AN UNBIASED ESTIMATE OF THE RELATIVE CRASH RISK OF CELL PHONE CONVERSATION WHILE DRIVING AN AUTOMOBILE

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• Richard Young received no funding or payments from any source in connection with the writing or content of this presentation or its accompanying paper
• On unrelated research projects, Richard Young has received financial support from automotive companies
Definitions

**Crash risk**
- The probability of a crash

**Relative crash risk (RR)**
- The crash risk when engaged in an activity while driving, divided by the crash risk when not engaged in that activity while driving

**Cell phone conversation**
- Talking or listening on a hands-free or hand-held device that communicates through wireless transmissions

**Talk**
- Shorthand for “cell phone conversation”

**Real-world driving study**
- Driving with one’s personal vehicle during daily driving, without experimental instructions

**Naturalistic driving study**
- A specific type of real-world driving, where the driver’s vehicle is equipped with video cameras and other recording instruments
Historically, most studies on cell phone conversation (Talk) and driving have been experimental studies

- Experimental studies cannot validly estimate crash risk
  - Real-world driving data is required
  - In real-world driving, drivers can choose whether, where and when to engage in a secondary task to driving (such as Talk), whereas in an experimental study they cannot
  - If, when, and where a task is performed affects crash risk.
- Therefore, the scope of this presentation is limited to real-world (not experimental) driving studies

Current real-world driving studies indicate that Talk does not increase the crash RR compared to Not Talk

- Talk may even decrease the crash RR
  - Likely reason is that drivers self-regulate their driving behavior during Talk
• Analyzed cell phone billing records of 699 Toronto drivers involved in a property-damage crash (Redelmeier and Tibshirani, 1997)
  – About 4 times more drivers engaged in calls in the 10-min window before a crash than in the 10-min window (with the same clock time) the day before the crash
  • Concluded that the RR when engaged in a call while driving was **four times higher** than when not engaged in a call while driving
  • Results replicated by McEvoy et al. (2005) in Australia
Dr. Richard A. Young, GM, USA

• Analyzed all OnStar advisor calls and all airbag deployment crashes of all vehicles in North America with active OnStar subscriptions (about 1 million, or 167,000 per month) from October, 1996 to May, 2001 (Young, 2001)
  – Found 1,910 airbag-deployment crashes and 8 million OnStar advisor calls
  • Only 2 advisor calls were in progress at the time of an airbag crash
  • Conclusion: “An embedded cell phone in use at the time of an airbag-deployment crash is … rare.”
• First real-world study to suggest that Talk risk was low, contrary to Redelmeier and Tibshirani (1997)
Dr. Richard A. Young (now at Wayne State University, USA) and Christopher Schreiner (then at OnStar, USA and now at Strategy Analytics, USA)

- Conducted the OnStar Personal Calling Study (Young and Schreiner, 2009)
- Estimated the RR for carrying on a personal conversation using the OnStar device while driving
- Analyzed cellular billing records of all vehicles with an OnStar subscription from June, 2001 to November, 2003 (2.5 years)
OnStar Personal Calling Study Data

- 3 million vehicles across North America
- 91 million personal calls
- 47,609 driving-years
  - 437 times the 109 driving-years in the 100-Car study
  - 12.5 times the 3,800 driving-years of the SHRP2 study (see Figure)
- 2,037 airbag-deployment crashes
OnStar Study Results

- 14 airbag-deployment crashes during Talk in 276 million driver-min (525 driving-years)
  - 5.08 crashes per 100 million minutes
- 2,023 airbag-deployment crashes during No Talk in 24.7 billion driver-min (47,000 driving-years)
  - 8.18 crashes per 100 million minutes
- RR estimate is 0.62
The OnStar RR is 7 times smaller than the Toronto RR.

Diagram:

- Toronto: RR Estimate = 4.3
- OnStar: RR Estimate = 0.62
The Toronto study RR may be biased too high, because:

1. Part-time driving during control periods not controlled for*
   - Driving occurred during only about 2 minutes of the 10 minute control periods, and calls occur at 7x lower rate when not driving*
   - Overestimates the RR by 3.2 times**

2. Call misclassification bias counted post-crash calls as pre-crash†
   - Crash time errors cause more post-crash calls to be misclassified as pre-crash, than pre-crash calls misclassified as post-crash**
   - Overestimates the Talk RR by 2.3 times**

3. Local. Toronto not representative of all of North America†

4. Combining Reach and Dial risk with Talk‡ (rejected)
   - However, such combining is not possible because the start time stamps in billing records for outbound calls from the driver are recorded only after a caller finishes dialing, presses “send,” the call is successfully routed, and the called party answers
   - There is no billing record if a crash occurs during cell phone tasks such as Reach or Dial that occur before the called party answers

*Young, 2012a. **Young, 2014. †Young and Schreiner, 2009. ‡McEvoy et al., 2012; Klauer et al., 2014
And/or, the OnStar RR may be biased **too low**. Why?

1. *Better human factors* for the OnStar device than portable devices (Young and Schreiner, 2009)

2. *Demographic variables* (age, sex, education, income, etc.) were not controlled for in the OnStar study and these biased the OnStar RR low (Young and Schreiner, 2009)

3. *Drivers used portable cell phones when not using OnStar* and that increased their baseline risk and so decreased the OnStar RR (Braver et al., 2009) (rejected)
   - Portable cell Talk risk is not greater than that of embedded cell Talk risk (Fitch et al., 2013), so portable cell Talk in the baseline cannot downwardly bias the embedded device Talk RR (Young, 2014)

4. *Questionable independence*. Young was part of GM and Schreiner was part of OnStar when the study was carried out, making their independence “questionable” (Martin, 2013) (rejected)
   - *Ad Hominem* fallacy, in which an argument is rejected “on the basis of some irrelevant fact about the author of or the person presenting the … argument.”

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*Current Knowledge: OnStar Discussion (3)
Why is the OnStar RR 7 Times Smaller than the Toronto RR?*
A sufficient reason is that the Toronto RR is biased too high because of (1) *part-time driving* and (2) *call misclassification bias*

- The combination of these factors caused an overestimate of the Toronto (and Australian) RR by a factor of 7
  - These pioneering RR estimates of 4 must be adjusted downwards by 7 times to remove both part-time driving and call misclassification bias
- The Toronto RR estimate reduces to 0.61 (Young, 2014), now in close agreement with the OnStar RR estimate of 0.62
- The Australian RR (McEvoy et al., 2005) similarly reduces to 0.64 (Young, 2014)

<table>
<thead>
<tr>
<th>#</th>
<th>Study</th>
<th>Metric</th>
<th>Design</th>
<th>RR</th>
<th>Adj. RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Toronto [3]</td>
<td>Rate Ratio</td>
<td>Case-Crossover</td>
<td>0.61</td>
<td>0.61</td>
<td>0.38 0.98</td>
</tr>
<tr>
<td>2</td>
<td>Australia [17]</td>
<td>Rate Ratio</td>
<td>Case-Crossover</td>
<td>0.64</td>
<td>0.64</td>
<td>0.32 1.27</td>
</tr>
<tr>
<td>3</td>
<td>OnStar [12]</td>
<td>Rate Ratio</td>
<td>Cohort</td>
<td>0.62</td>
<td>0.62</td>
<td>0.37 1.05</td>
</tr>
</tbody>
</table>
Dr. Gregory Fitch and colleagues at Virginia Tech Transportation Institute (VTTI), USA

- Fitch et al. (2013) (hereafter called the *cell phone* study) employed naturalistic study methods, where video cameras and other instruments are placed in a driver’s own vehicle.
  - They estimated an RR of 0.75 (95% CI 0.49 to 1.15) for conversation combined across all phone types (hand-held, portable hands-free, and embedded hands-free wireless devices), and all safety-critical events (crashes, near-crashes, crash-relevant conflicts, and curb strikes).
- This RR estimate is biased slightly high, because a non-standard epidemiological method was used, comparing “Talk” to “No Task.”
- When a standard method is used, comparing “Talk” to “Not Talk,” the RR is 0.71.

<table>
<thead>
<tr>
<th></th>
<th>Talk</th>
<th>Not Talk</th>
<th>Total</th>
<th>Odds</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety-Critical Event</td>
<td>28</td>
<td>154</td>
<td>182</td>
<td>0.1818</td>
<td>8.2%</td>
</tr>
<tr>
<td>Matched Baseline</td>
<td>259</td>
<td>1,068</td>
<td>1,327</td>
<td>0.2425</td>
<td>11.2%</td>
</tr>
<tr>
<td>RR (95% CI)</td>
<td>0.75 (0.49 to 1.15)</td>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
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<th>Not Talk</th>
<th>Total</th>
<th>Odds</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety-Critical Event</td>
<td>28</td>
<td>314</td>
<td>342</td>
<td>0.089</td>
<td>8.2%</td>
</tr>
<tr>
<td>Matched Baseline</td>
<td>259</td>
<td>2,049</td>
<td>2,308</td>
<td>0.126</td>
<td>11.2%</td>
</tr>
<tr>
<td>RR (95% CI)</td>
<td>0.71 (0.47 to 1.06)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPF% (95% CI)</td>
<td>3.3% (-0.3% to 6.9%)</td>
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</table>
Dr. Sheila Klauer and colleagues at VTTI, USA had a larger RR estimate than the OnStar and Fitch et al. estimates

- Klauer et al. estimated an RR of 1.29, almost double the RRs found by Young and Schreiner (2009) and Fitch et al. (2013), and on the opposite side of the baseline crash risk of 1.
  - However, Young (2013a, 2014) showed that the Klauer et al. (2006) study had a selection bias:
    - All drivers (regardless of fault) were sampled in the cases (i.e., those drivers engaged in cell phone conversation before a crash or near-crash)
    - But only at-fault drivers were sampled in the crashes/near-crashes with no secondary task (controls)
    - The adjusted Talk RR estimate reduces to 0.78 for all crashes/near-crashes, regardless of fault (Young, 2013a, 2014), and to 0.76 for only at-fault crashes in the 100-Car data (Klauer et al., 2014)
    - These adjusted RRs are consistent with the Fitch et al. (2013) RR of 0.75 (or standard method RR of 0.71) for all safety-critical events (crashes, near-crashes, curb strikes and incidents) in passenger vehicles
The 100-Car RR of **0.76** reduces to **0.56** using matched baseline clips

- This adjusted 100-Car RR estimate of **0.76** was still biased upward by environmental variables (such as traffic, closeness to junction, weather, and time of day)
  - These variables were unmatched between case and control video clips in the Klauer et al. (2006) 100-Car study
- Young (2013a, 2014) compared the data for the crash/near-crash video clips in the publicly-released 100-Car database (VTTI, 2014) with the matched baseline video clips from Klauer et al. (2010)
  - The adjusted RR estimate for cell phone conversation declines to 0.56 (95% Confidence Interval from 0.41 to 0.76)
Current Knowledge:
Meta-Analysis of All Real-World Studies of Talk Adjusted RRs

The Talk RRs in all 5 real-world studies agree (after adjustment)

- The pooled RR is **0.61** (95% Confidence Interval 0.47 to 0.74)

![Bar chart showing adjusted RRs for different studies with Talk > Not Talk, Talk = Not Talk, and Talk < Not Talk]

**Pooled Result:** Talk reduces crash risk* compared to Not Talk.

*and near-crash, incident, and curb strike risk
Compensation/self-regulation reduces Talk risk

- Drivers engaged in Talk during real-world driving tend to change their driving behavior such that there is no net safety decrement from the slight increase in event response time from cell phone conversation
  - Talk in less-demanding situations
  - Decrease speed during Talk
  - Increase time and distance headway during Talk

Gaze concentration reduces Talk risk

- More eyes-on-the-road time during Talk than Not Talk
  - Eyes-on-road time (i.e., gaze concentration on the forward roadway) reduces crash risk (Klauer et al., 2006; Young, 2012b)
  - Most road hazards (and crashes) occur in the forward view (Young, 2012b)

Talk reduces risk from drowsiness

- Drivers when drowsy may adopt a strategy to engage in Talk, which reduces drowsy driving risk (Young, 2013b).
  - If so, Talk is symptomatic of this strategy, and not a causal factor of crashes
The protective effect does not directly arise from Talk
• The protective effect likely arises from the compensatory/self-regulatory behavior and effects around using the cell phone
  – Such self-regulatory behavior requires that the driver has the opportunity to make choices as to if, when, where, and how to Talk

It is important not to jump to incorrect conclusions:
• “It is best if the driver Talks on the phone 100% of the time driving”
  – False. Instead, crash risk will increase in the real world, because the driver no longer has the choice to Talk only in relatively benign environmental conditions
• “If the driver is in a hazardous situation, it is best to get on the phone to reduce the crash risk”
  – False. Attempting to Talk while in a hazardous situation does not reduce the risk from the hazard. Talk reduces crash risk because drivers tend to Talk in less hazardous situations, not more hazardous situations
• The only known exception is that Talk reduces the hazard from drowsy driving (Young, 2013b)
  – But the drowsy RR during Talk is still > 1, so more effective countermeasures should be undertaken
Legislation, regulations, or guidelines that prohibit cellular conversation with a portable hand-held, portable hands-free, or embedded hands-free device while driving may not reduce crashes

- Efforts to curb secondary tasks in vehicles should be carefully considered to assure that behaviors without harmful effects are not unnecessarily prohibited
- Indeed, such bans may increase crashes if:
  - The RR estimate is less than 1, indicating a protective effect that would be prevented by a ban
  - Drivers attempt to continue to make calls but do so in a more secretive way, which might lead to less safe driving behavior
- The evidence to date indicates that such bans have little or no detectable effect on crash rates, either in U.S. (McCartt et al., 2004, 2014) or Europe (Janitzek et al., 2006)
  - It can be logically concluded that either the RR is near 1 (so bans make little difference in crash rate), or that drivers ignore the bans (that is, driving behavior stays constant, so crashes stay constant)
1. The early real-world studies of cell phone conversation effects on crashes overestimated the relative risk by about 7 times because of bias from part-time driving in control windows and misclassification of calls as pre- or post-crash.

2. After adjusting for these and other biases in five real-world major epidemiological studies of conversation on cellular devices in passenger vehicles:
   - The Talk RRs estimates are all near to, or somewhat below, 1.
   - The pooled Talk RR estimate is $0.61$ (95% CI 0.51 to 0.74).

3. These data and analyses show that when biases are removed, talking on a cellular device (whether portable hands-free, portable hand-held, or embedded hands-free) while driving an automobile does not increase crash risk compared to not talking on such a device while driving, and may even reduce it, as a result of self-regulation by the driver.
I thank the following colleagues for helpful comments and assistance on earlier drafts of the paper or presentation:

- Li Hsieh
- Jay Joseph
- Katja Kircher
- Bruce Papazian
- Mike Posner
- Sean Seaman
- Barbara Wendling
- Amanda Zeidan
References (1)


