# The Likelihood of Human Casualty in Highway Crashes

## Second Briefing: A Sensitivity Analysis

Based on an Investigation Conducted for
the FHWA/NHTSA Crash Analysis Center
at George Washington University, Virginia

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Washington, D.C.

"The Likelihood of Casualty in Highway Crashes"

Many outcomes and their severity may be considered individually or in combinations for the purpose of casualty prediction.

The baseline in this briefing is: Fatality or MAIS 3+

Other possibilities to be addressed and evaluated later include:
- Severe Injury, Irrespective of Fatality,
- Extensive Hospitalization, Irrespective of Other Factors,
- Post Crash Fatalities, in Addition to All Fatalities,
- The Injury Severity Score, etc.
- Most Severe Injury or Injuries and Accompanying Attributes

Predictors Selected for this Briefing:
- Delta V in Planar Crashes,
- General Area of Damage in Planar Crashes,
- Rollover Occurrence, by Quarter Turns,
- Occupant's Age,
- Restraint Use, and
- Seating Position.

Additional Predictors to be Addressed and Evaluated Later, Especially with the Benefit of Crash Scene Observables:
- Door Opening,
- Direction of Force,
- Size, Shape, and Rigidity of Collision Partner,
- Extent of Damage,
- Specific Horizontal and Vertical Location of the Crush,
- Crush Distribution,
- Roadway Class, for Possible Resolution of R/O Severity,
- Occupant Gender, Size, and Shape, and
- Make, Model, and Model Year as Surrogates of Many Non Observables.

Processing of Raw Data from the NASS/CDS 1988-1994

In view of the dichotomous outcome under consideration (i.e. "Yes" or "No" Fatality or MAIS 3+) a maximum likelihood procedure, specifically a logistic regression with weighing factors, is used to fit various models to the raw data. Essentially, the probability of casualty is modeled as:

$$P = 1 / [1 + \exp(-w)]$$

where $w = A + B*x + C*y + etc$
where x, y, etc are the selected predictors.

Specifically, the procedure estimates the coefficients: A, B, C, etc., and their standard errors.

Programmable Algorithms (to be used as examples only)

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<u>For Planar Crashes</u>, the probability of fatality or MAIS 3+ is given (in 0 to 100%) by:

P = 100 / [1 + exp(-w)]  where

w = A + B*DeltaV + C*Age + D + E + F

| | | | |
|---|---|---|---|
| A = | -8.65 | +/- 0.43; | |
| B = | 0.13 | 0.00 | if DeltaV in mph; |
| C = | 0.03 | 0.00 | if Occupant's Age in Years; |
| D = | 2.18 | 0.33 | if DOF=Frontal, Else Zero; |
| | 2.57 | 0.34 | if DOF=Left, Else Zero; |
| | 2.66 | 0.39 | if DOF=Right, Else Zero; |
| | 0.00 | 0.00 | if DOF=Left, Else Zero; |
| E = | -0.94 | 0.15 | if Occupant is Restrained, Else Zero; |
| | 0.00 | 0.00 | if Occupant is Unrestrained, Else Zero; |
| F = | -0.13 | 0.23 | if Occupant is the Driver; Else Zero; |
| | 0.17 | 0.24 | if Occupant is Front Passenger; Else Zero; |
| | 0.00 | 0.00 | if Occupant is Rear Seated; Else Zero. |

<u>With Rollover Occurrence</u> the probability of fatality or MAIS 3+ is given (in 0 to 100%) by:

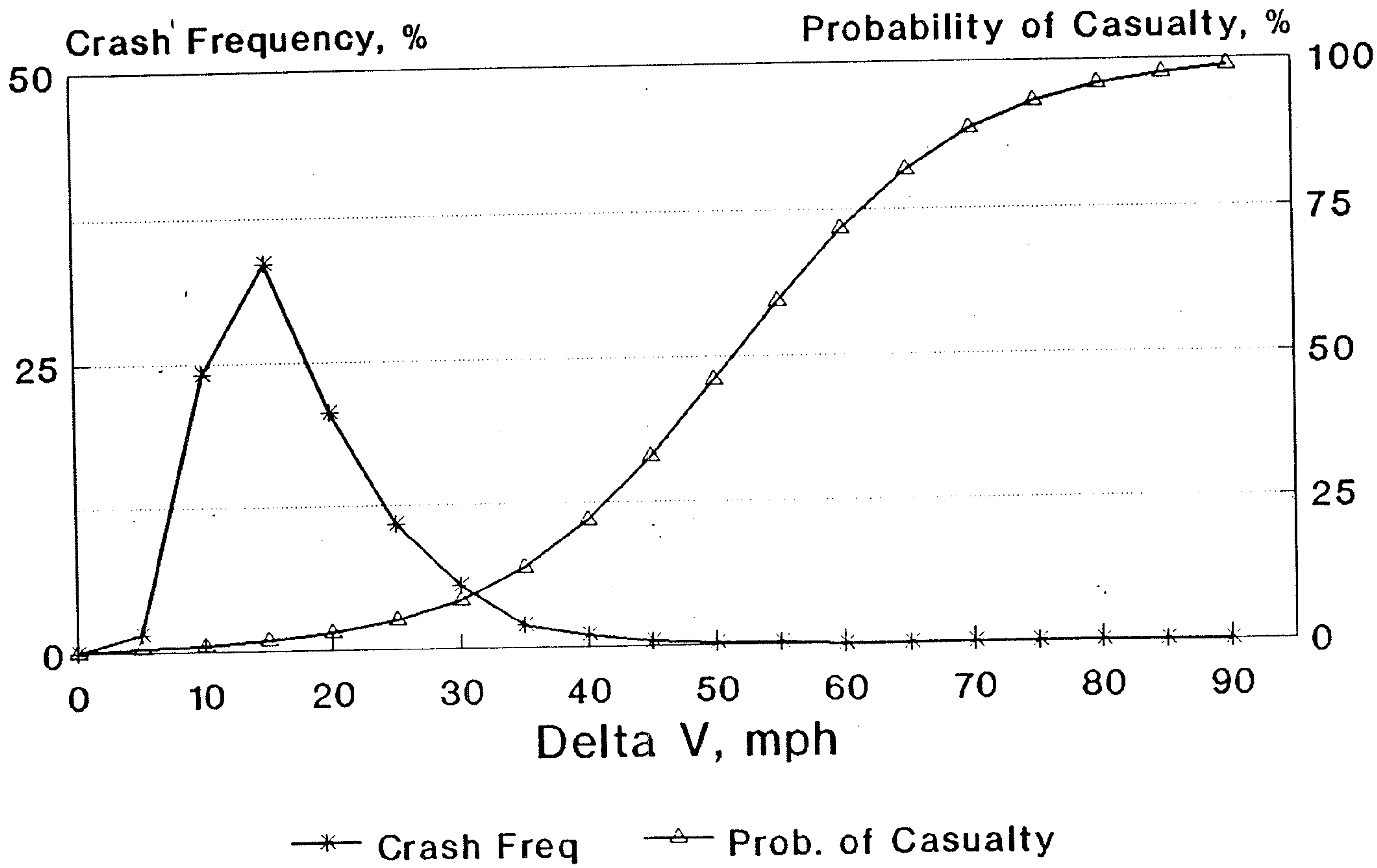
P = 100 / [1 + exp(-w)]  where

w = A + B + C*Age + D + E

| | | | |
|---|---|---|---|
| A = | -4.07 | +/- 0.11; | |
| B = | 0.77 | 0.19 | if One Quarter Turn Rollover; Else Zero; |
| | 0.67 | 0.17 | if Two or Three Quarter Turns Rollover; Else Zero; |
| | 1.44 | 0.11 | if Four or More Quarter Turns Rollover; Else Zero; |
| | 0.00 | 0.00 | if No Rollover; Else Zero; |
| C = | 0.02 | 0.00 | if Occupant's Age in Years; |
| D = | -1.07 | 0.08 | if Occupant is Restrained, Else Zero; |
| | 0.00 | 0.00 | if Occupant is Unrestrained, Else Zero; |
| E = | 0.18 | - 0.11 | if Occupant is the Driver; Else Zero; |
| | 0.23 | 0.12 | if Occupant is Front Passenger; Else Zero; |
| | 0.00 | 0.00 | if Occupant is Rear Seated; Else Zero. |

<u>This briefing emphasizes several sensitivity analyses</u>. Applications are illustrated in attached Figures 13 to 28. More detail may be found in Tables I and II of the 3/19/96 briefing.

Fig. 13. Crash Frequency & Probability of Fatality or MAIS 3+, as a Function of Delta V for Planar Car Crashes




The NASS/CDS 1988-1994

Fig. 14. Cumulative Crash Frequency and Cumulative Fatalities or MAIS 3+, as a Function of Delta V

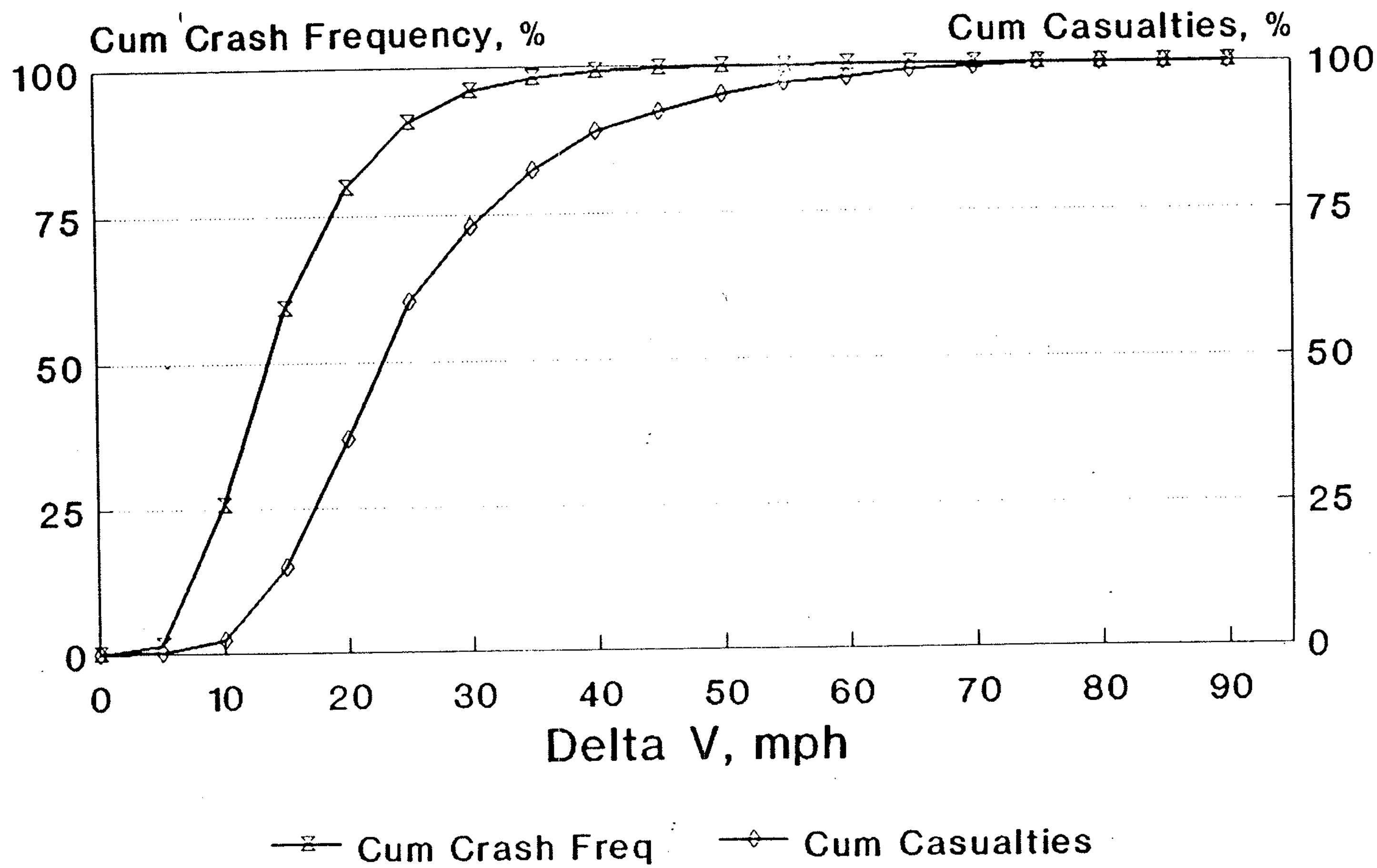



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Fig. 15. Distribution of Car Occupants and Shown Casualties among Severities of Planar Crashes

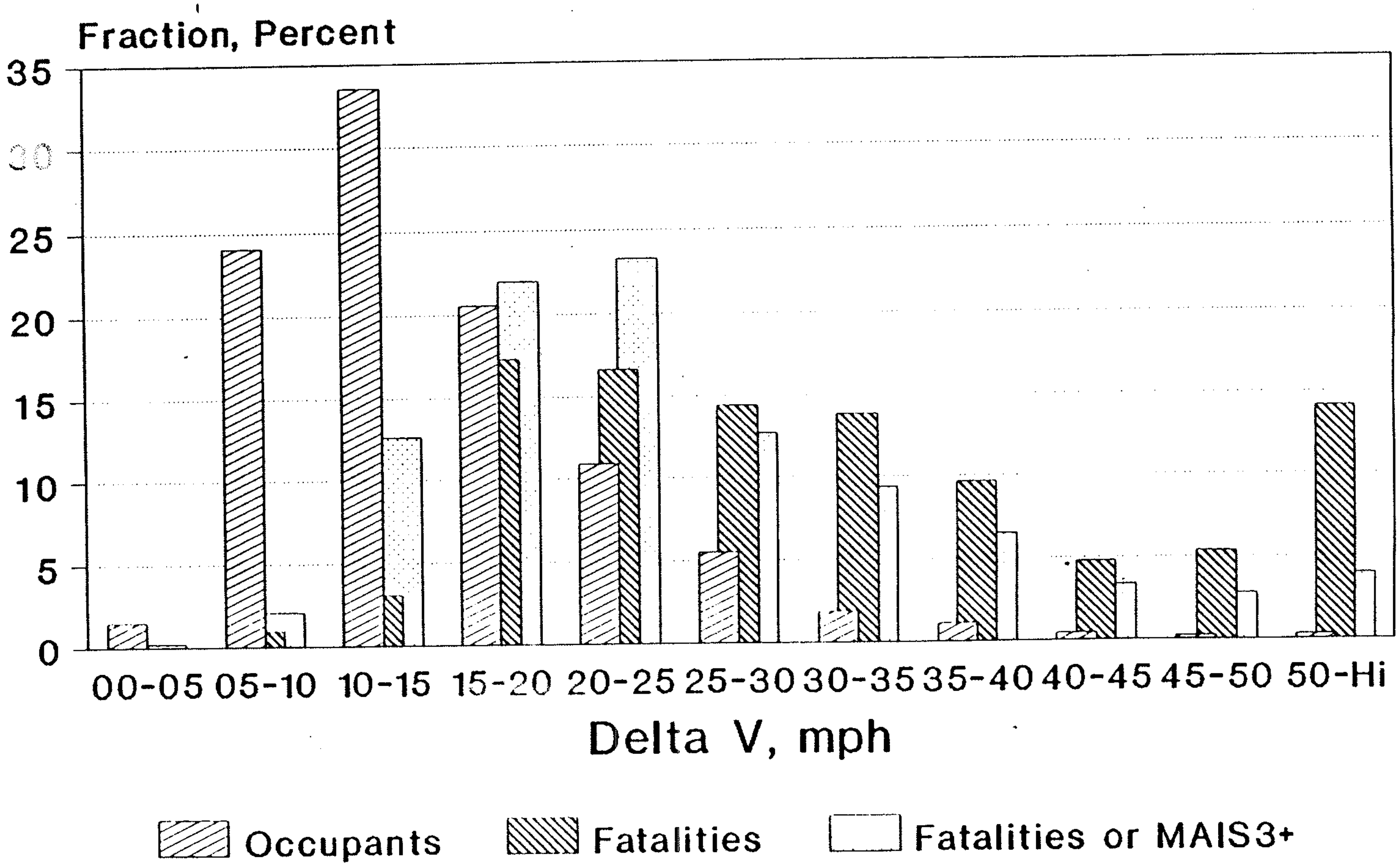


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Fig. 16. Distribution of Restrained Car Occupants and Shown Casualties among Severities of Planar Crashes

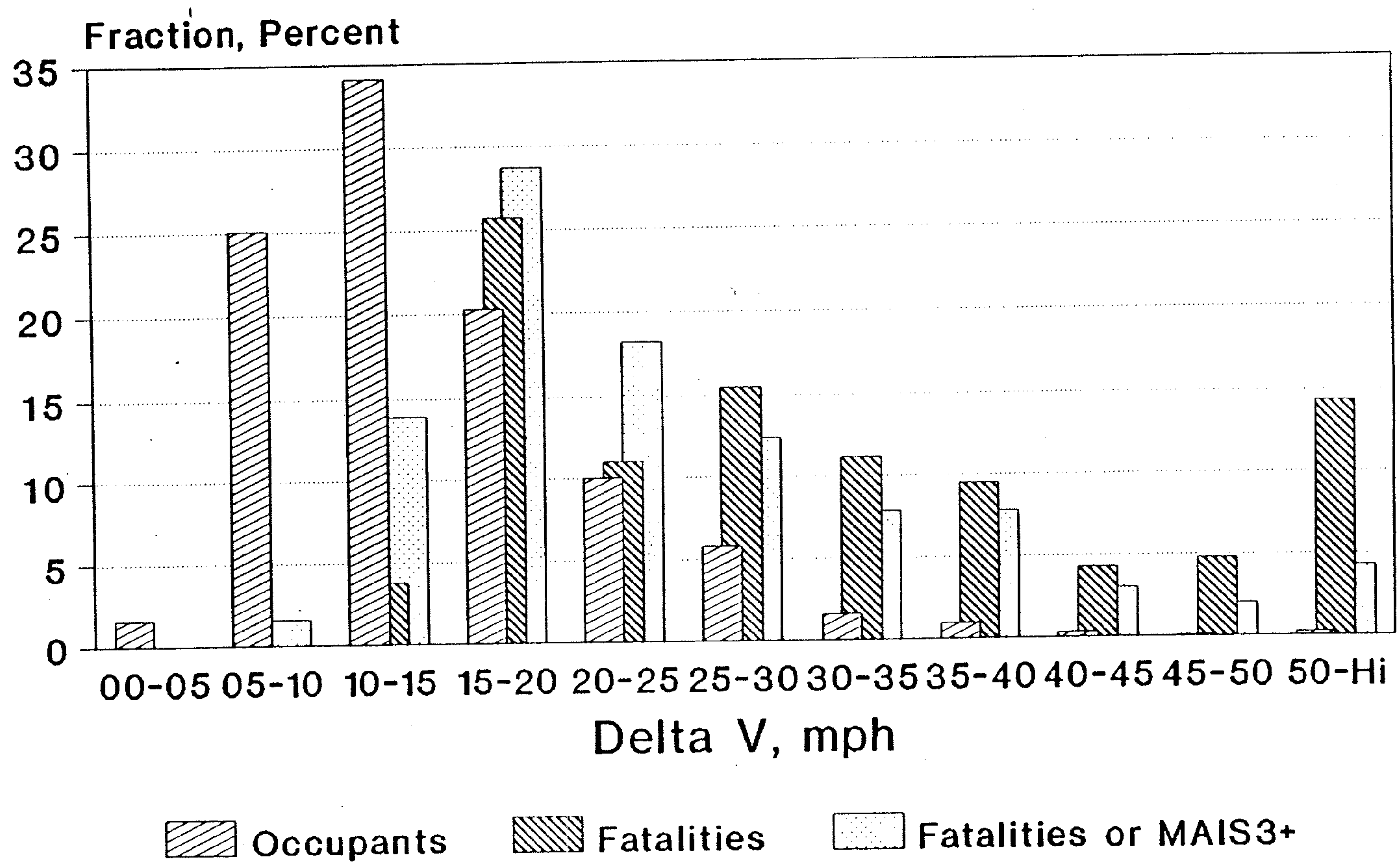


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Fig. 17. Probability of Shown Casualty versus Car Crash Severity, Delta V

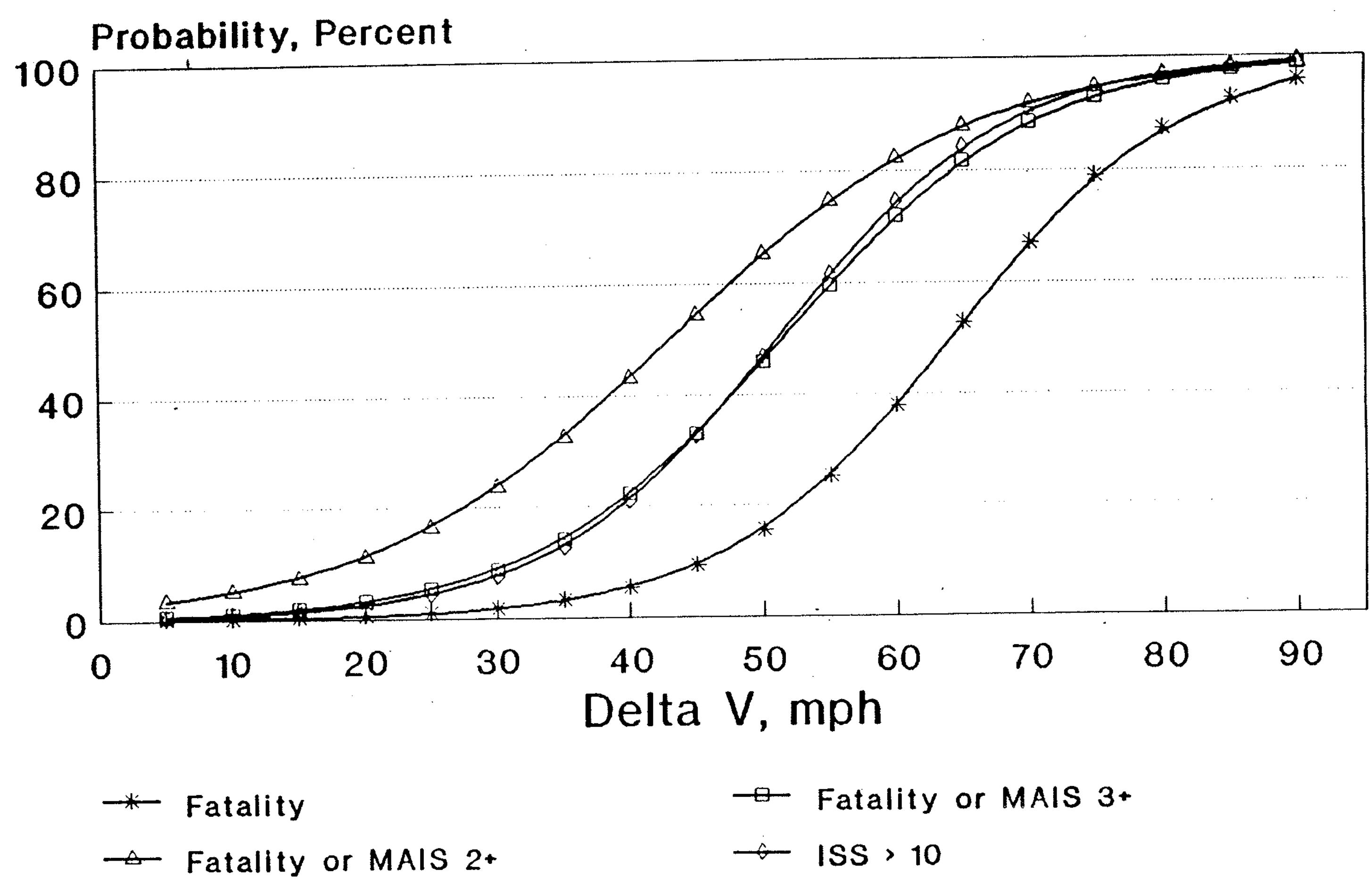


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Fig. 18. Probability of Fatality or MAIS 3+, versus Delta V, for Shown Car Damage Areas

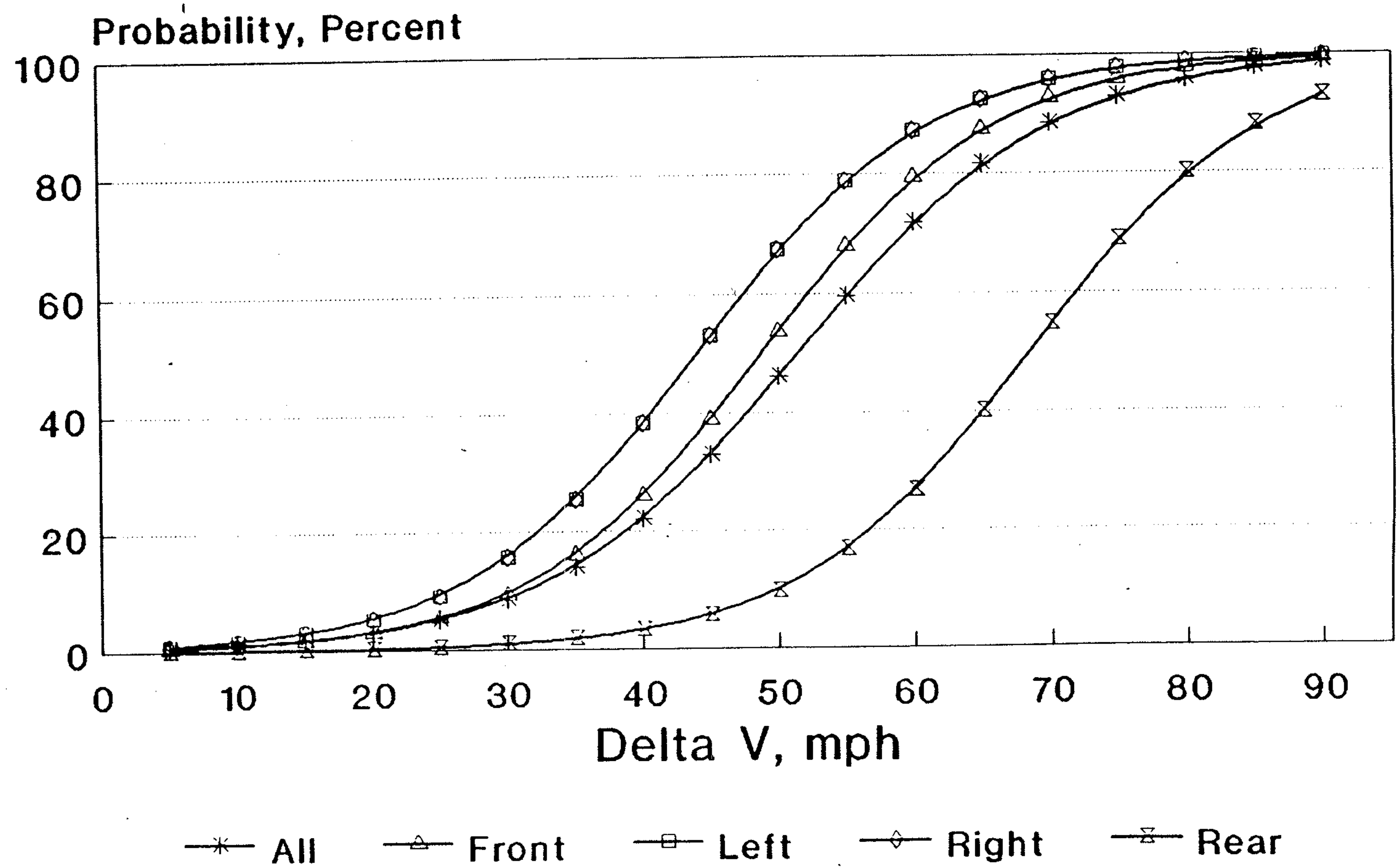


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Fig. 19. Probability of Fatality or MAIS 3+, versus Delta V, for Shown Car Occupant Restraint Use

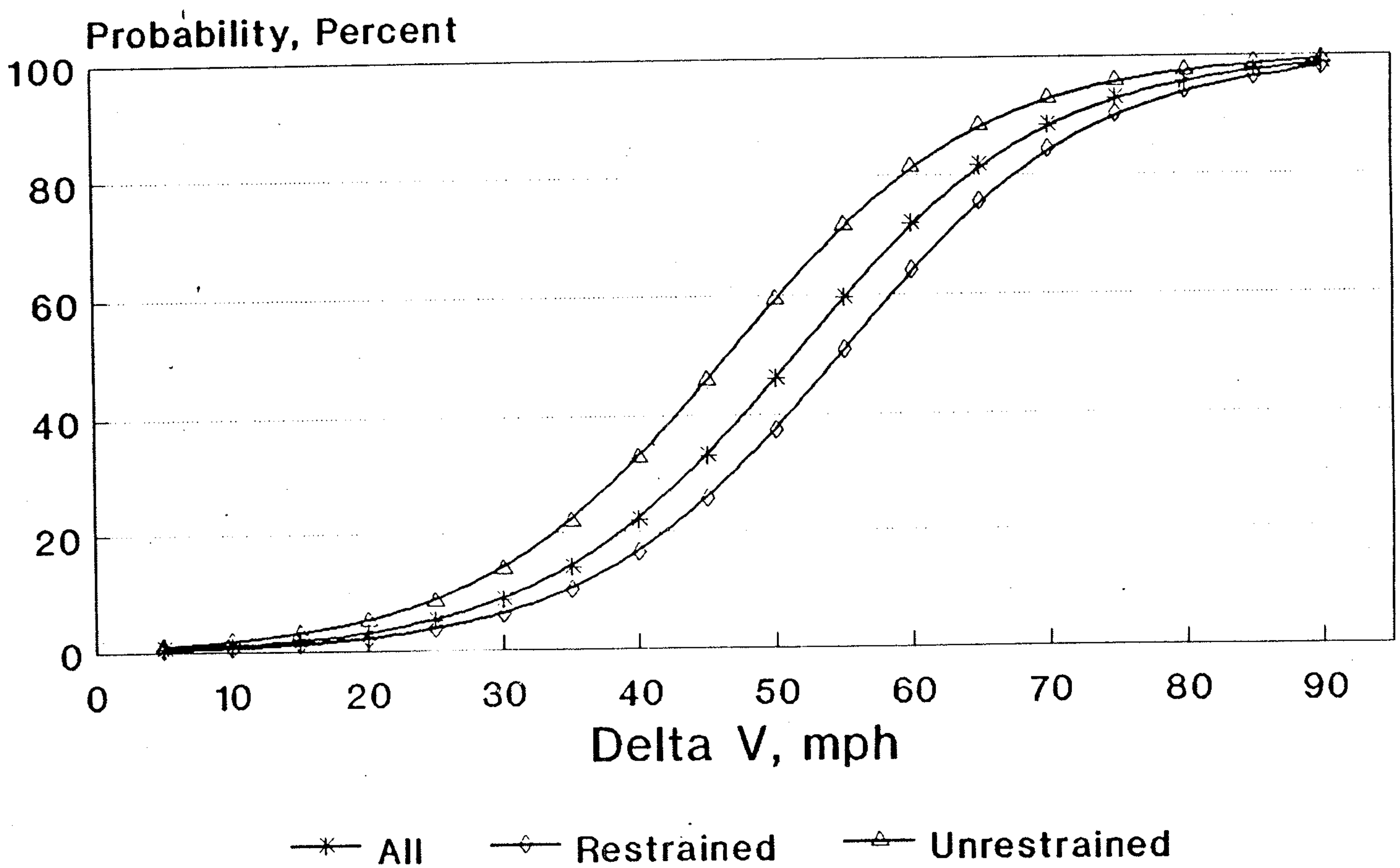


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Fig. 20. Probability of Fatality or MAIS 3+, versus Delta V, for Shown Car Occupant Age

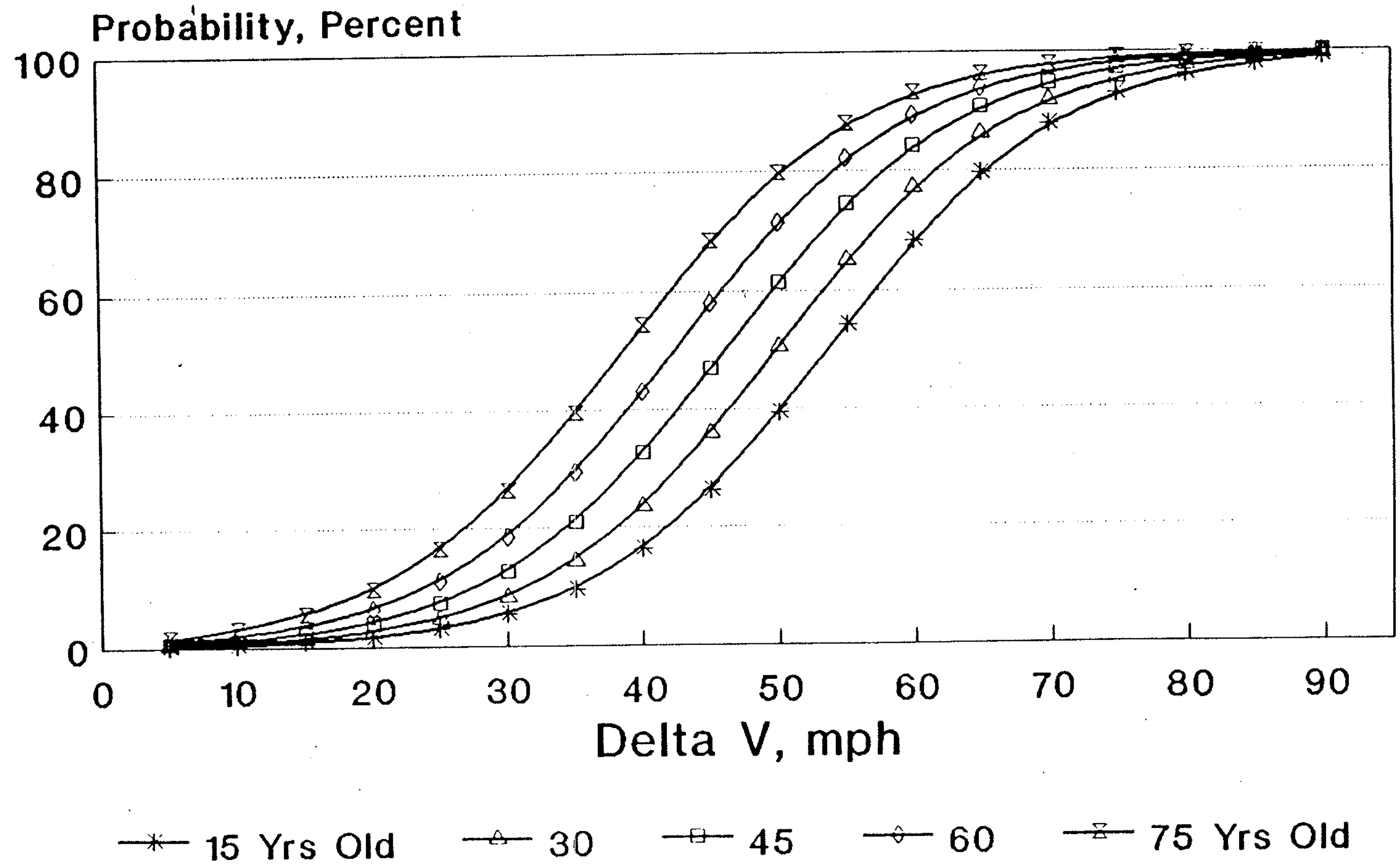


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Fig. 21. Probability of Fatality or MAIS 3+, versus Delta V, for Shown Car Occupant Seating Position

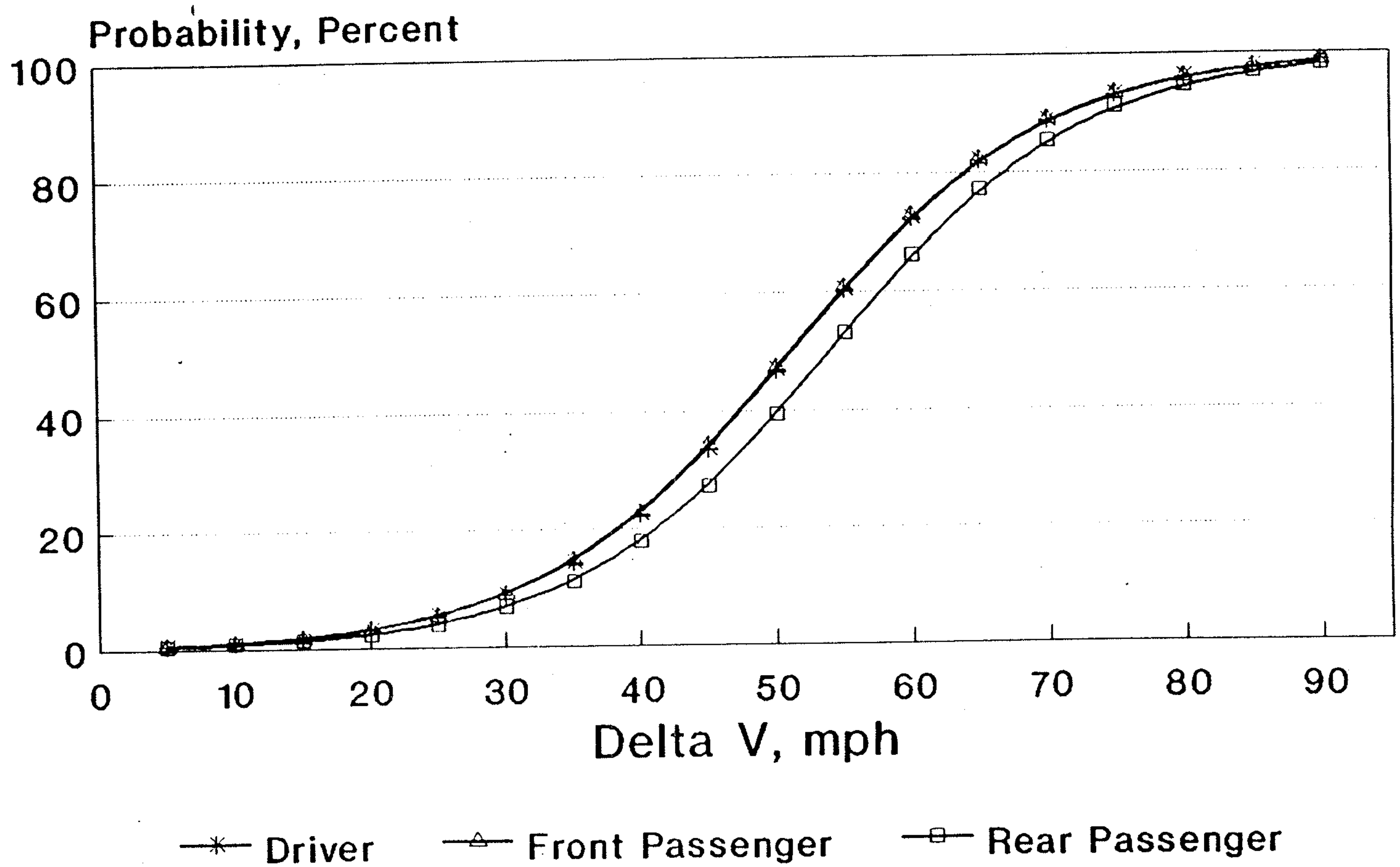


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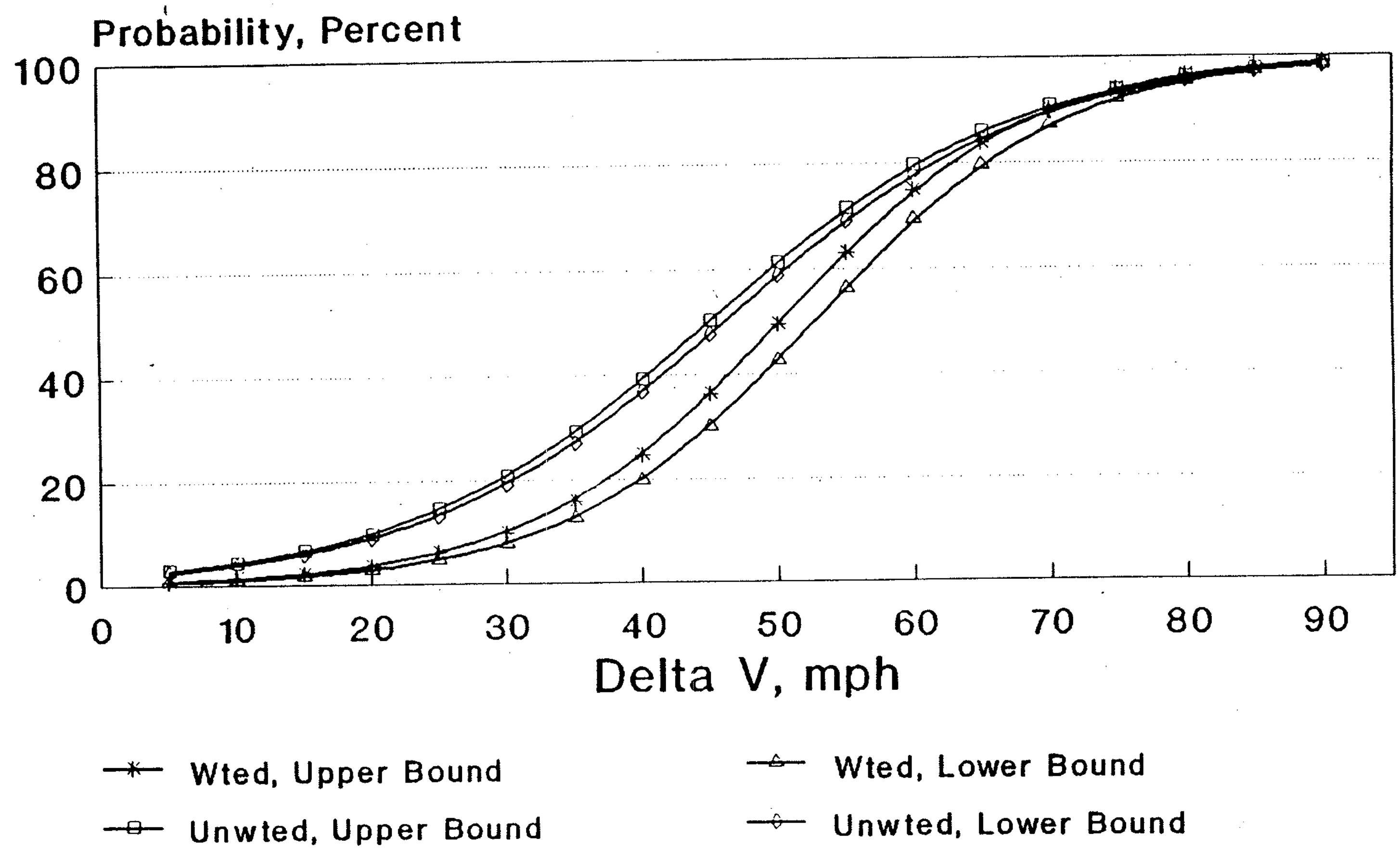
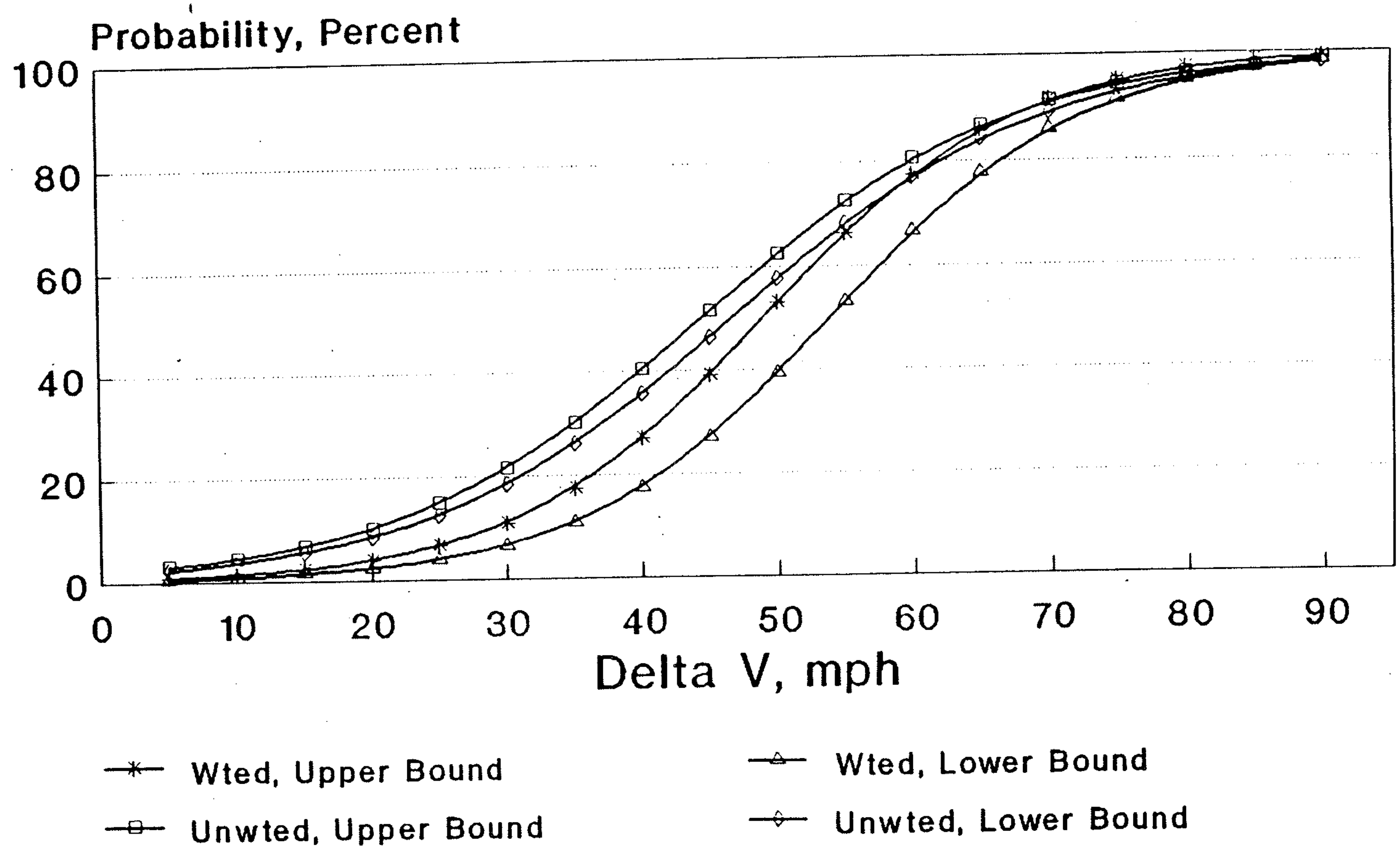
Fig. 22. Probability of Fatality or MAIS 3+, +/- Standard Error v. Delta V, for Weighted or Unweighted NASS Data



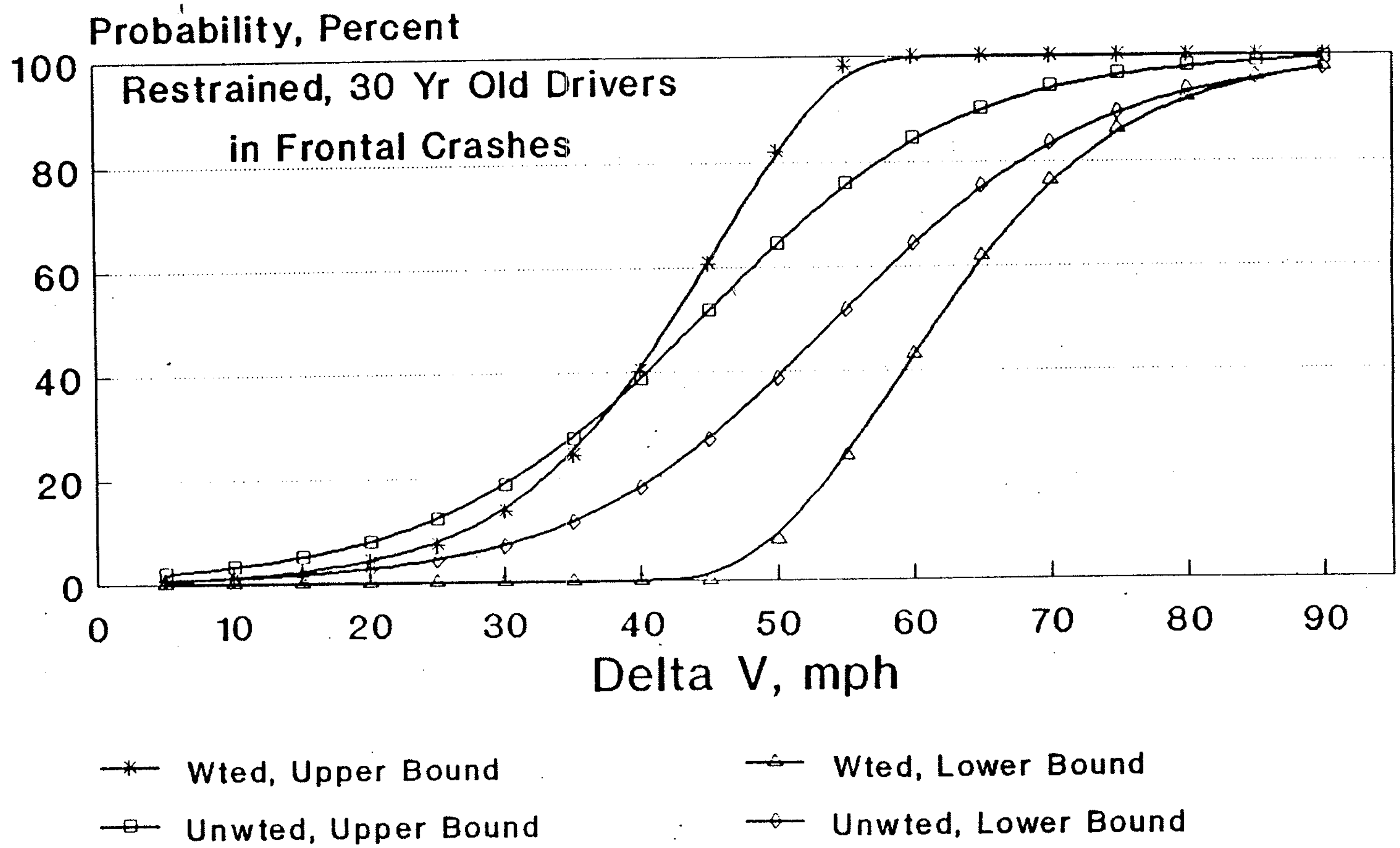

The NASS/CDS 1988-1994

Fig. 23. 95% Confidence Bounds of the Probability of Fatality or MAIS 3+, for Weighted or Unweighted NASS Data



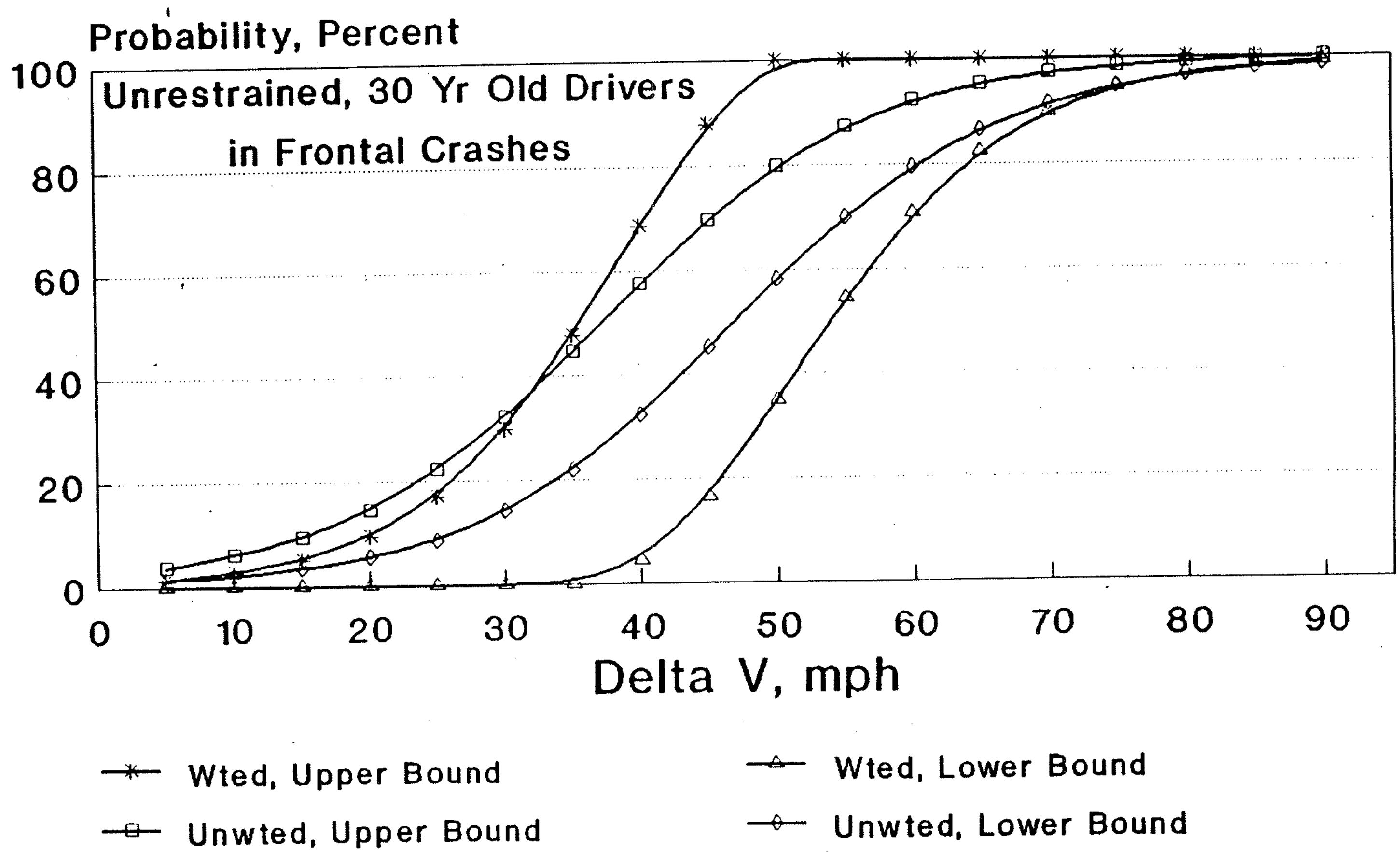

The NASS/CDS 1988-1994

Fig. 24. 95% Confidence Bounds of the Probability of Fatality or MAIS 3+, for Weighted or Unweighted NASS Data




The NASS/CDS 1988-1994

Fig. 25. 95% Confidence Bounds of the Probability of Fatality or MAIS 3+, for Weighted or Unweighted NASS Data




The NASS/CDS 1988-1994

Fig. 26. 95% Confidence Bounds of the Probability of Fatality or MAIS 3+, v. Rollover Quarter Turns for Car Crashes

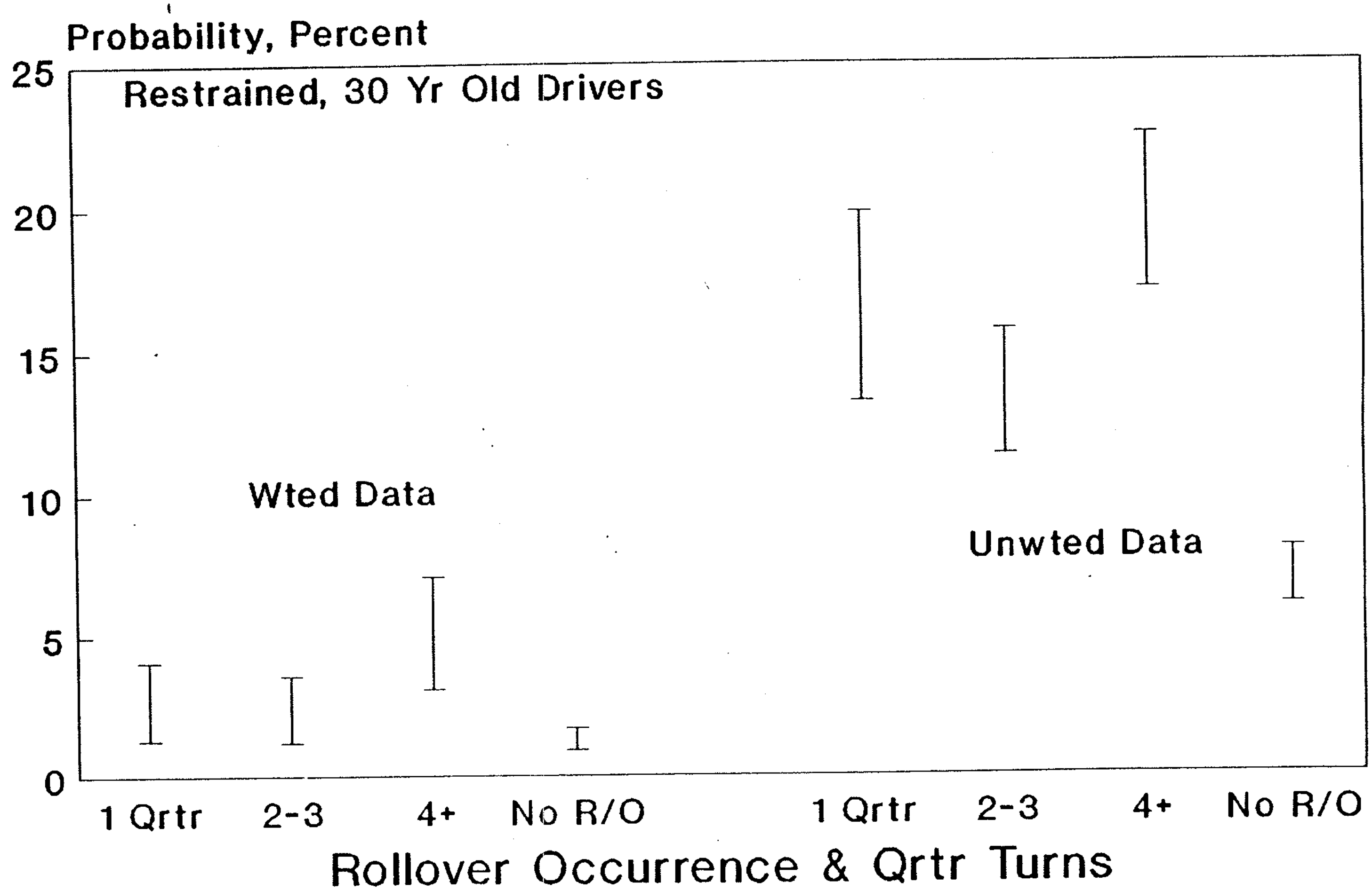



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Fig. 27. 95% Confidence Bounds of the Probability of Fatality or MAIS 3+, v. Rollover Quarter Turns for Car Crashes

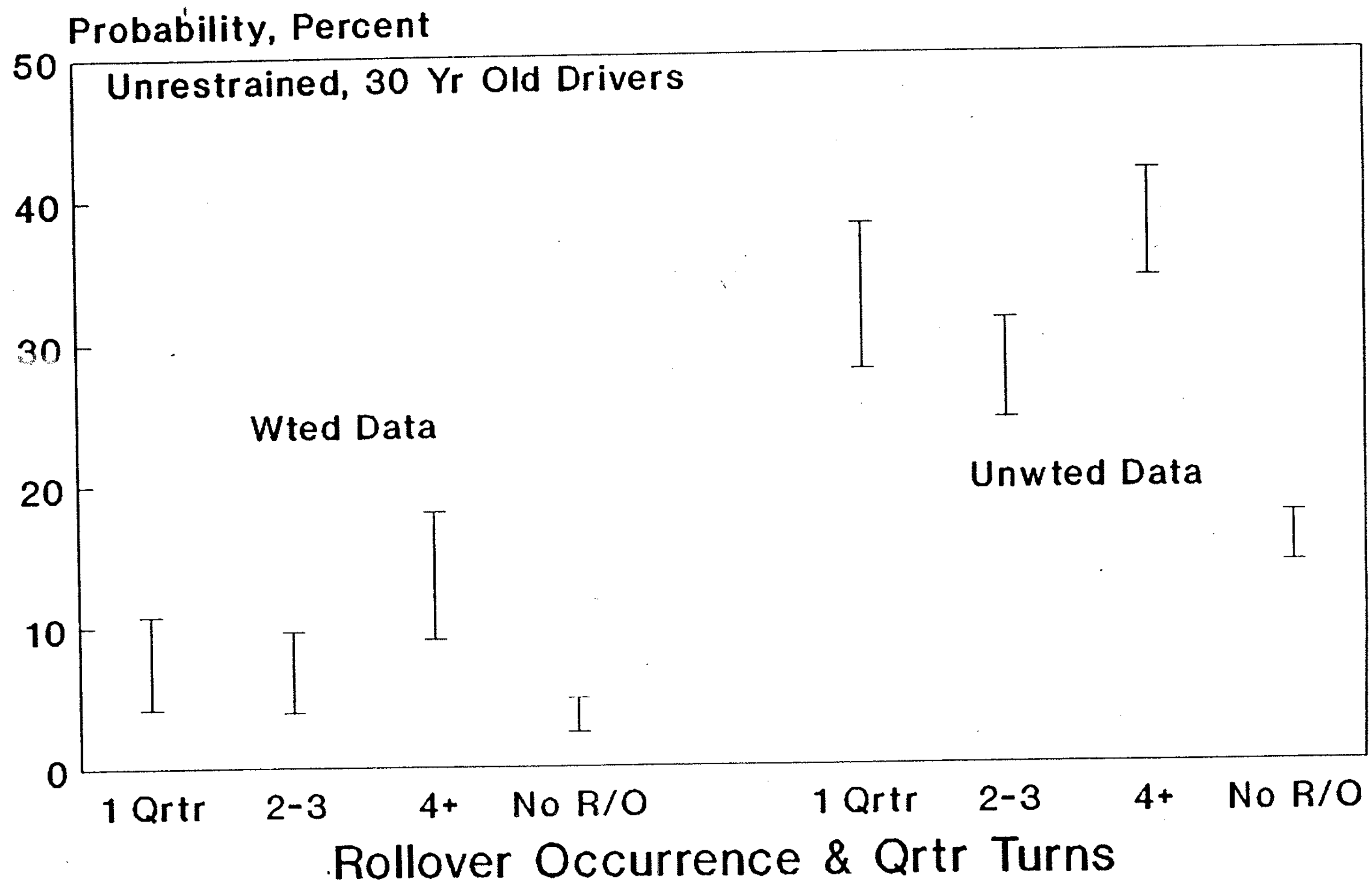


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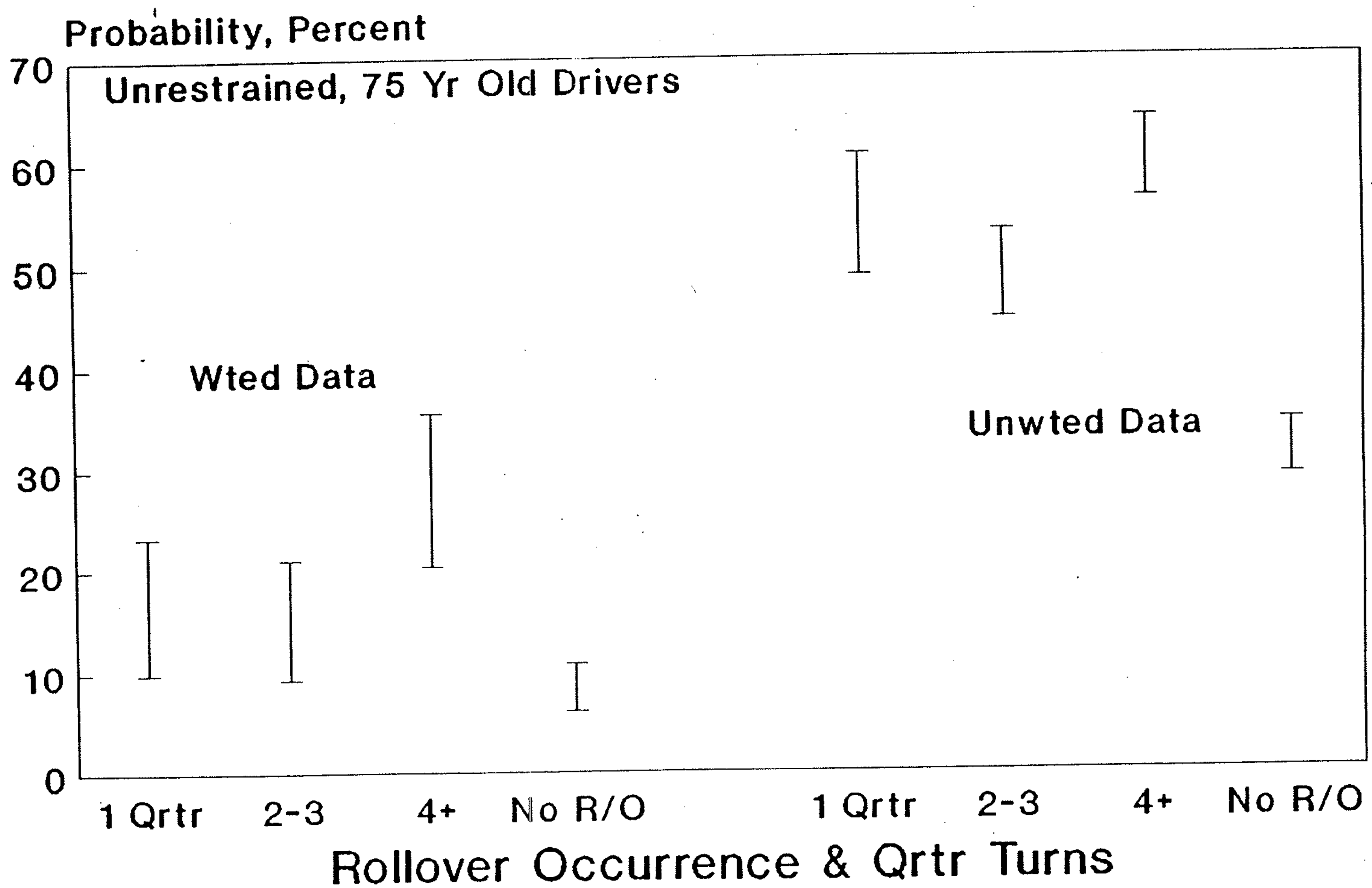
Fig. 28. 95% Confidence Bounds of the Probability of Fatality or MAIS 3+, v. Rollover Quarter Turns for Car Crashes

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