic regressions, relative risks, odds ratios
- Unless the conclusions rely on Hill’s requirements – and these include theory – they are likely to be spurious.

7 safeguards for Causation from Statistical Associations (Hill, 1965)

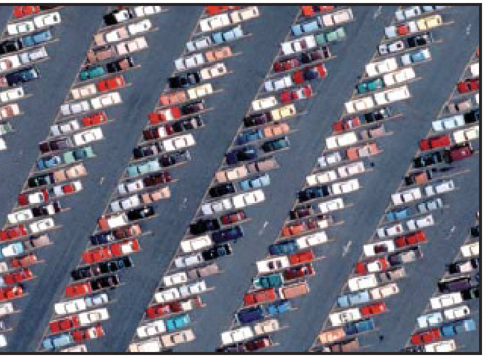
To imply causation from the observation of association we should consider seven features:

1. Strength
2. Consistency
3. Specificity – of conditions
4. Temporality – the order of events

Safeguards for Causation from Statistical Associations (Hill, 1965)

5. Biological Gradient - dose-response relationship,
6. Theoretical plausibility, and
7. Coherence – the consistency with other related phenomena.

Sir Austin Bradford Hill, past president of the British Royal Society of Medicine. (Proc. Royal Soc. Med. Section on Occupational Med., 1965, 295-300)

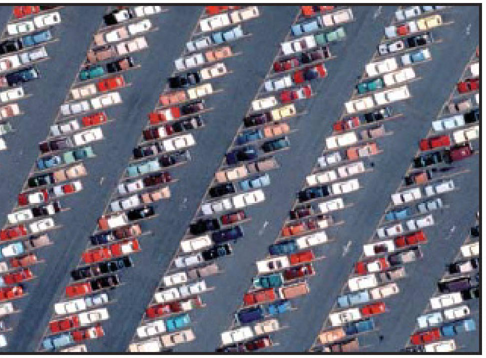


Statistical Analysis of Vehicle Color as Crash Cause (Furness, Connors, Robinson, et al. 2003)

Association of car colour with car crash injury in Auckland

Car colour	No (%) of cases(n=567)
White	145 (25.6)
Yellow	31 (5.5)
Grey	52 (9.2)
Black	36 (6.4)
Blue	91 (16.1)
Red	85 (15.0)
Green	42 (7.4)
Brown	55 (9.7)
Silver	30 (5.3)
P value	—

*Proportions of controls are adjusted for the cluster sampling design.
†Adjusted for driver's age, ethnicity, alcohol consumption in past 6 hours, seat belt use, vehicle speed, average driving time each week, driving licence status, vehicle insurance status, and weather.

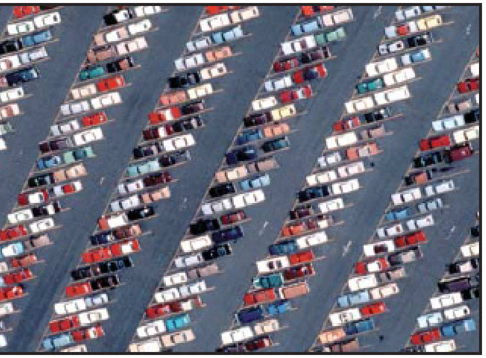


Statistical Analysis of Vehicle Color as Crash Cause (Furness, Connors, Robinson, et al. 2003)

Association of car colour with car crash injury in Auckland

Car colour	No (%) of cases(n=567)	No (%) of controls*(n=588)
White	145 (25.6)	146 (25.9)
Yellow	31 (5.5)	15 (2.8)
Grey	52 (9.2)	61 (10.0)
Black	36 (6.4)	34 (5.5)
Blue	91 (16.1)	96 (17.4)
Red	85 (15.0)	82 (13.3)
Green	42 (7.4)	44 (7.0)
Brown	55 (9.7)	49 (6.8)
Silver	30 (5.3)	61 (11.3)
P value	—	—

*Proportions of controls are adjusted for the cluster sampling design.
†Adjusted for driver's age, ethnicity, alcohol consumption in past 6 hours, seat belt use, vehicle speed, average driving time each week, driving licence status, vehicle insurance status, and weather.

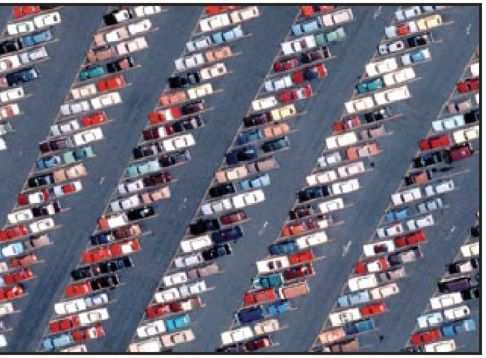


Statistical Analysis of Vehicle Color as Crash Cause (Furness, Connors, Robinson, et al. 2003)

Association of car colour with car crash injury in Auckland

Car colour	No (%) of cases(n=567)	No (%) of controls*(n=588)	Univariate odds ratio
White	145 (25.6)	146 (25.9)	1
Yellow	31 (5.5)	15 (2.8)	2.0 (1.0 to 4.0)
Grey	52 (9.2)	61 (10.0)	0.9 (0.6 to 1.5)
Black	36 (6.4)	34 (5.5)	1.2 (0.7 to 2.0)
Blue	91 (16.1)	96 (17.4)	0.9 (0.6 to 1.4)
Red	85 (15.0)	82 (13.3)	1.1 (0.7 to 1.8)
Green	42 (7.4)	44 (7.0)	1.1 (0.6 to 1.8)
Brown	55 (9.7)	49 (6.8)	1.4 (0.8 to 2.5)
Silver	30 (5.3)	61 (11.3)	0.5 (0.3 to 0.8)
P value	—	—	0.04

*Proportions of controls are adjusted for the cluster sampling design.
†Adjusted for driver's age, ethnicity, alcohol consumption in past 6 hours, seat belt use, vehicle speed, average driving time each week, driving licence status, vehicle insurance status, and weather.



Statistical Analysis of Vehicle Color as Crash Cause (Furness, Connors, Robinson, et al. 2003)

Association of car colour with car crash injury in Auckland

Car colour	No (%) of cases(n=567)	No (%) of controls*(n=588)	Univariate odds ratio	Multivariable odds ratio†
White	145 (25.6)	146 (25.9)	1	1
Yellow	31 (5.5)	15 (2.8)	2.0 (1.0 to 4.0)	0.8 (0.3 to 2.3)
Grey	52 (9.2)	61 (10.0)	0.9 (0.6 to 1.5)	0.6 (0.3 to 1.3)
Black	36 (6.4)	34 (5.5)	1.2 (0.7 to 2.0)	2.0 (1.0 to 4.2)
Blue	91 (16.1)	96 (17.4)	0.9 (0.6 to 1.4)	0.9 (0.5 to 1.6)
Red	85 (15.0)	82 (13.3)	1.1 (0.7 to 1.8)	0.7 (0.4 to 1.4)
Green	42 (7.4)	44 (7.0)	1.1 (0.6 to 1.8)	1.8 (1.0 to 3.6)
Brown	55 (9.7)	49 (6.8)	1.4 (0.8 to 2.5)	2.1 (1.1 to 4.2)
Silver	30 (5.3)	61 (11.3)	0.5 (0.3 to 0.8)	0.4 (0.2 to 0.9)
P value	—	—	0.04	0.003

*Proportions of controls are adjusted for the cluster sampling design.
†Adjusted for driver's age, ethnicity, alcohol consumption in past 6 hours, seat belt use, vehicle speed, average driving time each week, driving licence status, vehicle insurance status, and weather.

Given consistent results from IU, UDA, and NMVCCS where to now?

- Can we do another/better Tri-Level In-Depth Multi-disciplinary study?
  - Yes, we are good at the methodology and can improve on representativeness and quality. Common worldwide
- Can we afford another such study?
  - Yes, the IU study cost was equivalent to the cost of a Chevy Impala per each in-depth investigation. 420 x 28,000 = $11,760
- Do we really want/need another study?
  - Yes. Vehicles, Environment, Drivers – have all changed

So why not a new in-depth study

- If we do anther in-depth study, will we get the same results? If yes, are the results methodology-bound?
- Could we do better without resorting to drivers' subjective recollections and researchers' subjective introspection? E.g. Use the vehicle's black box?
- Can we pick a new methodology? Yes – hence the NDS

NDS - Prospective, In-Vehicle Monitoring Approach

- Automate data recording and storage to analyze the last few seconds prior to a crash
- Obtain objective data from which behavior can be inferred
  - View scene as it was available to the driver and view the driver actions just before the crash
  - Obtain objective vehicle and roadway performance data
- But add insights from valid driver reports that can be corroborated with objective data

Are they feasible? Popular? Practical?

- They are feasible:
  - 100 Car - U.S. Study
  - PROLOGUE - EU Study
- They are popular
  - SHRP2 (U.S.A. and Canada)
  - UDRIVE
  - Beginnings in Australia and Japan
- Practical? – time will tell.

What have we learned from the 100-car study

- Crashes are rare events – especially police-reported crashes – (12 of 69 'crashes' for ~2m vehicle-miles)
- The NDS provides a within-subject case control by providing exposure/control data for every crash
- Inattention is the major human factor – 78%
  - Secondary task engagement (e.g. wireless)
  - Fatigue
  - Driving-related inattention to roadway ahead (e.g. mirrors)
  - Non-specific eye glance (towards a blank area)

Main Conclusion (for me at least)

- If we want to focus on specific types of crashes in specific circumstances, with specific types of drivers *we need a very very large sample*

IU Study vs. SHRP2

Indiana University

- Retrospective
- Clinical
- Little corroboration of driver/occupant reports
- Somewhat representative
- Very limited geographic area
- Detailed environmental data – but missed transient cues
- No exposure data

SHRP2

- Prospective
- Statistical
- Relies mostly on “hard” vehicle based recordings
- Skewed/biased
- Much greater and more varied catchment area
- Detailed environmental data – with transient cues
- Exposure data can be gotten from same drivers

IU vs. SHRP: study questions

- I.U. – What are the causes of highway traffic accidents?
- SHRP2 >400 questions related to the role of:
  - Road departure – e.g., how frequent are they for various sets of roadway variables?
  - Intersection – e.g., how do traffic control devices influence braking?
  - Driving performance - e.g., how is it affected by fatigue, topography, visual and auditory distraction, etc.?
  - Interactions with advanced vehicle technology -

IU vs. SHRP: clinical insights vs. objective derivations

- IU – Independent variables (e.g., inattention) → Dependent measures (crashes). Key data reduction was a mental subjective group effort that generated psychologically meaningful concepts
- SHRP – multiple data items → intervening variables (e.g., inattention) → dependent measure (hopefully crashes). Algorithms needed to deduce meaningful concepts

IU vs. SHRP: consider ‘looked but did not see’

- IU – Driver reported looking but not seeing – often corroborated by D2.
- SHRP - “rather than making a judgment as to where people are looking, the researchers have developed a video mask which overlays numeric coordinates on the driver’s face, which can provide objective data points relating to where the driver’s attention is focused.”

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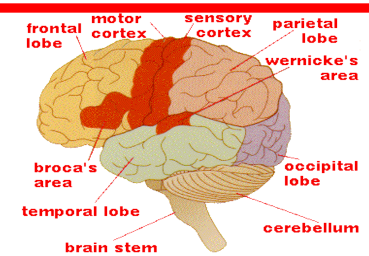
I.U. vs. SHRP - Where do expert opinions and insights come in?

	Inputs	Throughputs	Outputs
IU	Observed scene+vehicle Driver reports		Frequencies in preconceived categories
SHRP2	Recorded digital and video data		**?**

SHRP NDS – The vision

- "Both vehicle-based and infrastructure-based technologies will be used to gather pre-crash, crash, and exposure data. The data can then be analyzed and applied to safety countermeasures."
- "Naturalistic Driving Study (NDS) will allow us to record and study the driving behavior of a large sample of drivers in their personal vehicles"
  - Projected >3,900 vehicle years (~3,000 vehicles)
  - Projected ~ 150 crashes (currently 48 triggered crashes)

NDS Study Objectives

- to address the role of driver performance and behavior in traffic safety, including:
  - Developing an understanding of how the driver interacts with and adapts to the vehicle, traffic environment, roadway characteristics, traffic control devices, and the environment.
  - Assessing the changes in collision risk associated with each of these factors and interactions.
- This information will support the development of new and improved countermeasures with greater effectiveness.

SHRP2 NDS data expectations

- Amount expected to exceed 1 petabyte (million gigabytes).
- Will provide a wealth of information regarding driving behavior, lane departures, and intersection activities,
- Should be relevant to transportation safety researchers for at least 20 years
- But there will be access ‘issues’

NDS Analysis

- analyze the data to quantify the contribution of relevant driver, roadway, vehicle, and environmental factors to the research questions selected and assess the countermeasure implications of the findings

Biggest challenges to SHRP2

- Sample bias – safety-oriented older volunteers
- Sample size – too few crashes
- Data reduction – May be different for different questions. ‘Chunking’ is suggested by specific relevant conditions.
- Dissemination to stakeholders - “researchers, manufacturers, and lawmakers”.
  - Data base is complex
  - Privacy issues abound.

Added value of NDS

- Almost 40 years later – all has changed
  - Cars are different (e.g., IIHS '59 Chevy Bel Air vs. '09 Malibu)
  - Infrastructure has changed (e.g., medians, traffic circles)
  - Traffic mix has changed (more pedestrians, cyclists)
  - Drivers have Changed too: safety oriented, uses belts, refrains from DWI, but time-shares, and goes as fast as ever.
- Things not considered before:
  - What if we find the same things? We will understand them better and plan better countermeasures
  - What if we don't find the same things?

Where can we expect the 'big' payoff relative to *driving behavior*?

- Not just in understanding crashes, but in understanding driving *behavior* in specific contexts and with specific vehicle systems - which is >99% of the time we are on the road.
- We can study:
  - Risky driving
  - Adjusting to adverse weather and road conditions,
  - Driving styles of men and women of different ages
  - Impact of new technologies on behavior
  - Driving while impaired
  - Inattention in more details than ever before

Where can we expect the 'big' payoff relative to *driving performance?*

- In understanding driving *performance under pressure:* in the context of incidents, near-crashes, and crashes.
- We can study the impact on performance of:
  - Information overload and underload
  - Unfamiliar or unexpected situations
  - Gender, age, and driving skills
  - Impact of new e-safety technologies
  - Impairments
  - Inattention in more details than ever before

The #1 human factor: inattention?
Is it increasing? Decreasing? The same?

- Inattention: due to much faster pace of life
- External distraction: electronic billboards, road-sharing with other vehicle types (that are less conspicuous), and multi-modal road sharing
- Internal distraction: infotainment systems
- Reduced alertness: due to more autonomous vehicles (e.g. parking), increase in collision warning and avoidance systems

But it's certainly not new

- Remember the Oxfordshire report from 1937:
  - "In many, indeed the error was such that any normal person might commit under the stress of circumstances or owing to momentary lack of attention"
- SHRP may just give us the key to coping with it.

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THANK YOU

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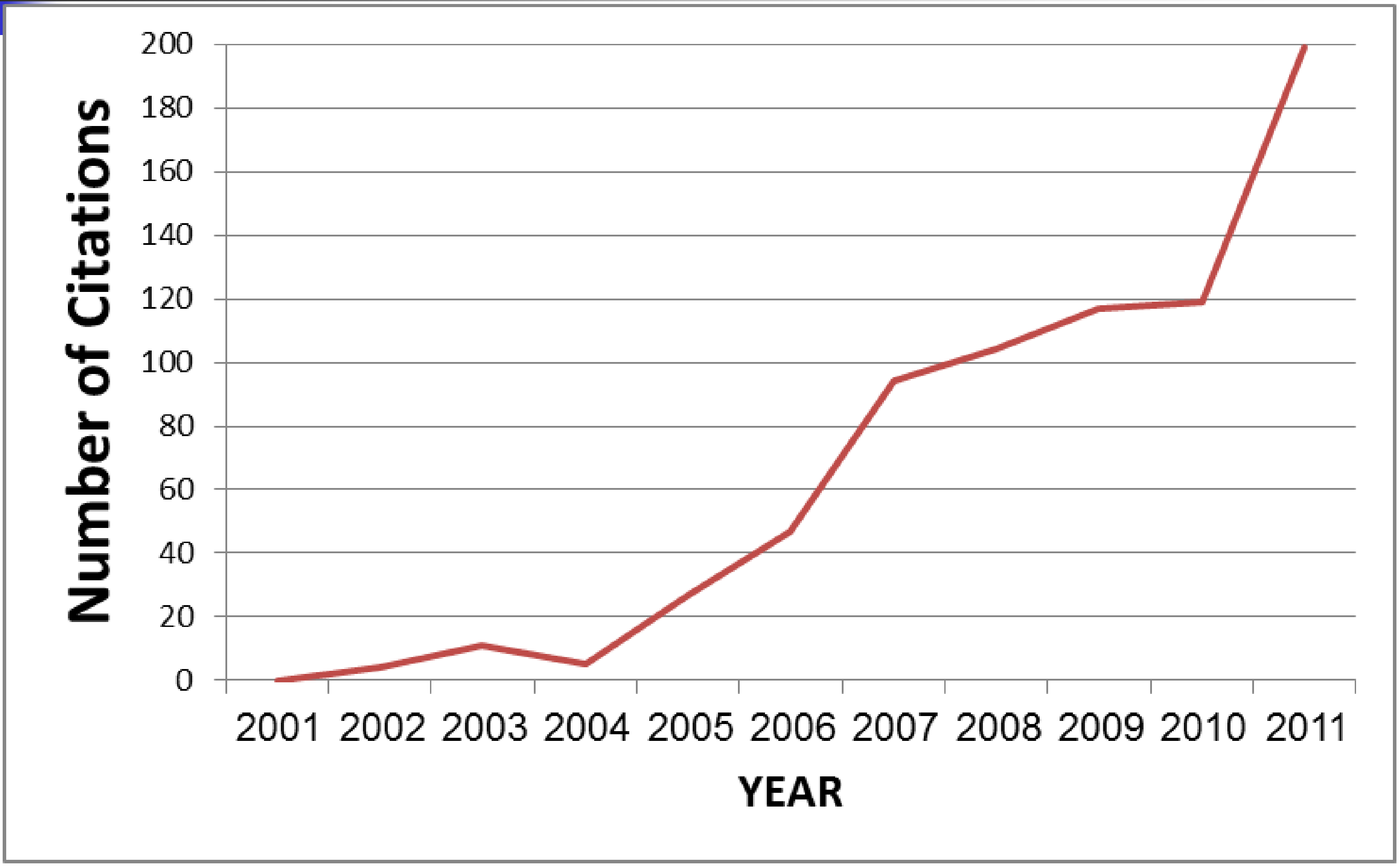
The growth of the "naturalistic driving study" – citations in www.scholar.google.com



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Crash as a function of ‘circumstances’ and ‘lack of attention’/ human resource allocation (from Blumenthal, 1968)