SPEED AS A RISK FACTOR IN FATAL RUN-OFF ROAD CRASHES

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BACKGROUND

SAFETEA-LU

- Emphasis on reducing fatal (and severe crashes)

Rural areas over-represented in fatal crashes

Road departure over-represented in fatal crashes

SOLOMON'S CURVE

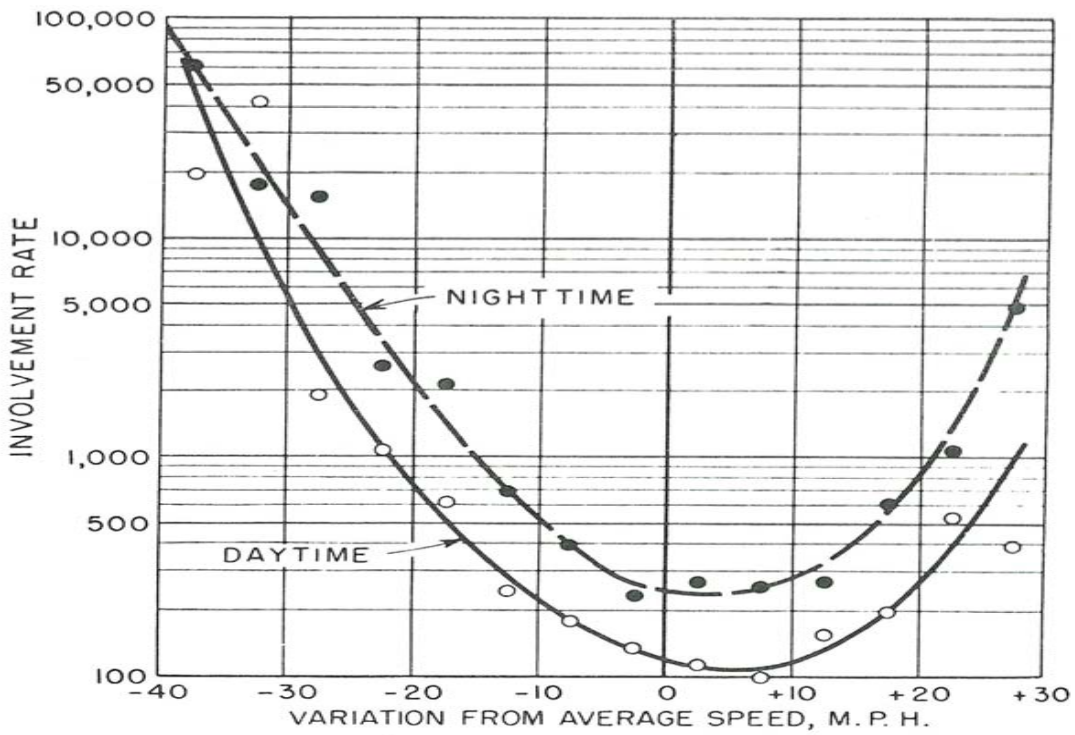


Figure 7.—Involvement rate by variation from average speed on study section, day and night.

SOLOMON'S CURVE IMPLICATIONS

U-shaped relation between speed and crash risk

Lowest risk occurs around 8 mph above average speed

Suggests that 85%-ile speed is safe (safest?)

Question: Is there U-shaped relation between speed and risk of a fatal run-off road crash?

CASE CONTROL STUDY

Road Accident Research Unit
University of Adelaide

Speed Diff.	Rel. Risk
-10	0.54
-5	0.72
0	1.0
5	1.45
10	2.20
15	3.49
20	5.77
25	9.96

Speed Diff = difference from average control speed at a given site (v_m)

Rel. Risk =

$P[crash|v_m+v]/P[crash|v_m]$

Crashes on rural roads

Case speeds estimated accident reconstruction

MINNESOTA
DATA ACQUISITION

(1)Mn/DOT personnel identified 60 fatal crashes occurring near one of Mn/DOT'S automatic speed recorders (ASR)

(2) During Fall 2001, PI visited MSP district offices to obtain investigation reports for 46 fatal crashes

(3) Mn/DOT provided speed data from ASRs

ESTIMATING SPEEDS IN RUN-OFF ROAD CRASHES

Yawmarks? speed estimated using measured radius and **critical speed formula**

Otherwise, 3-phase speed change:

- **Rollover phase** using constant deceleration model
- **Tripping phase** using constant impulse model
- **Pre-tripping phase** using simple skidding model

MATCHED CASE-CONTROL STUDY FOR RUN-OFF ROAD CRASHES

Crash	Case Speeds		Control Speeds									
#	Mean	St.Dev	1	2	3	4	5	6	7	8	9	10
1	69.8	5.6	58	58	66	50	56	65	60	70	72	54
2	71.0	5.0	57	53	38	55	65	51	59	61	55	56
3	71.4	4.4	69	75	82	77	75	82	78	70	77	71
4	81.4	2.1	69	75	89	70	75	77	87	65	77	71
5	59.8	3.6	52	60	56	55	56	56	58	53	54	62
6	80.8	2.1	69	78	71	82	80	70	69	70	70	78
7	74.5	5.0	85	78	85	71	83	72	85	71	63	79
8	67.7	4.0	69	68	65	56	72	75	75	69	70	70
9	80.4	1.7	77	81	78	77	72	75	74	80	70	76
10	73.3	4.0	73	73	71	75	80	82	78	70	87	77

LOGIT MODEL DEVELOPMENT

$P[crash|v] =$

$\exp(a+f(v))/[1+ \exp(a+f(v)]$

$f(v)=b1(v-v_m)+b2(v-v_m)^2$ (U-shaped)

$f(v)=b(v-v_m)$ (Monotonic)

v = speed

v_m = mean (control) speed

a,b,b1,b2 = model parameters

ESTIMATION USING CASE-CONTROL DATA

Aggregate Data:

Coefficients, b, b1, b2 can be estimated from matched case-control data

For individual crashes (linear model):

P[crash avoided, v2|crash occurred, v1]

$\approx 1-\exp(b(v1-v2))$

MODEL ESTIMATION RESULTS

	Linear Model			(Constrained) Quadratic Model		
Variable	**Mean**	**2.5%-ile**	**97.5%-ile**	**Mean**	**2.5%-ile**	**97.7%-ile**
b_1	0.19	0.03	0.46	0.14	-0.013	0.381
b_2	--	--	--	0.006	0.0003	0.016
Deviance	40.3	29.5	47.9	40.6	230.8	48.5
DIC	41.1			40.3		

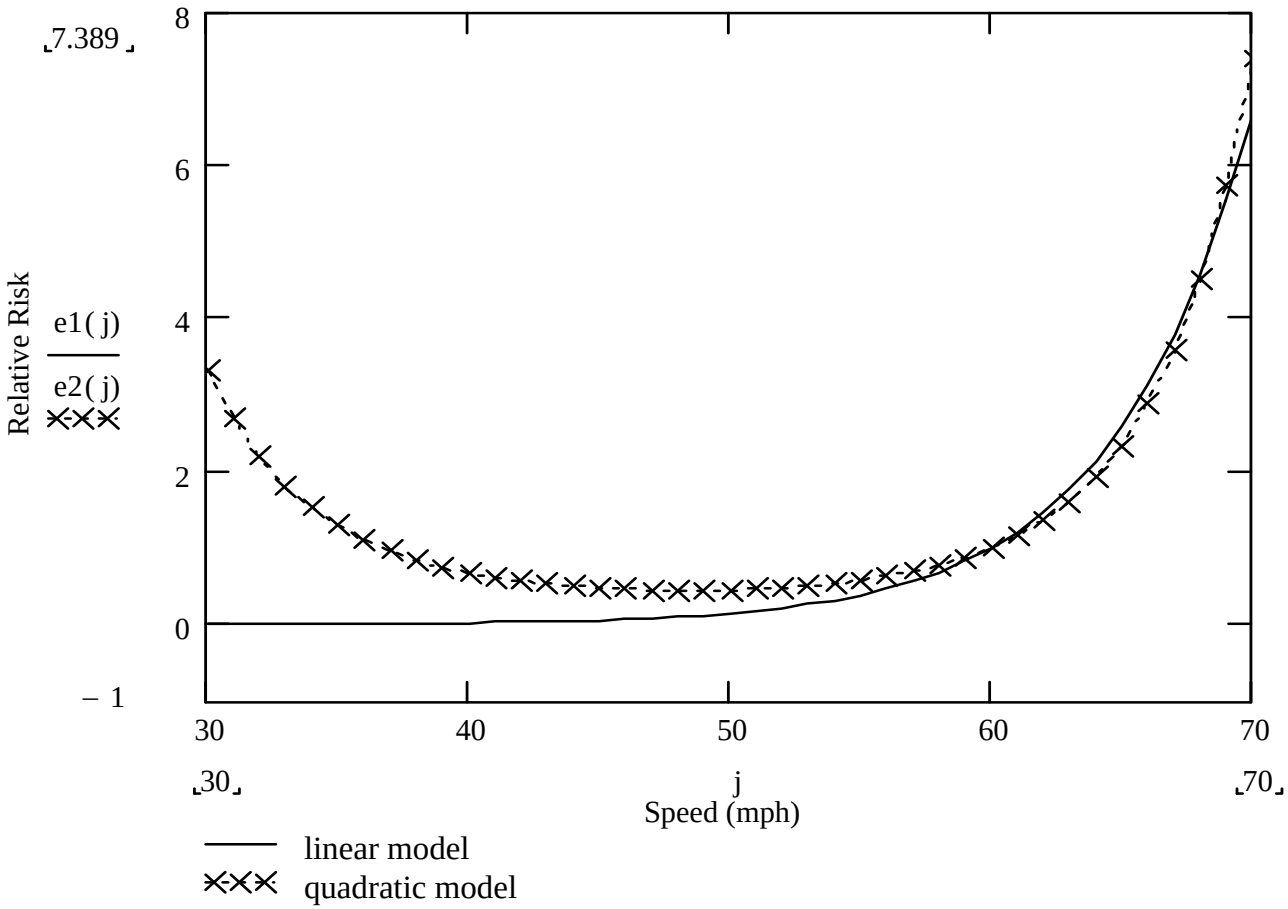
Linear and quadratic models fit equally well

Quadratic coefficient b2 probably > 0

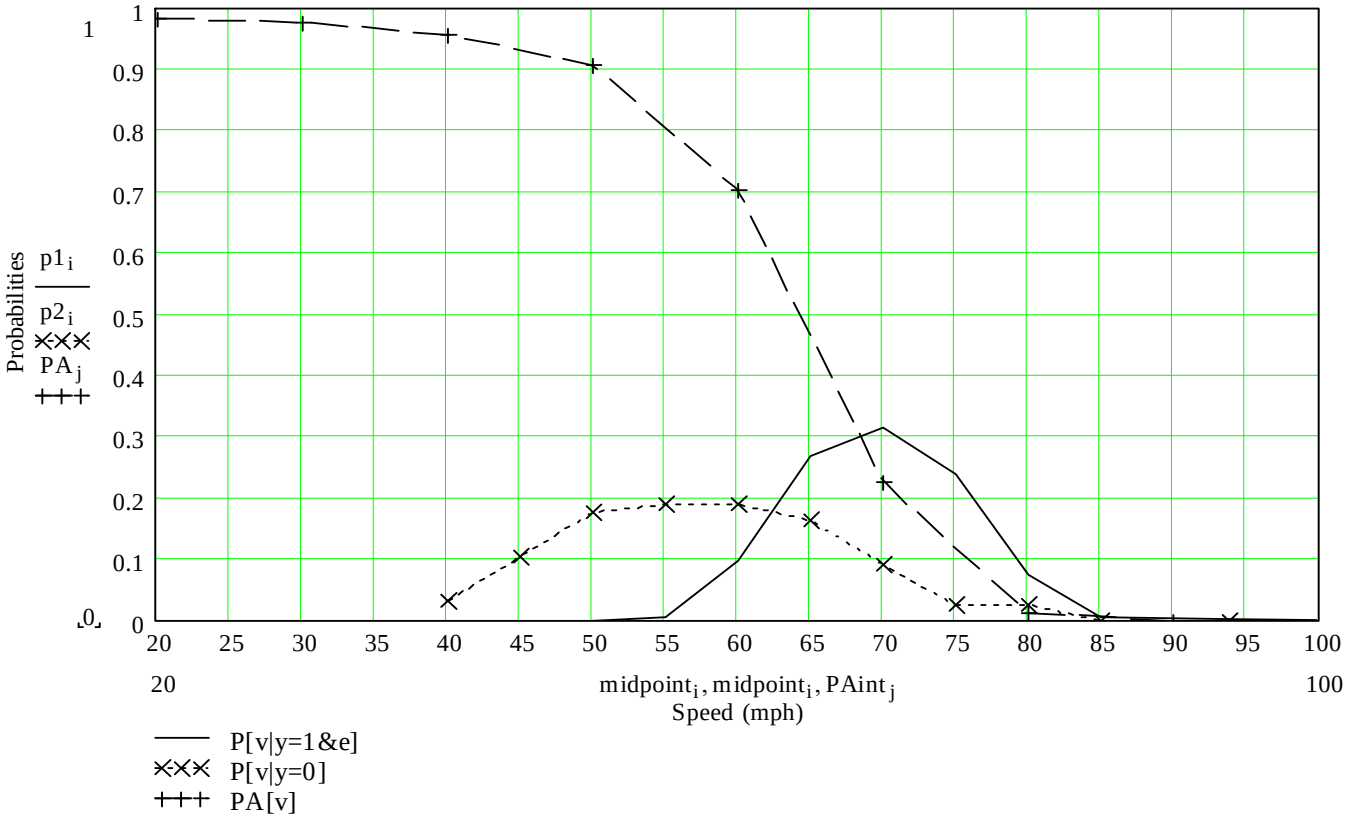
In this data set, all observed speeds > 50 mph

Linear and quadratic models monotonic, and essentially equivalent, over range of available data

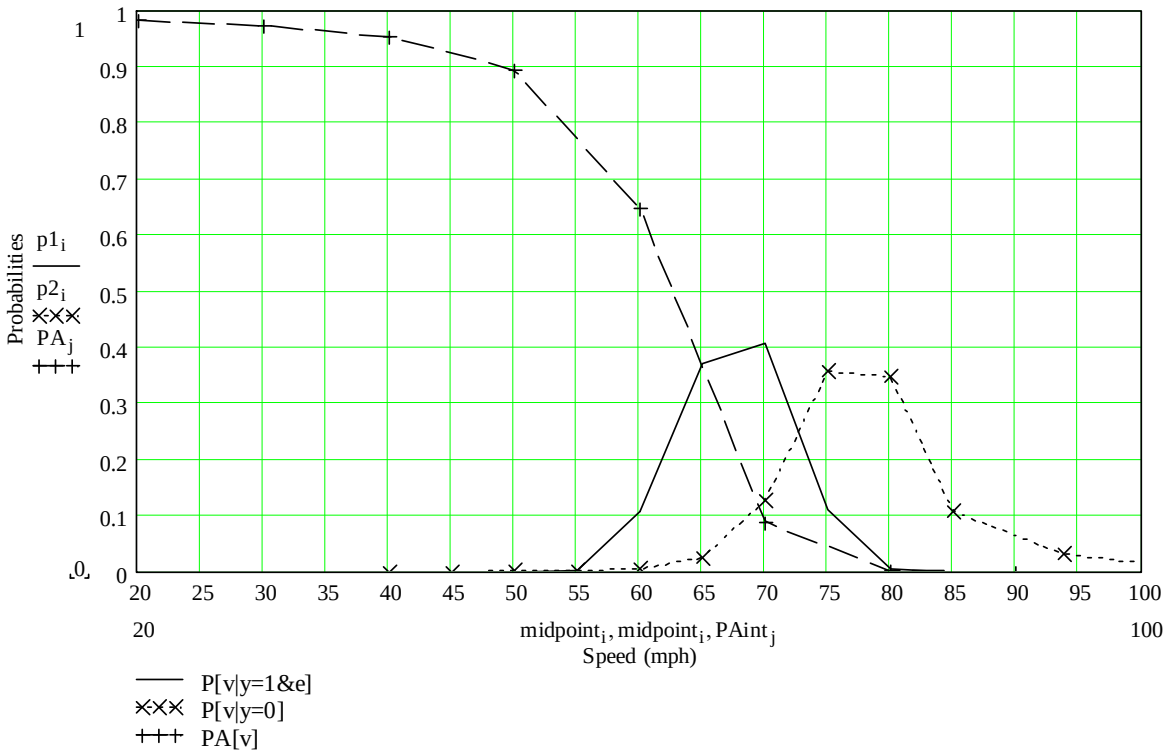
RELATIVE RISK: LINEAR VS QUADRATIC



INDIVIDUAL CRASH RESULTS: CRASH #1



INDIVIDUAL CRASH RESULTS: CRASH #8



PROBABILITIES OF AVOIDANCE: THREE SPEED SCENARIOS

Crash Number	Posted Limit	Mean Case Speed	Mean Control Speed	Posted Limit PA	Control Mean PA	55 mph PA
1	70	69.8	57.7	0.23	0.75	0.80
2	65	71.0	56.2	0.51	0.82	0.84
3	70	71.4	74.2	0.28	0.17	0.85
4	65	81.4	73.0	0.87	0.64	0.95
5	55	69.2	58.3	0.47	0.27	0.47
6	70	80.8	74.2	0.80	0.54	0.94
7	70	74.5	74.5	0.46	0.28	0.89
8	70	67.7	77.4	0.09	0.02	0.77
9	70	80.4	74.4	0.79	0.50	0.94
10	70	73.3	75.8	0.40	0.17	0.88

CONCLUSIONS

Not so controversial:

No evidence for a U-shaped (‘Solomon’s curve’) relation between speed and crash risk

- Minnesota data
- Australian data

More controversial:

Crash reduction effect on individual crashes:

- Traveling a posted limit: **4.9/10**
- Traveling at mean speed: **4.2/10**
- Adherence to 55 mph limit: **8.3/10**

REFERENCES

Davis, G., Davuluri, S., and Pei, J-P, Speed as a risk factor in serious run-off-road crashes: Bayesian case-control analysis with case speed uncertainty, *Journal of Transportation and Statistics*, **9**, 2006, 17-28.

Kloeden, C., McLean, J., and Glonek, G. *Reanalysis of Traveling Speed and Risk of Crash Involvement in Adelaide South Australia*, Road Accident Research Unit, University of Adelaide, Adelaide, Australia, 2002.

Kloeden, C., Ponte, G. and McLean, J. *Traveling Speed and Risk of Crash Involvement on Rural Roads*. Road Accident Research Unit, University of Adelaide, Adelaide, Australia, 2001.

Shinar, D. Speed and crashes: A controversial topic and elusive relationship, *Managing Speed*, Special Report 254, Transportation Research Board, Washington, DC, 1998, 221-276.