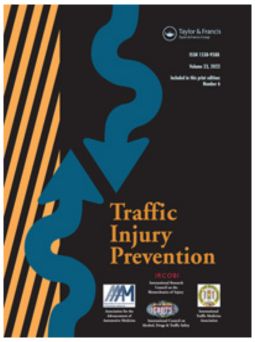

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Distracted pedestrian behavior: An observational study of risk by situational environments

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ABSTRACT

Objective: Pedestrian-related death rates are increasing in the United States, partly due to increased use of distracting smartphones by pedestrians. Previous research documents high frequency of smartphone use while crossing streets near college campuses and in downtown business districts, but little is known about distracted pedestrian behavior in other urban environments. The current study used observational methods to examine and compare distracted pedestrian behavior in four urban areas – near an urban college campus, in a downtown commercial business district, near middle and high schools, and in entertainment districts – as well as examining whether the occurrence of distraction was associated with unsafe crossing behaviors.
Methods: We observed 112 intersections in 46 downtown, 30 school, 25 entertainment district, and 11 college campus-area intersections. Coders recorded distraction, crossing safety, pedestrian demographics, and traffic volume. Chi-square tests compared pedestrian characteristics by intersection type. Log binomial regressions estimated risk ratios (RRs) and associated 95% confidence intervals (CIs) for associations between pedestrians walking alone and traffic volume with distracted crossing behavior, adjusting for age and gender. Similar models examined risk of unsafe crossing behavior by distraction behavior. All models were stratified by intersection type.
Results: Distraction incidence was highest in campus locations (52.9%) and lowest in entertainment districts (16.2%). Walking alone was associated with a 45% higher risk of distraction (RR 1.45, 95% CI 1.30-1.62), although the increased association was limited to entertainment locations (RR 1.61, 95% CI 1.25-2.08) and was significantly decreased in all other locations. Higher traffic volume was associated with lower risk of distraction in downtown locations (RR 0.69, 95% CI 0.56-0.85) but higher distraction risk in entertainment locations (RR 1.71, 95% CI 1.27-2.31). Associations between distraction and unsafe crossing behaviors were minimal.
Conclusion: Distracted pedestrian behavior occurs at different rates and in different circumstances, depending on the setting. These results offer valuable data to inform intervention programs that target appropriate populations in appropriate locations.

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Distracted pedestrian behavior; observational research; road traffic injury; traffic safety; urban environments

Introduction

Pedestrian injury rates in the United States (US) demonstrate an alarming trend over recent years. Unlike most other public health domains, the number of pedestrian deaths in the US climbed from 4,725 to 7,005 during the ten-year period encompassing 2011-2020 (the latest data available) (CDC [Centers for Disease Control and Prevention], 2021). There was a concomitant 37% increase in the age-adjusted pedestrian-related mortality rate (2.02/100,000 persons in 2020 vs 1.47/100,000 in 2011).

Reasons behind the increase in fatal pedestrian injuries are likely multifaceted. One contributor represents conflicting public health goals: with increased national emphasis on physical activity, more people are walking on roadways, creating increased exposure to pedestrian injury risk. A second factor is the increasing size of vehicles. Increasing rates of pedestrian injuries from collisions with SUVs are documented in particular, and attributed to design of the leading edge of taller, larger vehicles now used more frequently by American drivers (Hu and Cicchino 2018; Monfort and Mueller 2020). A third factor, and the present focus, is distraction. Both pedestrians and drivers are engaging with traffic while distracted by mobile devices (Ralph and Girardeau 2020; Retting 2020). Attention is diverted to smartphones instead of potential roadway hazards, and crashes occur.

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Documentation about distracted driving risks is widespread (Caird et al. 2018; Stavrinos et al. 2018). Research on distracted pedestrian risks is less pervasive but equally convincing (Stavrinos et al. 2018; Simmons et al. 2020). In both cases, research conducted in virtual reality simulators suggests drivers and pedestrians distracted by telephone calls, text-messaging, and listening to music have significantly higher crash risk than those who are undistracted (Stavrinos et al. 2018; Simmons et al. 2020).

Observational research confirms that distracted pedestrian behavior is commonplace (Wells et al. 2018; Simmons et al. 2020; Piazza et al. 2020). The bulk of such research was conducted in two high-risk locations, urban downtown areas and college campuses (Simmons et al. 2020). Rates of distraction generally fall between 20%-50% in those locations, with rates varying across time, location, and population studied. Recent studies report distraction rates of 41% (Wells et al. 2018) and 25% (Piazza et al. 2020) on American college campuses. Studies in urban centers report rates of 20% in Melbourne, Australia (Horberry et al. 2019); 13.5% at a study conducted in both Flagstaff, Arizona and New York City (Russo et al. 2018); and 16.6% in Athens, Greece (Ropaka et al. 2020).

Distraction rates in other types of pedestrian environments and populations are rarely studied, but epidemiological research suggests the largest portion of fatal pedestrian injuries occur in urban non-intersection areas in darkness (Hu and Cicchino 2018). There also is evidence that between 25% and 33% of pedestrians killed on American roads were intoxicated when they were killed (Chong et al. 2018; Eichelberger et al. 2018). It is surprising, therefore, that little research examines distracted pedestrian rates during evening and nighttime hours around nightclub/bar/entertainment districts.

One other high-risk but understudied situation is distracted pedestrian behavior rates among youth. One recent study reported significant distraction among Israeli adolescents, but less distraction among younger children (Gitelman et al. 2019). Risk among children is elevated in pedestrian settings, however, as neuropsychological research suggests adult levels of cognition and impulse control may not emerge until the early to mid-20s (Giedd 2015). Evidence also suggests that over 80% of American teens own smartphones and use them extensively (Common Sense Media 2019). The lack of observational data concerning distracted pedestrian behavior near middle and high schools, therefore, represents a gap in public health knowledge.

The present study was designed to observe and compare the rates and types of distracted pedestrian behavior occurring in the same city and over the same time period in four high-risk areas: an urban commercial downtown district; near middle and high schools; entertainment districts with restaurants, bars, and nightclubs; and near an urban college campus. Based on epidemiological data, we hypothesized distraction rates might be highest in the entertainment districts. Based on human development and risk-taking that might occur among younger people and intoxicated people, we hypothesized distracted pedestrian behavior might be lowest in the urban downtown area. We also conducted secondary analyses to consider whether distraction related to situational factors like walking alone and traffic volume in each location, and safety outcomes like looking left and right, crossing with a walk signal, and exiting the crossing within the crosswalk lines.

Methods

Intersection selection

Data were collected in Birmingham, Alabama, a Southeastern US city with a population of ~200,000 people and metropolitan area population of ~1.1 million. Study intersections were selected through a systematic process of empirical review of electronically-reported crash data accessed from the Critical Analysis Reporting Environment (CARE) system (see https://www.caps.ua.edu/software/care/); review of local newspaper archives from the past 3 years to gather information on fatal and serious pedestrian injuries reported in media; informant interviews with representatives of the Birmingham Department of Transportation, Birmingham Police Department, and Birmingham Safe Routes to School Program; and on-site observation by the research team. Our objective was to identify sites with frequent pedestrian traffic and moderate to high risk of pedestrian-vehicle crashes. We compiled information from all sources and created a list of all signalized and unsignalized intersections that appeared to have significant risk present.

We included 46 downtown, 30 school, 25 entertainment district, and 11 college campus area intersections. Observations were scheduled during peak pedestrian hours, which we determined to be 11AM-1PM for downtown areas, thirty minutes before and after school start/end times for school areas, 7-9PM for entertainment district areas, and 11:30AM-1:30PM for college campus intersections. Coding was scheduled in all weather conditions except heavy rainfall or lightning. Given Birmingham's location on the eastern edge of a time zone and seasonal timing of the observations, all entertainment district coding periods were conducted after sunset, when it was dark outside. Most intersections were observed on two separate occasions, with the exception of downtown locations that were coded once because so many intersections were included.

In Birmingham, unlike some other cities, downtown and entertainment districts are distinct geographic areas. Birmingham's downtown district is heavily occupied during the daytime and has many restaurants, but they primarily serve lunchtime customers. The largest clusters of bars and nightclubs are located on the outer fringes of downtown. Those areas are most heavily populated in the evening.

Coding protocol

Pedestrian behaviors were coded using rotating coders. Logistically, coding was divided into 30-minute blocks. Each coding block was conducted at a single intersection and involved 4 phases. First, for 5 minutes coders counted vehicular traffic. Second, for the next 12 minutes coders recorded pedestrian behavior of all pedestrians approaching them from the crosswalk on their right. Third, after a 2 minute break coders spent 12 minutes recording pedestrian behavior of all pedestrians approaching them from the crosswalk on their left. Coders then took a 5 minute break, crossed the street clockwise, and re-initiated the cycle from the next corner.

Coding was conducted in pairs, with coders located in cattycorner positions, to assure complete coverage of each intersection. If pedestrian traffic was light, coding of pedestrians walking away from the corner, or walking on the crosswalk on the non-assigned side, was permitted.

In occasional cases of mid-block crosswalk crossings, coding was conducted for 1 hour (30 minutes on each side of the street). At school areas, because pedestrian behavior was expected to be concentrated before and after school start and end times, one-hour coding sessions were scheduled. At all locations, coders worked to position themselves in discreet places to minimize disruption of typical pedestrian behavior.

The study protocol was approved by the Institutional Review Board at University of Alabama at Birmingham (Protocol#: IRB-300005799). Given the low-risk observational nature of the study in a public location, informed consent requirements were waived.

Outcome measures

Vehicular traffic

Vehicular traffic was measured as a count of motorized vehicles traveling on either roadway in either direction and crossing the observed crosswalk during the five–minute coding session. Each coder counted vehicles on one of the two cross-streets. We summed the counts and multiplied by 12 to yield a measure of vehicles/hour.

Pedestrian characteristics and behaviors

The following were recorded concerning each pedestrian:

a. apparent gender (male, female);
b. estimated age (child ages 0-12, teen ages 13-17, young adult ages 18-34, adult ages 35-54, older adult ages 55+). Children were almost never observed and teens rarely, so the first three categories were combined for analysis;
c. crossing with walk signal, defined as stepping off sidewalk into crosswalk when walk signal was illuminated (omitted in rare cases where walk/don't walk signals were absent);
d. looking left before stepping into road, defined as pedestrian turning head left to look at oncoming traffic within 2 seconds before stepping into intersection;
e. looking right at oncoming traffic, defined as pedestrian turning head to look right at oncoming traffic within 2 seconds before stepping into lane with oncoming traffic from right;
f. exiting road in crosswalk, defined as pedestrian's final step off roadway and onto sidewalk occurring from within painted lines of crosswalk (omitted if no crosswalk lines painted onto roadway);
g. alone or accompanied, a binary measure of pedestrian walking with one or more people they appeared to know personally versus walking alone;
h. distracted behavior while crossing, defined as pedestrian distracted by talking on phone; texting and/or looking down at phone; wearing headphones/earbuds; reading; eating; or in other visually apparent ways. Multiple distractions could be recorded. Distraction was recorded if it occurred at any point during the crossing while pedestrian was in roadway where vehicles might pass, but not on sidewalks.

Reliability and training

All coders were extensively trained and achieved perfect or near-perfect (>95% agreement) with an experienced coder for a one-hour session prior to coding independently.

Data analysis

Analyses were conducted in four steps. First, we considered descriptive data, including demographics of pedestrians at each location (campus, downtown, schools, entertainment districts), situational factors observed in them, and safety behaviors of pedestrians at the locations. Second, we considered our primary hypothesis: does the rate of distraction vary across the four types of locations? We considered descriptive results and also compared differences using chi-square. Third, we considered whether distraction risk associated with situational factors of walking alone and low traffic volume, the latter of which might be perceived as a safer time to cross while distracted. Last, we considered whether distraction associated with risk of safety outcomes. Were distracted pedestrians more likely to take safety-related risks, defined as failing to look or left before entering the roadway, walking against a signal, or exiting crossings outside crosswalk lines? For the latter two questions, a log binomial regression was used to estimate risk ratios (RRs) and associated 95% confidence intervals (CIs), adjusting for age and gender.

Results

Appendix Table 1 considers demographic, situational and safety factors in each location. We observed slightly more male pedestrians in downtown and school areas; campus and entertainment districts were split evenly by gender. As expected, there were more young pedestrians in the campus area and more middle-aged and senior pedestrians downtown. Contrary to expectations, school areas included 52% young pedestrians and 42% middle-aged.

Pedestrians tended to walk alone in campus and school areas (82.7%, 80.0% respectively), and largely downtown (64.4%), but not in the entertainment area (18.9% alone).

Table 1. Comparison of distraction type among pedestrians by type of location.

	Campus (n = 272)	Downtown (n = 1283)	Schools (n = 169)	Entertainment (n = 1524)	χ^2	p-value*
Any distraction (%)	144 (52.9)	457 (35.6)	66 (39.1)	247 (16.2)	235.50	<0.0001
Talking (%)	60 (22.1)	210 (16.4)	23 (13.6)	88 (5.8)	107.46	<0.0001
Texting (%)	35 (12.9)	99 (7.7)	16 (9.5)	51 (3.3)	50.39	<0.0001
Headphones (%)	46 (16.9)	84 (6.5)	16 (9.5)	11 (0.7)	158.35	<0.0001
Eating (%)	2 (0.7)	6 (0.5)	5 (3.0)	4 (0.3)	21.55	<0.0001
Reading (%)	1 (0.4)	12 (0.9)	2 (1.2)	7 (0.5)	3.38	0.3371
Other (%)	8 (2.9)	77 (6.0)	15 (8.9)	90 (5.9)	7.05	0.0703

*Estimated from a chi-square test.

Table 2. Risk ratios* (RR) and associated 95% confidence intervals (CIs) for the association between any distraction type and both whether the person was walking alone and traffic volume.

	Distraction (%)	RR (95% CI)	p-value
Walking alone	484 (33.0)	1.45 (1.30-1.62)	<0.0001
Not walking alone	426 (24.3)	Referent	–
<175 vehicles/hour traffic volume	252 (27.3)	0.99 (0.86-1.13)	0.8371
175-349 vehicles/hour traffic volume	309 (27.7)	Referent	–
350 vehicles/hour traffic volume	353 (29.1)	1.01 (0.89-1.15)	0.8809

*Estimated from a log binomial regression model adjusted for age and gender.

Traffic volume was heaviest in the campus area and lightest in the entertainment areas.

Safety measures indicated somewhat higher rates of looking left and right downtown, somewhat better obedience to crossing with walk signals in campus and school areas, and somewhat lower crossing within the crosswalk rates in school areas.

Table 1 provides descriptive data on the number and percent of distracted pedestrians at each location, plus chi-square analyses of differences. Distraction was most common at the campus location (52.9% distracted), followed by school areas (39.1%), downtown (35.6%), and the entertainment districts (16.2%). Differences were statistically significant across locations for any distraction as well as all types of distraction except the rare instances of reading (non-phone material) and other distractions.

Next, we considered whether distracted behavior was more common under particular situational circumstances. We merged all types of distraction for this analysis. As shown in Table 2, across all locations distraction was 45% more common when pedestrians were alone (RR = 1.45, 95% CI = 1.30-1.62) than when accompanied by other pedestrians. No difference in distraction emerged based on traffic volume. When considered separately by location (Appendix Table 2), increased association for walking alone was observed only for entertainment locations (RR = 1.61, 95% CI = 1.25-2.08). In fact, there were significantly decreased risks of distraction in campus (RR = 0.52, 95% CI = 0.45-0.62), downtown (RR = 0.85, 95% CI = 0.74-0.99), and school (RR = 0.60, 95% CI = 0.42-0.87) locations when walking alone.

Examining associations between risk of distraction and traffic volume by location (Appendix Table 2), no observed association emerged at campus and school locations. For downtown locations, low traffic volume associated with higher distraction risk (RR = 1.40, 95% CI = 1.21-1.62) while higher traffic volume associated with lower distraction risk (RR = 0.69, 95% CI = 0.56-0.85). Conversely, in entertainment locations there was no association for low traffic volumes (RR = 0.98, 95% CI = 0.69-1.37) and a significant 75% increased distraction risk for high traffic volume (RR = 1.71, 95% CI = 1.27-2.31).

Last, we considered how distraction related to safety outcomes. As shown in Table 3, overall there was no association between being distracted and crossing streets unsafely. Stratified by intersection location (Appendix Table 3), in the downtown-located intersections distraction associated with lower risk of crossing against walk signals (RR = 0.74, 95% CI = 0.61-0.89) but higher risk of not looking left (RR = 1.21, 95% CI = 1.00-1.45) or right (RR = 1.34, 95% CI = 1.13-1.59). Distracted pedestrians downtown were also more likely to exit crosswalks outside the lines (RR = 1.52, 95% CI = 1.26-1.85). The only other significant association was observed in entertainment-located intersections, where distraction associated with 55% lower risk of exiting outside the crosswalk (RR = 0.45, 95% CI = 0.31-0.66).

Discussion

Our results suggest distracted pedestrian behavior is not consistently engaged in across situations and locations. Specifically, we found distraction to be most common in the urban university campus areas and least common in entertainment districts, despite epidemiological data suggesting the highest risk of pedestrian fatalities occurs among intoxicated individuals and at dark, situations that overlap with entertainment district walking rather than college campus areas. Pedestrian distraction rates near middle and high schools and in the urban downtown area fell in the middle of the other two areas. We also discovered previously-unreported patterns of distraction based on other situational factors, including whether pedestrians were walking alone or were accompanied by others and how heavy traffic volume was. Finally, we observed distracted pedestrians were generally no less likely to violate most safety requirements across all locations. We address each of these sets of findings below.

Our investigation of distraction rates in four targeted locations – an urban university campus area, a downtown business district area, near middle and high schools, and in entertainment districts – revealed some surprises. Based on epidemiological data, we hypothesized distraction might be highest in entertainment areas, where some pedestrians would be walking while intoxicated and crossing streets in darkness. We also hypothesized younger pedestrians, who would be more commonly seen near schools and in the university campus area, would be distracted more often. The

Table 3. Risk ratios* (RR) and associated 95% confidence intervals (CIs) for the association between any distraction type and risk of unsafe crossing behaviors.

	Performed unsafe crossing behavior (%)			
	Undistracted	Distracted	RR (95% CI)	p-value
Did not look left	713 (34.5)	308 (37.9)	1.02 (0.92-1.13)	0.7585
Did not look right	780 (37.8)	354 (43.4)	1.08 (0.98-1.19)	0.1143
Crossed against walk signal	706 (35.5)	237 (30.2)	0.89 (0.79-1.01)	0.0626
Exited outside crosswalk	526 (22.8)	232 (25.6)	1.12 (0.98-1.28)	0.1086

*Estimated from a log binomial regression model adjusted for age and gender.

data suggested distraction was significantly more common in the campus area, and least common in the entertainment district. Thus, despite epidemiological data indicating pedestrian fatality risk among intoxicated pedestrians (Chong et al. 2018; Eichelberger et al. 2018), distraction was comparatively uncommon in entertainment areas. On the college campus, where students frequently cross streets and frequently travel on foot, distracted behavior was observed among over half the pedestrians we studied.

We found pedestrians were somewhat more likely to be distracted when walking alone overall, but this result was impacted greatly by results from the entertainment district, where walking alone was associated with higher distraction rates. There are a few possible explanations for this result. One possibility is that pedestrians in the entertainment district were trying to connect to friends they were meeting nearby, and therefore walking alone was associated with distraction in that contextual environment. Another possibility is that people use their phones in situations where they are worried about social impressions but not in other situations. In entertainment districts during the evening, there may be more pedestrians around, or increased desire to be socially acceptable, and people might turn to their phones as a way to maintain social status when walking alone. Future research should evaluate these possibilities.

Results concerning traffic volume and distraction were intriguing. Traffic flow was low to moderate in all locations, but within the levels we observed, different patterns of distraction emerged in different locations. In the urban commercial downtown area, where businesspeople were observed during midday hours, often walking to and from lunch, distraction was more common with low traffic volume and less common with high traffic volume. This might reflect experienced adult pedestrians who judged it safe to take risk by crossing streets while distracted when traffic was light. In the entertainment district, contrarily, distraction was far more common when traffic was heavy. This might reflect a busier situation, perhaps where pedestrians experienced trouble locating friends they planned to meet at bars or restaurants. It could also reflect decreased caution and self-control among pedestrians who are intoxicated. Future research examining the impact of traffic volume on distracted pedestrian behavior may be valuable to guide intervention programs.

We found few relations between distracted pedestrian behavior and the measured safety outcomes. Among the few significant findings we did discover, in some cases safety was improved when the pedestrian was distracted. For example, distracted pedestrians in the downtown locations were more likely to cross when a walk signal appeared, likely compensating for their recognition that they were distracted. In a few other cases, distracted pedestrians did take more risks, but these results were inconsistent and scattered. Of course, our results should be interpreted cautiously as our assessments of pedestrian safety were rather crude. Looking left and right does not necessarily imply the pedestrians carefully attended to or processed the traffic stimuli they perceived. Crossing with walk signals does not necessarily guarantee safety for distracted pedestrians, nor does exiting crosswalks within the lines. Previous research conducted within virtual reality scenarios, where risks can ethically be elevated for scientific purposes, suggest distracted walking does lead to safety risks (Stavrinos et al. 2018; Simmons et al. 2020). Future research translating such findings to real-world settings in an ethical manner might be considered.

Our findings have multiple implications for distracted pedestrian prevention programs. When merged with epidemiological data, preventionists might jointly consider high-risk situations to reduce risk. Intoxicated pedestrians walking alone in heavily-trafficked entertainment districts, for example, may have particular risk of distracted pedestrian behavior and might be aided through programs that encourage putting phones aside while walking. Such programs could potentially extend successful drunk driving programs in those districts. Similarly, our data indicate pedestrians walking with others at urban university settings had high risk of distracted pedestrian behavior. Previous attempts to reduce distracted pedestrian behavior in those sorts of settings achieved mixed results (Schwebel et al. 2017, 2021) and might be adjusted in continued attempts to reduce high-risk behavior among college students in heavily-trafficked urban street-crossings.

Like all research, our study had limitations. We restricted our study to a single city and to intersections our systematic *a priori* evaluations suggested would have significant pedestrian activity. We also restricted our observations to hours of the day when pedestrian activity was expected to be high. There may be elevated risk when there are few pedestrians walking, at "off-hours" or in "off-intersections". In addition, it is possible that pedestrians not walking with a group of friends/acquaintances may alter behavior in the presence of unfamiliar pedestrians. We did not systematically collect information on pedestrian volume at the time of crossing in order to determine whether this was the case. Future research might evaluate such situations.

We relied on observational data collection and therefore estimated age and used visual observations to detect distracted behavior such as headphones and smartphone conversations. We did not delve into relevant details such as whether the person was listening to loud distracting music or a quiet podcast, or whether conversation was about a mundane topic like which restaurant to meet at versus a highly-emotional topic such as the end of a relationship. Such distinctions may impact the extent of distraction while crossing streets. Finally, our data are limited almost entirely to intersections with signals, which limits generalizability. Future research examining whether similar behavior trends are observed at midblock intersections or intersections without signaling is recommended.

In summary, our results suggest distracted pedestrian behavior occurs at different rates in different settings, and at different rates with different situational circumstances present. Intervention program development should leverage these findings, and future results along these lines, to best capture the risks present and address those risks through effective, theory-driven programs that alter risky behavior and improve pedestrian safety.

Disclosure statement

No potential conflict of interest was reported by the authors.

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