

Children's expectations and beliefs toward the relative safety of riding bicycles at night

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Abstract

This study examined middle-school-aged children's expectations, attitudes, and perceptions toward the relative safety of riding bicycles at night with reflectors and/or head and tail lights. Three hundred and sixty-three children in grades 7 through 9 were surveyed. Half of the children reported that it was not dangerous to ride a bicycle at night with only reflectors or only lights, while almost all reported that it was safe to ride at night if they had both reflectors and lights. More than half reported that it was difficult to see a bicycle that had reflectors but no lights. However, bicycles that had lights but no reflectors were perceived not difficult to see. Most of the children reported that they would not ride their bicycle at night without lights if they knew it was dangerous because drivers could not easily see them. The findings also indicated that only 22% of the children had lights on their bicycles; while over 51% reported riding their bicycles at night at least once in a while. The results of the study suggest that children riding their bicycles at night without lights are under-estimating the dangerousness of the activity. Furthermore, a large percentage of children are underestimating the ease at which drivers can see them on their bicycle at night without lights.

Keywords: Warnings, Safety, Risk Perception, Bicycles, Children

1. Introduction

In the United States (U.S.), there are nearly 28 million children between the ages of five and 14 that ride bicycles [1]. Many of these children ride their bicycles in or near roadways at dawn, dusk, and at night. To do so safely, they must be seen by other roadway vehicles. Vehicle operators must be able to see the bicyclist and have enough time and distance to adjust their driving to safely share the roadway.

In 1976, the U.S. Consumer Product Safety Commission (CPSC) began to regulate the number and type of reflectors required on bicycles in section 16 of the Code of Federal Regulations (CFR) 1512.16: Requirements for reflectors [2]. The CPSC

offers the following rationale for adding reflectors to the requirements for bicycles:

Bicycles shall be equipped with reflective devices to permit recognition and identification under illumination from motor vehicle headlamps.

The CPSC requires all bicycles sold in the U.S. to have a white reflector on the front of the bicycle, a red reflector on the rear of the bicycle, white reflectors on both wheels, and reflectors on the front and rear surface of each pedal.

Over the last two decades there have been a number of published studies and reports on the hazards associated with bicycle riding in the U.S.

Most of the studies provide published injury and death statistics collected by the U.S. Department of Transportation (US DOT) and the National Electronic Injury Surveillance System (NEISS). These studies examined the injury and death statistics available and then categorize them by factors such as age, location, and time of day.

The following was reported by the U.S. National Highway and Transportation Safety Association (NHTSA) in 2003 [3]:

- There were 622 bicyclists killed and an additional 46,000 injured in traffic crashes;
- Bicycle fatalities occurred more often in urban areas, between 5 and 9 p.m., and during the summer months;
- More than 23% of bicyclists killed in traffic crashes were between the ages of 5 and 15 years old;
- The fatality and injury rates for the 5 and 15 year old age group were 50% and 60% higher, respectively, than all bicyclists.

The Insurance Institute for Highway Safety (IIHS) reported that in the year 1997 [4]:

- 31% of all bicycle related deaths were children younger than 16 years old;
- Bicycle deaths per million were highest among 11 and 14 year olds;
- 62% of bicycle deaths occurred in urban areas, while 34% occurred at intersections.

Data provided by Rodgers [5] for the years of 1992 and 1993, showed that 23.5% of bicycle related deaths occurred between 9 p.m. and 6 a.m. and 27% occurred at intersections. Rodgers [5] also found that 12% of the riders surveyed reported to riding occasionally after dark.

Furthermore, Green, Hill, and Hayduk [6] in analyzing CPSC reported bicycle fatalities; found that 46% of all bicycle related deaths may be linked to riding at night.

Tinsworth [7] found that in the year 1993, children riding their bicycles at dawn, dusk or night are 3.64 times more likely to be injured than when riding in daylight. Tinsworth [7] also found that less than 8% of all bicycles involved in injuries were reported to have been equipped with lights and that most of the bicycles involved were equipped with the CPSC mandated reflectors.

It is apparent from these studies and injury statistics that children riding bicycles at night are at higher risk of collision than riders of any other age group riding at any other times during the day. It is also apparent from the research that even with bicycles equipped with the required CPSC reflectors, riders are still at a higher risk of collision at night. For example, Rodgers [5] concluded:

Since most of these nighttime riders (i.e., those from the exposure survey) ride only a small proportion of the time after dark, nighttime riding appears to be an important contributing factor to bicycle deaths.

The intended purpose of the reflectors is to increase the visibility of bicycles at night [2]. However, the data suggest this is not always the case. There are several factors that determine the effectiveness of the reflectors including the distance and angle between the vehicle and the bicycle, the cleanliness of the reflector lens, and the presence of obstructions.

Of interest in this study are the unintended consequences of the presence of reflectors on children's bicycles. The presence of the reflector may imply an invitation to safely ride the bicycle at night. Furthermore, the presence of the reflector may provide a false sense of safety that bicycles so equipped can be safely ridden at night and be seen by traffic. For example, Tinsworth [7] concludes:

While it seems intuitively apparent that riding during dawn, dusk, or night would be riskier than at other times, it is possible that some people perceive reflectors as adequate protection at times when they may not be sufficient. ... Night riding may be an area deserving future information and education efforts (e.g., the need for bicycle lights, reflective clothing, etc.)

A purpose of this study was to determine middle-school-aged children's bicycle riding habits and patterns. A second purpose of this study was to determine middle-school-aged children's reasonable expectations, attitudes, and perceptions toward the relative safety of riding bicycles at night with reflectors and/or head and taillights.

2. Methodology

2.1 Questionnaire Design

The questionnaire consisted of three sets of questions. The first set of questions concerned demographic issues including age, grade, gender, and school attended.

The second set of questions was intended to capture respondents riding experience, knowledge, and habits. Respondents were asked to answer “Yes” or “No” to the following questions:

- Do you currently have a bicycle?
- Have you ever had a bicycle?
- Do you know what a bicycle reflector is?
- Does or did your bicycle have reflectors on it?
- Does or did your bicycle have a headlight on it?

Respondents were also asked to indicate “how often they rode their bicycle during the day” and “how often when it is dark,” using the following scale: never / once in a while / once a week / a few times a week / every day.

The third set of questions was intended to capture respondents’ attitudes and beliefs toward bicycle riding safety at night. Participants were asked to rate the following questions using an 11-point Likert-type scale with numerical and textual anchors: 1 = very dangerous; 3 = dangerous; 5 = somewhat dangerous; 7 = somewhat safe; 9 = safe; 11 = very safe:

- How safe is it to ride a bicycle at night if it has reflectors on the wheels, pedals, and front and back tires but no lights?
- How safe is it to ride a bicycle at night if it has a headlight and taillight but no reflectors?
- How safe is it to ride a bicycle at night if it has reflectors on the wheels, pedals, and front and back tires, a headlight, and a taillight?

Participants were also asked to rate the following questions using an 11-point Likert-type scale with numerical and textual anchors: 1 = very difficult; 3 = difficult; 5 = somewhat difficult; 7 = somewhat easy; 9 = easy; 11 = very easy:

- How easy is it for a car to see a bicycle at night with reflectors on the wheels, pedals, and front and back tires but no lights?

- How easy is it for a car to see a bicycle at night with a headlight and taillight but no reflectors?

Finally participants were asked to answer “Yes” or “No” to the following question: Would you ride a bicycle at night that had reflectors but no headlight or taillight if you knew it was dangerous because cars cannot see you and the bicycle at night?

2.2 Participants and Procedure

Pilot surveys were conducted with several middle-school-aged children to ensure the questions and the language was understandable. Questions and responses that were deemed inadequate or misunderstood by the pilot participants were re-worked or deleted.

The questionnaire was completed by 363 middle school children from Lancaster, PA ($N = 159$); Wayne (Philadelphia suburb), PA ($N = 99$); and Los Angeles, CA ($N = 105$). The questionnaire was distributed by classroom teachers during the school day. Proctors were asked to provide the students with the following instructions before giving them the questionnaire to complete:

1. Students should complete ALL of the questions on BOTH sides of the survey (a total of 17 questions).
2. Students should NOT go back and change an answer after reading a subsequent question.
3. Students should NOT provide their name or any other identification on the surveys except for responses to the first four questions.

3. Results

3.1 Demographics

Participants reported an average age of 12.86 years old ($SD = 1.16$ years) and 49.6% reported being male. Fifty-two percent reported being in the 7th grade, while 22% and 26% reported being in the 8th and 9th grade, respectively. Forty-one percent reported going to a private school.

Eighty-five percent of the participants reported owning a bicycle, while 99.5% reported owning a bicycle at some point. Eighty-eight percent of the participants reported knowing what a bicycle reflector is. Seventy percent reported that their

bicycle had reflectors, whereas 22% reported that their bicycle had a light.

Table 1 provides the percentages of how often participants reported riding their bicycles in the day and at night:

Table 1:
Percent amount of time riding

<i>Time Riding</i>	<i>Daytime</i>	<i>Nighttime</i>
Never	7	38
Once in a while	43	42
Once a week	14	5
A few times a week	24	11
Every day/night	13	4

3.2. Participant city comparison.

Analyses of variances (ANOVA) were conducted using student city and type of school as independent variable on the participant ratings. Tukey-Kramer Honestly Significant Difference (HSD) post hoc tests were used to determine if the means differed significantly from one another using a two-tailed alpha level of .05. Only the significant results are described.

Participants from Philadelphia were more likely to have a bicycle ($M = 0.93$, $SD = 0.26$) than the participants from Los Angeles ($M = 0.69$, $SD = 0.47$). Participants from Lancaster did not differ from either group ($M = 0.90$, $SD = 0.30$).

Participants from Philadelphia were more likely to know what a bicycle reflector is ($M = 0.93$, $SD = 0.26$) than the participants from Los Angeles ($M = 0.76$, $SD = 0.45$). Participants from Lancaster did not differ from either group ($M = 0.94$, $SD = 0.24$).

Participants from Los Angeles were more likely to have a light on their bicycle ($M = 0.41$, $SD = 0.53$) than the participants from Philadelphia ($M = 0.15$, $SD = 0.36$). Participants from Lancaster did not differ from either group ($M = 0.15$, $SD = 0.36$).

3.4. How safe is it to ride at night?

When participants were asked how safe it was to ride a bicycle at night with reflectors on the wheels, pedals, and front and back but no lights, 53% reported that it was not dangerous ($M = 5.79$, $SD = 2.13$).

When participants were asked how safe it was to ride a bicycle at night with a headlight and

taillight but no reflectors 62% reported that it was not dangerous ($M = 6.24$, $SD = 2.12$).

When participants were asked how safe it was to ride a bicycle at night with both reflectors on the wheels, pedals, and front and back and head and taillights, 93% reported that it was not dangerous ($M = 8.90$, $SD = 1.97$).

Table 2 provides the rating percentages for the question: How safe is it to ride at night?

Table 2:
Percent safe to ride at night

<i>Scale</i>	<i>Reflectors</i>	<i>Lights</i>	<i>Both</i>
Very safe / Safe	12	14	66
Somewhat safe	28	38	24
Neutral	13	10	3
Somewhat dangerous	29	25	6
Very dangerous / dangerous	18	13	2

3.3 How easy is it to see a bicycle at night?

When participants were asked how easy drivers can see a bicycle at night with reflectors on the wheels, pedals, and front and back but no lights, 48% reported that it was not difficult ($M = 5.80$, $SD = 2.06$).

When participants were asked how easy drivers can see a bicycle at night with a headlight and taillight but no reflectors, 59% reported that it was not difficult ($M = 6.15$, $SD = 2.14$).

Table 3 provides the rating percentages for the question: How easy is it for vehicles to see a bicycle at night?

Table 3:
Percent easy to see bicycle at night

<i>Scale</i>	<i>Reflectors</i>	<i>Lights</i>
Very easy / easy	13	16
Somewhat easy	24	31
Neutral	11	12
Somewhat difficult	38	29
Very difficult / difficult	15	12

Finally, when participants were asked if they would ride a bicycle at night that had reflectors but no headlight or taillight and if they knew it was

dangerous because cars cannot see them and the bicycle at night, 68% said they would not.

4. Discussion

The ratings for each of the bicycle safety related questions did not differ based on the city in which the participants lived. Participants were sampled from a large metropolitan city (Los Angeles, CA), the suburban area of a metropolitan city (Philadelphia, PA) and from the area in and around a small city (Lancaster, PA). Furthermore, the ratings for each of the bicycle safety related questions did not differ between the public and private school children.

These results indicate that children's attitudes and beliefs about the safety of bicycle riding at night are consistent. Their attitudes and beliefs do not appear to be affected by the type of school they attend, the size of the city in which they live, their geography, or whether they live in the city or the suburbs.

The data and conclusions from the Rodgers [5] and Tinsworth [7] studies are reflected in the data found in our survey. Namely, children are riding their bicycles at night without lights and underestimating the dangerousness of the activity.

Furthermore, a large percentage of children are underestimating the ease at which drivers can see them or their bicycles at night without a light. These results are similar to the research findings concerning pedestrian's attitudes and beliefs about the ability of drivers to see them at night.

Tyrrell, Wood, & Carberry [8] have found that pedestrians greatly over estimate the distances at which they could be seen by vehicle drivers at night. Pedestrians mistakenly assume that since they are able to see the lights of an approaching vehicle at great distances the driver is able to see them at that distance as well. Unfortunately, this is usually not the case and many drivers are not able to see the pedestrian until it is too late to avoid a collision.

The reflectors used on the bicycles have several limitations that impact their effectiveness "...to permit recognition and identification under illumination from motor vehicle headlamps" [2].

The first issue is line of sight. In order for the reflectors to be effective they must be able to reflect the headlight illumination back to the vehicle. If something is either blocking the headlight from reaching the reflector or blocking the light reflecting

back to the vehicle, they will not be effective (e.g., bushes and/or trees on a street corner).

The second issue involves the properties of the reflective surface. The ability to reflect light back to a source is greatest at a 90 degree angle (perpendicular) and decreases as the angle increases or decreases. For example, as a car approaches the side of a bicycle the reflectors on the wheels of the bicycle will reflect the headlight illumination back towards the vehicle. However, the reflectors on the front, rear, or pedals of the bicycle will not reflect the light back to the vehicle because they are parallel to the light source.

This means the amount of light being reflected from the different reflectors depends upon the approach angles of the bicycle and vehicle. Furthermore the amount of light reflected from each reflector changes as the bicycle and vehicle move relative to their paths of travel.

The third issue is the cleanliness or integrity of the reflector itself. Use of the bicycle over time can result in reflectors becoming covered with dust, mud, and/or grease. These and/or other substances can dramatically reduce the performance of the reflector by blocking the light from on-coming vehicles. Furthermore, bicycle usage can result in the reflector being cracked, broken, or lost. When a reflector becomes damaged or missing, its effectiveness will decrease.

In addition, since reflectors are designed and provided for night use, their presence on bicycles constitutes an implied invitation to ride the bicycle at night. Their presence creates a false sense of safety that bicycles so equipped can be safely ridden at night and be seen by traffic.

The lack of effectiveness of the reflector system is part of the rationale that influenced each of the 50 states to adopt traffic laws that require lights to be used on bicycles ridden at night. For example, New Jersey State Traffic Regulation 39:4-10.1 states:

Every bicycle when in use at nighttime shall be equipped with a lamp on the front which shall emit a white light visible from a distance of at least 500 feet to the front, and with a lamp on the rear which shall emit a red light visible from a distance of at least 500 feet to the rear.

Based on the results of this study, government and industry regulations and practices should take greater steps to protect children riding at night. Lights can be provided on all children's bicycles consistent with state traffic laws. Also, adequate

warnings and safety information should be provided to alert parents and riders of the danger of riding at night without lights.

Furthermore, parents, riders, and bicycle shops should be informed and encouraged to routinely check the performance of the lights and reflectors. Reflector and light inspection can be conducted as part of the routine maintenance that is normally encouraged for other bicycle parts including the chains, cables, tires, and brakes. Through inspection, the reflectors and lights will be assured to work to their fullest potential.

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