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PEDESTRIAN AND DRIVER SAFETY PROBLEMS CAUSED BY THE USE OF A MOBILE PHONE - PILOT STUDIES

Damian FREJ[1], Marek JAŚKIEWICZ[2], Milos POLIAK[3]

[1, 2] *Department of Automotive Engineering and Transport, Kielce University of Technology, Kielce, Poland*

[3] *Department of Road and Urban Transport, University of Žilina, Žilina, Slovakia*

Abstract:

The use of hand-held mobile phones by drivers and pedestrians is common and is becoming more common every year. Mobile phones have become an integral part of our everyday life, accompanying us in almost every respect. Modern smartphones perform functions that go far beyond their original purpose as devices for making telephone calls. We use them for GPS navigation and electronic banking. Moreover, using mobile applications, we can make purchases and sales of products quickly and safely. The number of people owning mobile phones is growing all over the world, and access to the Internet, which is an integral part of the functioning of modern smartphones, is becoming more and more common. Basic functions of mobile phones, such as making and receiving calls or sending short SMS messages, have long ceased to be sufficient. Thanks to them, we can conduct videoconferences, use advanced applications for time management or health monitoring, and even perform complex professional tasks in mobile mode. Thus, the growing popularity and versatility of mobile phones make them an indispensable tool in our everyday lives, not only as a means of communication, but also as an irreplaceable source of information, a work tool and a facilitation in everyday activities. The aim of the article is to find out respondents' predispositions to use telephones made of corrugated cardboard during activities such as walking on the street, side of the road, sidewalk, while crossing a pedestrian crossing and while driving. The lack of statistics on road accidents caused by the use of a telephone makes it difficult to determine how big a problem it is to use a telephone in situations where we should maintain limited trust in other road users. The research shows that respondents use a mobile phone while crossing a pedestrian crossing or driving a vehicle. In addition, as many as 19% of respondents admit that they have crossed a pedestrian crossing at least once. The conducted surveys and observational studies constitute an introduction to the development of a system for detecting pedestrians and drivers using mobile phones.

Keywords: *drivers, pedestrians, mobile phones, security systems*

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Contact:
1) dfrej@tu.kielce.pl [https://orcid.org/0000-0003-1899-4712] - corresponding author, 2) m.jaskiewicz@tu.kielce.pl [https://orcid.org/0000-0002-0032-9477], 3) milos.poliak@fpedas.uniza.sk [https://orcid.org/0000-0002-9149-2439]

1. Introduction

It's no secret that some people lead incredibly busy lives. As a result, they try to multitask at the same time. While this may seem effective to some people, it can be deadly behind the wheel of a vehicle. Using a mobile phone or other electronic device while driving is extremely dangerous. It should be noted that driver distraction is the main cause of road accidents, and mobile phones are the main source of distraction (Chen et al., 2017; Khurana, and Goel, 2020; Hwei et al., 2022). Also in the case of pedestrians, the distraction of a pedestrian with a mobile phone is the main cause of road accidents (Jin et al., 2020; Frej et al., 2022).

The use of a mobile phone causes traffic accidents because the driver's cognitive performance decreases significantly when using a mobile phone. Because he has to focus on two activities at the same time. In fact, using a mobile phone while driving increases the likelihood of causing a traffic accident (Sobrinho-Junior et al., 2022; Frej et al., 2020; Nguyen-Phuoc et al., 2020). Texting is also dangerous because the driver takes their eyes off the road and hands off the wheel. Driving a vehicle requires a high level of concentration and attention. The use of a mobile phone threatens the safety of oneself and other people on the road (Singh et al., 2021; Kent et al., 2021; Larue et al., 2022).

Using a mobile phone while driving increases the risk of an accident. Researchers have consistently linked texting or otherwise manipulating a mobile phone with increased risk. Some, but not all, studies have shown that talking on a mobile phone also increases the risk of an accident (Lino et al., 2023; Ropaka et al., 2020).

2. Literature review

In the article (Strayer et al., 2004) observers recorded the behavior of 2,280 pedestrians at crossings and noticed that almost one-fifth (16.6%) of them, while crossing, performed activities that distracted from the phone. It should come as no surprise that using a mobile phone while driving carries many risks. This is because using a mobile phone, whether in the vehicle or elsewhere, requires the attention of the eyes, brain and hands.

In an article (Johnson et al., 2004), they conducted a survey of 699 people in the United States who had been involved in a vehicle accident. The results showed that 25% of them were talking on a mobile phone 10 minutes before the accident. Two possible sources of distraction when using a mobile phone have been documented. The first type of distraction relates to the physical aspect of holding the phone and dialling (Wijayaratna et al., 2019; Noble et al., 2021), and the second refers to focusing the person's attention on the conversation on the mobile phone

Since crossing the road requires a lot of knowledge and attention, pedestrians using a mobile phone are less likely to look at traffic before crossing, wait for traffic to stop, look at traffic while crossing or walk quickly (Langer et al., 2005). In an article (Laberge-Nadeau et al., 2003), the authors showed that the use of mobile phones while driving can cause some problems, for example, pedestrians using mobile phones had more time to reach their destination, changed directions frequently, and were less aware of their unusual surroundings at much higher levels than pedestrians who did not use them on their mobile phones.

In article (Hatfield, Murphy 2007), the authors conducted a study to determine the effectiveness of activities such as listening to music, talking on a mobile device, and sending and receiving messages on a mobile phone in terms of pedestrian distraction among 138 University of Alabama students in a semi-annual study of a virtual crosswalk environment. The results clearly showed that performing these activities significantly reduces the awareness of passers-by performing these activities and increases the likelihood of collisions with motor vehicles.

In an article (Hyman et al., 2010; Schwebel et al., 2012), the authors conducted an observational study on women and men who were crossing the road and found that both time crossing the road while using the phone increased, and thus the likelihood of a vehicle accident increased.

In an article (Campisi et al., 2022) conducted a study to determine the impact of technology-induced distraction on pedestrian behavior at crossings. They conducted a study at 20 high-risk intersections in Seattle, America, at three different random intervals. 1,102 people were registered at pedestrian crossings, the results showed that about a third (29.8%) of pedestrians were distracted while crossing the road. These pastimes include listening to music (11.2%), writing short messages (7.3%) and using a mobile phone (6.2%).

In an article (Nasar, Troyer, 2007; Thompson et al., 2013), the authors demonstrated three distracting factors that are associated with mobile phone use, with text distraction being the most influential, followed by phone call distraction and music distraction. Not only mobile phones and text messages can distract drivers. The National Road Safety Administration defines distracted driving as any activity that may distract from the primary task of driving. In addition to using electronic gadgets, entertainment can also include radio control, eating and drinking, reading, body care and interaction with passengers (Thompson et al., 2013; Hao et al., 2022; https://motoryzacja.interia.pl). Laws limiting the use of mobile phones by drivers and accident prevention technologies are two approaches that can help reduce the number of accidents caused by distraction. Broad bans on tampering with electronic devices, rather than laws focusing solely on calls and texting, seem to be the most promising. Collision avoidance systems can draw the driver's attention back to the road, regardless of the cause of the distraction (Dalibor et al., 2016; https://www.bankier.pl). Refraining from using mobile phones while driving is the most effective way to reduce the risk of legal and physical consequences.

3. Road traffic accidents

Among all types of road accidents, in the analyzed period from 2012 to 2022, side collisions come first. In 2012, there were as many as 10,408 side collisions on Polish roads. Unfortunately, in the analyzed period, this is not the maximum number, because in 2015, as many as 10,511 side collisions were recorded on Polish roads. over the last 10 years. The second place on the list of the most common road accidents in Poland is occupied by hitting a pedestrian. In 2012, there were 10,042 road accidents caused by hitting a pedestrian. In 2022, 4,609 such events were recorded. It can be noticed that over the 10 years, the number of accidents due to hitting a pedestrian has decreased by 54%, and side collisions by about 35%. Rear impacts and frontal impacts are ranked next, followed by rollovers and collisions with a tree. The number of rear collisions in the analyzed period of time decreased by 35%, and the number of frontal collisions by 42%. It should be noted that road accidents due to vehicle rollover in the period from 2012 to 2022 decreased by 38%, and collisions with a tree by 51% (Figure 1). Unfortunately, it should be noted that the classification of road accidents in Poland does not take into account the cause of the accident due to the use of a mobile phone. This makes it difficult to prove that the driver was using a mobile phone. In addition, there is also a difficult problem of routinely checking by police officers whether the driver of the vehicle is using the telephone.

Undoubtedly, it should be noted that the use of a mobile phone causes the driver's or pedestrian's attention to be shifted to the mobile phone screen. Reducing concentration may result in not noticing a hazard in road traffic, not keeping the correct distance from the vehicle ahead or not adjusting the speed to the prevailing road conditions. Unfortunately, as police reports show, the most common causes of road accidents include: failure to adjust speed to traffic conditions, failure to give right of way, incorrect behavior towards pedestrians, incorrect overtaking and failure to keep a safe distance between vehicles. As you can see, all the most common causes of road accidents can be caused by the loss of concentration of the driver or pedestrian caused by the use of a mobile phone. In the analyzed period of time from 2012 to 2022, the main cause of road accidents on straight road sections was the failure to adjust the speed to the prevailing road conditions. In 2012, there were 4,417 road accidents due to the failure to adjust the speed to the road conditions, and in 2022 the number dropped to 2,214. Therefore, it should be stated that the number of road accidents on straight road sections due to the failure to adjust the speed to the prevailing conditions decreased in the analyzed time period by about 50%. The second most common cause of road accidents on straight sections is failure to yield the right of way In 2012, 2,217 road accidents were recorded due to failure to yield the right of way on a straight road section, and in 2022 this number dropped to 1,490. Therefore, it should be noted that the number of road accidents on straight sections due to failure to yield the right-of-way decreased by 33% in the analyzed period of time. Over a period of 10 years, on average, 2019 road accidents are recorded annually on straight road sections in Poland due to failure to yield the right of way. The next most common cause of road accidents on straight sections of road is the incorrect behavior of the vehicle driver towards the pedestrian. The average number of these accidents in the analyzed period of time is 1,914 per year. Unfortunately, it should be

noted that the number of road accidents due to improper behavior towards pedestrians in the analyzed period of time does not show a visible downward trend, as in the case of failure to yield the right of way or failure to adjust the speed to the prevailing conditions. The largest number of road accidents on straight road sections due to improper behavior towards pedestrians occurred in 2016 and amounted to 2,499, while the smallest occurred in 2021 and amounted to 1,225. A similar situation occurs due to the mismatch of the distance from the vehicle. In the analyzed period, the number of road accidents on a straight road section due to misadjustment of the distance from the vehicle is on average 1,445 per year. 2020 and amounted to 1,108. In the case of incorrect overtaking in the analyzed period of time, the total number of road accidents on a straight road section amounted to 10,840 accidents. On average, there are 985 road accidents on straight sections of road every year due to incorrect overtaking. The main causes of road accidents on straight road sections in Poland in 2012-2022 are presented in Figure 2.

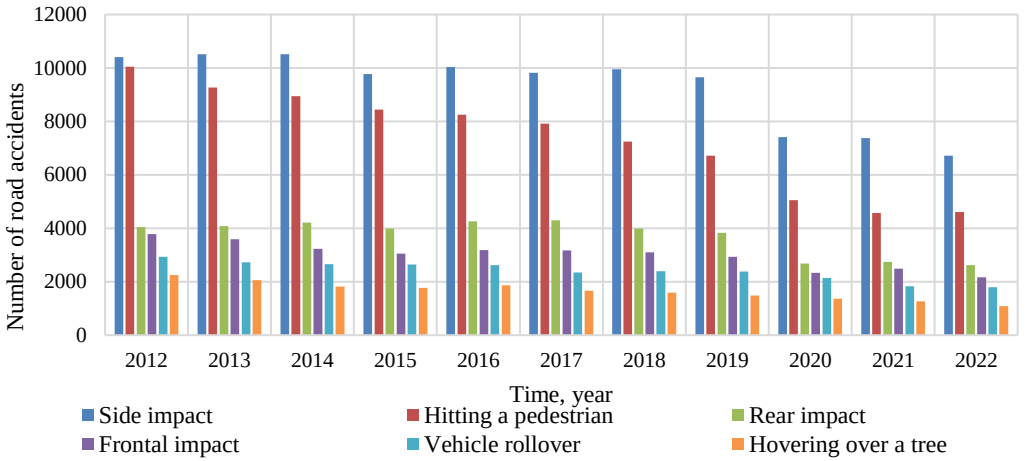

Fig. 1. Road accidents from 2012 to 2020 in Poland

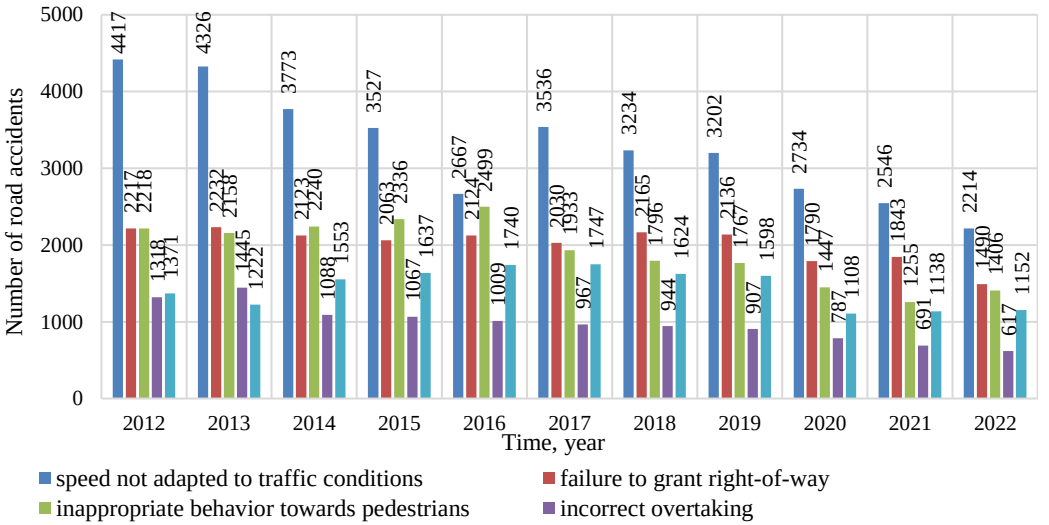

Fig. 2. The main accidents on a straight stretch of road

The main causes of road accidents at priority intersections in the analyzed period from 2012 to 2022 are presented in Figure 3. The most common cause of road accidents at priority intersections is failure to give (priority) right of way. In 2012, the number of road accidents at right-of-way intersections due to failure to give (priority) right-of-way was 52,026, while in 2022 this number decreased to 2,474. will decrease by 51%. The second most common cause of road accidents at right-of-way intersections is inappropriate behavior towards pedestrians. In the analyzed period of time, the number of accidents at priority intersections due to improper behavior towards pedestrians decreased by 67%. The next most common cause of road accidents at priority intersections is not adjusting speed to road conditions. In the analyzed period of time, on average, there are 647 road accidents every year at intersections with right-of-way due to the speed not being adjusted to the road conditions.

The causes of road accidents on roads with dual carriageway are the same as those of road accidents at priority intersections. The most common cause of road accidents in the analyzed section of time on roads with dual carriageway is failure to yield the right of way. In 2012, there were 1,154 road accidents on roads with dual carriageway due to failure to yield the right of way, and in 2022 this number dropped to 497. It should be noted that the number of road accidents on roads with dual carriageway decreased in the analyzed period of time by approx. 57%. The second most common cause of road accidents on roads with dual carriageway is failure to give way to a pedestrian on a pedestrian crossing. In the analyzed period of time, the number of road accidents on roads with dual carriageway due to failure to give way to a pedestrian on a pedestrian crossing decreased by approximately 56%. The next most common cause of road accidents on roads with dual carriageway is not adjusting speed to road conditions. In the analyzed period of time, the number of road accidents on roads with dual carriageway decreased by 56%. The causes of road accidents on roads with dual carriageway are shown in Figure 4.

The main cause of road accidents on single carriageway or two lanes is failure to yield the right of way. In the analyzed period of time on single-carriageway and two-way roads, the number of road accidents due to failure to yield the right of way decreased by 41%. The largest number of road accidents on two-way single-carriageway roads due to failure to yield the right of way was 6,565 in 2012, and the least 3,804 in 2022. Another cause of road accidents on single-carriageway two-way roads in the analyzed period of time is the failure to adjust the speed to the prevailing conditions. It should be noted that in 2013, 2014 and 2016 the number of road accidents on single-carriageway and two-way roads was the highest due to the speed not being adjusted to the prevailing weather conditions. The next cause of road accidents on single-carriageway two-way roads in the analyzed period of time was failure to give way to a pedestrian on a pedestrian crossing. In the analyzed period of time, the cause of road accidents on single carriageway or two lanes due to failure to give way to a pedestrian on a pedestrian crossing decreased by 47% in 2022 compared to 2012. The next most common cause of road accidents on single carriageway two-way roads is failure to keep a safe distance from the vehicle. In the analyzed time period from 2012 to 2022, the number of road accidents on single carriageway or two lanes due to failure to maintain a safe distance from the vehicle decreased by 27%. The causes of road accidents on single carriageway or two lanes are shown in Figure 5.

Not only drivers are responsible for road accidents. Pedestrians attempting to cross the road in unauthorized places or entering a pedestrian crossing without observing basic safety practices can also cause accidents. The use of mobile phones by pedestrians is as dangerous as in the case of the driver. Pedestrians often using phones while walking along the sidewalk or street are able to bump into another pedestrian, hit a road sign, or fall into a fountain full of water because they did not notice it. Also, a pedestrian using a mobile phone may force priority by entering a pedestrian crossing under a speeding vehicle or may not notice the change of traffic signals from green to red. Based on Polish police reports from 2012 to 2022, it can be seen that the main cause of a road accident involving pedestrians is: careless entry of a pedestrian onto the road, crossing the road in prohibited places, entering the road at a red light and moving on the wrong side of the road. Figure 6 shows the characteristics of the causes of pedestrian-vehicle road accidents. It should be noted that the biggest problem of pedestrian accidents with a vehicle is careless entry onto the road. Road accidents involving pedestrians with a vehicle due to careless entry of a pedestrian onto the road account for

almost 70% of all pedestrian-vehicle accidents. The number of road accidents of pedestrians with a vehicle due to careless entry of a pedestrian onto the roadway in the analyzed time period from 2012 to 2022 decreased from 2504 to 677, which is a percentage decrease of approximately 73%. Crossing the road by pedestrians in an unauthorized place is the cause of, on average, 261 road accidents in the analyzed period of time. On the other hand, when a pedestrian enters the roadway at a red light, an average of 204 road accidents occur. Moving on the wrong side of the road by pedestrians in the analyzed period of time is the cause of, on average, 119 road accidents per year. Undoubtedly, it should be noted that road accidents caused by pedestrians are caused by the lack of awareness of pedestrians about the consequences of road accidents and reduced concentration.

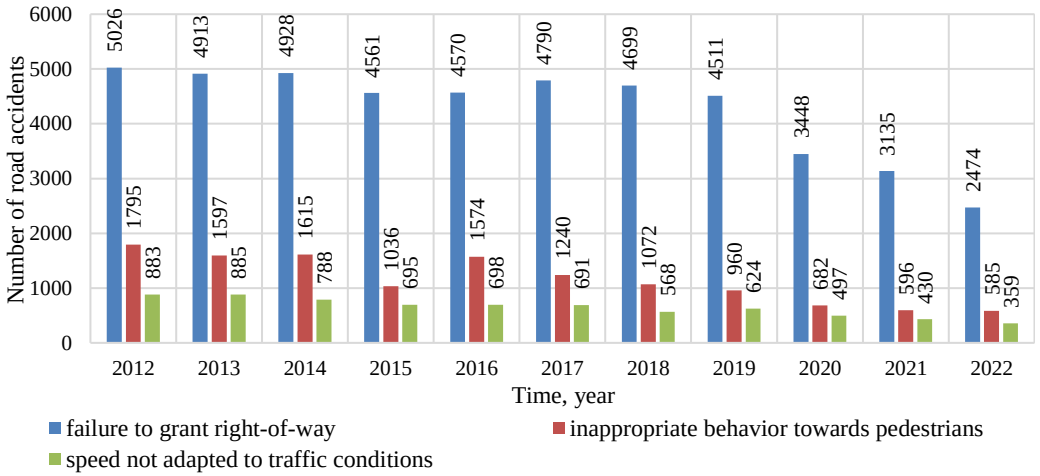

Fig. 3. The main causes of road accidents at intersections with priority

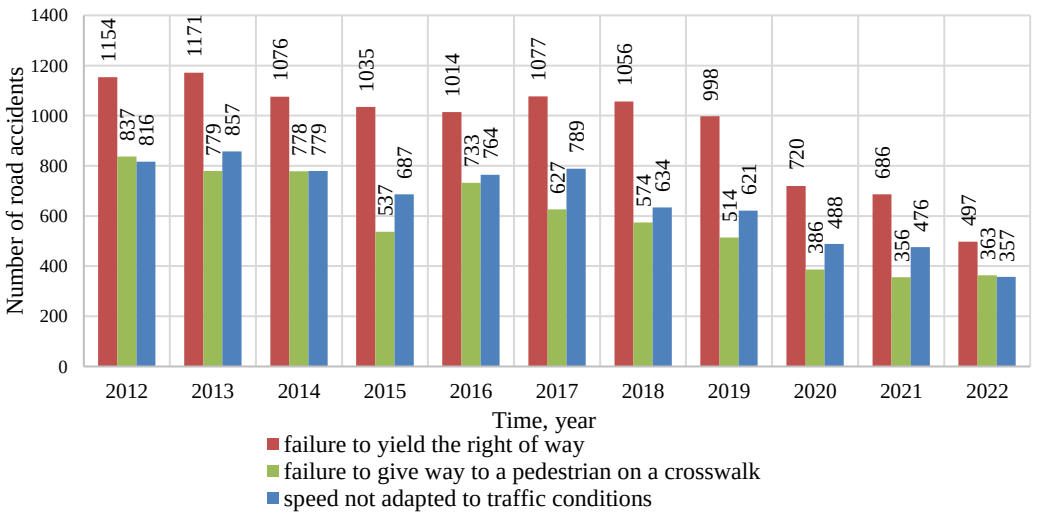

Fig. 4. The causes of road accidents on roads with dual carriageway

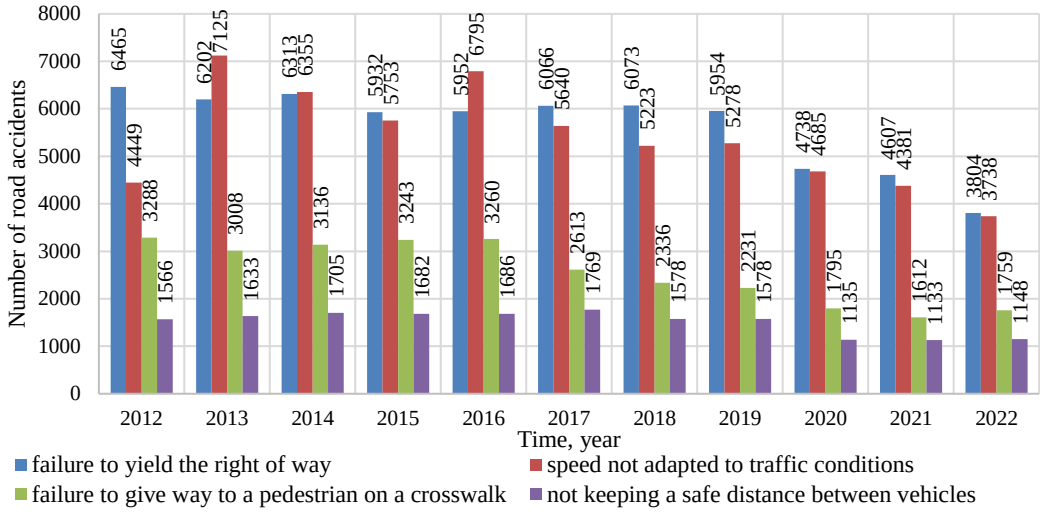

Fig. 5. The causes of road accidents on single carriageway or two lanes

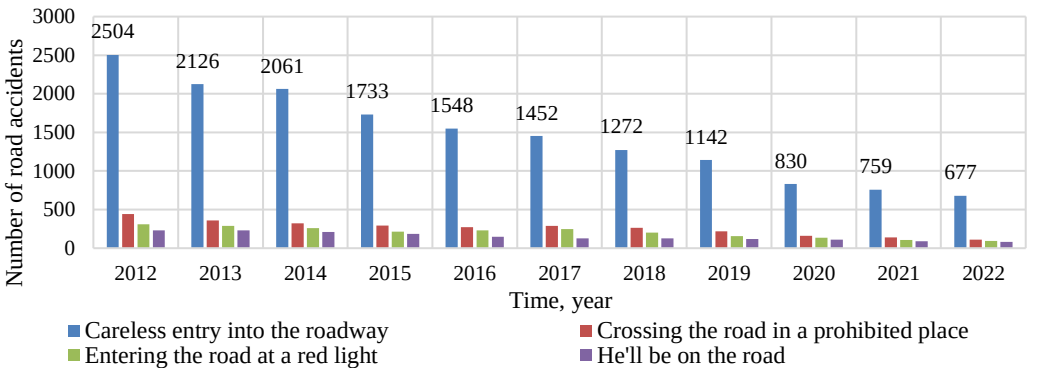

Fig. 6. Characteristics of the causes of road accidents of pedestrians with a vehicle

Figure 7 presents sales statistics of new passenger cars in Poland in 2010-2022. It should be noted that most registrations of new vehicles took place in 2019. The Covid-19 pandemic caused a decline in the number of newly registered vehicles, but the number was still above 410,000 per year.

In new passenger cars, we primarily find a tablet instead of a speedometer and a large touch screen replacing the small radio screen. The touch screen usually allows you to dial and call numbers via a speakerphone, navigate navigation settings or read SMS text messages. In addition, modern cars have a "drive alert system" designed to measure and analyze the driver's level of concentration. If the system detects that your current driving style deviates from the initial results, a message is displayed suggesting you stop the vehicle and rest. Unfortunately, there are no solutions to detect the mobile phone used by the driver while driving. It should be noted here that the driver's distraction by using a mobile phone is comparable to using a touch screen built into the car's cockpit. Using the Android Auto or Apple Car function distracts the driver, causing him to focus on the device screen and not on the road. Therefore, the problem of distracting a driver by a mobile phone is nowadays so great that the use of other devices while driving, even those built-in and included in the equipment of a new vehicle, may cause distraction, which may ultimately lead to a road accident.

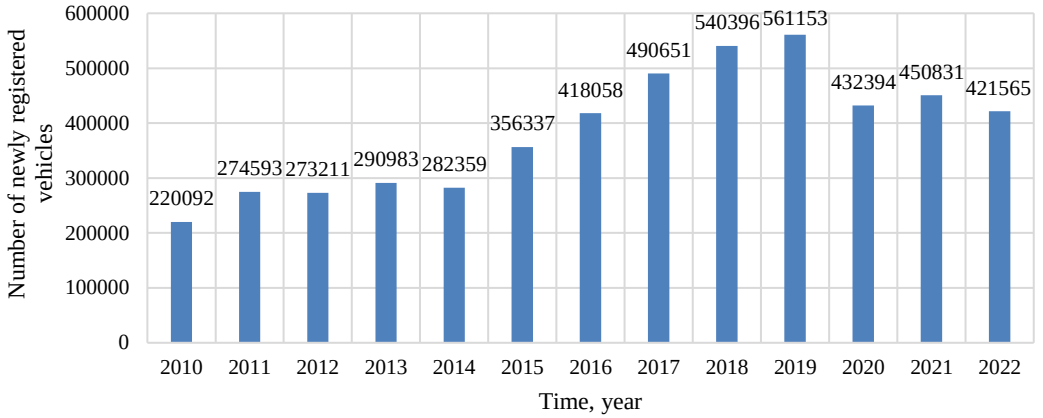

Fig. 7. Number of newly registered vehicles in Poland in 2010-2022

4. Behavior of pedestrians and drivers - survey research

The article uses survey research as a source of information about the behavior of pedestrians and drivers. Anonymous survey research has shown the problem among pedestrians and drivers. The research confirmed the authors' fears that nowadays people do not part with their phones, even when performing important activities such as crossing a pedestrian crossing or driving a vehicle. In the case of pedestrians, it should be noted that the problem of using a mobile phone by pedestrians crossing a pedestrian crossing in most EU countries is solved by law as a fine for an offense. In smaller local towns, there are signs informing pedestrians to put down their phones or audible signals at pedestrian crossings asking them to put their phones away. You can also see signs on the sidewalk in front of a pedestrian crossing: "put your phone away".

In the survey studies, anyone who has a driver's license and is over 18 years old could participate. These were the first two questions in the survey questionnaire. In total, 2573 people participated in the surveys. However, only 820 met the established criteria. Individuals who did not have a driver's license or were not of legal age could not answer the remaining questions.

In the further part of the article, the results of the survey carried out at the Kielce University of Technology will be presented. The respondents were diverse in terms of gender. The study involved 451 women and 369 men. The survey questionnaire allowed people who had a driving license and reached the age of majority to participate in the survey. The breakdown of respondents by age is shown in Figure 8. As many as 42% of respondents aged 18 to 25 participated in the research, 28% of respondents aged 26 to 35, 19% of respondents aged 36 to 45 years of age, 7% of respondents aged 46 to 60 and 4% of respondents over 60 years of age. The largest share in the surveys (70%) were young people aged 18 to 35.

In one of the questions, respondents were asked to indicate whether their mobile phone has an Internet connection. In this question, 100% of respondents indicated that their phones have access to the Internet. Also when asked if the respondents could imagine functioning during the day without a telephone, 100% of the respondents replied that they could not imagine functioning without a mobile phone. In one of the questions, respondents were asked if they always have a phone with them. The respondents' answers to this question are presented in Figure 9. It should be noted that 60% of the respondents definitely always have a phone with them. On the other hand, 31% of respondents declare that they always have a phone with them. Survey data shows that only 4% of respondents do not carry a mobile phone with them all the time and 1% of respondents declare that they definitely do not keep a mobile phone with them all the time.

In the next question, respondents were asked to indicate the time they spend on using a mobile phone per day. The respondents' answers to this question are presented in Figure 10. Less than an hour a day is used by only 8% of respondents. Two or three

hours a day are used by 29% of respondents. 35% of respondents spend three or four hours a day using a mobile phone. It should be noted that this is the largest group of respondents. Moreover, only 17% of respondents spend four or five hours a day using a mobile phone. More than five hours a day as many as 11% of respondents.

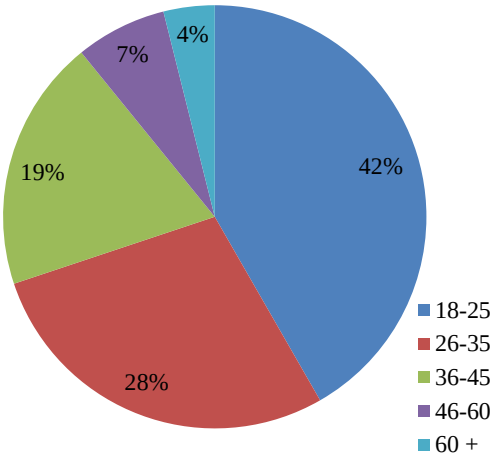

Fig. 8. Characteristics of the age of the respondents

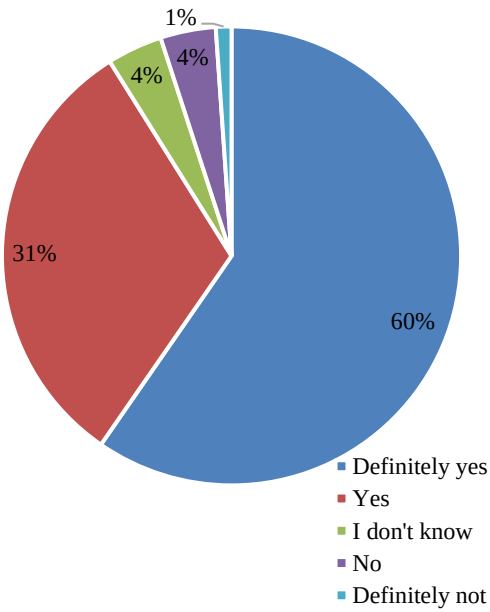

Fig. 9. Do you always have a mobile phone with you?

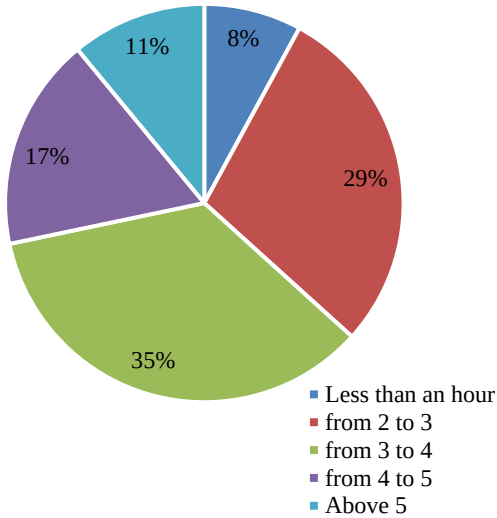

Fig. 10. How much time a day do you use your mobile phone?

In the next question, respondents were asked if they could imagine leaving home without a mobile phone for a long time. The indications of the respondents are presented in Figure 11. The data shows that only 1% of the respondents would be able to leave the house without a mobile phone for a long time. Probably only 3% of respondents could go without a mobile phone for a long time. Definitely, without a mobile phone, 51% of the respondents could not leave the house and 41% of the respondents probably could not leave the house for a long time without a mobile phone.

Respondents were asked if they ever forget their mobile phone and if in such a situation, they feel that something is missing or they feel anxious. Respondents' indications regarding this question are presented in Figure 12. The data shows that 41% of respondents feel that something is missing or they feel anxious when they forget their phone, 51% of respondents declare that when they forget their phone, they probably feel that something is missing or feel anxious. Only 7% (3% definitely not, 4% rather not) of respondents do not feel anxious or lack something if they forget their mobile phone.

In the next question, respondents were asked whether they use a mobile phone while walking on the sidewalk or roadside. The indications of the respondents are presented in Figure 13. The data

shows that 37% of the respondents use a mobile phone while walking along the sidewalk or roadside. Rather, 46% of respondents use a mobile phone while walking on the sidewalk or roadside. Only 5% of respondents definitely do not use a mobile phone while walking along the sidewalk or roadside, and 9% of respondents probably do not use a mobile phone while walking along the sidewalk or roadside.

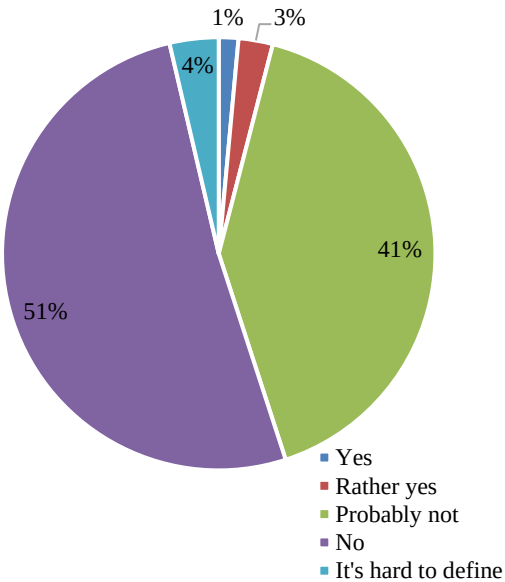

Fig. 11. Can they imagine leaving home without a mobile phone for a long time?

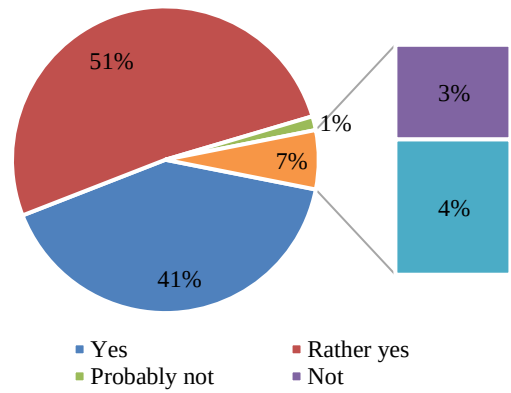

Fig. 12. Do they happen to forget their mobile phone and do they feel that something is missing or anxious?

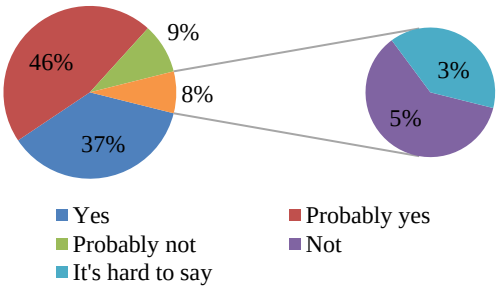

Fig. 13. Do you use your mobile phone while walking on the sidewalk or roadside?

In the next question, the respondents were asked if you happen to run into another pedestrian while using your mobile phone while walking along the street, pavement or roadside. The respondents' indications regarding this question are presented in Figure 14. It should be noted that as many as 21% of the respondents admit that while walking on the sidewalk, street or shoulder while using the phone, they bumped into another pedestrian. As many as 31% of respondents rather admit to doing so. In addition, 39% of respondents probably never bumped into another pedestrian when using their mobile phone, and 7% of respondents never bumped into another pedestrian while using the phone.

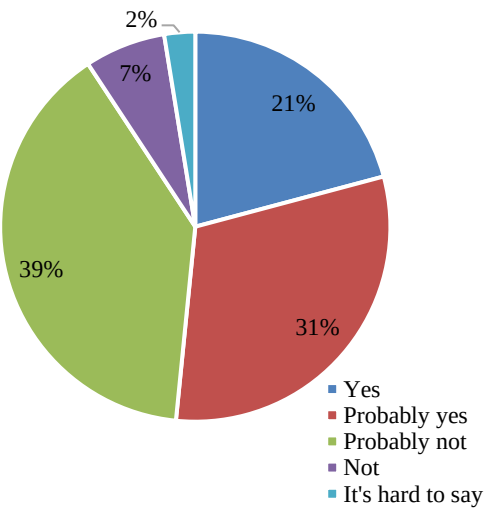

Fig. 14. Do you happen to run into another pedestrian while using your mobile phone while walking along the street, sidewalk, roadside?

In the next question, respondents were asked whether they use a mobile phone while crossing a pedestrian crossing. Respondents' answers are shown in Figure 15. It should be noted that 21% of respondents admitted to using a mobile phone at a pedestrian crossing, and 21% of respondents strongly denied it. 25% of respondents probably use a mobile phone when crossing a pedestrian crossing. 30% of respondents probably do not use a mobile phone when crossing a pedestrian crossing.
Respondents were then asked if they had ever entered a pedestrian crossing while using a mobile phone. The answer to this question is presented in

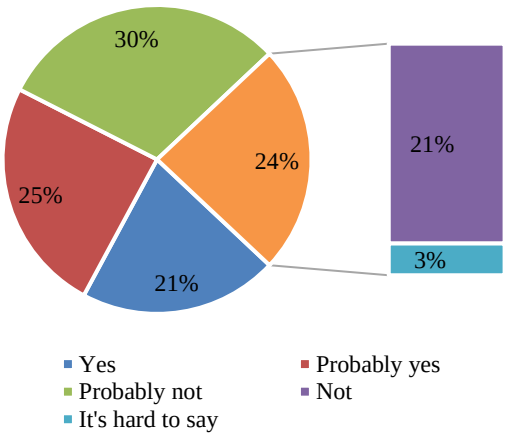

Fig. 15. Do you use your mobile phone while crossing a pedestrian crossing?

Figure 16. Unfortunately, as many as 19% of respondents have entered a pedestrian crossing at least once using a mobile phone. 17% of respondents probably entered a pedestrian crossing while using a mobile phone. Only 20% of respondents declare that they have never trespassed on a pedestrian crossing and 43% of respondents declare that they have probably never trespassed on a pedestrian crossing.
Respondents were asked whether they use a mobile phone while driving. The respondents' indications are presented in Figure 17. It should be noted that as many as 31% of respondents use a mobile phone while driving, and 33% of respondents declare that they rather use a mobile phone while driving. Only 12% of respondents declare that they do not use a mobile phone while driving.

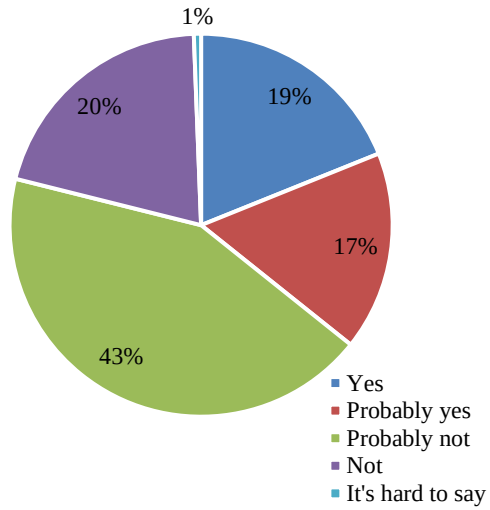

Fig. 16. Have you ever trespassed on a crosswalk while using your mobile phone?

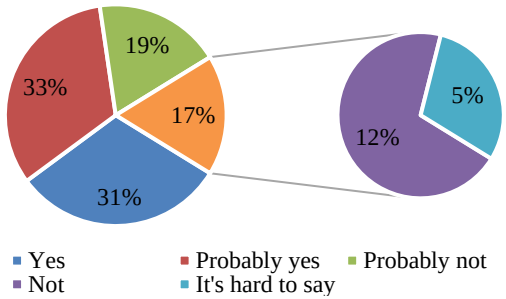

Fig. 17. Do you use a mobile phone while driving?

5. Observation of pedestrian and driver behavior at the intersection with traffic signals - observational studies

Observational studies were carried out at an intersection with traffic signals. The conducted observational research concerns a number of aspects of pedestrian and driver behavior as well as the occurrence of the "green wave" phenomenon. During the observations, the number of vehicles passing through traffic signals, the number of drivers using mobile phones, the number of vehicles waiting for the traffic signals to change, the number of pedestrians crossing the pedestrian crossing taking into account the transmitted signal, and the number of pedestrians crossing the pedestrian crossing with a mobile phone were counted. In order to avoid errors,

observations were made by two groups on opposite sides of the street, regardless of the part of the intersection. Each group for a particular task consisted of two people observing and recording the results of the observations. The observation results are presented in Table 1. Observational studies were carried out at three times of the day. The article presents collected data from two working days (Wednesday, Thursday) during which the observation was carried out. The location of the observation is shown in Figure 18. The observation studies included observations of four parts of the intersection and four pedestrian crossings. They are marked from 1 to 4 in the figure below.

Based on observational studies, it should be noted that on average every 3 pedestrians crossing a pedestrian crossing uses a mobile phone. Based on the results of observations conducted over two working days, a total of 9,564 pedestrians crossed the intersection (the sum of all observed pedestrian crossings), of which as many as 2,730 used mobile phones. The most people with mobile phones on Wednesday and Thursday during the two-hour observation were observed at crossing number 2 (172 people Wednesday, 169 people Thursday). The observation results illustrate the scale of the problem of using phones by pedestrians. During the observations, no pedestrian entered the pedestrian crossing when the red signal was on. Moreover, a total of 35 pedestrians entered the pedestrian crossing while the red light was already flashed by the traffic signals, but vehicle traffic was still suspended. In this group, as many as 21 people used the telephone.

Based on observational studies carried out over two working days, it should be noted that on average every fifth driver uses a phone in a passenger car while waiting for traffic signals. In the analyzed period of time (two working days), a total of 15,516 passenger vehicles passed through the intersection (all parts), among which as many as 2,265 drivers used mobile phones. The largest number of people during the two-hour observation was recorded on the first day of observation in 4 parts of the intersection (139 drivers using a mobile phone). On the second day of measurement, the largest number of drivers using a mobile phone was observed on the second part of the intersection (102 drivers using a mobile phone). The results of observing driver behavior during observational studies are presented in Table 2.

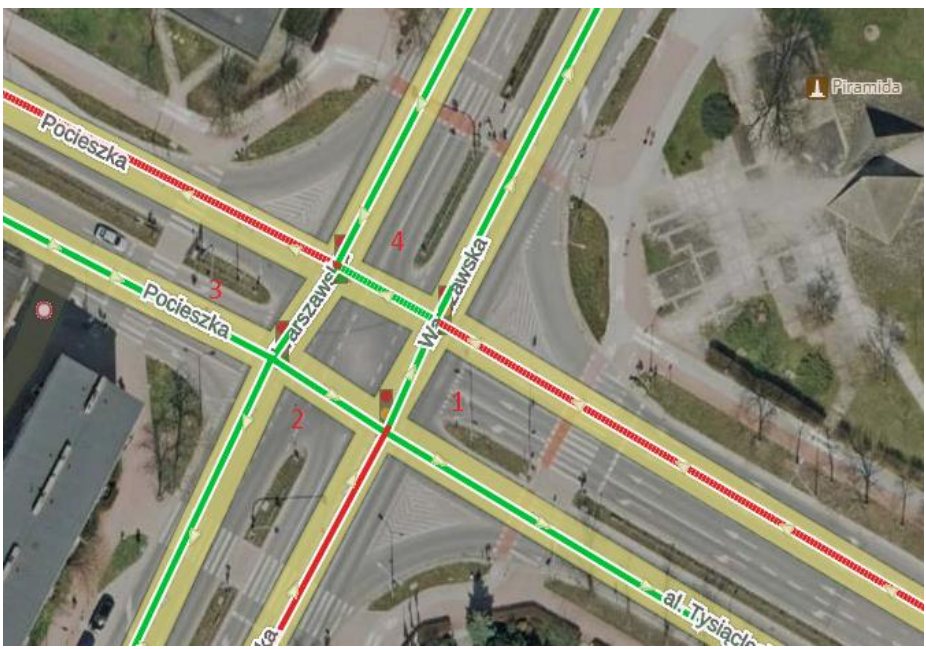

Fig. 18. Place of observational studies

Table 1. Results of observational studies

Traffi light number	First measurement from 8:00 am to 10:00 am		Second measurement from 10: 00 am to 12:00 pm		Third measurement from 2:00 pm to 4:00 pm	
			Wednesday			
	Total number	Pedestrians with a phone	Total number	Pedestrians with a phone	Total number	Pedestrians with a phone
1	311	81	259	77	531	142
2	431	99	432	112	653	172
3	342	108	403	126	433	121
4	309	83	321	101	397	122
Traffic light number	First measurement from 8:00 am to 10:00 am		Second measurement from 10:00 am to 12:00 pm		Third measurement from 2:00 pm to 4:00 pm	
			Thursday			
	Total number	Pedestrians with a phone	Total number	Pedestrians with a phone	Total number	Pedestrians with a phone
1	326	89	332	101	554	155
2	372	111	501	169	562	161
3	342	77	319	99	399	132
4	329	92	301	88	405	112

Table 2. Driver observation results

Traffic light number	First measurement from 8:00 am to 10:00 am		Second measurement from 10: 00 am to 12:00 pm		Third measurement from 2:00 pm to 4:00 pm	
			Wednesday			
	Number vehicles	Drivers with a phone	Number vehicles	Drivers with a phone	Number vehicles	Drivers with a phone
1	429	88	596	93	669	429
2	702	103	719	119	831	702
3	469	96	512	79	533	469
4	699	107	723	121	821	699
Traffic light number	First measurement from 8:00 am to 10:00 am		Second measurement from 10:00 am to 12:00 pm		Third measurement from 2:00 pm to 4:00 pm	
			Thursday			
	Number vehicles	Drivers with a phone	Number vehicles	Drivers with a phone	Number vehicles	Drivers with a phone
1	551	75	621	81	668	83
2	681	92	751	102	802	90
3	421	67	536	77	541	69
4	708	99	691	88	842	91

The percentage share of pedestrians and drivers with a mobile phone in relation to the total number of pedestrians and the total number of passenger car drivers is presented in Figure 19. It should be noted that during the observations on the first day, as many as 27.87% of pedestrians using a mobile phone crossed the pedestrian crossing. On the second day of observation, this number was 29.23%. In the case of vehicle drivers, on the first day of observation, as many as 16.24% of passenger car drivers used a mobile phone at all parts of the intersection. However, on the second day of observation, the number of drivers using mobile phones while driving decreased to 12.98%.

Based on the collected data from observational studies, the Pearson correlation coefficient was determined regarding the number of people using mobile phones at a pedestrian crossing in relation to the total number of people crossing the pedestrian crossing. In addition, the Pearson correlation coefficient was determined relating to the number of drivers using mobile phones while driving a passenger car to the total number of cars passing through the intersection. The Pearson correlation results are presented in

Table 3. It should be noted that in the case of pedestrians, the correlation coefficient, depending on the time of measurement, ranged from 0.55 to 0.99. This means there is a strong correlation between the number of pedestrians crossing a pedestrian crossing and the number of pedestrians using a mobile phone while crossing a pedestrian crossing. In the case of vehicle drivers, the Pearson correlation coefficient was above 0.9 in each analyzed case. It should therefore be noted that the number of drivers passing through an intersection and using a telephone has a strong impact on the total number of drivers passing through the intersection. For all correlations performed, the significance of the correlation coefficient was higher than the assumed significance level ($p>\alpha$).

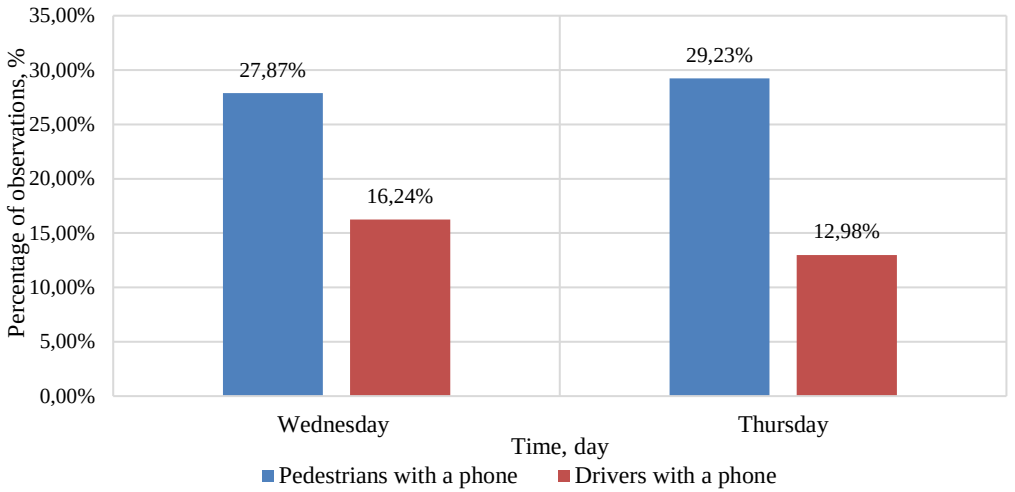

Fig. 19. The percentage share of pedestrians and drivers with a mobile phone in relation to the total number of pedestrians and the total number of passenger car drivers

Table 3. Pearson correlation coefficients

Correlation ratio of the number of pedestrians using a mobile phone to the number of all pedestrians crossing the intersection			
Wednesday			
Pearson coefficient	First measurement from 8:00 am to 10:00 am 0.558125	Second measurement from 10: 00 am to 12:00 pm 0.892733	Third measurement from 2:00 pm to 4:00 pm 0.9858199
Thursday			
Pearson coefficient	First measurement from 8:00 am to 10:00 am 0.695951	Second measurement from 10: 00 am to 12:00 pm 0.998972	Third measurement from 2:00 pm to 4:00 pm 0.9183347
Correlation coefficient of the number of drivers using a mobile phone to the number of all drivers of passenger cars passing through the intersection			
Wednesday			
Pearson coefficient	First measurement from 8:00 am to 10:00 am 0.935653	Second measurement from 10: 00 am to 12:00 pm 0.99801	Third measurement from 2:00 pm to 4:00 pm 0.944888
Thursday			
Pearson coefficient	First measurement from 8:00 am to 10:00 am 0.976582	Second measurement from 10: 00 am to 12:00 pm 0.940595	Third measurement from 2:00 pm to 4:00 pm 0.9755769

The collected results from surveys and observational studies confirm the problem of excessive use of mobile phones by pedestrians and drivers. Dangerous behavior of pedestrians and drivers may result from distraction caused by using a mobile phone. The correlation shows that the number of people using mobile phones is closely related to the total number of people and drivers at the intersection. The lack of a developed system controlling the behavior of pedestrians and drivers, which would be able to detect and inform a pedestrian or a vehicle driver about excessive distraction caused by using a telephone, would largely contribute to improving road traffic safety. Moreover, road infrastructure should be adapted to prevailing social trends. Therefore, there should be warnings at intersections and pedestrian crossings informing people to put away their mobile phones.

6. Discussion

In article (Pešić, Antić, Glavić, Milenković, 2016), a study was conducted to examine the impact of mobile phone use on pedestrian behavior at pedestrian crossings. Data collected through field observations were analyzed, taking into account various variables such as gender, age, number of accompanying pedestrians, and method of mobile phone use. The results of the authors' research showed that pedestrians using mobile phones behave less safely than those who do not use them. The greatest impact on unsafe behavior was found to be talking on a mobile phone, while listening to music had the least impact. Based on observational studies conducted in this article, it can be observed that although many people use mobile phones while crossing pedestrian crossings, none of the pedestrians entered the intersection when traffic was open.

In article (Campisi, Otković, Šurdonja, Deluka-Tibljaš, 2022), a study was described aimed at investigating the impact of technology-related distraction on pedestrian behavior at pedestrian crossings. The study was conducted at 20 high-risk intersections in Seattle, USA, in three different random time intervals. A total of 1102 individuals were observed crossing pedestrian crossings during the study. The results showed that approximately one-third (29.8%) of pedestrians were distracted while crossing the road. Distraction was mainly due to activities such as listening to music (11.2%), texting (7.3%), and using mobile phones (6.2%).

In article (Hualong, Cunbao, Feng, YuanYuan, 2019), the influence of mobile phone use on pedestrian behavior at unsignalized intersections was examined. The study included three locations in Wuhan, China, where statistical analysis of pedestrian behavior was conducted, and a logistic regression model was applied to analyze safety. The results showed that 15.6% of pedestrians used mobile phones while crossing intersections, mainly young pedestrians. Those who used phones were more prone to accidents, walked more slowly, and less frequently checked traffic. The likelihood of conflicts was significantly higher among phone users than among non-users. Based on the research conducted in this article, it can be observed that 37% of respondents use mobile phones while walking on sidewalks or shoulders. Additionally, based on survey research, as many as 21% of respondents admitted to using mobile phones at pedestrian crossings.

Article (Zhou, Liu, Xu, Pu, Zhang, Zhou, 2019) analyzes the impact of mobile phone use on pedestrian behavior at signalized intersections in China. Using video recording and manual data counting, pedestrian behavior at crossings was observed, taking into account age, gender, phone use, and waiting time. Over a four-hour peak period, 4196 pedestrians were recorded, of whom 328 (7.82%) were using mobile phones. The average phone usage varied by age group but not by gender. The study found that mobile phone use could lead to safety violations, such as crossing on a red light and slower walking pace at crossings. Recommendations were provided to improve pedestrian safety at signalized intersections. Based on the research conducted in this article, difficulties in verifying pedestrian behavior were noted. Some pedestrians simply hold their phones, while others actively use them. Developing a system capable of detecting pedestrians using mobile phones could significantly enhance safety by alerting pedestrians to put down their phones.

7. Conclusions

Worldwide, there are approximately 6.57 billion mobile phones in operation, which is a clear indication of how technology has become a key element of social and economic progress over the past few decades. This dynamic technological development is particularly evident in developing countries and emerging markets, where mobile phone usage has become a significant competitive factor.

In recent years, there has been a significant increase in mobile phone penetration worldwide. In developed countries, as many as 84% of the population has access to these devices, demonstrating their ubiquity and popularity. It is estimated that globally there are over 10 billion devices connected to mobile networks, translating into the omnipresence of mobile technology in our daily lives.

However, with the growing popularity of mobile phones, the number of accidents caused by their use is also increasing. Both pedestrians and drivers are at risk when using mobile phones while navigating roads. Pedestrians, engrossed in their device screens, often fail to pay attention to their surroundings, leading to potentially dangerous situations on the streets. This is particularly hazardous when a pedestrian, focused on their screen, crosses the street, ignoring traffic signals at pedestrian crossings. It should be noted that pedestrians, while looking at their mobile phone screens, typically perceive vehicle traffic only superficially, significantly increasing the risk of road accidents. Therefore, despite the benefits brought by the development of mobile technology, it is essential for us to exercise caution and common sense when using these devices, especially on roads. Road accident statistics show that such behavior contributes to an increasing number of pedestrian deaths at crossings. Pedestrians account for the majority of road accident victims. In 2019 alone, nearly 7,000 accidents involving pedestrians resulted in the deaths of 780 individuals. To reduce these incidents, special traffic signals are installed at intersections, illuminating the sidewalk just before the road in red or green. Furthermore, informational campaigns are increasingly organized to raise awareness about the growing problem of irresponsible mobile phone use. Despite the tightening of Polish road traffic regulations, individuals can still be seen crossing pedestrian crossings with phones in their hands. For pedestrians, crossing roads or pedestrian crossings, both with and without traffic signals, requires special caution. Unfortunately, the use of mobile phones, listening to music, or watching videos on a phone or tablet distracts drivers, leading to a lack of necessary caution. Pedestrians entering pedestrian crossings without traffic signals can end tragically. In such situations, an approaching vehicle may not have enough time to stop before the pedestrian crossing.

In Poland, where over 64% of the population uses mobile phones, regulations prohibiting pedestrians from using phones or other electronic devices while crossing roads, bike paths, or tram tracks, including pedestrian crossings, have been in effect since June 1, 2021. Violating this regulation carries a fine of PLN 300. Undoubtedly, the problem of using mobile phones by pedestrians and drivers is constantly growing. Local initiatives seek to draw attention to this issue, and most EU countries are working on changes to regulations that prohibit the use of mobile phones by both drivers and pedestrians crossing pedestrian crossings. Unfortunately, enforcing these regulations becomes a challenge, as confirmed by analyses and recorded incidents of violations by pedestrians and drivers. In further research, the authors focus on improving road traffic safety and infrastructure by introducing a vision system that would detect pedestrians and drivers using mobile phones. Artificial intelligence and machine learning-based technology have the potential to detect phones in the hands of pedestrians at pedestrian crossings or drivers while driving, which could effectively counteract this problem by triggering sound signals.

The study conducted among respondents aimed to examine their behaviors related to using mobile phones in various situations, such as walking on the sidewalk, crossing pedestrian crossings, or driving a car. The results showed that a significant portion of the respondents use phones while walking (37%-46%), and even while crossing pedestrian crossings (21%-25%). Furthermore, some respondents admitted to crossing pedestrian crossings while using their phones (19%-17%). However, using mobile phones while driving was less common, although still a problem for 31% of respondents. These findings suggest the need to increase awareness of the safety implications of using mobile phones while walking or driving.

Observational studies conducted over two working days revealed that about one-third of pedestrians crossing pedestrian crossings use a mobile phone. Data analysis showed that out of a total of 9564 pedestrians crossing the intersection, 2730 of them were using mobile phones. The highest number of people with phones was observed on Wednesday and Thursday at one of the crossings. Furthermore, during the observation, no one entered the pedestrian crossing when the red light was on, but 35 people crossed it when the signals were already red.

Additionally, the studies showed that about one in five drivers of passenger cars use a phone while waiting at traffic signals. Pearson's correlation confirmed strong associations between the number of pedestrians using mobile phones and the total number of pedestrians crossing the crossing, as well as between the number of drivers using phones and the overall number of vehicles. These results suggest the need to increase awareness and implement remedial measures to improve road safety, including warnings at intersections regarding the use of mobile phones.

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