Driving consistency errors overestimate crash risk from cellular conversation in two case-crossover studies. Presentation at The Sixth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, Lake Tahoe, CA, June 29th, 2011.

**Goal**

To help explain the discrepancy in relative risk estimates between recent and early epidemiological studies of call-crash association.
What is the Discrepancy?
Crash Relative Risk (RR) while on Cell Phone

- Four recent epidemiological studies*
  - RR approximately 1
    (risk parity with baseline driving)
    *Klauer et al. (2006, 2010), Young & Schreiner (2009), Olson et al. (2009)

- Two early epidemiological studies**
  - RR approximately 4
    (four times more crash risk than baseline driving)
    **Redelmeier & Tibshirani (1997), McEvoy et al. (2005)

What Does the Discrepancy Mean?

- Different study designs should produce similar results if risk is small and no bias is present (Rothman et al., 2008).

- Discrepancy (RR of 1 vs. 4) implies bias.*
  *epidemiological, not personal bias

- This paper examines “driving consistency” bias.
Crude Relative Risk Estimate

- The *crude* RR is unadjusted for driving bias.

- The early epidemiological studies* recognized that their crude estimates were biased (confounded) by non-driving on the control day.

*Redelmeier & Tibshirani (1997), McEvoy et al. (2005)

Control for Driving Consistency

- Redelmeier and Tibshirani (1997) interviewed 100 people (not in their original study):
  - "...35 percent of them did not drive during the selected period."
  - That is, 65% of them recalled driving in a "selected period," presumably on a previous day.

- Redelmeier and Tibshirani (1997) adjusted RR:
  - Multiply crude RR by driving consistency estimate of 65%
  - $6.54 \times 0.65 = 4.3$
Crude Data*
RR = 6.54
*Redelmeier & Tibshirani (1997)

Control Day
Call  No Call
Crash Day
Call  13  157
No Call 24  505
RR = 157/24 = 6.54

Control Day Window

Adjusted Data*
RR = 6.54 x 0.65 = 4.3
*Redelmeier & Tibshirani (1997)

Control Day
Call  No Call
Crash Day
Call  13  102
No Call 24  505
RR = 102/24 = 4.3

Control Day Window

Key:
- 10 driving
- 10 calls

Driving Consistency Errors
New Estimate of Driving Consistency

- GPS sub-sample from the Chicago “Travel Tracker” database of heavy travelers, at least 10 trips per day
- Known trip activity for 240 GPS-instrumented vehicles during 2007-2008
- Minute-by-minute comparison of driving on day 2 for consistency with day 1

Hypothetical Consistency Examples

<table>
<thead>
<tr>
<th>Minute of Driving</th>
<th>Day 2</th>
<th>Day 1</th>
<th>Consistent?</th>
<th>Sum</th>
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Key: 1=Yes, 0=No

- Number of consistent minutes: 0
- Number of minutes in day 2: 10
- Driving consistency: 0%

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Key: 1=Yes, 0=No

- Number of consistent minutes: 2
- Number of minutes in day 2: 10
- Driving consistency: 20%
New Results: Consistency of GPS Driving Times

Consistency of Driving Times on Successive Days

- Only 2 vehicles (1%) had complete overlap (100% consistency) of day 2 to day 1
- Most vehicles had only part-time driving on day 1 that overlapped day 2
- Average of the 130 vehicles with at least some consistency was 27.4%
- Average across all 240 vehicles was 14.8%

Key Point: Part-Time Driving

- Redelmeier and Tibshirani (1997) and McEvoy et al. (2005) apparently retained a subject if they recalled driving at any time during the control window (that is, any person with more than 0% consistency).

- This method does not control for part-time driving in the control window.

- Accounting for the full range of driving consistency in the control window yields driving consistency = 14.8%.
Driving Consistency = 14.8% Implies RR = 1.0

- Redelmeier and Tibshirani’s (1997) raw RR
  - RR = 6.54 (C.I. of 4.5 to 9.9)

- Apply driving consistency of 14.8%
  - RR = 0.96 (C.I. 0.67 to 1.5)

- Consistent with recent studies*
  *Klauer et al. (2006, 2010), Young and Schreiner (2009), Olson et al. (2009)

Adjustment of Odds Ratio Estimate of McEvoy et al. (2005)

- Raw RR: 4.1 (C.I. of 2.2 to 7.7)
  - McEvoy et al. pre-censored those who did not recall driving during control windows (0% consistency), but again assumed 100% consistency for the rest.

- Driving consistency should be 27.4%
  - Average for all vehicles with > 0% consistency

- Resulting RR: 1.1 (C.I. of 0.60 to 2.1)

- Consistent with recent studies*
  *Klauer et al. (2006, 2010), Young and Schreiner (2009), Olson et al. (2009)
**Discussion (1)**

- Early case-crossover studies properly removed control windows in which the subject did not recall driving
  - People may have more calls per minute when driving, biasing RR upwards
- These studies did not control for part-time driving during control windows
- GPS data indicate driving consistency is lower than previously estimated
  - Raw RR (without adjustment for driving consistency) in earlier studies likely biased upward

**Discussion (2)**

- Applied Redelmeier and Tibshirani (1997) methodology using a more accurate driving consistency estimate
- The adjusted relative risk estimates of Redelmeier and Tibshirani (1997) and McEvoy et al. (2005) are near one
- These adjusted estimates are consistent with recent epidemiological studies results
  **Klauer et al. (2006, 2010), Young and Schreiner (2009), Olson et al. (2009)**
Discussion (3): Limitations

- Did not use the same drivers as in the early case-crossover studies to estimate driving consistency
- Did not prove high relative risk estimates in early case-crossover studies entirely attributable to driving consistency errors
- To prove, must use case-crossover design with instrumented vehicles
  - Must also have cellular call billing data when not driving
  - Not collected in any naturalistic study to date, including SHRP 2
- Driving consistency should be calculated with GPS data from additional cities

Discussion (4)
Present Study Supports:

- The hypothesis that the two early case-crossover studies overestimated RR
- Overestimating driver consistency accounts for much of the discrepancy between the recent and early relative RR estimates.
Visual-Manual Risks while Driving

- Cell phone “usage” comprises two separate types of tasks
  - conversation (auditory-vocal)
  - visual-manual

- Earlier studies may have overstated conversation risks
- Does not mean cell phones are “safe”
- Studies suggest elevated visual-manual risks
  - 3-7 times increase in risk for manual 10-digit dialing or reaching for a cellular phone; 23 times increase for texting (Klauer et al., 2006; Olson et al., 2009)

Conclusion

Objective GPS data indicates that two early case-crossover studies likely overestimated the amount of driving during control windows, which translates into lower exposure for cellular conversation during control vs. crash windows, introducing overestimates of relative risk.
Acknowledgments

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References


Thank you!