

# Laws of accident causation

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# Multiple theories of accident causation

1. Accidents as random events
2. Accident proneness theory
3. Causal theory (in-depth approach)
4. Systems theory
5. Behavioural theory

No synthesis of these theories has emerged

# The nature of causal relationships

- Laws of nature (can be approximated as deterministic relationships – usually stated in mathematical terms)
- Agency relationships (acts of man and their precursors and consequences)
- Random (or chaotic) processes (can be modelled statistically)

# The complexity of accident causation

- All types of relationships are involved
- There is no general theory that specifies in what ways or mixtures the different types of relationships contribute
- Causal relationships are deeply random and cannot be reduced to sets of conditions that are necessary or sufficient

# Taxonomies $\neq$ theories

- Several taxonomies of factors contributing to accidents have been developed
- A taxonomy is basically only a classification of something
- A taxonomy is not a theory
- Theories are systems of testable hypotheses

# A plea for reductionism

- It is possible, but not very informative, to provide endless lists of risk factors that are associated with accidents
- It is also possible form fairly abstract and general groups of these factors
- Does this provide an explanation of accidents?

# Good explanations are general

- Ideally speaking, an explanation is a statement of a scientific law
- The possibility of giving law-like explanations in social science has long been denied or treated with considerable scepticism
- Are we forever confined to statements that are, at best, accidental generalisations?

# A basic postulate of accident theory

- If road users were always:
  - Perfectly rational, and
  - In perfect control of all hazards
- Then:
  - There would be very few serious accidents
- Therefore:
  - Accidents can always be modelled as a failure of rationality of hazard control

# Laws of physics or laws of psychology?

- Both
- I will concentrate on laws of psychology
- These laws summarise in general terms factors that limit human rationality

# Laws of accident causation

- The law of learning
- The law of the unpredictable
- The law of complexity
- The law of limited human capacity
- Laws of motion (physical laws)
- Laws of energy dissipation (physical laws)

# The logical structure of accident causes

Accident	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	C(A)
1	X		X		Y	Y						Z								5
2		X		Y		Y			Y										Z	5
3	X	X			Y				Y				Z							5
4	X	X	X				Y			Y						Z				6
5	X	X	X	Y				Y			Y									6
6	X	X	X	Y				Y							Z					6
7	X	X	X	Y					Y									Z		6
8	X	X	X		Y			Y					Z							6
9	X	X	X		Y		Y							Z						6
10	X	X	X		Y					Y										5
11	X	X	X			Y				Y										5
12	X	X	X			Y					Y							Z		6
13	X	X		Y		Y			Y									Z		6
14		X	X	Y			Y							Z						5
15	X	X	X			Y		Y			Y									6
N(A)	13	14	12	6	5	5	4	4	4	3	3	1	2	2	1	1	1	2	1	84
P(E)	12	15	12	4	4	3	2	1	2	1	1	0	0	0	0	0	0	0	0	

# Rearranging the factors contributing to accidents

Accident	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	C(A)
2		X		Y		Y			Y										Z	5
13	X	X		Y		Y			Y									Z		6
5	X	X	X	Y				Y			Y									6
6	X	X	X	Y				Y							Z					6
7	X	X	X	Y					Y								Z			6
14		X	X	Y			Y							Z						5
1	X		X		Y		Y					Z								5
3	X	X			Y				Y				Z							5
8	X	X	X		Y			Y					Z							6
9	X	X	X		Y		Y							Z						6
10	X	X	X		Y					Y										5
11	X	X	X			Y				Y										5
12	X	X	X			Y					Y							Z		6
15	X	X	X			Y		Y			Y									6
4	X	X	X				Y			Y						Z				6
N(A)	13	14	12	6	5	5	4	4	4	3	3	1	2	2	1	1	1	2	1	84
P(E)	12	15	12	4	4	3	2	1	2	1	1	0	0	0	0	0	0	0	0	

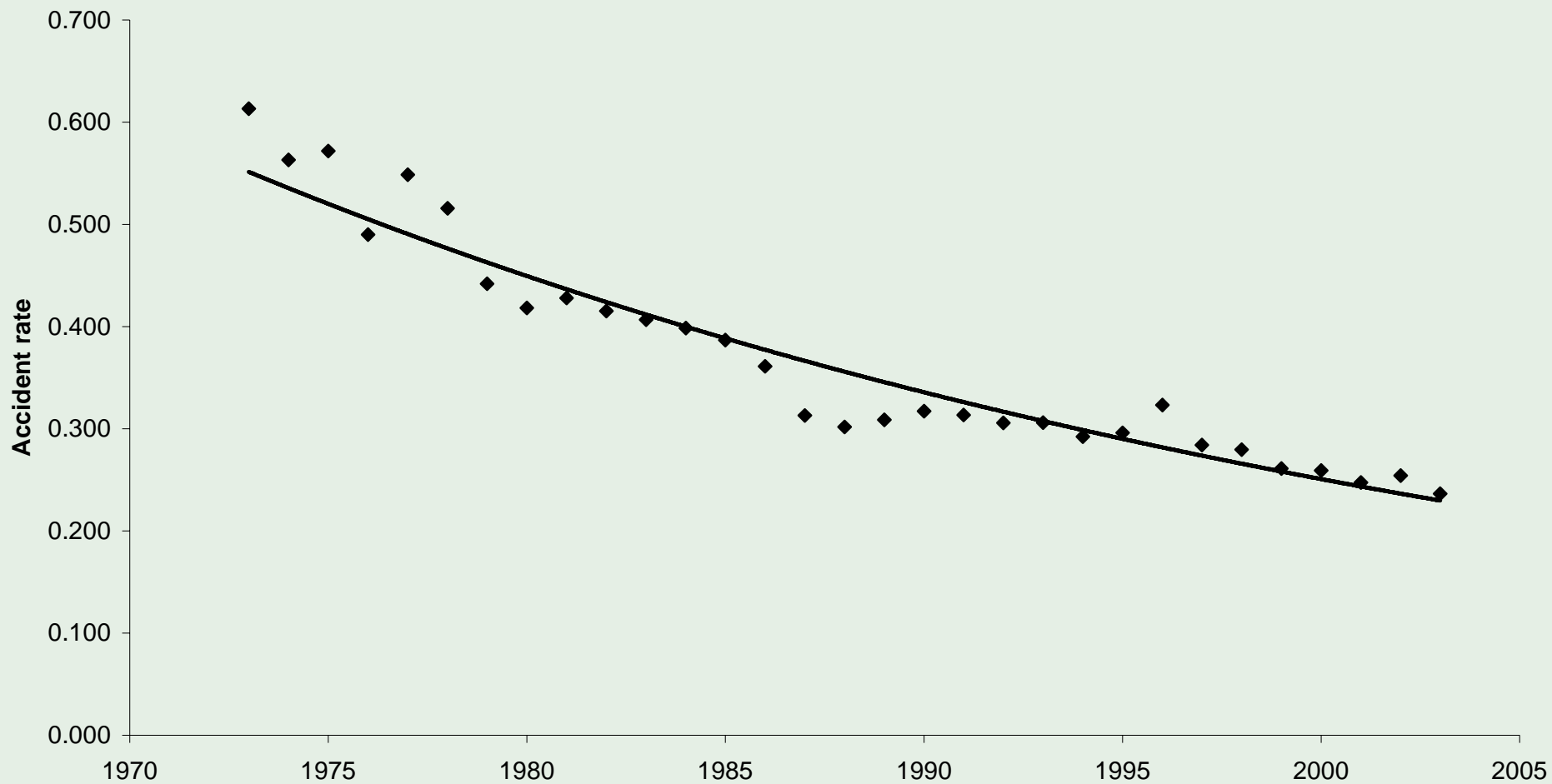
# The universal law of learning

- The rate of accidents per unit of exposure drops as exposure increases
- This holds both at the individual and the societal level
- Effects of risk factors tends to vanish

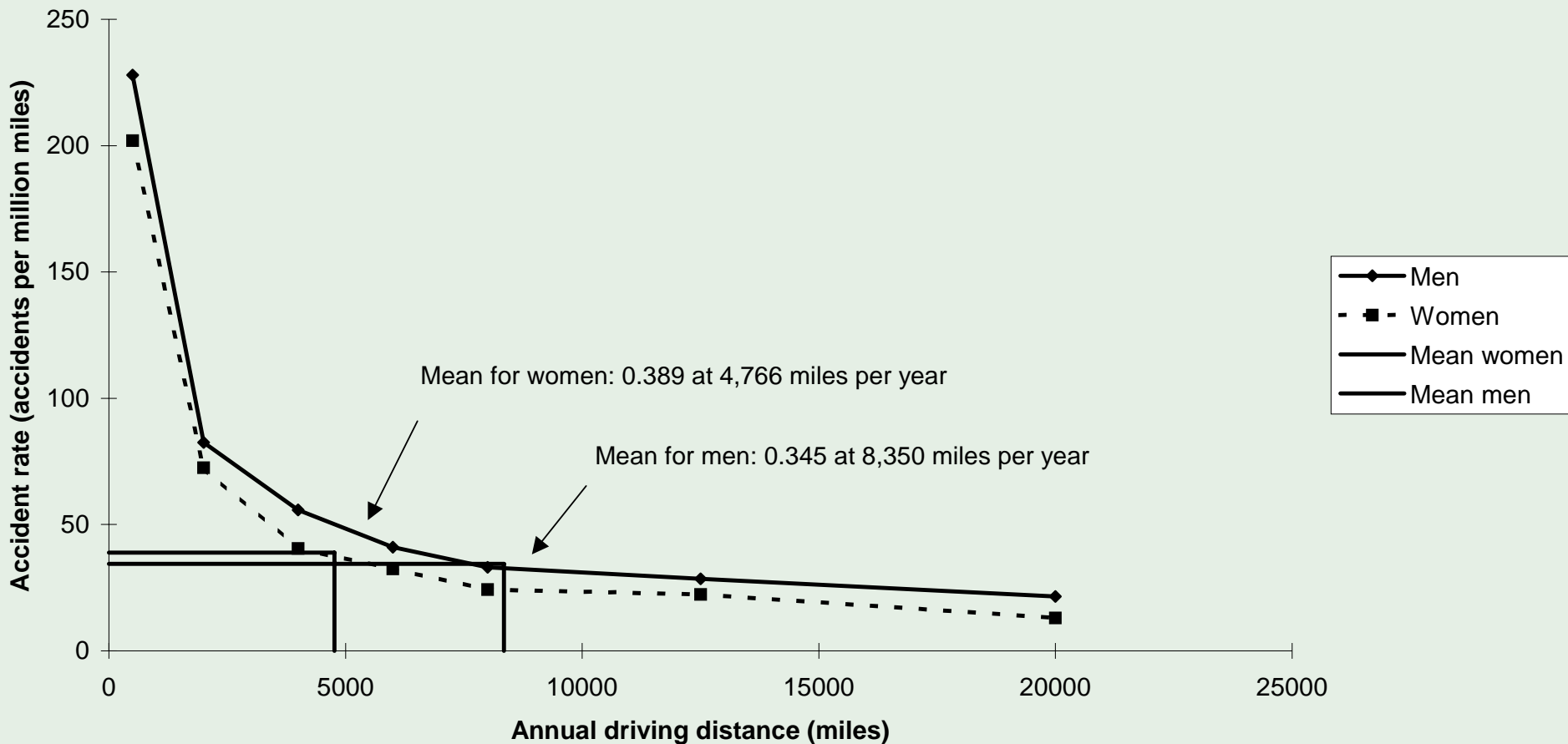
# Some instances of the universal law of learning

- Individual driver accident rates drop as annual driving distance increases
- The overall accident rate of a country drops over time
- Both instances can be interpreted as the result of an ongoing process of learning

## Injury accidents per million vehicle kilometres - Norway 1973-2003



**Relationship between annual driving distance and accident rate. Source: Forsyth, Maycock and Sexton 1995**



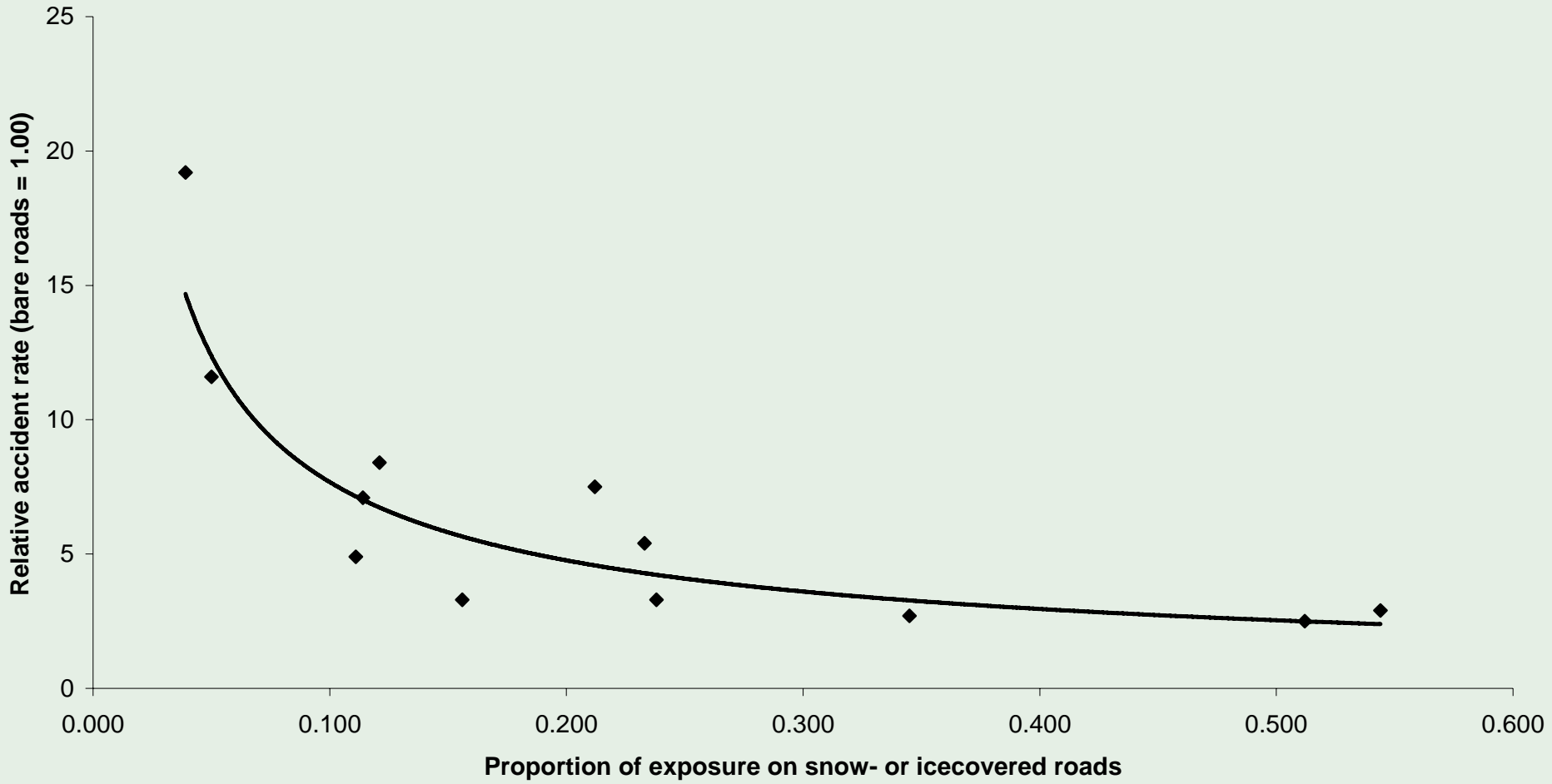
# The law of the unpredictable

- The more rarely a risk factor is encountered, the larger is its effect on accident rate
- Applies to risk factors that everybody may, in principle, encounter
- Rare encounters provide few opportunities for learning

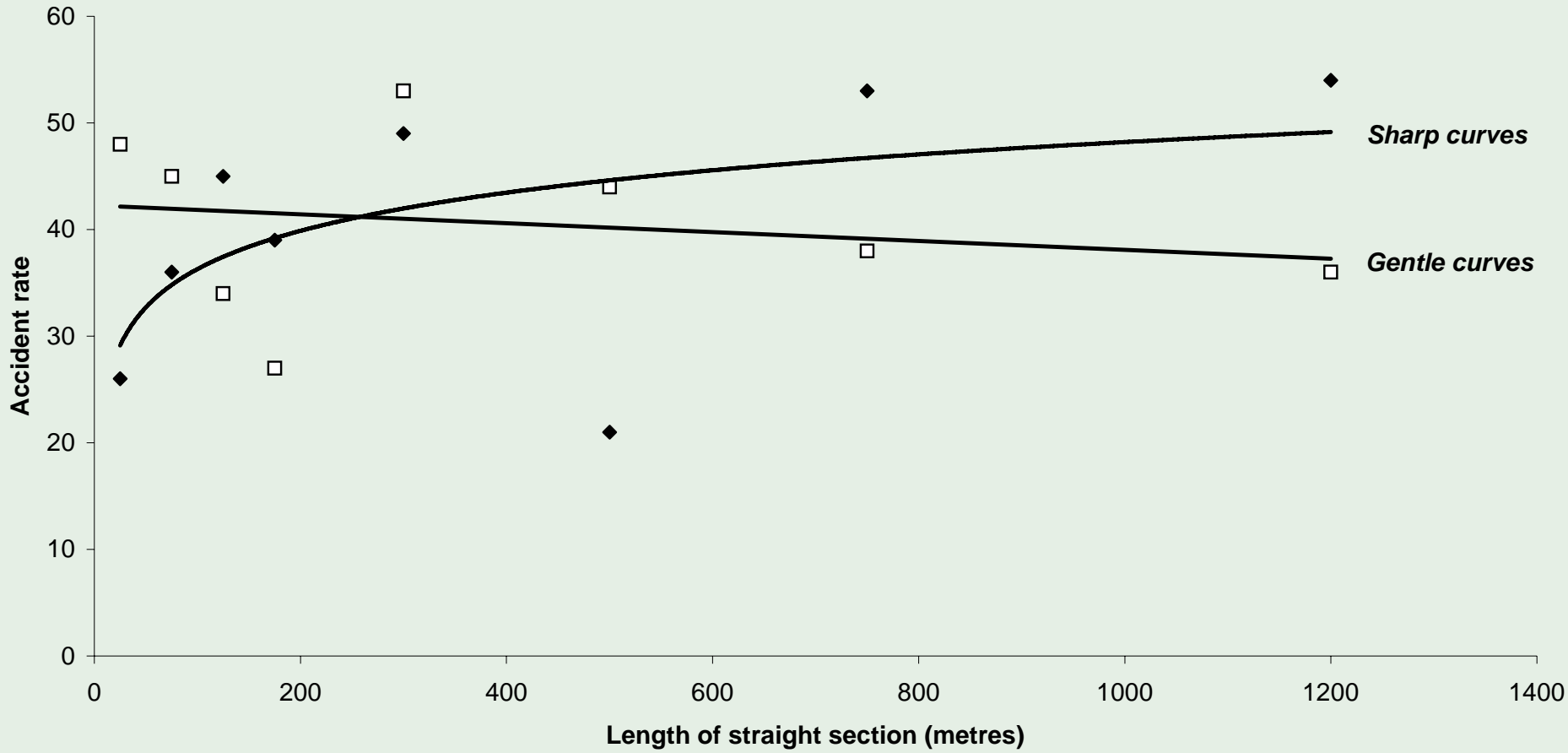
# Some instances of the law of the unpredictable

- The effect of snow or ice on accident rates
- The effect of rainfall on accident rates
- The effect of horizontal curves on accident rates
  
- Driver expectations are violated

### Relative accident risk on snow- or icecovered roads in Sweden



### Accident rate in curves depending on the length of the straight section before the curve



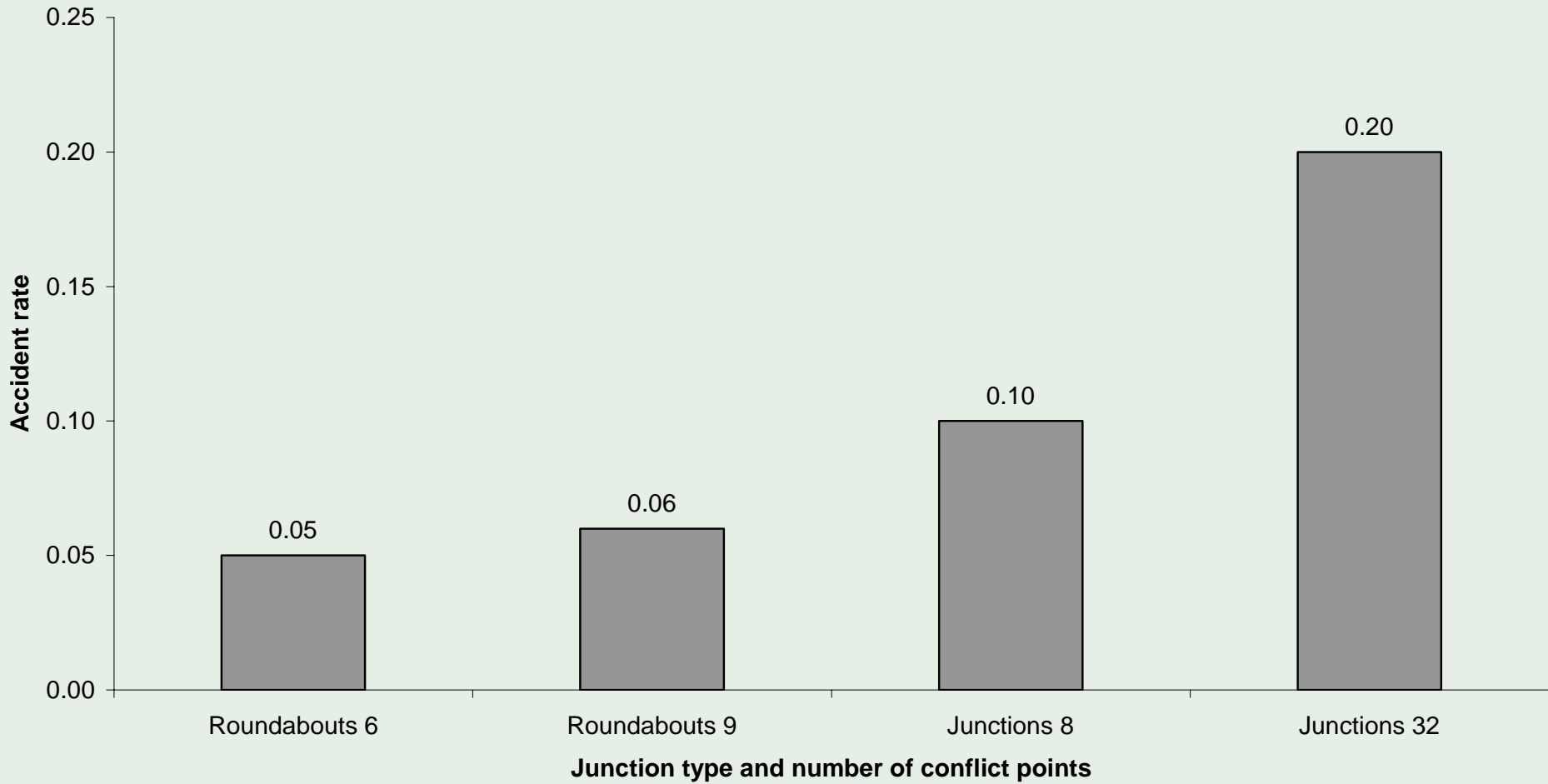
# The law of complexity

- The more elements a road user has to observe per unit of time, the higher the accident rate
- Complexity is a measure of the richness of information
- Human information processing capacity is limited

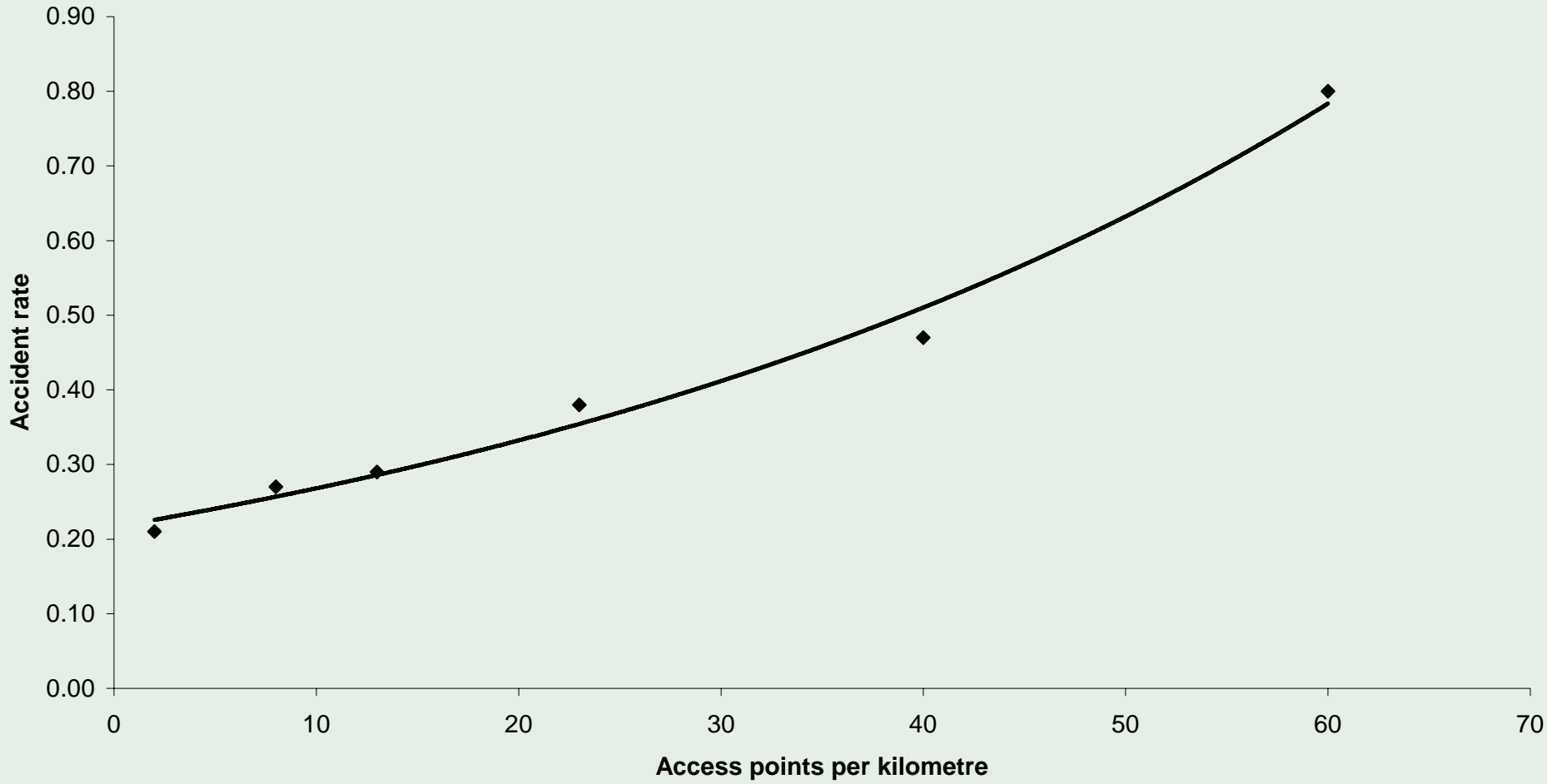
# Some instances of the law of complexity

- The effect of the number of conflict points on junction accident rates
- The effect of the number of access points on overall accident rate
- The effect of highly mixed traffic on accident rates

### Injury accident rates in junctions



### Effect of access point density on injury accident rate



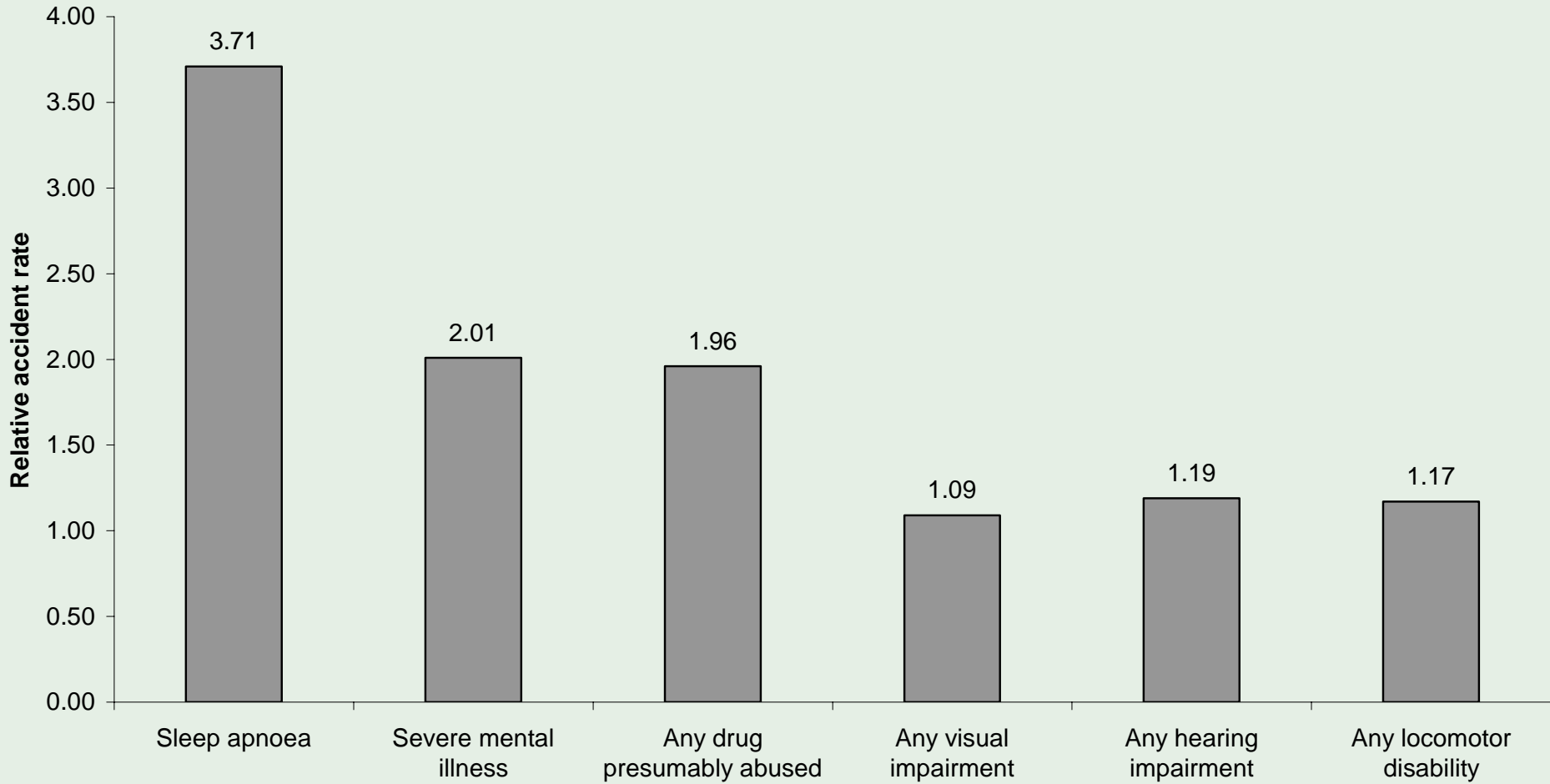
# The law of limited human capacity

- Human rationality is limited by the structure of the environment, by information processing capacity, and by factors influencing skills and judgement
- Information processing capacity is limited
- Mental or physical impairments may further reduce capacity

# Some instances of limited capacity

- Errors made by novice drivers
- Effects of disease and chronic medical conditions
- Effects of alcohol and other drugs
- Effects of fatigue
- Effects of other temporary conditions

### Effect of medical conditions etc on accident rate



# Laws of motion

- Physical laws of motion set absolute limits to evasive actions road users can take
- Speed determines stopping distance
- Friction determines stopping distance and manoeuvrability
- Mass determines stopping distance

# Laws of energy dissipation

- Kinetic energy is dissipated in the form of:
  - Braking
  - Structural deformation
  - Rotation
  - Heat
  - Biomechanical impacts
- Within the duration of accident ( $< 1$  second)