



Research article

Differences in drivers' risk behaviour behind the wheel in relation to road risk perception: Insights from a study on a group of Polish car drivers

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ABSTRACT

Numerous risky driving behaviours are considered the main causes of road accidents. Meanwhile, a number of studies conducted so far indicate that perceiving a higher risk in a certain behaviour is associated with a lower tendency to engage in that behaviour. Accordingly, the aim of this study was to examine whether there are differences in specific types of risky behaviours behind the wheel in relation to drivers' perceptions of road risk. The Road Traffic Behaviour Questionnaires KZD and KZD-P were used to evaluate, respectively, different risky behaviours and risk perceptions in road traffic. Two groups of Polish car drivers with similar average KZD scores but significantly different KZD-P scores, i.e., higher vs. lower, were compared. The profiles of the answers were statistically analysed. It was found that drivers with a lower risk perception were far more likely to engage in those behaviours that are the most commonly reported and directly endanger road safety, e.g., speeding and running a red light. Simultaneously, there were several unsafe driving behaviours, e.g., driving without a seatbelt or speaking on a mobile phone while driving, which were taken regardless of risk perception, i.e., even by the drivers who were aware of their riskiness. The results suggest that risk perception is a significant factor in preventing not all types but only selected hazardous behaviours in road traffic. The significance of the findings for traffic safety as well as ideas for further research in this area are discussed.

1. Introduction

The relationship between driving behaviour and road safety remains unquestionable in view of the accident rates, the number of fatalities in traffic crashes, the constantly increasing number of vehicles on the roads, as well as the extant literature in this research domain [e.g., 1–4]. As Ka and his team [5] noted, about 90 percent of traffic accidents are caused by human error, and most of these errors involve risky driving. Moreover, drivers with risky driving behaviours such as speeding, erratic driving, following other vehicles too closely, and violating traffic laws accounted for approximately 52 percent of severe traffic accidents [5]. And as pointed out by Yang et al. [3], road traffic accidents caused by bad driving behaviours are becoming increasingly serious and have become a major global public health problem due to their negative consequences in terms of deaths, injuries, and psychological trauma [2,6].

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Risky driving is defined as engaging in risky behaviours that raise the possibility of a crash, like speeding, running red lights, or manoeuvring without a signal [7]. The literature lists several prevalent incidents of risky driving behaviours, such as speeding, disregarding the priority of passing, improper manoeuvring, failing to maintain a safe distance between vehicles, driving under the influence of alcohol, and engaging in secondary behaviours such as using cell phones and text messaging while driving [1,4,8–12]. One study, for example, found that four primary road behaviours - speeding, driving under the influence of alcohol, seat belt violations, and red light violations - were critical in predicting the likelihood of traffic accidents [13]. Speeding as a risky driving behaviour has been extensively researched and is considered one of the major causes of road crashes, regardless of the driver's age or skill level [14]. Interestingly, in a study by Love et al. [15], it was shown that speeding and the use of technology that distracts attention while driving were the most commonly reported risky driving habits, whereas speeding in particular appeared to be both habitual and unintentional, and cell phone use was more related to addiction and drivers' attitudes.

Meanwhile, the best-known theoretical approach for classifying drivers' risk behaviour in road traffic is the aberrant driver behaviour model by Reason et al. [16]. When this concept was first developed, violations and errors were the two main kinds of abnormal behaviours. In contrast to errors, i.e., slips, lapses, and mistakes, which involved the failure of planned activities to accomplish a goal and resulted from the driver's difficulties in cognitive functioning, violations were treated as intentional behaviours that differed from a norm and were driven by social and motivational factors. Further analyses, however, carried out across multiple nations with a variety of sample groups, have suggested that the more general concept of aberrant driving behaviour may be divided into four distinct categories: ordinary violations, including, e.g., exceeding the speed limit and crossing red lights; aggressive violations, such as honking, dangerous overtaking, or preventing other vehicles from overtaking; and simple errors and lapses [17–21]. Viewed from this perspective, although both types of violations may pose an equally high danger to other drivers on the road, what clearly distinguishes deliberate ordinary violations from intentional aggressive ones is the intention of the latter to cause damage to other road users, both physical and psychological harm, e.g., in the form of verbal abuse of other drivers [20]. Nevertheless, regardless of their type, it is certain that preventing inappropriate driving behaviours, such as breaking the rules and engaging in other risky behaviours, is a fundamental part of ensuring the safety of all road users.

Hence, considering the perspective of road safety, researchers examining driver risky behaviours and trying to understand them look for a variety of their determinants, including factors related both to the driver himself, e.g., age, gender, driving experience, or selected personality and temperamental traits, and variables related to the external environment and circumstances that influence specific road behaviour. As an example, according to studies based on sociodemographic data, younger drivers are more likely to break the law and to be involved in accidents than older drivers, while the most common factors influencing their behaviour are sensation-seeking, inexperience, and recklessness [13,22]. Curiously, one study in this area has found that men and younger drivers behave more aggressively than women and older drivers, but these differences were most evident in the rarest but at the same time most extreme aggressive driving behaviour on the road, i.e., cutting across multiple lanes and passing on the shoulders [23]. Moreover, in a study by Bazilio et al. [24], most risky behaviours were, in fact, more prevalent in males, with the exception of using a cell phone while driving. Additionally, it was found that male professional drivers engaging in such dangerous driving behaviours as unsafe passing, speeding, and tailgating were more likely than females to be involved in an accident [25].

According to the model of cognitive and perceptual processes proposed by Deery [26], there are several reasons why a driver may take risks, such as continuing to drive at a relatively high speed when a pedestrian steps off the curb to cross the road. Thus, a driver may have poor driving skills and an extended reaction time to events on the road, have a high level of risk acceptance in order to achieve his or her intentions and, for example, get to a certain place on time without additional delays, and finally, a driver may have poor risk perception, i.e., perceive a low level of risk in maintaining a relatively high speed due to misjudging the distance to the pedestrian or the braking distance of his or her own vehicle or overestimating his or her own ability to cope if a problem actually occurs. All in all, given the various factors associated with risky driving behaviour, it is the perception of road risk that is the main focus of this study.

In the existing literature in this area, researchers point out that risky behaviours undertaken by drivers in road traffic are evaluated from the perspective of subjective risk [12]. It has to do with the fact that engaging in risky behaviour depends, among others, on how a person perceives the risk, i.e., how they assess the magnitude of a given risk, what emotions are associated with it, and how appealing taking the risk seems to be [27]. As an example, Cheng et al. [28] have shown that there is a relationship between driving-violation behaviours and risk perception, whereas Jing et al. [29] revealed that both risk preference and risk perception predict risky driving behaviours, with risk perception having even greater predictability. According to Deery's [26] model, risk perception refers to the subjective experience of risk and may affect driver behaviour in response to traffic hazards, being at the same time predictive of accident involvement. Hence, for the reasons already set out, drivers' perception of risk, i.e., their assessment of how much a given behaviour may endanger road safety, is an important factor that should be taken into consideration in the search for determinants of risky behaviours in road traffic [e.g., 30].

Traffic risk perception can be defined as a subjective assessment of the risk involved in different traffic situations [26,31]. In this view, risk perception is regarded as a precursor to driver behaviour under actual driving conditions. A number of studies conducted so far have found a negative correlation between risk perception and risky behaviour, meaning that higher levels of risk perception related to a particular behaviour are associated with a lower probability of engaging in that behaviour [14]. Hence, many authors point out that higher risk perception can increase the likelihood of adopting safer and more defensive driving behaviours as well as enhance driving efficiency [1,32,33]. One study found that risk perception was negatively related to attitudes towards risky driving [34], whereas in another paper, the authors noted that a low level of risk perception was strongly related to road traffic accidents [35]. Khan et al. [36] reported that risk perception is a vital predictor of drivers' behaviour, as drivers mostly adopt protective traffic behaviours whenever they perceive high traffic risks. Curiously, there is also research on drivers' self-perception of their own driving skills, in

which relationships between greater perceptions of driving skills and a perceived lower crash risk have been demonstrated. For this reason, researchers postulate that biased perceptions of one's own driving skills, behaviours, and performance may give drivers overconfidence and a lower risk perception and consequently increase the likelihood of being involved in a traffic crash as a result of assuming a higher risk, especially among young and inexperienced drivers [e.g., 37,38,9,26]. Overall, researchers agree that a better understanding of how people perceive the risks associated with driving contributes to the establishment of more appropriate countermeasures, particularly those related to traffic safety education [39].

To date, there have been many studies exploring the relationship between risk-taking and risk perception [34,40], with much of them concluding that traffic risk perception can significantly predict drivers' behaviours [31]. There is also a lot of research investigating different types of aggressive driving behaviour and such factors as age, gender, the presence or absence of passengers in the car, and the type and perceived status of the vehicle [e.g., 23]. However, studies focused on the association between traffic risk perception and some specific types of risky driving behaviours are still scarce. As an example, a study by Machin and Sankey [14] assessed the relationship between a few risk perception variables, i.e., worry and concern about traffic injury and risk, likelihood of accident, perceived efficacy in driving and aversion to risk taking, and risky driving behaviour, but referred only to one indicator of this road behaviour, namely speeding. Interestingly, Nordfjærn and Rundmo [41] pointed out that the weak relationship between road risk perception and driving behaviour found in some studies may be due to the measurement of general road risk perception rather than risk perception related to specific traffic situations [31]. In view of this, we evaluated drivers' risk perceptions in our study based on ratings of particular risky activities they engaged in while driving.

All in all, in light of the aforementioned, the aim of the current study is to determine whether there are differences in drivers' risk behaviour behind the wheel depending on their risk perception. Thus, the research question that the presented study sought to answer is whether it is possible to identify specific risky behaviours on the road that would be characteristic of both those drivers who see the risk in road traffic and those who are unaware of it. Ultimately, the paper also formulates some specific objectives, which include the following.

- to present the results of risk behaviour research carried out on a group of Polish car drivers,
- to explore and confirm with the results of previous studies the relationship between risk perception and the general tendency to take risks on the road,
- to present KZD and KZD-P questionnaires for studying the tendency towards risky behaviour on the road and road risk perception, respectively, useful for both scientific research and practical settings.

2. Materials and methods

2.1. Participants and procedure

The whole studied group of 306 Polish car drivers (143 females) aged 19–65 ($M = 35.73$; $SD = 11.61$) was asked to complete specially developed questionnaires, i.e., the *Road Traffic Behaviours Questionnaire* KZD, which aimed to assess the tendency to take risks on the road and driving-violation behaviours, and the *Road Traffic Behaviours Questionnaire* KZD-P, which enabled the assessment of risk perception, i.e., awareness of potential dangers and risks associated with certain behaviours in road traffic. To avoid the particular order in which the questionnaires were completed from impacting the results, the sequence in which they were done was random; that is, some respondents completed the KZD questionnaire first, while others answered the KZD-P questionnaire first.

2.1.1. Ethics and consent

The study was questionnaire-based and did not require any special bioethics committee approval. Nevertheless, the research prioritised the privacy and confidentiality of all participants' data and was conducted according to the ethical standards set out in the Declaration of Helsinki. All the drivers participated in the study anonymously and voluntarily and did not receive any material gratification for their participation. They were recruited individually and informed in detail about the aim and nature of this scientific research. Respondents gave written informed consent to take part in the study. The inclusion criterion for the study group was daily car driving.

2.2. Measures

Questionnaire methods, i.e., the *Road Traffic Behaviours Questionnaires* KZD and KZD-P, were used to assess risk behaviours and risk perception in road traffic, respectively.

The tendency to take risks on the road and different driving-violation behaviours of car drivers were evaluated by means of the Polish version of the *Road Traffic Behaviours Questionnaire* KZD [30,42]. The task in the questionnaire was to rate, on a four-point Likert scale from 0 to 3, the frequency of engaging in certain behaviours on the road. The evaluated risky behaviours mainly related to traffic violations and often cited in the literature as the most common causes of car accidents [e.g., 43,5], were as follows: driving too close to other vehicles, driving without wearing a seat belt, exceeding the speed limit, running a red light at an intersection, forcing a priority crossing, overtaking on a continuous line, overtaking in low visibility, driving for long periods of time in a state of fatigue, driving at high speed in adverse weather conditions, driving without low-beam headlights on, failing to stop in front of a railroad crossing, changing lanes without signalling to other drivers, racing other cars, talking on a cell phone or texting while driving, parking in a forbidden place, drinking or eating while driving, honking at drivers who are driving too slowly, and impeding other drivers. The high

frequency of engaging in various risky behaviors was an indicator of car drivers' strong overall tendency to take risks on the road.

In addition, the Polish version of the *Road Traffic Behaviours Questionnaire* KZD-P was used to assess drivers' risk perceptions in road traffic [30,42]. The questionnaire was constructed in such a way that it included the same risky behaviours that drivers rated in the KZD questionnaire, i.e., diagnostic items only, with the difference that this time they were asked to rate, on a five-point Likert scale from 1 to 5, how threatening the behaviour is to the drivers themselves as well as to other traffic users. A high overall score in the KZD-P questionnaire indicated a high risk perception on the road.

Noteworthy, both KZD and KZD-P questionnaires have been validated in studies conducted on a group of 306 Polish car drivers [30]. The study showed high values of Cronbach's alpha reliability coefficients, i.e., 0.87 for diagnostic items in both questionnaires, as well as high discriminatory powers of the positions falling within 0.33–0.61 and 0.35–0.61 in the KZD and KZD-P, respectively. Additionally, the good psychometric properties of the KZD questionnaire and its applicability in driver testing have been described in detail in recent validation studies [44]. Overall, it is reasonable to conclude that the questionnaires are highly reliable for measuring both risk behaviour and risk perception in road traffic.

English translations of the validated Road Traffic Behaviour Questionnaires KZD and KZD-P are included in the attachments as supplementary data (*Appendices A and B*).

2.3. Statistical analyses

The results of the study were analysed by means of the R statistical programme version 3.2.2 [45], accompanied by packages *effsize* version 0.8.1 and *iccde* version 0.3.5. The traditional alpha level of 0.05 was taken as a threshold for statistical significance, and the Hedges' *g* index [46] was used as an effect size measure in assessing the between-group differences. Since there are certain limitations and risks associated with this type of study, including but not limited to sampling, choice of type of statistical analysis, etc., all assumptions for the statistical tests used were reviewed prior to conducting the analyses, and limitations in interpreting the results are included in the *Discussion* section.

3. Results

In the whole group ($N = 306$), there was a moderate, negative correlation between the risk taking (KZD scores) and risk perception (KZD-P scores), with $r_{(304)} = -0.39$ ($p < .001$), which means that the lower risk perception is associated with overall more risky behaviour. However, as the main aim of the analysis was to search not for the quantitative but for the qualitative differences in behaviours among people with different levels of risk perception, regardless of their overall tendency for risky behaviour, comparable subgroups were chosen from the whole study group before computing the profile analysis. At first, the whole group was split into two halves on the basis of the KZD-P median score (70 points). Then, where it was possible, every subject from the below-median group was paired with the subject from the above-median group with the same KZD score. As a result, there were two groups of 93 people each, with the same average KZD score in both groups ($mean = 16.13$, $sd = 7.46$) and significantly ($p < .001$, Hedges' $g = 2.55$) different KZD-P scores, with the mean KZD-P score being 63.95 ($sd = 5.25$) in one group and 77.97 ($sd = 5.70$) in the other. There was also no significant correlation between the KZD and KZD-P scores ($r_{(184)} = -0.08$, $p = .300$), and no significant sex differences between the two groups (35 females in the first group and 46 females in the other, $\chi^2(1) = 2.187$, $p = .139$). There were, however, small but statistically significant differences in age ($p = .033$, Hedges' $g = 0.31$) and in driving experience ($p = .036$, Hedges' $g = 0.31$), with subjects in the group with higher KZD-P scores being slightly older and more experienced than subjects in the group with lower risk perception (in both variables, the mean difference was about 3 years). Because of these differences, age and driving experience may be seen as confounding variables, but, on the other hand, they are the proof of ecological validity. Higher risk perception is generally connected with older age and longer driving experience [e.g., 47,14,30,], which is also true for the sample of the current study (correlation of KZD-P scores with age is $r_{(304)} = 0.37$, $p < .001$, and with experience $r_{(304)} = 0.30$, $p < .001$), so equating these variables could lead to artificial differences between the higher and lower risk perception groups, which would not reflect the psychological reality. This, and the fact that the effect size for the age and experience differences was small, led to the decision to continue the analysis and compare the selected subgroups as they were. The possible connection between age and experience differences and achieved results is also addressed in the *Discussion* section.

In the next step, in each group, the profile of the answers was computed, which consisted of the mean scores of every item on the KZD scale. While the mean KZD score was the same in both groups, differences in these two profiles could provide information about possible qualitative differences in risky behaviours between people with relatively higher and lower risk perceptions.

When assessing the profile similarity, a few characteristics of the profiles could be taken into account. These are.

- shape (pattern of high and low points in the profile);
- elevation (mean of profile elements; there could be two profiles of the same shape but with one of them more elevated than the other);
- scatter (variability of the profile points around the average profile value).

Different indexes of profile similarity could be sensitive to all or only some of these factors [e.g., 48]. For the current study, two indexes were chosen: the simple Pearson correlation, which is sensitive only to shape and insensitive to other profile characteristics [49], and the double-entry Intraclass Correlation Coefficient (ICC_{DE}), which is also mostly sensitive to differences in the profile shape but at the same time takes into account the elevation and scatter [50]. It is also proven to be superior to simple intra-class correlation

[51]. Both measures could be easily interpreted, and the joint use of these two indexes is thought to best serve the aim of the current analysis.

Fig. 1 presents two profiles (from groups with lower and higher risk perceptions) of the means of the raw scores of the questionnaire items taken into analysis. The shapes of the profiles are practically identical, with a correlation coefficient of $r_{(18)} = 0.96$ ($p < .001$) and a similar level of intra-class correlation, $ICC_{DE} = 0.96$. There are no significant group differences between any of the item mean scores.

The profiles depicted in Fig. 1 are characterised by a generally large scatter, with some of the item means being much higher than the others. In that case, there is a risk of so-called *stereotypic accuracy* [52], meaning that a large part of the agreement between the two profiles could be due to the similarity of normative scores and the individuating information of the two groups being obscured by a common normative pattern of responses. To deal with this normative pattern, the scores for each of the questionnaire items were standardised with the mean and standard deviation of the whole study group ($N = 306$). As a result, each item's score distribution has a mean of 0 and a *SD* of 1. Based on those standardised scores, the profiles were again computed for the two selected subgroups (lower and higher risk perception), which, with the normative pattern removed, showed only *differential accuracy*.

The profiles for standardised item scores are presented in Fig. 2. The correlation coefficient of these two profiles is $r_{(18)} = -0.53$ ($p < .001$), and the intra-class correlation is $ICC_{DE} = -0.49$ (it is possible for double-entry ICC to have negative values, as it ranges from -1 to 1 ; see Ref. [50]). Such values show the moderate dissimilarity of the two profiles, mostly noticeable in their shapes. Item-by-item analysis (a series of Student's *t*-tests) showed significant differences ($p < .05$) for items 4, 5, 16, and 34, with relatively lower scores for the group with higher risk perception and an average effect size for the difference (Hedges' *g* from 0.51 for item 5 to 0.69 for item 34).

Afterwards, a qualitative analysis of the statements that differentiated both groups of car drivers was carried out, i.e., statement no. 4: "speeding", statement no. 5: "driving through a red light", statement no. 16: "driving at high speed in poor weather conditions (i.e., fog, rainfall, sleet)", and statement no. 34: "texting while driving". Statements 4 and 16 addressed speeding, which has been linked to most traffic accidents according to numerous prior studies [e.g., 14]. Statement 5 dealt with common violations of traffic laws, which is partially related to speeding, as running red lights seems to be naturally motivated by the desire to avoid stopping at an intersection and, thus, avoid having to wait and waste time while driving. Yet, statement 34 discussed writing while driving a car, which is a behaviour that seriously interrupts a driver's attention and poses a direct threat to road safety [e.g., 53]. Overall, all the behaviours included in the above-mentioned statements are typical and common traffic violations. Accordingly, this study found that drivers with higher risk perception scores in the KZD-P, i.e., perceiving higher risk in road traffic, significantly less often risked exceeding the speed limit, running a red light, and texting while driving compared to those who underestimated the road risk.

The remaining KZD questionnaire questions revealed no differences in various types of behaviours between the groups of drivers surveyed, showing that drivers act similarly on the road regardless of whether they perceive a risk or not. Examples of these behaviours include the following: failing to maintain a safe distance from other vehicles; driving without a seatbelt; operating a vehicle while fatigued; speaking on a mobile phone while driving; parking in an illegal location; and eating or drinking while driving.

4. Discussion

The main aim of this study was to examine whether perception of road risk differentiates the specific types of risky behaviours drivers engage in behind the wheel and which pose a real threat to traffic safety.

Accordingly, the obtained response profiles in the KZD questionnaire turned out to be similar in most of the statements, with the exception of four, which significantly differentiated the distinguished groups of car drivers, i.e., those perceiving high and low road risks. First of all, the research has shown that behaviours such as exceeding the speed limit, running red lights, and texting while driving are undertaken by drivers with lower risk perception, i.e., those who do not perceive them to be risky. Consequently, as perception of road risk rises, the tendency of car drivers to refrain from these particular risky behaviours becomes noticeable.

Undeniably, the aforementioned behaviours pose a large, direct threat to traffic safety. Primarily, according to the data available in the literature [e.g., 13–14], driving too fast is one of the leading causes of traffic accidents and premature deaths, especially among

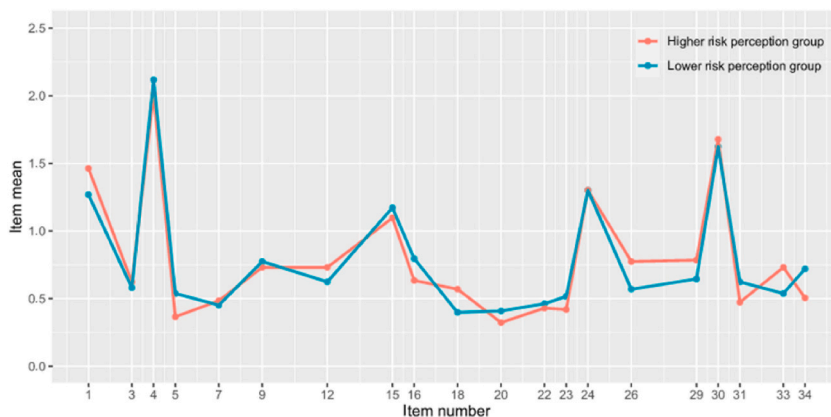


Fig. 1. Profiles of the answers in the KZD questionnaire in groups with higher and lower risk perceptions.

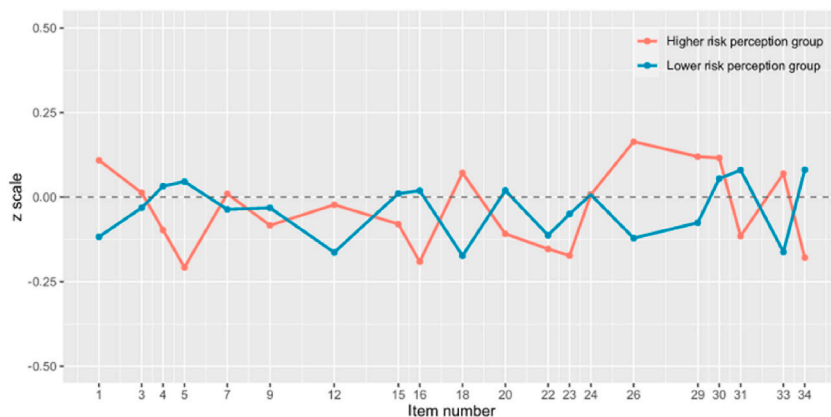


Fig. 2. Profiles of the standardised answers in the KZD questionnaire in groups with higher and lower risk perceptions.

young drivers. According to estimates, excess or inappropriate speed is a factor in about one-third of all fatal collisions. Speeding is a significant contributing factor in about 30 % of fatal traffic accidents in European countries, for example, and just to make things worse, between 35 % and 75 % of vehicle speed observations on urban roads across the continent are higher than the speed limit [54]. For comparison, speeding was the leading cause of traffic violation deaths in China in 2006, accounting for 14.4 % of all road traffic accident deaths; in the USA, speeding was linked to around 29 % of fatal crashes [55]. It is also obvious that the negative health effects of road accidents due to speeding, which mainly result in severe injuries and long-term disability for road users, pose a heavy burden on all, without exception, healthcare systems. Interestingly, as, for example, the research by Bener et al. [56] revealed that male drivers were significantly more likely than female drivers to drive too fast, in our study there were no statistically significant differences between the two groups of drivers in terms of gender, so there are no grounds for assuming an indirect effect of this variable on the results obtained. What is also worth noting is that age and driving experience are regarded as significant predictors of risk-taking among the drivers who are aware of existing risks in road traffic [14,30,47]. Our study compared the groups of drivers in terms of age and driving experience; however, the effect sizes for these differences were low, i.e., of three years (the effect size was only $g = 0.3$, whereas, for example, for differences in risk perception, the effect size reached $g = 2.5$), suggesting the small practical importance and similarity of both groups on the above-mentioned variables. Independently, the study's finding of higher risk perception in slightly older and more experienced drivers not only does not disturb the interpretation of the results in terms of the significant role of risk perception, but primarily reflects and confirms the existence of real psychological interactions in the study group of drivers found in many previous studies. In view of the above, the obtained result suggests that increasing drivers' risk perception may make sense in the context of preventing them from exceeding the speed limit on the road.

Furthermore, texting while driving appeared to be another behaviour that set apart the groups of drivers investigated. Remarkably, as communication technology has advanced, it has been noticed that drivers are sending and receiving text messages while driving increasingly frequently. Such driving habits, however, pose a severe risk to road safety since they can divert attention, lengthen the amount of time drivers spend looking away from the road, reduce drivers' reaction times, degrade their ability to drive, and ultimately result in accidents. According to Bendak [53], texting while driving in a simulator study resulted in five times as many crashes as not texting while driving, as well as frequent unnecessary lane and road boundary crossings. Adding to this, as demonstrated by Love et al. [15], the most frequently reported risky driving behaviours in road traffic are precisely speeding and the use of technology, which diverts people's attention while driving. Generally speaking, the results obtained indicate that increasing risk perception may be effective in deterring drivers from behaviours such as speeding, running red lights, and texting while driving, which are identified in the literature as common causes of road traffic incidents involving drivers.

However, the study's findings appeared to be different with regard to the other risk behaviours analysed. Thus, it has been noted that all car drivers surveyed, regardless of their risk perception, similarly frequently engaged in risky behaviours such as failing to maintain a safe distance from other vehicles, driving without wearing seat belts, operating a vehicle while fatigued, speaking on a mobile phone while driving, parking in an illegal location, and eating or drinking while driving. This means that certain road behaviours, like, among others, driving without a seat belt, occur regardless of risk perception, i.e., they are occasionally undertaken even by those drivers who are aware of their obvious risk. This might be due to the fact that people find these behaviours to be less risky and of minor importance overall than behaviours like going over the speed limit, running a red light, and texting while driving, thus making them more acceptable on the road. Hence, despite individual characteristics, e.g., personality traits, a greater tolerance and acceptance of risk, including hazardous road behaviours, may be the result of some cultural influences and the specific characteristics of the population studied. As observed in one study, Norwegians reported, among other things, safer attitudes regarding speeding in road traffic and more seat belt use than respondents from sub-Saharan Africa and Tanzania [57]. Such results confirm the existence of cross-cultural differences in road traffic risk perceptions, attitudes towards traffic safety, and driver behaviour, which is important in terms of interpreting the causes of different driver behaviour in road traffic and at the same time justifies conducting comparative research in this area.

Moreover, it's possible that other factors not explored in this study influenced the drivers to engage in the specified behaviours even

though they perceived the risks that accompanied them. Firstly, our previous studies have shown that as much as 29 % of the variance of risk taking behind the wheel can be explained by a combination of several personal-demographic variables and personality traits, whereas impulsiveness was a significant factor for risky driving regardless of risk perception [30]. Secondly, beyond the individual factors that drive people to engage in risky behaviours even when they are fully aware of the dangers they pose, there are also situational ones that play an important role in risk-taking while driving a car. As an example, a study by Xu et al. [58] found that high time pressure and unsafe common social norms increased drivers' tendencies to commit violations, respectively. Also, as driving experience increased, drivers became less susceptible to individual factors and more sensitive to environmental cues. As a consequence, drivers were more likely to behave in a way that was consistent with other people and the circumstances around them. After all, the above-mentioned variables, which were not analysed in this study, may be relevant to risky driving regardless of risk perception.

Finally, the study also showed a moderate, negative correlation between risk taking and risk perception. This result is consistent with the data available in the literature [e.g., 14], and hence it seems clear that lower risk perception is associated with overall more risky drivers' behaviour in various road traffic conditions.

Nevertheless, the current study has some limitations that should be addressed in future research. Primarily, a questionnaire-based and self-reported approach was used to evaluate drivers' risk perception and risk behaviours, including recklessness and posing threats to other car users. Indeed, one drawback of self-reported methods is the potential impact of the social approval variable on the results obtained, and the respondent's desire to present oneself favourably in combination with low self-awareness means that the results may not always be a reliable indicator of behaviours seen in actual day-to-day situations. This limitation is, however, solely a result of the peculiarities of questionnaire research, so it should be taken into consideration when interpreting the findings and drawing further practical conclusions. Whereas this is the methodology most commonly used in studies of drivers' risk behaviour, future research should consider using more objective ways of measuring risky driving behaviour. In this sense, some behavioural procedures should be considered. Hence, it would be beneficial to use additional methods, such as behaviour analysis of drivers in real-world task situations with simulated traffic, to supplement questionnaire approaches for identifying drivers' unsafe driving behaviours. Even though they require costly equipment and the setting up of suitable research facilities, such experimental studies would enable the observation and classification of various risky driving behaviours based not only on the information self-reported in the questionnaire but also on actual samples of behaviour under simulated road conditions.

Afterwards, the current study has been conducted on a sample taken from the Polish general drivers' population, which in some way limits the possibility of extending the results to apply to the entire population of car users. Instead, conclusions ought to be drawn in light of the research group. However, for this reason, future research should replicate the current findings with more specific samples coming from other countries, including, for example, traffic offenders or novice drivers. And lastly, in relation to the small differences found between lower and higher risk perception groups of drivers in terms of age and driving experience, it would be beneficial to consider and control these variables in future research to both check their importance in searching for individual differences in road risk perception and risky driving behaviour and provide a more nuanced understanding of the results obtained.

Despite the limitations discussed above, the study's results are significant as they expand the existing theoretical knowledge of the risky behaviour of car drivers in road traffic. They showed explicitly that risk perception has a significant relationship with taking risks while driving and can differentiate certain driving behaviours, as in this research, the most frequently reported and directly violating ones such as speeding, running red lights, and texting while driving. However, beyond conducting scientific research in this area and their theoretical value, the results could also imply some practical conclusions and be used to orientate traffic safety policies, education, and campaigns with the aim of raising drivers' perceptions of road risk to ultimately minimise the number of road accidents. An effective way to increase drivers' awareness of road risks is to apply, for example, naturalistic driving videos of near-crash situations. Such movies, which have been used effectively in experimental research [59], could be shown during driving safety training or courses for driver's license candidates. Moreover, researchers around the world are successfully incorporating real crash video clips into driver training programmes. The data gathered so far clearly demonstrates that these interventions significantly improve drivers' hazard perception response times and hazard prediction scores, and they also have an impact on real driving, leading drivers to, among other things, approach intersections at slower speeds and check them more often and thoroughly [60,61]. Adding to this, the *Road Traffic Behaviours Questionnaire* KZD-P used in this study could be helpful in assessing the effectiveness of the measures taken, i.e., to evaluate the level of risk perception in drivers before and after the intervention was applied.

Practically speaking, the findings can give both academics and practitioners involved in educational campaigns and other initiatives that promote road safety a basic understanding that whether drivers decide to take risks in road traffic, especially with regard to the several specific behaviours mentioned above, depends to a certain degree on how they perceive this risk at all. This is in line with the views of some researchers, who point out that risky behaviours need to be measured in order to provide drivers with the necessary feedback that could increase their perception of risk and help reduce risky driving [e.g., 62,5]. On the other hand, the results also show that raising risk awareness may not be an effective method of preventing all types of risky behaviour on the road and that there are some behaviours that are undertaken by those drivers who perceive them to be risky, and hence, much effort must be put into measures aimed at counteracting them.

Overall, drivers' risky behaviours, which are primarily related to violations of the law, vary in type and severity. Subsequently, all of those that were included in the KZD questionnaire and further analysed continue to pose an actual threat to both drivers' and other road users' safety. Interestingly, while the majority of the questionnaire's statements revealed no differences between car drivers who perceive higher and lower road risk, it was still possible to identify in this study some specific behaviours that distinguished the two groups of car drivers differing in the level of risk perception. As this study only examined the relationship between risk perception and certain risky driving behaviours, it would be recommended to explore in future works the relationship between risk perception,

specific types of risky driving behaviours, and other variables, such as sociodemographic, personality, or environmental ones. Such further study might offer new insights and broader perspectives on the intricate factors that influence unsafe road behaviours. Finding factors other than risk perception that might influence even risk-averse drivers to choose to take these risks seems crucial in the context of countering some hazardous traffic behaviour. Hence, as stated both in this paper and by other researchers dealing with this issue [e.g., 63,5], the investigation of drivers' risk behaviours should be continued in subsequent works and constantly expanded to increase knowledge and consequently enhance the safety of all road users.

5. Conclusions

Research on differences in drivers' risk behaviour behind the wheel in relation to road risk perception has led to the following final conclusions:

- Drivers with low risk perception are much more likely to engage in the most frequently observed on the road and directly threatening risky driving behaviours, i.e., exceeding the speed limit, running a red light, and texting while driving.
- As risk perception rises, there is a tendency to avoid the above-mentioned behaviours, and hence, the perception of risk seems crucial in counteracting them.
- There are some risky traffic behaviours that drivers engage in just as often regardless of their perception of risk, among which the following can be mentioned: failing to maintain a safe distance from other vehicles, driving without wearing seat belts, operating a vehicle while fatigued, speaking on a mobile phone while driving, parking in an illegal location, and eating or drinking while driving.
- Raising drivers' awareness of the risks on the road and the effects of particular behaviours, especially the most common ones like speeding, ignoring red lights, and texting while driving, seems to be a good method to counteract negative traffic phenomena and thus a crucial component of creating a culture of road safety.
- From the perspective of the results obtained, it appears that raising drivers' risk perception won't be enough to be able to prevent any kind of risky behaviour, and therefore more efforts need to be made in this area.

CRedit authorship contribution statement

Paulina Baran: Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Piotr Zieliński:** Writing – review & editing, Writing – original draft, Visualization, Formal analysis. **Mariusz Krej:** Writing – review & editing. **Łukasz Dziuda:** Writing – review & editing, Supervision.

Data availability statement

The data that has been used in this study is confidential.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e39375>.

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