

The Impact of Hand-Held and Hands-Free Cell Phone Use on Driving Performance and Safety-Critical Event Risk

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Purpose

- Investigate SCE risk and performance when using 3 phone types
 - Hand-held (HH)
 - Portable hands-free (PHF)
 - Integrated hands-free (IHF)

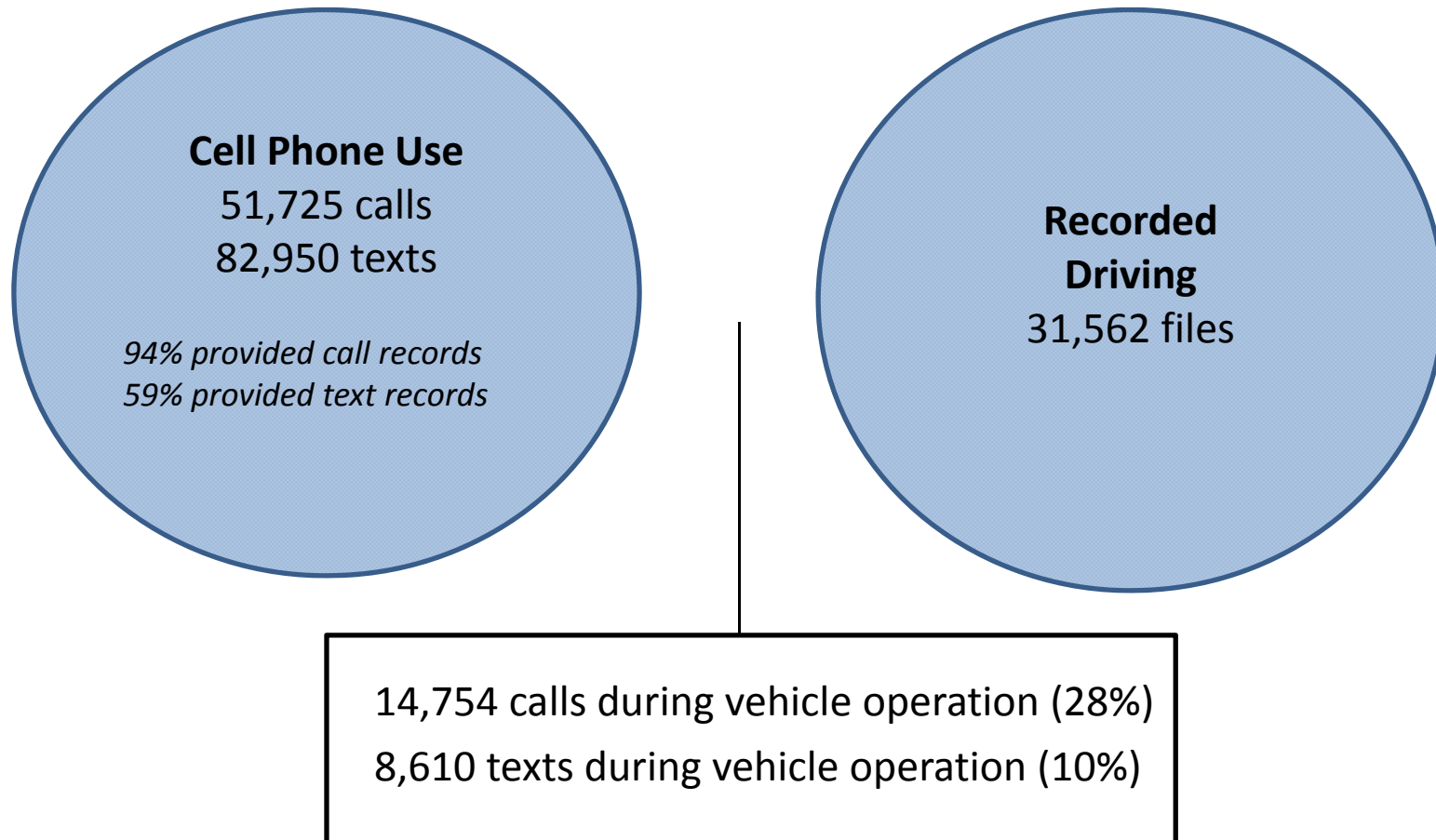


Naturalistic Driving Study Method

- Instrumented 204 vehicles
 - Continuous video and sensor data
 - Mean of 31 days
 - February - December, 2011
- Demographics
 - 129 females, 75 males
 - Median age 41 years (18 – 84 years)
 - Reported using cell phone once per day while driving

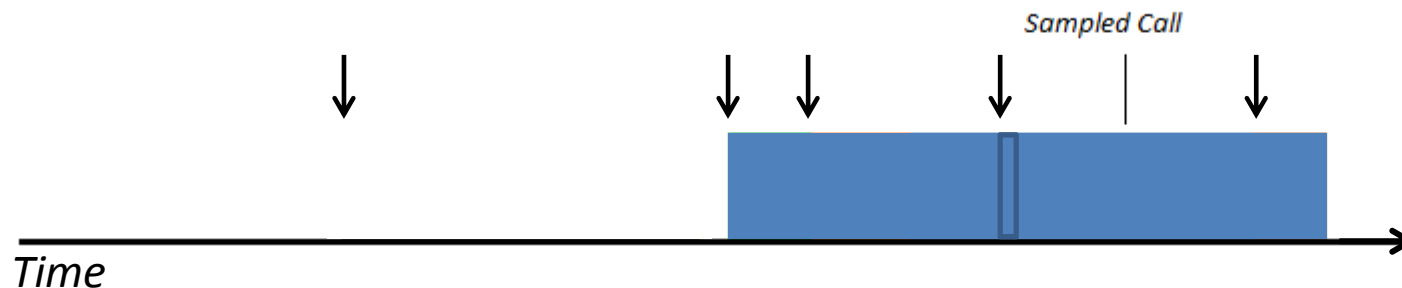


NDS Data + Cell Phone Records



Data Reduction

- Sampled 10% of cell phone use while driving
 - 1,564 calls sampled, 844 texts sampled
- Identified phone type and duration of each subtask
- Sampled 20-s baseline 30 s prior to sample
- Reduced driver, vehicle, and environmental factors for each



How Do Drivers Use Cell Phones?

- Drivers conversed on cell phone 10.6% of time
- Mean call length during vehicle operation was 4.02 minutes
- Drivers made more calls per minute and talked longer with PHF

Estimating SCE Risk

- Identified 342 SCEs
 - 6 crashes
 - 72 near-crashes
 - 264 crash-relevant conflicts
- Reduced driver, vehicle, and environmental factors
 - Determine what type of cell phone use took place prior to SCE

Estimating Subtask Exposure

- Used cell phone records to determine when call/text made
- Used reduced data to determine average subtask duration
- Multiplied together to assess exposure
- Considerations made for driver, speed, direction of call/text, and other demographic factors

Risk Rate Approach

- Used a Poisson random effect model to test SCE rate during cell phone use to SCE rate when not using cell phone

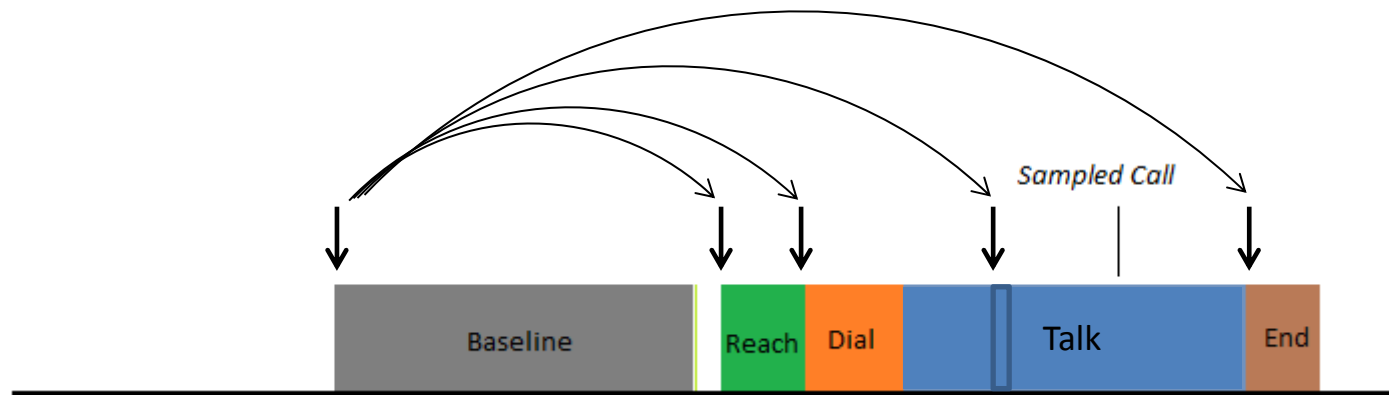
$$\text{Rate 1: } \frac{\text{\#SCEs During Driving + Talking}}{\text{Total Time Spent Driving + Talking}} > \text{Rate 2: } \frac{\text{\#SCEs During Driving}}{\text{Total Time Spent Driving}}$$

SCE Risk Rate Results

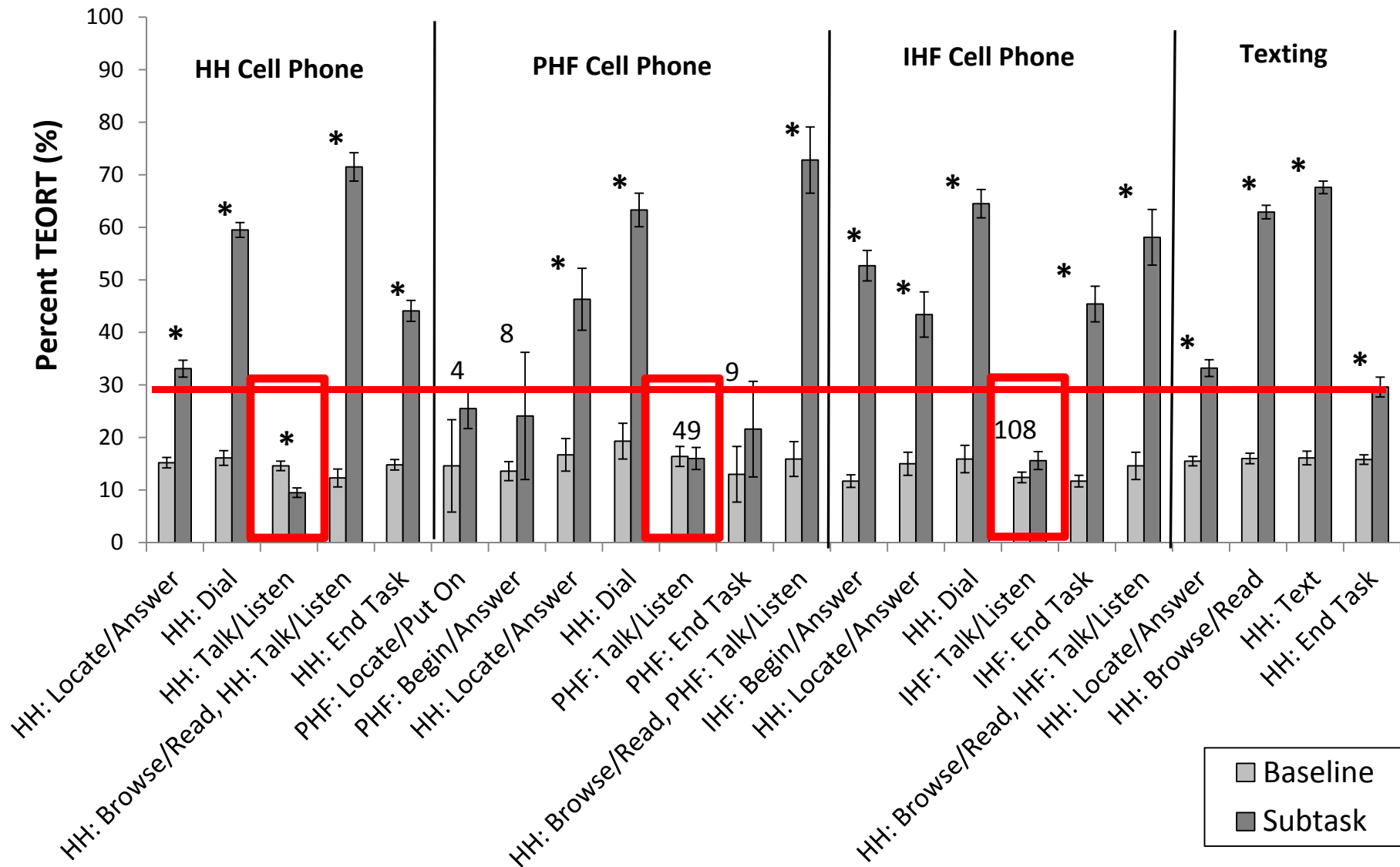
| Subtask | Rate Ratio | LCL | UCL | p-value |
|--------------------------------|------------|------|------|---------|
| Visual-Manual | 2.93* | 1.90 | 4.51 | < .0001 |
| Call-related Visual-Manual | 3.34* | 1.76 | 6.35 | .0003 |
| Text-related Visual-Manual | 2.12* | 1.14 | 3.96 | .0184 |
| Talking/Listening | 0.84 | 0.55 | 1.29 | .4217 |
| Talking/Listening HH | 0.84 | 0.47 | 1.53 | .5764 |
| Talking/Listening PHF | 1.19 | 0.55 | 2.57 | .6581 |
| Talking/Listening IHF | 0.61 | 0.27 | 1.41 | .2447 |
| Cell Phone Use – Collapsed | 1.32 | 0.96 | 1.81 | .0917 |
| HH Cell Phone Use (Collapsed) | 1.73* | 1.20 | 2.49 | .0034 |
| PHF Cell Phone Use (Collapsed) | 1.06 | 0.49 | 2.30 | .8780 |
| IHF Cell Phone Use (Collapsed) | 0.57 | 0.25 | 1.31 | .1859 |

Controlled Tests of Driver Performance

- Compared driver performance during baseline to performance during each subtask



Percent TEORT



Vehicle Control

- **Longitudinal vehicle control**
 - Headway increased from 0.4 s to 0.6 s when texting, $p < 0.05$
 - Speed standard deviation and peak deceleration increased when ending HH cell phone use, $p < 0.05$ (*by 1 km/h and 0.02 g*)
- **Lateral vehicle control**
 - The unintentional lane bust rate decreased from 0.003 busts/s to 0.001 busts/s when talking on a HH cell phone, $p < 0.05$
- **Lane Change Behavior**
 - Drivers changed lanes more when locating HH cell phone (10% vs. 4%), $p < 0.05$
- **Downstream Effects**
 - Rear vehicle more likely to be close (*increased from 6% to 12% during cell phone use, $p < .0165$*)

Discussion

- Findings agree with previous large-scale NDSs
- Visual-manual hand-held subtasks increased SCE risk and degrade driving performance
- Pure hands-free cell phones not found to increase SCE risk
 - Hand-held cell phone used half of the time
 - Demonstrates need for hands-free interfaces to be reliable and easy-to-use

Questions

