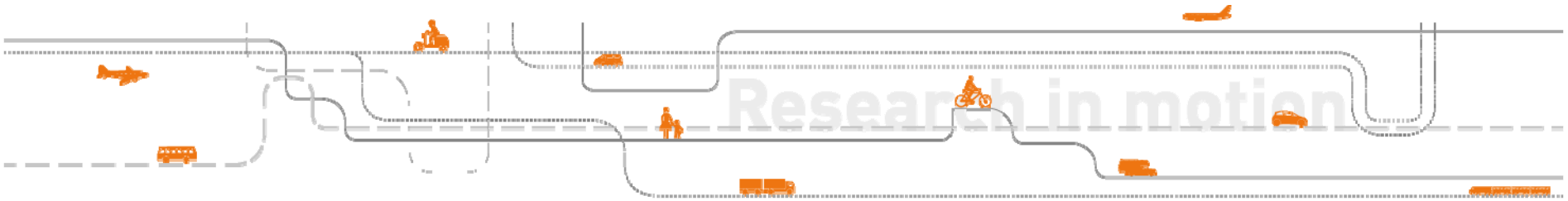
Institute of Transport Economics
Norwegian Centre for Transport Research
www.toi.no

The safety-in-numbers effect is inversely related to the number of pedestrians or cyclists

29th ICTCT Workshop, Lund, October 20-21, 2016

Rune Elvik, Institute of Transport Economics (re@toi.no)



Key points about safety-in-numbers

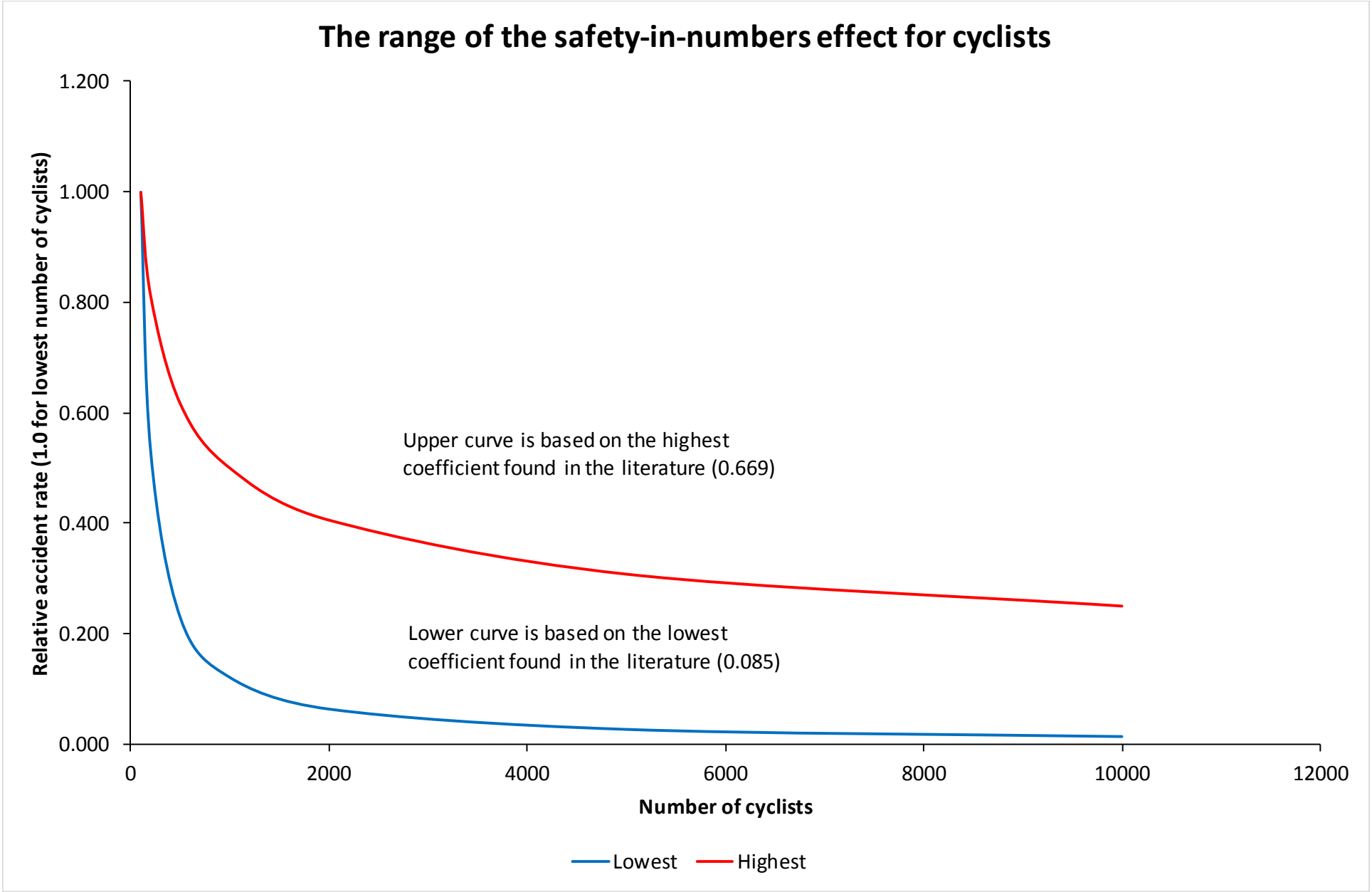
- There is safety-in-numbers if an increase in the number of road users in a specific group is associated with a less than proportional increase in the number of accidents involving the road user group
- Example:
  - *The number of cyclists doubles (+100 %)*
  - *The number of accidents involving cyclists and motor vehicles increases by forty percent (+40 %)*
- Cycling then becomes safer for each cyclist
- Safety-in-numbers has been studied mostly with respect to pedestrians or cyclists

The strength of the safety-in-numbers effect

- The strength of the safety-in-numbers effect varies
- How is the strength of the effect measured?

$$\text{Number of accidents} = e^{\beta_0} MV^{\beta_1} CYCL^{\beta_2} e^{\left(\sum_n^{i=1} \beta_n X_n\right)}$$

- The closer to zero the coefficients β_1 and β_2 are, the stronger is the safety-in-numbers effect
- In the next figure:
  - *Upper curve: risk at 10,000 cyclists is 25 % of risk at 100 cyclists*
  - *Lower curve: risk at 10,000 cyclists is 1.5 % of risk at 100 cyclists*


The range of the safety-in-numbers effect for cyclists
Relative accident rate (1.0 for lowest number of cyclists)
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0
2000
4000
6000
8000
10000
12000
Number of cyclists
Upper curve is based on the highest coefficient found in the literature (0.669)
Lower curve is based on the lowest coefficient found in the literature (0.085)
Lowest
Highest

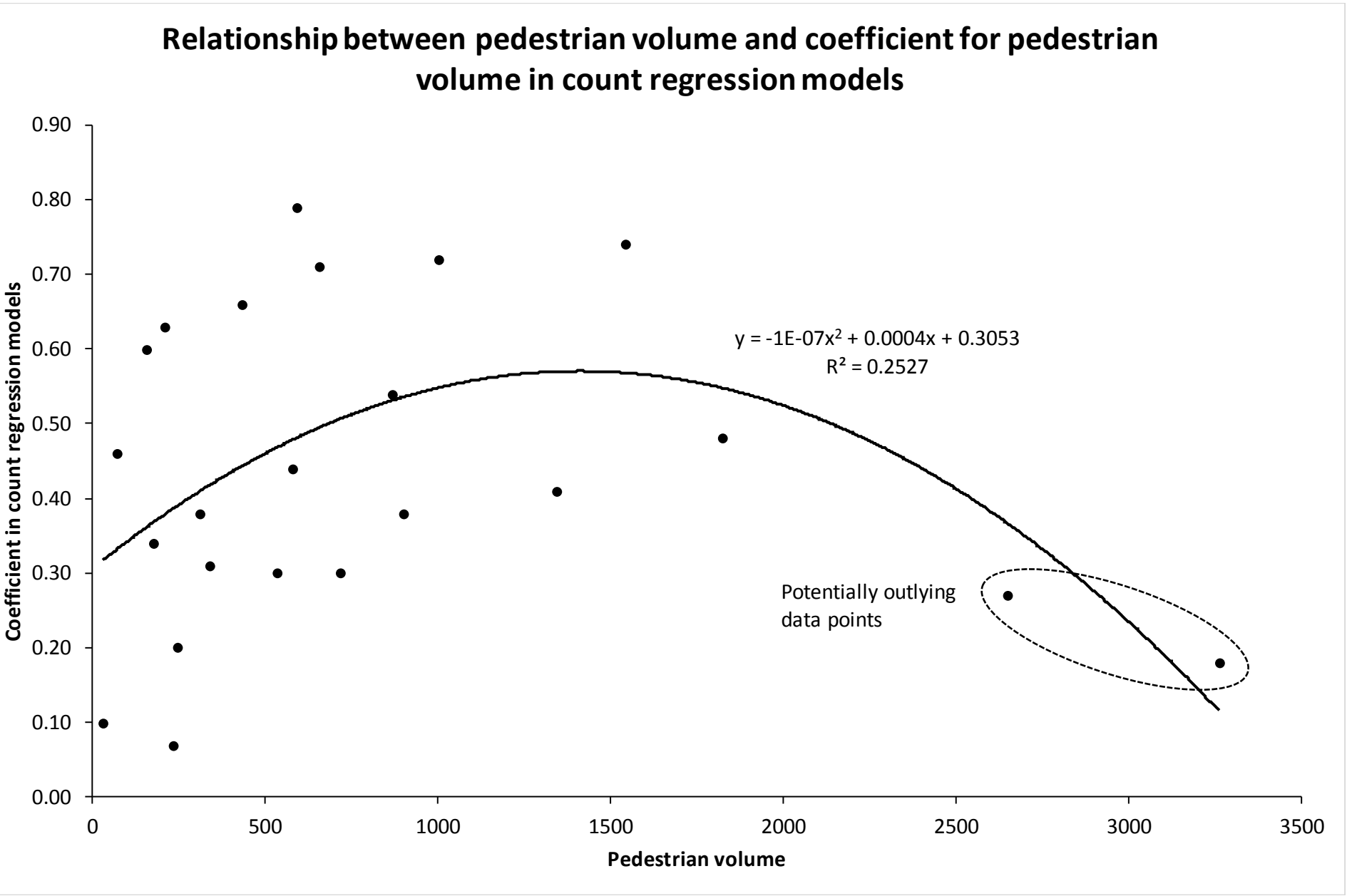
Factors associated with the strength of the safety-in-numbers effect

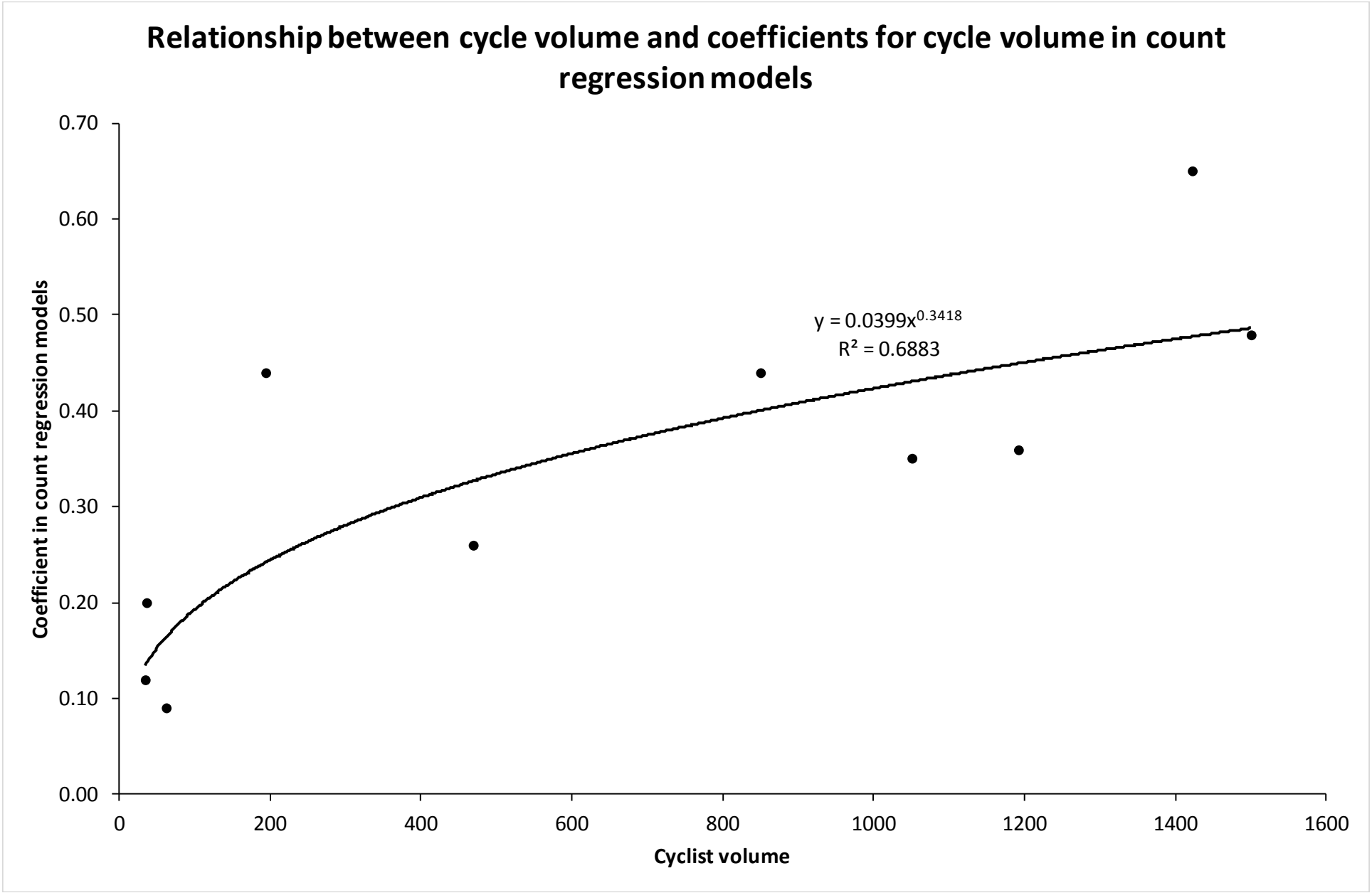
- The number of pedestrians, cyclists or motor vehicles
- The ratio of the number of motor vehicles to the number of pedestrians or cyclists
- The quality of the infrastructure for pedestrians or cyclists (not well described in most studies)
- Characteristics of pedestrians or cyclists (not well described in most studies)

- The study could only include the traffic volume variables

The data

Study	Authors	Country	Year	Years for data	Volume MV	Volume P	Volume C	Coeff MV	Coeff P	Coeff C	MV/P	MV/C
1	Inwood, Grayson	Great Britain	1979	1973-1978	15687	2646		0.92	0.27		5.93	
1	Inwood, Grayson	Great Britain	1979	1973-1978	8751	591		0.58	0.79		14.81	
2	Hall	Great Britain	1986	1979-1982	21180	3260		1.27	0.18		6.50	
3	Brüde, Larsson	Sweden	1993	1983-1988	14548	1004		0.50	0.72		14.49	
3	Brüde, Larsson	Sweden	1993	1983-1988	17465		1423	0.52		0.65		12.27
4	Summersgitt, Layfield	Great Britain	1996	1983-1988	5820	579		0.72	0.44		10.05	
5	Lyon, Persaud	Canada	2002	1985-1995	37705	1544		0.57	0.74		24.42	
5	Lyon, Persaud	Canada	2002	1985-1995	29285	1342		0.40	0.41		21.82	
5	Lyon, Persaud	Canada	2002	1985-1995	30999	432		0.53	0.66		71.76	
5	Lyon, Persaud	Canada	2002	1988-2000	26356	655		0.58	0.71		40.24	
6	Jonsson	Sweden	2005	1998-2002	9500	900		0.83	0.38		10.56	
6	Jonsson	Sweden	2005	1998-2002	9500		1050	0.76		0.35		9.05
7	Turner	New Zealand	2006	1994-2003	6783		63	0.29		0.09		107.67
7	Turner	New Zealand	2006	1994-2003	894		36	0.36		0.20		24.83
7	Turner	New Zealand	2006	1994-2003	15116	210		0.80	0.63		71.98	
7	Turner	New Zealand	2006	1994-2003	838	71		0.56	0.46		11.80	
8	Zegeer et al	United States	2006	1994-1998	12828	312		1.01	0.38		41.12	
8	Zegeer et al	United States	2006	1994-1998	12817	155		0.30	0.60		82.69	
9	Harwood et al	United States	2008	1997-2005	36617	867		-0.32	0.54		42.23	
9	Harwood et al	United States	2008	1997-2005	41708	1823		0.38	0.48		22.88	
9	Harwood et al	United States	2008	1997-2005	29984	32		0.62	0.10		937.00	
9	Harwood et al	United States	2008	1997-2005	32465	178		0.18	0.34		182.39	
10	Daniels et al	Belgium	2011	1991-2001	12782	246		1.62	0.20		51.96	
10	Daniels et al	Belgium	2011	1991-2001	12782		470	0.91		0.26		27.20
11	Miranda-Moreno et al	United States	2011	2000-2008	12893		195	0.40		0.44		66.12
12	Schepers et al	Netherlands	2011	2005-2008	2200		1500	0.73		0.48		1.47
13	Schepers et al	Netherlands	2011	2005-2008	7000		850	0.70		0.44		8.24
14	Elvik et al	Norway	2013	2004-2010	8186	340		0.59	0.31		24.08	
15	Kröyer	Sweden	2015	2008-2012	13100	719		0.64	0.30		18.22	
15	Kröyer	Sweden	2015	2008-2012	13100		1192	0.71		0.36		10.99
16	Senna et al	United States	2015	2009-2014	100588	533		0.36	0.30		188.72	
17	Elvik	Norway	2016	2003-2010	8181	233	35	0.05	0.07	0.12	35.11	233.74


Relationship between pedestrian volume and coefficient for pedestrian volume in count regression models
Coefficient in count regression models
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
500
1000
1500
2000
2500
3000
3500
Pedestrian volume
y = -1E-07x² + 0.0004x + 0.3053
R² = 0.2527
Potentially outlying data points


Relationship between cycle volume and coefficients for cycle volume in count regression models
Coefficient in count regression models
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
y = 0.0399x^0.3418
R² = 0.6883
0
200
400
600
800
1000
1200
1400
1600
Cyclist volume

Meta-regression

	Model 1: Pedestrian coefficients, all data points (n = 20)		Model 2: Pedestrian coefficients, two data points omitted (n = 18)		Model 3: Cyclist coefficients, all data points (n = 7)		Model 4: Pedestrians and cyclists in same model (n = 27)
Terms	Estimate (standard error)	P-value	Estimate (standard error)	P-value	Estimate (standard error)	P-value	Estimate (standard error)
Constant	-3.2217 (1.9336)	0.0957	-3.8953 (1.6189)	0.0161	-2.8543 (1.8518)	0.1232	-3.1222 (1.3734
Ln(pedestrian volume)	0.2920 (0.2131)	0.1706	0.4444 (0.1836)	0.0155			
Ln(ratio motor vehicles/pedestrians)	0.0944 (0.1881)	0.6158	0.0504 (0.1570)	0.7483			
Ln(cyclist volume)					0.2848 (0.2200)	0.1954	
Ln(ratio motor vehicles/cyclists)					-0.0131 (0.1825)	0.9428	
Ln(pedestrian or cyclist volume)							0.2945 (0.1567)
Ln(ratio motor vehicles/peds or cyclists)							0.0620 (0.1319)
Comparison of models 1 and 2	Pedestrian coefficient in model 1 versus model 2: t = -2.3676, df = 35.94, p = 0.0117						
Comparison of models 1 and 3	Pedestrian coefficient in model 1 versus cyclist coefficient in model 3: t =0.1022, df = 10.24, p = 0.5397						
Comparison of models 1 and 4	Pedestrian coefficient in model 1 versus pedestrian or cyclist coefficient in model 4: t = -0.0442, df = 33.36, p = 0.4825						
Comparison of models 3 and 4	Cyclist coefficient in model 3 versus pedestrian or cyclist coefficient in model 4: t = -0.1128, df = 7.76, p = 0.4566						

Concluding comments

- The more pedestrians or cyclists, the weaker the safety-in-numbers effect
- The more motor vehicles per pedestrian or cyclist, the weaker the safety-in-numbers effect
- Both these findings are counterintuitive

- It is difficult to give a good explanation of these findings

- Recent Norwegian data indicate a strong behavioural adaptation on the part of pedestrians or cyclists