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Novel Smartphone-based Measures of Cell-Phone Use in a Sample of Newly Licensed Adolescent Drivers

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Abstract

Background: Motor vehicle crashes are the leading cause of adolescent death. Cell phone use while driving is a contributor to adolescent motor vehicle crash risk. Objective and directly observable measures of cell phone use while driving are needed to implement interventions aimed at reducing cell phone related crash risk.

Aims: To describe novel smartphone based measures of cell-phone use while driving in a sample of newly licensed male and female adolescent drivers.

Methods: Newly licensed adolescents in Pennsylvania installed a windshield-mounted device that pairs with a smartphone application to collect data on cell phone use while driving over 2-weeks during June 2016-October 2016. Descriptive statistics, Independent t-tests, and Wilcoxin Mann–Whitney U were used to characterize handheld cell phone use (“unlock”) and call time while accounting for driving exposure.

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Human Participant Protection: The protocol was approved by the Institutional Review Board at Children's Hospital of Philadelphia with a cooperative agreement with the University of Pennsylvania. This research adhered to the Principles of the Ethical Practice of Public Health of APHA.

Results: Data from 16 adolescents (50% male) resulted in 5624 miles in 705 trips, 964 cell phone unlocks, and 146.22 minutes of call time. Participants had a mean of 23.96 unlocks/100 miles (sd=22.97), 1.23 unlocks/trip (sd=0.96), and 4.87 unlocks/hour driven (sd=3.93). Males had significantly more unlocks/100 miles, unlocks/100 miles at speeds >25 mph, unlocks/hour driven and unlocks at speed > 25 mph/hour driven ($p<0.05$).

Conclusions: Smartphone-based applications are an innovative means by which to collect continuous data on cell phone use while driving that can be used to better understand and intervene on this frequent behavior in newly licensed adolescent drivers.

Introduction

Motor vehicle crashes (MVC) are the leading cause of adolescent death and disability in the United States (Centers for Disease Control and Prevention, 2017)). Cell phone use while driving contributes to MVC risk (Asbridge, Brubacher, & Chan, 2013; Carney, Mcgehee, Harland, Weiss, & Raby, 2015; Klauer et al., 2014). Adolescent drivers disproportionately account for distraction-related crashes, with cell phones involved in 22% of distracted-related fatal crashes with adolescent drivers (NHTSA, 2017).

Current data collection methods (Klauer et al., 2014; Lenhart, Ling, Campbell, & Purcell, 2010; Olsen, Shults, & Eaton, 2013), coupled with rapidly changing technology and communication norms (Lenhart, 2015), limit our understanding of the problem and ways to measure cell phone use while driving (McDonald & Sommers, 2015; Vrijheid et al., 2009). Recently, smartphone applications aimed at promoting safer driving that continuously monitor cell phone use while driving have emerged, representing a promising innovation for better understanding of behaviors and a means to deliver automated interventions (Delgado et al., 2018; Delgado, Wanner, & McDonald, 2016). The purpose of this study was to describe novel smartphone-based measures of cell-phone use while driving in a sample of newly licensed adolescent drivers.

Methods

Study Design

Newly licensed 16–17 year-old adolescent drivers were recruited to participate in a pilot randomized controlled trial (RCT) of an intervention designed to reduce adolescent driver inattention (NCT02319317). Participants completed an on-line questionnaire, installed a commercially-available cell phone monitoring device (CellControl Drive ID™) in their vehicle, and downloaded a smartphone application that paired with the device. We report on data collected in the first 2-weeks of enrollment prior to completion of intervention activities.

Inclusion Criteria

Inclusion criteria were: Age 16–17 years; Pennsylvania (PA) driver's license for 90 days; iPhone 4S or newer or Android 4.3 or newer smartphone with data plan; Primarily drove one vehicle with the ability to accommodate Drive ID™; Personal email address; Access to computer and internet and; Ability to read and write English. Exclusion criteria were:

Participation in a Children's Hospital of Philadelphia (CHOP) Center for Injury Research and Prevention adolescent driving study within the past 6 months or inability to follow study procedures.

Recruitment and Consent

Adolescents were recruited through presentations, letters, and emails to families affiliated with CHOP and word of mouth. The protocol was approved by the Institutional Review Board at CHOP with a cooperative agreement with the University of Pennsylvania. Parental/guardian written electronic consent and adolescent written electronic assent were obtained via REDCap.

Measures

A commercially-available cell phone monitoring device (Cellcontrol DriveID™) paired with a smartphone application was used to collect data on cell phone use while driving and driving exposure. The device was windshield mounted behind the rear-view mirror and Bluetooth paired to the adolescent's phone. The device contained a global positioning system (GPS) unit, accelerometer, and sensors to detect engine on and presence of the paired cell phone as either on the driver or passenger side of the vehicle. Data were collected in 1-second intervals, including continuous state of the vehicle and phone, presence of the engine on, GPS coordinates, vehicle speed (calculated based on GPS and accelerometer sensors), cumulative mileage and total trip length, cumulative and total trip time in seconds, and cell phone use. Cell phone use metrics included: cell phone screen off/on; cell phone screen locked/unlocked, phone call dialing activity, phone call answering, call time length and location of phone on the driver or passenger side of the vehicle during use. Once driving data were collected, adolescents could not delete information.

Self-report data were collected via REDCap prior to device installation. Participants reported demographic information (gender, age, race, ethnicity (Hispanic origin)), driving history (driving frequency, crashes, driving with adolescent passengers), cell phone version, length of licensure and past month cell phone use while driving.

Procedures

Participants were mailed a package with the cell phone monitoring device and instructions on how to install the device and download the application. Data were collected and transferred to the study team via secure files. Participants were compensated up to \$100 and the device for participation in the pilot RCT study.

Analysis

We examined driver trips (frequency, distance, and duration of time driven (hours)), driver cell phone unlock, and driver call time (seconds), each described below. Analytic trips met the following criteria: vehicle engine on; tagged as driver for the majority of the trip; distance >0.10 miles; trip duration >60 seconds and; maximum speed >2.5 miles per hour (mph). Trips are described by frequency, duration (time), and length (distance).

Cell phone unlock was defined as a change from screen locked to unlocked in two consecutive seconds. A cell phone unlock occurred by handheld manipulation of the phone and therefore was indicative of handheld cell phone use. Analytic unlocks met the following criteria: engine on, data tagged as driver, occurred at >2.5 mph if within 20 seconds of end/beginning of trip (i.e. to exclude activity at the beginning/end of a trip when vehicle was not moving) and collected in the first 2-weeks of data collection. Unlocks within 20 seconds of the beginning/end of a trip at a speed >2.5 mph were included. Cell phone unlocks are described by frequency, rate per mile, rate per trip, rate per hour, speed at time of unlock, and unlocks at speed >25 mph, defined a-priori as a measure of high-risk use based on the exponential increase in the risk of pedestrian severe injuries if struck above this speed (Tefft, 2011).

Call time was recorded in 1-second intervals. Call time is described as minutes or seconds per trip or per mile. Call time data were aggregated, regardless of the method used (hands-free or hand-held).

Descriptive statistics were used to describe trips, cell phone unlocks, call time, and self-reported cell phone use. Independent t-test and Mann-Whitney U tests were used to compare gender differences in trips, cell phone unlocks, call time, and differences in these metrics while accounting for exposure (trip, duration or miles).

Results

Twenty-eight participants enrolled; two were ineligible due to length of licensure >90 days; two withdrew, three were lost to follow up, and five had limited baseline data due to improper device installation and data collection issues. We report on the first 2-weeks of data collection for the 16 participants with reliable data prior to completing the intervention assigned in the pilot RCT. Table 1 describes the demographic characteristics, self-reported driving behavior, and cell phone use while driving in the 30 days prior to start of data collection. All participants reported having iPhone model phones. From self-report data, in the last month while driving, 40% used made a handheld phone call; 40% accessed the internet; 60% used a hands free device to make a call; 73% read a text, whereas 47% sent a text; and 67% used a handheld cell phone to use GPS. All participants reported driving with other adolescent passengers.

Driving Exposure

There were 705 trips that met inclusion criteria, resulting in 195.1 hours of driving and 5,624 miles. Males accounted for more than 2/3 of all trips (n=447) and hours driven (n=135.9), as well as over 75% of the miles driven (n=4265.21). Table 2 outlines driving exposure, indicating that males drove significantly more miles and length of time (hours)

Cell Phone Unlocks and Call Time

Data were collected on 1,412 unlocks, with 964 unlocks meeting inclusion criteria; 81 were excluded as passenger-side unlocks, 38 at the trip start/end and <2.5 mph, and 329 collected after the first 2-weeks of data collection. All participants unlocked their phone while driving and almost 50% of trips included an unlock. Over 11% of trips included active call time

(total 146.22 minutes of active call time). As indicated in Table 2, males had a higher median number of unlocks than females and a higher median number of unlocks at speeds >25 mph. When adjusting for exposure, males also had a higher rate of unlocks per trip per 100 miles and per hour driven than females.

Speed at Cell Phone Unlock by Gender

The speed at unlock ranged from 0–87.18 mph. Unadjusted, the average speed at unlock was 25.00 mph (sd 16.63); the highest individual average speed at unlock was 53.3 mph (sd 19.68) and every adolescent unlocked at speeds of ≥ 32 mph. Unlocks at speeds >25 mph accounted for 39.5% of unlocks, while unlocks at speeds <2.5 mph accounted for 18.5% of unlocks. As indicated in Table 2, males had more unlocks at speeds >25mph per 100 miles and per hour driven than females.

Discussion

This study described novel, objective smartphone-based measures of cell-phone use while driving in a sample of newly licensed male and female adolescent drivers. Results indicate that it is feasible to collect data on continuous cellphone use and driving exposure, highlighting granular information about cell phone use while driving. Even though adolescents only had a license for 90 days, all engaged in cell phone use while driving behavior, with many doing so at high-risk speeds of >25 mph.

The adolescent males in our sample engaged in high-risk scenarios of cell phone use while driving. In their analysis of MVCs, Carney and colleagues (2015) found that adolescent females engaged in more cell phone use while driving than males. Goodwin and colleagues (2012) also found in their in-vehicle video data that adolescent females were more likely to engage in electronic device use (OR: 1.96, 95% CI: 1.58–2.44). However, adolescent males are more likely to crash than females (CDC, 2017), yet females report more frequent texting and calls (Lenhart et al., 2010). Our data on cell phone unlocks helps provide additional information that accounts for driving exposure and measurement of activity while driving.

The metric of “unlock” provides important discrete information about the instance a cell phone is engaged, though it does not indicate what the adolescents are doing with their phone (e.g. text, app or maps). Given the paucity of research on the effects of the different types of adolescent communication activities with a phone (texting, messaging, social media, browsing the web) on crash risk, the metric of unlock may act as a good indicator of attention being drawn from the roadway. With adolescents at highest risk for crashes in the first 6-months of licensure (Foss, Martell, Goodwin, & O’Brien, 2011), any behavior that takes attention off the roadway can increase MVC risk. Given the surge of smart-phone based applications that private companies are developing and deploying, these data on metrics of cell phone use while driving can be used to guide implementation of automated interventions as well as measurement of driving behavior and intervention outcomes.

Limitations

Technological challenges resulted in only 16 participants having evaluable data. The goal of mailing the technology and detailed installation instructions was to minimize participant

burden of travel for a study visit. However, installation problems prohibited data collection. As interventions that rely on technology are implemented, monitoring systems set up by the end-users need to be considered. These findings rely on cell phone data with no cameras in the vehicle, and therefore verification that the adolescent was the one to unlock the phone or engage in call time could not occur. Given that the adolescent's cell phone was paired to the device, which is meant to differentiate between driver and passenger behavior, these data were treated as driver behaviors. This was a small sample, which limits generalizability of the findings. If an adolescent drove in another vehicle without the device, data from that trip would not be captured. Data were collected from June-October 2015, so analysis does not account for seasonal variations in adolescent driver behaviors.

Conclusions

Cell phone use while driving among adolescents is a threat to public health—that of the adolescent and those that share the road with them. Our results indicate that newly licensed drivers frequently use their cell phone while driving, and many do so at elevated speeds. Efforts to decrease cell phone use while driving require a thorough understanding of the behavior. These data demonstrate a novel way to collect data, with potential for automated translation into smartphone-based interventions that involve feedback, notifications, and/or education

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Table 1:

Adolescent baseline self-report of demographics and driving behaviors (N=16)

	N (%)	Mean (sd)
Gender		
<i>Male</i>	8 (50)	
<i>Female</i>	8 (50)	
Race		
<i>White</i>	15 (93.75)	
<i>Unknown</i>	1 (6.25)	
Ethnicity		
<i>Hispanic</i>	1 (6.25)	
<i>Not Hispanic</i>	15 (93.75)	
Involved in prior MVC	2 (12.5)	
Age (years)		16.95 (0.36)
Length of Licensure (days)		39.69 (24.02)
Hours Driven/Week		7.33 (3.74)
Days driving in last month		21.13 (6.48)
Days handheld phone calls in last month		0.8 (1.15)
Days hands free phone calls in last month		3.4 (5.03)
Days read text in last month		3.14 (5.46)
Days send text in last month		2.27 (3.69)
Days used internet on cell phone in last month		4.4 (9.81)
Days used GPS on phone in last month		4.21 (3.85)
Days drove with teen passengers in last month		9.87 (7.60)
Highest number of teen passengers in last month		2.2 (1.26)

Table 2:

On-road in-vehicle data of driving exposure and handheld phone use (unlocks and call time)

	Full Sample	Females	Males	p
	Median (IQR)	Median (IQR)	Median (IQR)	
# of Trips^a	33.5 (27–51)	31 (23–38)	41 (32.5–77)	0.14
Miles Driven^a	183.12 (107–577)	114.33 (93–183)	577.32 (178–709.75)	0.04 *
Time driven (hours)^a	9.18 (6.08–16.42)	6.87 (4.97–8.48)	16.0 (10.59–24.98)	0.03 *
Unlocks^a	30.5 (12.5–94)	12.5 (10.5–23)	94 (54–153.5)	<0.01 *
Unlocks > 25 mph^a	4 (1–9)	4 (2.5–7.5)	26.5 (12.5–71.5)	<0.01 *
Call Time (seconds)^a	58.5 (0–435)	73 (0–333)	42.5 (0–347.5)	0.88
	Mean (sd)	Mean (sd)	Mean (sd)	
Miles/trip^b	8.79 (9.61)	5.44 (4.01)	12.14 (12.5)	0.19
Driving time (minutes)/trip^b	15.9 (8.42)	12.5 (4.6)	19.3 (10.23)	0.12
Unlocks/trip^b	1.23 (0.96)	0.51 (0.23)	1.95 (0.85)	<0.01 *
Unlocks/100 miles^b	23.96 (22.97)	12.295 (7.31)	35.64 (27.67)	0.05 *
Unlocks/hour driven^b	4.87 (3.93)	2.32 (1.16)	7.41 (4.12)	0.01 *
Active call time (seconds)/100 miles^b	162.9 (258.35)	173.75 (269.8)	152.05 (264.51)	0.87
Active call time (seconds)/trip^b	7.96 (12.38)	7.22 (10.41)	8.70 (14.79)	0.82
Unlocks at speed > 25 mph/trip^b	0.50 (0.66)	0.20 (0.16)	0.80 (0.84)	0.09
Unlocks at speed > 25 mph/100 miles^b	6.25 (4.63)	3.63 (1.66)	8.87 (5.25)	0.03 *
Unlocks at speed > 25 mph/hour driven^b	1.57 (1.59)	0.76 (0.41)	2.38 (1.94)	0.05 *

* p 0.05 testing differences between sexes

^a Mann-Whitney U Test^b Independent T-Test (Equal Variances not assumed)