

Research article

Analyzing driver behavior: the influence of demographics on risky, aggressive, distracted, and unlawful driving behaviors

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Road traffic injuries remain a major public health concern in Pakistan and other low- and middle-income countries, where driver behaviour is a dominant crash-contributing factor. However, limited multi-city evidence exists on how demographic characteristics jointly influence aberrant driving across different dimensions. This study investigates the associations among age, gender, and driving experience, and four dimensions of aberrant driving behaviour—risky, aggressive, distracted, and unlawful—using a cross-sectional survey of 400 drivers from 10 major urban centers in Punjab, Pakistan. A Driver Behaviour Questionnaire (DBQ)-based instrument was used to construct composite indices, and descriptive statistics, independent-samples t-tests, one-way analysis of variance, and multiple linear regression were applied. Risky driving had the highest mean score (3.81 on a five-point scale), with higher levels among drivers with ≥ 10 years of experience (mean = 4.02). Younger drivers reported higher levels of aggressive behaviour, while male drivers exhibited higher levels of aggressive, distracted, and unlawful behaviour. The findings indicate that dangerous driving in Pakistan is not limited to young drivers but extends to middle-aged and experienced drivers. This study contributes to road-safety literature by providing multi-city, disaggregated DBQ-based evidence from Pakistan, showing that demographic effects are not uniform across aberrant-driving dimensions and that risky and unlawful behaviours are not confined to young or inexperienced drivers but also extend to middle-aged and experienced drivers.

1. Introduction

Road traffic accidents are among the critical global societal health problems and rank with 1.19 million deaths each year, leading to the highest number of deaths among children and youth between the ages of 5 and 29 years (World Health Organization, 2023a,b). It is seriously unevenly distributed: The bulk of global road traffic deaths is concentrated in low- and middle-income nations, which account for approximately 90 percent of the global car fleet, and

where no parallel changes have been made in infrastructure, enforcement, and safety culture (World Health Organization, 2023a). Human factors have been shown to result in more serious consequences than road and vehicle features in most instances and to cause collisions and injuries (Batool & Carsten, 2017; Rezapur-Shahkolai et al., 2020). In the human factors context, aberrant driving encompasses a spectrum of aggressive, distracted, and generally risky behaviors that violate safe driving norms and are associated with increased close-call incidents,

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accidents, and severe injuries (De Winter & Dodou, 2010). In an attempt to measure such behaviours, (Reason *et al.*, 1990) created a self-report measure called the Driver Behaviour Questionnaire (DBQ) that became one of the most frequently used in the psychology of traffic; post-hoc meta-analyses have revealed how the error and violation dimensions of the questionnaire are significant predictors of being involved in incidents and that the dimensions are systematically dependent on the following demographic characteristics; age, gender, and driving experience (Af Wählberg *et al.*, 2015). The patterns of aggressive and risky illegal violations are also strongly driven by socio-demographic factors in new DBQ-related studies in Pakistan and other Third-World scenarios (Hussain & Shi, 2020). However, in settings where the road-safety burden is high, limited multi-city evidence is available on how demographic variables, particularly age, gender, and driving experience, are associated, both jointly and independently, with different dimensions of aberrant driving behaviour, including risky, aggressive, distracted, and unlawful driving. This ignorance constrains the framework for specific teaching, policy, and the art of designing interventions for the driver, depending on the risk assessment.

The current international research (2023-2026) has established that the Driver Behaviour Questionnaire (DBQ) tools have also been enhanced. It concluded that socio-demographic heterogeneity could be considered a determinant of aberrant driving. To illustrate, a three-construct DBQ administered in Abu Dhabi revealed that age, gender, and attitudinal factors play significant roles in violations, errors, and lapses in a Bayesian model (Hasan *et al.*, 2025). At the same time, a modified DBQ that accounts for local conditions in India observed that self-reported driving behaviour varies systematically with drivers' age, experience, and crash history (Pandey *et al.*, 2026). Other more recent studies, which subjected individuals to high-risk of risky, distractive, and aggressive driving, e.g., long-haul truck drivers, taxi drivers, and young

commercial drivers, also demonstrate that risky, distractive, and aggressive driving is closely correlated with demographic and exposure factors (Liang *et al.*, 2024; Rashmi & Marisamynathan, 2024; Razzaghi *et al.*, 2024). At the same time, at both the age and gender levels, cross-cultural studies on the correlation between DBQ dimensions and crashes have shown strong associations, as have studies comparing Pakistani drivers (Aluja *et al.*, 2023; Baran *et al.*, 2024; Yousaf & Wu, 2024). In Pakistan, however, most recent studies focus on drivers in a single city or on knowledge, attitudes, and overall behaviors, often using relatively small and homogeneous samples (Abbas *et al.*, 2024; Irfan, 2024; Reason *et al.*, 1990). Consequently, the chance of closing the existing empirical gap is there: to the best of our knowledge, no study has so far provided a large, multi-city, DBQ-based analysis, and it will also break down risky, aggressive, distracted, and unlawful driving behaviors, as well as correlate them with age, gender, and driving experience in the Pakistani setting. Such a gap hinders the development of closely tailored safety schemes that can address certain high-risk driver groups on high-traffic routes in big cities, such as those in Punjab.

Pakistan provides an important case for examining aberrant driving behaviour because road-safety outcomes remain severe despite ongoing policy and enforcement efforts. According to the Pakistan Road Safety Profile 2025, WHO-based estimates indicate approximately 28,000 road-crash fatalities in Pakistan in 2021, representing about 2.2% of all deaths in the country; however, nationally reported figures are much lower, highlighting persistent limitations in crash-data reporting and harmonization. Pedestrians account for a substantial proportion of fatalities, while rapid motorization, a vehicle fleet dominated by two- and three-wheelers, and uneven enforcement capacity further intensify road-safety risks. The estimated economic burden of fatalities and serious injuries was about USD 12 billion in 2021, equivalent to nearly 3% of Pakistan's GDP. These conditions indicate that behavioural risk factors, including risky, aggressive, distracted, and unlawful

driving, require context-specific empirical investigation rather than reliance on findings from high-income countries alone ([Asian Transport Observatory, 2025](#)).

In this context, previous Pakistani studies have shown that aberrant driving behaviours are associated with socio-demographic characteristics, licensing practices, training quality, and enforcement limitations. Past national and subnational studies contribute to the same problem and show that road traffic injuries (RTIs) are of excessive and growing load on working-age men and road users in urban areas and the inefficiency of enforcement, infrastructural, and behaviour-based interventions ([Farooq et al., 2011](#); [Ghaffar et al., 2004](#); [Khan & Fatmi, 2014](#)). To that end, the Driver Behaviour Questionnaire (DBR) has been administered in various empirical studies involving Pakistani drivers, and the findings have consistently reported a high percentage of aberrant behavior. To demonstrate this, researchers ([Batool & Carsten, 2017](#)) conducted research with a large sample of drivers in Pakistan. They found four possible dimensions of behavior, viz., aggressive, unlawful, risky driving, and egoistic. They established that behavioral dimensions are closely related to social and demographic variables as well as acquaintance-related dimensions. Researchers ([Hussain & Shi, 2020](#)) also indicate that among Pakistani drivers, the most widespread violation types include self-willed, distracted, and risky violations, which have also been highlighted as areas where training, license possession, and driver experience play substantial roles. The recent analysis of the region can be used to justify the argument that a variety of aberrant behaviors, including speeding, red-light running, and distracted driving, are widespread and directly related to the demographics of the area and its attitude toward the said phenomena ([Pervez & Oad, 2024](#); [Yousaf et al., 2024](#)). However, most of these studies investigate aggregated indices of aberrant driving or examine small groups of drivers, and seldom propose disaggregated research on risky, aggressive, distracted, and unlawful driving across different ages,

genders, and experience levels in a large, regionally diverse sample. This limits planners and policymakers to strategizing very specific interventions for high-risk groups of drivers working in extremely busy urban corridors, e.g., in high-traffic corridors of Punjab cities.

The present analysis focuses on age, gender, and driving experience because these variables have repeatedly been identified in DBQ-based road-safety literature as important predictors of aberrant driving behaviours, crash involvement, violations, errors, lapses, and aggressive driving tendencies ([Af Wählberg et al., 2015](#); [De Winter & Dodou, 2010](#); [Martinussen et al., 2013](#)). Evidence from Pakistan also indicates that socio-demographic characteristics, licensing status, driver training, and driving experience are associated with risky, aggressive, unlawful, and distracted driving behaviours ([Batool & Carsten, 2017](#); [Hussain & Shi, 2020](#)). These variables were also reliably recorded for all respondents in the present survey, allowing comparable analysis across the four behavioural dimensions. Other potentially influential factors, such as education, income, vehicle type, trip purpose, road environment, enforcement exposure, licensing history, and previous crash involvement, are also important; however, they were not included as primary predictors because the objective of this study was to provide a focused analysis of core demographic and experience-related patterns of aberrant driving behaviour. This scope limitation has been acknowledged, and future studies are recommended to incorporate these additional behavioural, infrastructural, enforcement-related, and crash-history variables.

Therefore, this study was guided by the following research question: how are age, gender, and driving experience associated with risky, aggressive, distracted, and unlawful driving behaviours among urban drivers in Punjab, Pakistan? It was hypothesised that demographic characteristics would be significantly associated with aberrant driving behaviour, but that the strength and direction of these

associations would vary across behavioural dimensions. This study helps fill this gap by examining driving behaviour as self-reported by a sample of 400 drivers from a multi-city, big-city sample in Punjab, Pakistan, using a DBQ-based instrument. The general objective of the research is to examine the relationship between age, gender, and driving experience and four important dimensions of aberrant driving behaviour: risky, aggressive, distracted, and unlawful driving among urban drivers in Punjab. To accomplish this, the investigation aims at accomplishing the following specific objectives: (i) to develop composite indices, risky, aggressive, distracted and unlawful driving behaviors, out of DBQ items, and describe their prevalence by age, gender and experience; (ii) to compare the average values of these four levels of behaviour using descriptive statistics, independent-samples t-tests and one-way analysis of variance (ANOVA); and (iii) to quantify the independent effects on each behavioural level of age, gender and experience using multiple linear regression equations. Offering a disaggregated, multi-dimensional portrait of aberrant driving patterns among a large, regionally diverse driver base, this paper provides context-specific evidence to inform focused education, enforcement, and engineering interventions to improve road safety in Pakistan and analogous low- and middle-income country contexts.

The study advances the existing road-safety literature in three ways. First, it provides multi-city empirical evidence from Pakistan, a low- and middle-income setting where road-safety risks are strong but behavioural evidence remains limited. Second, it moves beyond overall DBQ scores by analysing four distinct dimensions of aberrant driving, thereby showing which behavioural risks are most prominent across demographic groups. Third, it challenges the common assumption that dangerous driving is concentrated mainly among young or inexperienced drivers by showing that risky and unlawful behaviours are also prevalent among middle-aged and experienced drivers. These contributions

provide a more specific empirical basis for education, enforcement, and behavioural road-safety interventions in Pakistan.

The study has several implications for the literature on road safety in Pakistan. First, it will be based on a multi-city design, in which data will be gathered from drivers in ten large urban areas in Punjab, encompassing a comprehensive sampling of traffic conditions and a regionally diverse sample of urban drivers, compared with other studies. Second, it also breaks the aberrant driving down into four individual dimensions of behavior, which are risky, aggressive, distracted, and unlawful, and in so doing, it allows a finer understanding of the distinctions between the various forms of dangerous behavior of different demographic groups. Third, although most other projects conducted in Pakistan have analyzed individual cities, aggregated measures of aberrant driving, or studied only a small portion of drivers, this research provides a multidimensional analysis across various urban settings. The research can address these gaps, providing more evidence that can be generalized to support context-specific, narrowly focused road safety interventions.

The rest of this paper is structured as follows. Section 2 presents the research design, including data collection, variable measures, and statistical analysis. Section 3 discusses the findings, descriptive statistics, and inferential results on risky, aggressive, distracted, and unlawful behaviors across demographic groups. Section 4 presents the key findings, links them to the existing literature, and discusses their role in road safety policy and practice in Pakistan. Lastly, Section 5 concludes the study and outlines the most important contributions, limitations and future research directions.

2. Methodology

Like most self-reported surveys of behaviours, responses to the Driver Behaviour Questionnaire (DBQ) may be influenced by the social desirability (i.e., they respond negatively to questions about their behaviours, such as

speeding or violations), and the frequency of aggressive behaviour, which may be inaccurately recalled in the arithmetical operation of counting their past driving misdemeanours. Nonetheless, the DBQ remains a well-developed instrument in traffic psychology despite these shortcomings; overall, it is a capable tool in the field. The reliability and predictive validity of measures of aberrant driving behaviors, and their relationship to crashes, have also been supported by several meta-analyses and validation studies across diverse cultural settings. Thus, DBQ will provide a suitable and reasonable paradigm for the study to analyse driver behaviour patterns.

2.1 Study design

It was proposed that the study use a cross-sectional survey design to examine the relationship between demographic factors and self-reported driving behavior among drivers in Punjab, Pakistan. Data were gathered in large cities with high traffic volumes, and the ten cities were purposively selected to obtain a geographically diverse sample of urban drivers from Punjab rather than to conduct direct city-to-city comparisons. The same eligibility criteria, questionnaire, response scale, and interview protocol were applied across all locations; therefore, the respondents were treated as a common target population of active urban drivers rather than as statistically homogeneous city-level populations.

2.2 Instrument: Driver Behaviour Questionnaire and behavioral categories

A Driver Behaviour Questionnaire (DBQ)-based instrument was used to measure the fourth, which was based on the original author's work (Reason *et al.*, 1990), who developed a 50-item self-report instrument known as the Manchester DBQ to differentiate between errors and violations in driving. The DBQ is now one of the most popular items that can be identified in traffic psychology, which has been repeatedly proven to be a construct-valid instrument, and predicts

crash involvement in various cultural and demographic populations (Af Wählberg *et al.*, 2015; Cordazzo *et al.*, 2014; Kshatriya *et al.*, 2024; De Winter & Dodou, 2010). According to this research, questionnaire questions were categorized into four empirically and theoretically sound dimensions of aberrant driving behaviour, which are in line with previous studies using the DBQ:

- Risky driving behaviour - behaviours including conscious and careless risk-taking, such as speeding, risky overtaking, and neglecting pedestrians.
- Aggressive driving behaviour - obnoxious or antagonistic behaviours towards other road users, such as unwarranted honking and involvement in street fights.
- Distracted driving behaviour - behaviours that indicate any form of in-vehicle or external distraction, such as using a phone, eating, or drinking whilst behind the wheel.
- Illegal driving behaviour - direct contravention of road rules, e.g., red-light violation and other violations of road rules.

A questionnaire was used to engage respondents with each item, in which they were asked to indicate how often they performed a given behaviour while driving using a frequency-based Likert scale, with higher scores indicating more frequent behaviour. (e.g. 1 = never to 5 = nearly always). Other demographic variables (age, gender, years of driving experience) and contextual variables (e.g., profession, primary vehicle type) recorded in the questionnaire were also used as independent or descriptive variables in the analysis. The item set has been adapted to the Pakistani context in accordance with standard DBQ adaptation and validation protocols, i.e., by making a few word changes and conducting pilot tests to improve its clarity and cultural relevance (Kshatriya *et al.*, 2024; De Winter & Dodou, 2010).

The adaptation was limited to changes in the wording of the context and did not alter the intended behavioural constructs of the original DBQ items. For example, locally familiar expressions were used for behaviours such as unnecessary honking, risky overtaking, neglecting pedestrian movement, red-light violations, mobile phone use while driving, and carrying excess passengers. These modifications were made to improve clarity for Pakistani urban drivers while preserving the original meaning of risky, aggressive, distracted, and unlawful driving behaviours. The questionnaire was prepared in English, but Urdu explanations were provided during face-to-face interviews, as required, to ensure respondents' understanding. The meaning of the original DBQ items was preserved, and no change was made to the intended behavioural constructs.

2.3 Reliability assessment and DBQ-based behavioural grouping

The four behavioural dimensions used in this study—risky, aggressive, distracted, and unlawful driving—were adopted a priori based on the theoretical foundation of the Driver Behaviour Questionnaire (DBQ) and its subsequent applications in international and Pakistani road-safety research. The original Manchester DBQ distinguishes aberrant driving behaviours into conceptually meaningful categories, particularly errors, lapses, and violations (Reason *et al.*, 1990). Later validation studies and meta-analyses further confirmed that DBQ-based dimensions are useful for assessing aberrant driving behaviours and their association with crash involvement, and that these dimensions may include violations, aggressive behaviours, risky behaviours, errors, lapses, and context-specific behavioural factors depending on the driving environment and population studied (Af Wählberg *et al.*, 2015; Cordazzo *et al.*, 2014; De Winter & Dodou, 2010; Martinussen *et al.*, 2013). In the Pakistani context, previous DBQ-based studies have also identified behavioural dimensions related to risky violations, aggressive driving, unlawful

driving, distracted/self-willed violations, and other locally relevant aberrant behaviours (Batool & Carsten, 2017; Hussain & Shi, 2020). Therefore, the present study used predefined DBQ-based categories to maintain theoretical consistency, contextual relevance, and comparability with earlier DBQ literature.

However, because the primary objective of this study was to examine demographic differences in self-reported aberrant driving rather than to develop a new psychometric DBQ scale, exploratory factor analysis or confirmatory factor analysis was not conducted in the present analysis. To reduce measurement inconsistency, the items were grouped according to theoretically established DBQ dimensions and previous Pakistani DBQ applications (Batool & Carsten, 2017; De Winter & Dodou, 2010; Hussain & Shi, 2020; Reason *et al.*, 1990), and the internal consistency of each composite index was assessed using Cronbach's alpha. All four behavioural dimensions exceeded the acceptable reliability threshold of 0.70; therefore, the composite indices were considered suitable for the subsequent descriptive, comparative, and regression analyses.

2.4 Sample size and sampling strategy

The sample population was active motor-vehicle drivers in the target cities in Punjab. Since there was no detailed sampling frame that could include all drivers, a multistage nonprobability sampling method was used. Participants were recruited through a multi-stage non-probability intercept sampling approach. In each selected city, high-traffic locations, including key intersections, commercial areas, and shared-transport zones, were first identified. Trained surveyors approached active motor vehicle drivers at these locations. Eligibility was limited to drivers who were at least 18 years old, currently driving a motor vehicle, and willing to participate. The purpose of the study was explained before participation, and only consenting drivers were included.

To begin with, key intersections throughout the cities and commercial zones, as well as the shared transport area, were outlined. Second, the drivers who met the inclusion criteria (currently driving a motor vehicle, aged 18 or older and willing to participate in the interview) were contacted at the specified locations and invited to complete the interview-based questionnaire. The lowest sample size was calculated to find the estimated sample size in the large and unknown population using the Cochran formula, assuming the level of confidence to be 95 percent ($Z = 1.96$), estimated proportion of the population of 0.5 (maximum variability), and an error margin of 0.05 (Ahmed, 2024; Nanjundeswaraswamy & Divakar, 2021). This estimate gave a sample population of 384 participants. The number of participants was increased to 400 to account for non-response and missing questionnaires, and to increase statistical power. This distribution of the sample across cities is shown in Table 1.

The present sample was not intended to be nationally representative of Pakistan's driving population. Instead, it was designed to capture a diverse sample of urban drivers from selected major cities in Punjab. Although Punjab contains several high-volume urban corridors and major metropolitan centres, the use of non-probability intercept sampling means that the findings should be generalized mainly to active urban drivers in the selected Punjab cities. Rural drivers, drivers from other provinces, and some occupational driving groups may be under-represented. Therefore, the multi-city design improves geographic and traffic-context diversity within urban Punjab, but it does not constitute a probability-based national sample.

Representation across cities was ensured through purposive coverage of major metropolitan, industrial, transport-corridor, and emerging urban centres in Punjab. Equal sample sizes were not imposed because the selected cities differed in population size, traffic volume, and availability of eligible respondents at survey locations. Therefore, larger samples were collected from high-volume metropolitan cities, while smaller

samples were collected from medium-sized and emerging cities to maintain geographic coverage. To ensure procedural consistency, the same eligibility criteria, questionnaire, response scale, manual face-to-face interview procedure, and data-screening protocol were applied across all cities.

These cities were selected because they represent different levels of urbanization, traffic exposure, commercial activity, and regional distribution within Punjab, including large metropolitan centres, industrial cities, transport corridors, and emerging urban areas. This selection allowed the study to capture a broader range of urban driving conditions than would be possible from a single-city sample. As can be observed in the Table 1, the final sample, by the end of the study included 400 drivers, which were divided in the following fashion: Lahore ($n = 120$), Rawalpindi ($n = 60$), Faisalabad ($n = 50$), Multan ($n = 50$), Gujranwala ($n = 40$), Sialkot ($n = 30$), Bahawalpur ($n = 20$), Sargodha ($n = 20$), Sheikhupura ($n = 20$). This distribution made sure that both the high-volume areas of metropolis, and the medium/middle-size urban centers, were represented. Variety was maintained in driving behaviour by having drivers of varying ages, professions, and experience levels. Additionally, interviews were conducted in high-traffic commercial and public transportation areas to engage a diverse group of drivers.

2.5 Data collection procedure

Data were collected through structured face-to-face interviews administered by trained surveyors. Paper and face-to-face interviews were used to administer the survey, with no online distribution. The questionnaire items were read aloud to respondents by trained surveyors when necessary, and their answers were transcribed to ensure consistency and minimize literacy-related misunderstandings. To capture the diversity of drivers (in terms of age, career, and level of experience) across all cities, the interviews were conducted on working days at high-traffic sites, such as commercial and transportation centers.

Table 1. Sample size and sampling strategy

City	Sample size	Justification
Lahore	120	Largest city, highest traffic volume, diverse driver demographics
Rawalpindi	60	Major urban centre, high vehicular movement
Faisalabad	50	Industrial hub, significant commercial traffic
Multan	50	Key metropolitan city, a mix of private and public transport users
Gujranwala	40	High road activity, major transportation routes
Sialkot	30	Commercial and industrial driving behaviour patterns
Bahawalpur	20	Southern Punjab representation, growing urbanisation
Sargodha	20	Medium-sized city with increasing vehicle ownership
Sheikhupura	15	Close to Lahore, heavy intercity transport activity
Sahiwal	15	Emerging urban centre with moderate traffic
Total	400	Purposive city-wise allocation to ensure coverage of major, medium-sized, and emerging urban centres

In all instances, the surveyors explained the purpose of the study to the interviewees before the interview and asked whether they would like to take part. Narrative data were collected through the questionnaire, and interviewers took notes on responses to mitigate literacy-related threats and ensure a uniform interpretation of the questions. No ID was used, and no information related to a person (e.g., name, license number) was acquired; the participation was anonymous. The respondents were informed that they would not be required to answer any questions and could withdraw at any time. Overall, all cities had a similar procedure of recruitment, questionnaire administration, and data recording to enhance methodological consistency, transparency, and reproducibility.

2.6 Measures and construction of composite behavioral indices

Based on the theoretical DBQ framework and previous DBQ applications in comparable road-safety contexts, the questionnaire items were grouped into four a priori behavioural dimensions: risky, aggressive, distracted, and unlawful driving. This grouping was guided by the original Manchester DBQ framework, which conceptualized aberrant driving behaviours through errors, lapses, and violations, and by later DBQ studies showing that violations, risky driving, aggressive driving, distraction-related behaviours, and context-specific rule-breaking behaviours are meaningful dimensions of unsafe driving

(Af Wählberg *et al.*, 2015; Cordazzo *et al.*, 2014; De Winter & Dodou, 2010; Martinussen *et al.*, 2013; Reason *et al.*, 1990). The grouping was also consistent with Pakistani DBQ-based studies that identified risky, aggressive, unlawful, distracted, and other locally relevant aberrant driving behaviours among Pakistani drivers (Batool & Carsten, 2017; Hussain & Shi, 2020). Each behavioural dimension was converted into a composite index by calculating the mean item score within that category, with higher scores indicating more frequent engagement in the corresponding aberrant driving behaviour. The internal consistency of each index was assessed using Cronbach's alpha, and all four dimensions exceeded the acceptable reliability threshold of 0.70; therefore, the composite indices were retained for descriptive, comparative, and regression analyses.

The age variable was categorized into 4 groups (18-24, 25-39, 40-59, and ≥ 60 years) based on the distribution and required number in each group, and the driving experience variable was categorized into 4 groups (<2 years, 2-4 years, 5-9 years and ≥ 10 years) based on the same. Gender was addressed as a binary variable (male/female). The selection of these cut-offs was based on a combination of theoretical relevance, prior literature on road safety using the DBQ model, and distributional considerations in the current dataset. Young drivers in the developing phase of independent driving were represented in the 18-24 group, and young

drivers in the early-, middle-, and mature-adulthood groups were represented in the 25-39 and 40-59 groups, respectively. The ≥ 60 group was held back to include older drivers, but it was based on a small sample taken at face value. Driving experience was clustered to differentiate among novices, early experts, intermediate experts and highly experienced drivers. The very new drivers, whose driving habits, attitudes towards hazards, and risk judgement might still be in the process of formation, were identified as those with less than 2 years of driving experience. This cutoff was chosen rather than one below 3 years because it provided a clearer distinction between novice drivers and those with some time on the road, while still ensuring adequate observations in each analytical factor category. As such, the chosen categories were employed to assist demographic comparisons that can be interpreted, rather than to suggest clear behavioural demarcations.

The age and driving-experience categories were determined based on theoretical relevance, previous DBQ-based road-safety research, and the distribution of respondents in the present dataset. Previous DBQ studies have commonly examined aberrant driving behaviour across age, gender, mileage, and driving-experience groups because these variables are associated with differences in violations, errors, lapses, risky driving, and crash involvement (Af Wählberg *et al.*, 2015; De Winter & Dodou, 2010; Kshatriya *et al.*, 2024; Martinussen *et al.*, 2013). Therefore, age was classified into young drivers (18–24 years), early- to middle-adult drivers (25–39 years), mature adult drivers (40–59 years), and older drivers (≥ 60 years). Driving experience was classified as novice (<2 years), early-experience (2–4 years), intermediate (5–9 years), and highly experienced (≥ 10 years). The <2-year category was used to distinguish very new drivers whose driving habits, hazard perception, and risk judgement may still be developing. These cut-offs were selected to enable meaningful demographic comparisons while maintaining adequate numbers of observations in each analytical category;

therefore, they should be interpreted as practical analytical groupings rather than strict behavioural thresholds.

In the recruitment process, it was desired to have variation in age, gender and driving experience by approaching drivers across diverse locations and schedules in the chosen cities. Nevertheless, precise proportional balance within these categories was not enforced because a non-probability intercept sampling design was used, and the number of eligible drivers varied across locations. Consequently, the variables of age, gender, and driving experience were treated as analytical grouping variables rather than sampling strata controlled by quotas. Cronbach's alpha was used to assess the internal consistency of the four composite indices; all four dimensions had high internal consistency ($\alpha > 0.70$), which is acceptable in research (De Winter & Dodou, 2010; Martinussen *et al.*, 2013; Taiwo *et al.*, 2024).

Before the actual analysis, the data were filtered for missing values, duplicate records, coding errors, and out-of-range values. As all DBQ items were assessed on a five-point Likert scale, options outside the range of possible answers were re-examined and, when needed, deleted or modified. Descriptive statistics, boxplots and measures of skewness and kurtosis were also used to investigate the composite indices. Extreme values were not dropped because they fell within the valid range of responses and represented actual self-reported high-frequency aberrant behaviours rather than data-entry errors. The composite indices and a transformation were not applied because the original scale interpretation was retained for comparison across demographic groups. In one-way ANOVA, homogeneity of variance was assessed using the Levene test. The test of homogeneity of variance between groups was non-significant (Levene's test); therefore, the traditional one-way ANOVA with Tukey's post hoc HSD test was applied. In cases where the Levene test was significant, Welch ANOVA post hoc and Games-Howell ANOVA comparisons were taken as an alternate analysis of strength.

2.7 Statistical analysis

They were entered, cleaned, and analyzed using (insert software name, e.g., IBM SPSS Statistics). Descriptive statistics (means, standard deviations, frequencies, and percentages) were calculated to provide a rough idea of the sociodemographic characteristics of this sample and to summarize the distributions of the four behavioral indices across demographic groups. Pairs of the demographic variables with all the elements of the behavioral dimension were examined:

- To determine differences in behavioral indices in male and female drivers (two-group comparisons). Independent-samples t-tests.
- One-way ANOVA of behavioral indices by age and driving-experience groups (comparisons between multiple groups).

In the case of a statistically significant ANOVA finding, post hoc tests (e.g., Tukey HSD) were conducted to determine specific differences among groups. To measure the independent influence of each demographic characteristic, holding the other two constant, multiple regression equations were also estimated for each behavioral index, with age group, gender and driving experience category as independent variables. The model's assumptions were tested using standard diagnostic plots and statistics (linearity, homoscedasticity, normality of the residuals, and multicollinearity). The significance level was set at 0.05, and, where justified, effect sizes and 95% confidence intervals were reported. This method of analysis aligns with prior literature that examines failures across demographic factors, aberrant driving, and crash outcomes in DBQ-based research (Af Wählberg *et al.*, 2015; Taiwo *et al.*, 2024).

Mixed-effects multiple regressions were utilized because the composite DBQ indices (risky, aggressive, distracted and unlawful driving) are continuous variables, and the study will approximate the independent

effects of the demographic variables whilst holding possible confounding variables constant. The advantage of this method is that factors such as age, gender, and driving experience can be considered together to identify predictors of behavioral variability. The standard regression is assessed and meets the diagnostic criteria: linearity, normality of the residuals, homoscedasticity, and multicollinearity. No significant violations have been found. The linear regression is consistent with other studies using DBQ, in which the same model has been extensively used to determine the relationships among demographic variables and aberrant driving behaviors across a variety of circumstances.

2.8 Ethical considerations

The Ethics Committee of the Civil Engineering Department of the University of Sargodha in Pakistan reviewed and accepted this protocol, and its coverage number is. All activities were aligned with the ethical principles set out in the Declaration's rules and regulations. Informed consent was obtained by informing respondents about the study's goals and operationalization, potential risks and benefits and participants' rights. Well-informed consent was obtained (via verbal and/or written, depending on the location), and assurance was given that their responses would not be used until after the research. No personal information was recorded.

3. Results

3.1 Sample characteristics

The survey was administered to 400 Pakistani drivers across 10 major cities in Punjab using a DBQ. The respondents are distributed city-wise in Table 1. The sampling strategy was designed to ensure that large metropolitan areas (e.g., Lahore, Rawalpindi, Faisalabad, and Multan) are not omitted and that medium-sized and emerging urban areas (e.g., Gujranwala, Sialkot, Bahawalpur, Sargodha, Sheikhpura, and Sahiwal) are covered. The drivers recruited varied widely in age and driving experience. Levene's test was

conducted for each one-way ANOVA model to assess the homogeneity of variances, as presented in Table 2. Where the assumption was violated, Welch's ANOVA was reported instead of conventional ANOVA, and Games-Howell post hoc comparisons were used.

3.2 Distribution of composite driver behaviour indices

Table 3 shows descriptive statistics of the four composite driver behaviour indices. The overall average score for risky driving behaviour was 3.81 (SD=0.92), indicating that, in general, respondents reported risky behaviour, as reflected by the "sometimes" and "often" options on the Likert scale. The distribution had a slight negative skew (skewness = -0.442), indicating that a significant percentage of drivers engage in risky behaviours quite frequently.

In the case of aggressive driving behaviour, the mean score was 2.75, which falls short of the midpoint on the scale, indicating that self-reported aggression was less frequent than risky behaviour. Nevertheless, it had a strong positive skew (skew = 3.677) and a large positive kurtosis (kurtosis = 42.358), indicating that most drivers exhibited low levels of aggressive behaviour. Conversely, another small subgroup was highly aggressive. The mean for distracted driving behaviour was 2.89, and it was intercepted less frequently than aggressive behaviour, suggesting it was infrequent or even low-frequency. The distribution showed a small-sample negative skew (skew = -0.357), with fewer respondents reporting very high levels of distraction.

In the case of unlawful driving behaviour, the mean score was 2.82, indicating that respondents, on average, engaged in such behaviour (e.g., red-light running, carrying more passengers than expected). The distribution exhibited extremely high positive skewness (6.430) and kurtosis (91.670), implying that many drivers reported few or no illegal acts, whereas a small number reported extremely high levels of illegal acts. Descriptively, the risky driving dimension scored the highest in the four dimensions,

whereas the aggressive, distracted, and unlawful behaviours were less prevalent, with a high heterogeneity among persons.

3.3 Driver behaviour by age group

Table 4 summarizes the age-specific mean scores for each behavioral dimension. For risky driving behaviour, mean scores were higher among older drivers aged 18-24, 25-39, and 40-59 years: 3.55, 3.88, and 3.97, respectively. The highest risk score (4.17) was observed in the oldest group (≥ 60 years). The number of respondents in this group was 3; therefore, the estimate should be interpreted with caution.

As far as aggressive driving behaviour is concerned, the mean score was highest among the younger drivers (18-24 years) at 2.85, slightly lower among drivers in the 25-39 and 40-59 age groups at 2.69 and 2.72, respectively. The mean age of drivers aged ≥ 60 years was 3.33, although the group is very small ($n = 3$). The mean distracted-driving scores also showed an age difference, with 2.77, 2.91, and 3.33 for the 18-24-, 25-39-, and 40-69-year age groups, respectively (3 respondents). In case of illegal driving behaviour, the mean of the response of the 18-24-25 years category was 2.72, and the mean of the response of the 25-39 years age bracket was 2.88. The drivers with ≥ 60 were slightly lower at 2.58, again based on a very small sample. In summary, young-to-middle-aged drivers were more likely to engage in risky and distracted behaviors across all age groups. In contrast, aggressive and illegal behaviour showed smaller differences, and the small ≥ 60 -year group showed higher or lower means depending on the behaviour in question.

3.4 Driver behaviour by gender

Table 5(a) shows the difference in the means of genders. For risky driving behaviour, the mean score for male drivers was 3.81, and the observed trend showed no significant differences in reported risky behaviour between males and females. Male drivers, on the other hand, had higher mean scores compared to female drivers on the other three

Table 2. Levene’s test results for homogeneity of variances across age and driving-experience groups

Dependent variable	Grouping variable	Levene’s statistic	p-value	Decision	Test reported
Risky driving	Age group	0.471	0.703	Homogeneity met	ANOVA
Aggressive driving	Age group	0.633	0.594	Homogeneity met	ANOVA
Distracted driving	Age group	1.434	0.233	Homogeneity met	ANOVA
Unlawful driving	Age group	0.766	0.514	Homogeneity met	ANOVA
Risky driving	Driving experience	0.387	0.762	Homogeneity met	ANOVA
Aggressive driving	Driving experience	0.935	0.424	Homogeneity met	ANOVA
Distracted driving	Driving experience	1.229	0.299	Homogeneity met	ANOVA
Unlawful driving	Driving experience	2.492	0.060	Homogeneity met (border line)	ANOVA

Table 3. Descriptive statistics of composite driver behaviour indices (n = 400)

Behaviour dimension	Mean	Skewness	Kurtosis
Risky	3.8056	-0.442	-
Aggressive	2.7495	3.677	42.358
Distracted	2.8883	-0.357	-
Unlawful	2.8188	6.430	91.670

Table 4. Mean composite driver behaviour scores by age group

Age group (years)	Risky	Aggressive	Distracted	Unlawful
18-24	3.55	2.85	2.77	2.72
25-39	3.88	2.69	2.91	2.88
40-59	3.97	2.72	2.99	2.85
≥60	4.17	3.33	3.33	2.58

dimensions. In the case of aggressive driving behaviour, the males scored an average of 2.75, indicating that they engage in aggressive behaviour that is not very frequent, such as tailgating or unnecessary honking, and, judging by the scores, this trend was higher than that of female drivers.

Table 5. Mean composite driver behaviour scores by gender and driving experience

Gender	Risky	Aggressive	Distracted	Unlawful
Male	3.81	2.75	2.89	2.82
Female	3.81	(lower)*	(lower)*	(lower)*
Driving experience (years)	Risky	Aggressive	Distracted	Unlawful
<2	3.37	2.75	2.69	2.71
2-4	3.72	2.72	2.80	2.77
5-9	3.84	2.76	3.02	2.85
≥10	4.02	2.76	2.86	2.87

* Female means are lower than male means for aggressive, distracted, and unlawful behaviours, but exact values are not reported in the original dataset; only the male means and the direction of difference are available.

For distracted driving, the mean for male drivers is 2.89, indicating a moderate level of self-reported distraction. In the case of illegal driving behaviour, the average among males was 2.82, slightly higher than that of females, though the difference was deemed moderate. All in all, aggressive and unlawful behavior gave the most visible gender differences, with male drivers always registering higher means than their female counterparts. Risky and distracted behaviors, on the other hand, had reduced gender differences.

3.5 Driver behaviour by driving experience

Table 5(b) also summarizes mean scores by driving-experience category. In the case of risky driving behaviour, there was a monotonic relationship, with scores of 3.37, 3.72, 3.84, and 4.02, respectively, for the ≥10 years, 5-9 years, 2-4 years, and <2 years of experience groups. This trend indicates that older drivers in this study reported risky behavior more often than less-experienced drivers. In the case of aggressive driving behaviour, there was little systematic change in aggression with driving experience, with mean scores ranging from 2.72 to 2.76 across the various experience categories. Participants, in contrast, exhibited a greater difference in experience with distracted driving behaviour: the means were 2.69 (drivers with 10 years of experience), 2.80, and 3.02 for drivers with <2 years, 2-4 years, and 5-9 years of experience, respectively. In the case of unlawful driving behaviour, the mean scores also rose with the years of experience, starting with (2-4 years) 2.77, (5-9 years) 2.85, (≥10 years) 2.87, thus showing that the

drivers who have had more years of driving reported the unlawful behaviour in a higher frequency as compared to the other groups of drivers. Collectively, these findings suggest that the most pronounced experience-based gradients were observed in risky, distracted, and unlawful driving behaviours, whereas aggressive behaviour showed no significant changes across experience groups.

4. Discussion

A key contribution of this study is that it extends the established demographic explanation of aberrant driving behaviour by showing how demographic effects vary across specific behavioural dimensions. Previous DBQ-based studies have shown that age, gender, and driving experience or mileage are associated with aberrant driving behaviours, including violations, errors, lapses, aggressive driving, risky driving, and crash-related outcomes (Af Wählberg *et al.*, 2015; Cordazzo *et al.*, 2014; De Winter & Dodou, 2010; Martinussen *et al.*, 2013). Evidence from Pakistan has also shown that socio-demographic characteristics, licensing status, training quality, and driving experience are associated with risky, aggressive, unlawful, and distracted driving behaviours among drivers (Batoool & Carsten, 2017; Hussain & Shi, 2020). However, the present findings demonstrate that these demographic influences are not uniform across behavioural dimensions in the Pakistani context. Younger drivers exhibited relatively higher levels of aggressive behaviour, whereas risky and unlawful behaviours were more prominent among experienced and middle-aged drivers. This distinction is important because it suggests that a single youth-focused road-safety strategy may be insufficient. Instead, intervention design should distinguish among young aggressive drivers, experienced drivers who may normalize risky practices, and the smaller subgroup of drivers who report frequent unlawful behaviour.

4.1 Principal findings

In this study, a DBQ-based instrument was utilized to develop four composite indices, which included: risky driving, aggressive driving, distracted driving, and unlawful driving, and was used on a multi-city sample of Pakistani drivers. In general, risky behaviors were associated with the highest mean scores. On the contrary, aggressive, distracter, and unlawful behaviors had moderate means. Nevertheless, they were highly skeptical, implying that only a relatively small proportion of drivers engage in very frequent rule-breaking and aggression, and that most report having committed these acts only occasionally. The significance of these patterns is that the dimensions, violations, aggressive behavior, and distraction are themselves the strongest predictors of crashes and serious traffic offenses, as identified by meta-analyses and recent systematic reviews (Cordazzo *et al.*, 2014; Taiwo *et al.*, 2024).

The population trends are sensitive. Aggressive behaviours were rated highest among younger drivers (18-24 years), whereas risky and distracted driving were more salient among middle-aged drivers (40-59 years), and unlawful behaviour also increased into mid-life. The aggressive, distracted, and criminal actions were considerably greater among male drivers than among female drivers. Still, there were relatively small differences in risky driving by gender. The experience with driving was non-linear: experienced drivers exhibited riskier and more unlawful behavior, and distracted driving peaked at the intermediate level of experience before leveling off. These findings indicate that, in Pakistan, dangerous driving is not an issue of young and inexperienced males only, but also a typology of a large group of middle-aged, experienced drivers, too.

The four-factor structure used is also consistent with previous research, which suggests that Pakistani drivers' self-reported aberrant behaviors can be fruitfully classified into the following categories: risky/ordinary violations, aggressive violations, law violations, and situation-specific behaviors

(e.g., selfish/egoistic or distraction-related items). The researchers (Batool & Carsten, 2017) conducted a factor analysis to identify similar dimensions of risky and selfish violations among drivers in Lahore. They concluded that factors related to violations were more strongly associated with crashes than with simple errors (Yousaf *et al.*, 2024). Researchers (Hussain & Shi, 2020) also showed that violations and dangerous behaviors among Pakistani drivers are more common than actual errors and lapses, and that such violations are closely related to ineffective training and weak licensing systems (Abbas *et al.*, 2024). The observation that the model results of this study show a higher average prevalence of risky behaviors and lower, albeit high-skewed, scores for aggressive and unlawful behaviors contributes to the impression that unchallenged rule violations are common in day-to-day life. Meanwhile, a smaller group of drivers is involved in constant aggression and gross crimes.

At the global level, violations and aggressive behavior are more predictive of crashes in studies and meta-analyses on DBQ (Cordazzo *et al.*, 2014; Taiwo *et al.*, 2024). Comparable prevalence of violations and aggression, as the most important latent variables, can also be documented, according to recent work validating DBQ-type measures in India and the Middle East, as well as in other low- and middle-income countries (Bandyopadhyaya *et al.*, 2023; Pandey *et al.*, 2026). The findings presented in this study are therefore consonant with the general DBQ literature and are Pakistan-specific, with a four-dimensional structure that presents evidence specific to Pakistan.

The observation that experienced drivers rate riskier and more unlawful behaviors as less risky and less unlawful can indicate a behavioral adaptation process involving risk normalization and overconfidence. Over time, repeated exposure to traffic environments may lead drivers to develop a general attitude that such behavior is normal and acceptable in social settings (e.g., speeding or violating informal rules) and to feel less at risk. Skilled drivers would also be assured, which

would lead them to take measured risks, particularly in environments they are well familiar with. Additionally, the conducive state of enforcement fatigue, i.e., discouraging inefficient, unstable, or feeble enforcement, can also serve as an incentive to instil non-compliance. All these processes suggest that the accumulation of experience is not necessarily the cause of safer behaviour, but may be the means by which risk-management behaviour gradually normalizes in situations where enforcement and safety culture are limited, such as local traffic.

The results, nevertheless, highlight the necessity of distinguishing between high-risk driver groups rather than considering drivers as a homogeneous group. Another major trait of young drivers is higher levels of aggressive behaviour, likely reflecting impulsivity, sensation-seeking, and emotional responsiveness. The middle-aged drivers, on the other hand, are usually more exposed to driving risks and tend to engage in risky, distracted behaviours more frequently, as evidenced by time-constrained, routine-based decision-making. The third group consists of repeat unlawful offenders who persistently commit willful violations, such as running red lights, and may contribute disproportionately to grave safety outcomes. Such unique profile awareness can be exploited to deliver targeted interventions, such as behavioural prevention for young drivers, enforcement, and interventions for high-exposure and repeat-offender groups.

4.2 Age differences

According to numerous studies using DBQs in high-income areas, young drivers are singled out as the group with the highest rates of violations and aggressive driving (Sayed *et al.*, 2022; Sucha *et al.*, 2014). In our sample, the effects of age are more differentiated. The highest levels of aggressive behavior are observed in the 18-24 age group, which corresponds to long-established high levels of impulsiveness, anger, and sensation-seeking among young drivers (Sucha *et al.*, 2014). The risky and distracted behavior trends,

however, increase with age and are highest among middle-aged drivers (40-59 years), whereas unlawful behavior scores are also high among this age group.

These results are consistent with recent Pakistani and regional studies on the topic, which demonstrate that dangerous driving is not solely a youth phenomenon. According to researchers (Muneeb *et al.*, 2024), the impact of age on distracted driving is particularly pronounced in Pakistan, with older drivers reporting greater distraction under specific circumstances. Similarly, Yousaf & Wu (2023) found that in Pakistan, risky driving or riding practices increase with years of experience, do not decline for many years after early adulthood, and are strongly linked to crash involvement. Here, the findings build upon earlier research by showing that in a multi-city sample, middle-aged Pakistani drivers are relatively responsible and distracted drivers whose rates of unlawful and aggressive driving remain relatively high, which is a significant change to the existing policy-centric narratives that present young drivers almost as the sole focus in investigating the subject.

4.3 Gender differences

The distribution of grades for the aggressive, unlawful, and distracted indices, with higher scores among men, is consistent with the Pakistani and international literature. According to researchers (Batoool & Carsten, 2017), the top causes of involvement in crashes were aggressive and risky violations among male drivers in Pakistan compared to females. It is also common practice in meta-analyses and cross-national DBQ studies, indicating that male drivers report more violations and aggressive behaviors. Conversely, the number of high-risk behaviors is also lower in female drivers despite exposure control (Sucha *et al.*, 2014; Taiwo *et al.*, 2024). Recent research from India and other LMICs indicates that gender influences remain strong in contemporary DBQ tools (Gupta *et al.*, 2021; Kshatriya *et al.*, 2024).

It is worth noting that there is no significant difference between the risk of the gender gap in the risky-behaviour index, even though the gender difference is prominent in aggressive and unlawful behaviours. It might also indicate the particular makeup of the sample of female drivers (they may be more educated, urban, and self-selected in Pakistani cities), and potential social desirability bias in self-reports. Similar muting of gender differences has been reported in more recent generations of DBQ factors, where women are altering their exposure to driving and their driving functions (Grdinić-Rakonjac & Pajković, 2025). This implies that strategies which focus on gender issues in Pakistan need to remain, male drivers, particularly when their aggression and intentional violations are addressed, but also consider the possibility that the risky behaviours that women have towards driving could increase as they continue to experience more exposure to driving.

4.4 Driving experience

The correlation between greater driving experience and higher scores for risky and unlawful behaviors, in our case, runs counter to the traditional belief that experience can serve as a defense. Nevertheless, it is in agreement with several recent findings. According to researchers Hussain & Shi (2020), in Pakistan, a driver's experience does not always translate into greater safety: a shortage of formal training and lax enforcement can lead to the psychological normalization of risky behavior over time. Researchers (Muneeb *et al.*, 2024) found that driving experience mediated the influence of road and enforcement conditions on distracted driving in Pakistan, with experienced drivers more prone to distraction, especially in easy daytime conditions.

In Pakistan, researchers (Bandyopadhyaya *et al.*, 2023) and (Pandey *et al.*, 2026) demonstrated, with modified DBQ scales in India, that professional and long-hunt drivers with a long-term driving history tend to report a greater number of violations and aggressive behaviors than novice drivers,

and probably due to the effects of overconfidence, time pressure, and normalization of breaking the law. Likewise, researchers (Yousaf & Wu, 2023) proved that motorbike riding experience in Pakistan is a powerful predictor of risky driving and collisions. These research results contribute to this developing image by indicating that experience does not have a protective effect across the board, but can instead be a form of cumulative exposure and assimilation into risky behavior patterns and illegal shortcuts in a multi-city sample of Pakistani car drivers.

The four behavioural indices should also be interpreted in light of the measurement method used in this research. All the risky, aggressive, distracted, and unlawful driving indices were built on the pre-established DBQ-defined categories to ensure alignment with the well-known DBQ theory and other uses in Pakistan. This method allowed a qualitative comparison of the demographics of two theoretically different types of aberrant driving. Nonetheless, because the current sample lacks exploratory or confirmatory factor analysis, the results should be interpreted as evidence for theoretically derived composite indices rather than a brand-new psychometric factor structure. This problem does not nullify the observed demographic trends. Nevertheless, the study indicates that the latent structure of the driving behaviour constructs should be formally tested in future studies using the DBQ in Pakistan, and then used in predictive or policy models.

4.5 DBQ item-level patterns and national road-safety relevance

The item-level behaviours were put into perspective in relation to the overall road-safety situation in Pakistan to enhance the ecological relevance of the DBQ results. Risky driving had the highest composite score (Table 3), indicating that risky behaviours such as speeding, risky overtaking, close following, and ignoring pedestrians' movements were reported more often than aggressive, distracted, and unlawful behaviours. This

trend is in line with the road-safety profile of Pakistan, in which vulnerable road-users, especially pedestrians and two- and three-wheeler users, represent a sizeable portion of road-crash deaths, and where unsafe-speed decisions, inadequate lane-discipline, and ineffective yielding behaviour may contribute significantly to the severity of crashes (Asian Transport Observatory, 2025). The high skewness observed for aggressive and unlawful behaviours further suggests that, although these behaviours were not uniformly high among all respondents, a smaller subgroup of drivers reported frequent involvement in behaviours such as unnecessary honking, red-light violations, and other deliberate rule violations. These patterns are important because previous DBQ-based studies have shown that violations, risky driving, and aggressive driving are associated with crash involvement and unsafe road outcomes (Af Wählberg *et al.*, 2015; Taiwo *et al.*, 2024; De Winter & Dodou, 2010). In Pakistan, similar DBQ-based studies have also reported that risky, aggressive, and unlawful driving behaviours are important predictors of unsafe driving and crash-related risk (Batool & Carsten, 2017; Hussain & Shi, 2020; Yousaf & Wu, 2023). Therefore, the DBQ results are not only statistically meaningful but also policy-relevant, as they identify behavioural domains that correspond to nationally important road-safety risks, as summarized in Table 6.

4.6 Implications for road safety in Pakistan

There are three implications of particular importance for the policy. To begin with, scores on the risky behaviour index, which include speeding, following closely, and other deliberately immoral offences, were consistently high, confirming that breaches of everyday regulations remain a key danger on Pakistan's roads. This can be matched with the recent findings of KAP (knowledge-attitude-practice) studies in Karachi, Sahiwal, and Lahore that indicate that the proportions of drivers with basic knowledge of traffic rules are negative towards attitudes and violate the

Table 6. DBQ item-level behaviours and their relevance to Pakistan's road-safety context

DBQ dimension	Example item/local behaviour	Expected national relevance	Policy implication
Risky driving	Speeding, risky overtaking and close following	Linked with crash severity and unsafe movement on urban corridors	Speed enforcement, lane discipline, refresher training
Risky driving	Neglecting pedestrian movement	Relevant because pedestrians form a high share of fatalities	Pedestrian yielding enforcement and safe-crossing education
Aggressive driving	Unnecessary honking, verbal conflict, tailgating	Reflects low tolerance and conflict in mixed urban traffic	Behavioural training and conflict-control modules
Distracted driving	Mobile phone use while driving	Relevant to inattention-related crash risk	Mobile-phone enforcement and awareness campaigns
Unlawful driving	Red-light violation, excess passengers	Reflects deliberate non-compliance with traffic rules	Camera enforcement and graduated penalties

laws regularly (Abbas *et al.*, 2024; Iftikhar *et al.*, 2024; Umar *et al.*, 2024). This study's evidence supports the plea for integrated policies of education, behavior change, and visible enforcement to alter norms regarding the ordinary violation.

Second, the effect of age and experience appears strong, suggesting that only youth-oriented campaigns would not help. Middle-aged, experienced drivers, who tend to be working or, at times, the breadwinners of their families, are an important target market. Some measures may include periodic refresher training for license renewal, employer safety training for professional and high-mileage drivers, and increased enforcement of speeding and illegal maneuvering on the city's arterial roads, where drivers comprise a larger share of the population. It has been demonstrated in Pakistan and other LMICs that these measures are most effective when accompanied by a regular, non-corrupt enforcement strategy and socialization that make driving safety a social duty rather than an individual option (Yousaf & Wu, 2024; Zaman & Sabir, 2023).

4.6.1 Distal demographic predictors and intervention implications

Third, aggressive and unlawful behaviors have previously been associated with very skewed distributions, which indicates that a small, but excessively risky, single group may cause a disproportionate number of severe crashes, an idea consistent with DBQ-driven accident prediction research and

recent systematic reviews (Taiwo *et al.*, 2024; Thomas *et al.*, 2025). The demographic variables involved in the study are not causal factors in crashes but are instead distal predictors of aberrant driving behaviour. According to the Contextual Mediated Model, age, gender, and driving experience can promote road safety outcomes through more proximal effects, including risk perception, driving style, expression of anger, exposure to enforcement, driving-licensing history, and habitual adherence to traffic laws (Demir *et al.*, 2016). These distal features are especially crucial in the Pakistani context, as driving behaviour is influenced by high levels of motorisation, mixed traffic conditions, inconsistent enforcement, road-use norms, and inconsistent driver training. As an example, increased aggressive driving among young drivers might be due to impulsivity, intolerance of congested traffic and less robust hazard prediction. In contrast, greater risky and unlawful behaviours among experienced drivers might be due to risk normalisation, overconfidence, repeated exposure to low levels of enforcement, and becoming accustomed to informal road practices. Equally, the increased aggressive, distracted, and unlawful scores among male drivers might be associated with greater mobility exposure, work-related driving, and/or more intense engagement with high-traffic city routes. Thus, demographic features prove handy not because they can explain unsafe driving in isolation, but because they can identify classes of drivers with different proximal behaviours and intervention pathways.

According to the current results, the interventions can be distinguished by driver risk profile rather than by general enforcement measures. Among younger drivers who reported comparatively high rates of aggressive driving, licensing authorities and the traffic police should offer behavioral modules when issuing learner and renewal licences that cover topics such as anger management, impulse control, safe overtaking, and conflict avoidance in heavy urban traffic. Among middle-aged and highly experienced drivers, there is a reported increase in risky and illegal behaviours. Periodic refresher training ought to be coupled with licence renewal, with special attention to the following areas: speeding, risky overtaking, running red lights, and mobile phone use. The targeted enforcement of male drivers and of drivers with repeated acts of unlawful behaviour should be reinforced by automated red-light and speed cameras at intersections and along arterial corridors, the combination of challan/violation records and licensing databases, and incremental penalties for repeat offending. These interventions are specific to the situation in Pakistan, where inconsistent enforcement, mushrooming motorization, and the lack of connection between licensing, violation, and crash records make general awareness less effective.

4.6.2 Safe System

The practical implications of this research's results for the Safe System and Vision Zero are also relevant. The Safe System approach acknowledges that human beings are fallible and that the human body can only tolerate a certain amount of crash force. Road safety must be distributed among road users, road agencies, enforcement agencies, licensing authorities, vehicle regulators, and policymakers, rather than being placed exclusively on individual motorists (U.S. Department of Transportation, 2025; World Health Organization, 2021). Vision Zero also prioritizes the prevention of, and non-acceptance of, deaths and severe injuries caused by mobility systems (Vision Zero Network, 2026). Thus, the number of risky

driving behaviours observed in the current study should not be viewed merely as an indication of the need for driver awareness interventions; rather, it underscores the need for system-wide interventions that minimise the likelihood and consequences of human error. In the Pakistani urban context, this includes speed management on high-risk corridors, safer pedestrian crossings, traffic-calming measures near commercial and educational areas, automated red-light and speed enforcement, stricter licensing and renewal procedures, targeted refresher training for experienced drivers, and improved linkage between crash, challan, and licensing databases. Such measures are consistent with Safe System thinking because they combine safer road users, safer speeds, safer roads, improved post-crash data, and proactive enforcement to reduce the risk of fatal and serious injury (Asian Transport Observatory, 2025).

4.7 Strengths and limitations

One of the major strengths of the research is its multi-city design in a lower-middle-income country, which includes a large sample of drivers across several major urban centres, rather than a single city or occupational group. It also theorizes four dimensions of behaviour: risky, aggressive, distracted, and unlawful that overlap the original Manchester DBQ approach and latest extensions that characterize the varying types of dangerous driving (Cordazzo *et al.*, 2014; Hou *et al.*, 2025). The research provides an interesting behavioral description that can be readily compared with global data by correlating these indices with current theoretical literature on dangerous driving (e.g., the Dula Dangerous Driving Index, positive driving constructs, etc.) (Willemssen *et al.*, 2008; Yousaf & Wu, 2024).

Nevertheless, several drawbacks must be acknowledged. The cross-sectional design does not allow us to draw causal conclusions concerning the effect of age, experience, and dangerous driving; age and experience are somewhat collinear, and life-course

alterations in risk-taking cannot be identified directly. All of them are based on self-reporting, and this raises the issue of recall error and social-desirability bias; given that some drivers (specifically those committing the most serious offences) might under-report their behaviour, others might over-report to appear more assertive or competent (Thomas *et al.*, 2025; Wahlberg *et al.*, 2008). The sampling method, though multi-city in nature, is not necessarily probabilistic and may under-represent rural drivers, professional heavy-car operators, and low-literacy groups. Lastly, the current analysis is based on behavioral indices and socio-demographic data. Still, it does not directly correlate DBQ scores with police-recorded crashes, injuries, or enforcement information, which would be necessary to determine the actual risk consequences in Pakistan.

A further methodological limitation is that the present study adopted four predefined DBQ-based behavioural dimensions rather than conducting exploratory or confirmatory factor analyses on the current sample. Although the selected dimensions were theoretically grounded in the DBQ literature and supported by previous Pakistani driving-behaviour studies, the absence of sample-specific factor validation limits the extent to which the DBQ's latent structure can be confirmed in the present population. Future studies should apply EFA and CFA using larger and more diverse Pakistani driver samples to verify the factorial validity, convergent validity, and measurement invariance of DBQ-based constructs across gender, age, city, and driver-experience groups.

Although the study included ten major urban centres of Punjab, city-specific police-recorded crash, violation, and enforcement data were not consistently available in a harmonized format; therefore, the analysis was limited to self-reported DBQ-based behavioural data and demographic predictors. Because the city subsamples were unequal and city-specific crash, enforcement, and traffic-exposure data were not consistently available, formal city-level comparisons were not performed. Future research should

integrate DBQ responses with official crash records, challan/violation databases, licensing history, and enforcement exposure to provide a more comprehensive risk model.

5. Conclusions

The targeted topic in this study is the relationship between age, gender, and driving experience and four dimensions of aberrant driving behaviour, namely risky, aggressive, distracted, and unlawful driving, using a DBQ-based instrument constructed by the investigator on a multi-city sample of 400 drivers in Punjab, Pakistan. In pursuance of the mentioned purpose and three objectives, the key findings are:

- The study was able to develop four DBQ-based composite indices (i.e., risky, aggressive, distracted, unlawful driving) and conduct them on a heterogeneous, urban Pakistani population of drivers. The average score for risky driving was the highest, indicating that behaviors such as high-speed overtaking and dangerous overtaking are widespread. By contrast, aggressive, distracted, and illegal behavior had lower mean scores but highly skewed distributions. It showed a small subgroup of drivers who reported very frequent hostile or illegal behavior, while the majority reported such behavior only occasionally.
- Defined demographic trends were found in the four behaviour indices. Aggressive driving among young drivers (18-24 years old) was highest, but risky and distracted behaviours were higher among middle-aged drivers (40-59 years), and unlawful behaviours were more likely to increase with age and driving experience. The degree of aggressive behaviour, distracted behaviour, and illegal behaviour was significantly greater among male drivers compared to female ones, with comparatively small gender differences in risky behaviour. There was a consistent gradient in risky and unlawful behavior across the driving

experience, with drivers with ≥ 10 years of experience scoring higher than those with 5-9 years of experience, who in turn scored higher than those with < 2 years of experience.

- Combined, these results show that it is not just the young and inexperienced male drivers who engage in dangerous driving in Pakistan; it is shared among the age and experience cohorts, and that it is especially common in the middle and experienced age group drivers who develop a combination of more frequent, distracted, and illegal activities. This study adds to previous, single-city or single-factor studies of Pakistani drivers by offering a disaggregated, four-dimensional behavioral pattern of a large multi-city sample. It provides empirical grounds for the development of specific educational and enforcement measures. Specifically, instead of targeting young and aggressive drivers solely, high exposure of middle-aged drivers and the minority but critical subgroup with very high aggressive and unlawful scores should be prioritised to successfully produce meaningful positive changes in road safety in Pakistan and other environments with low and middle incomes.

Therefore, the main contribution of this study lies not in the isolated examination of age, gender, and driving experience, but in the disaggregated identification of how these demographic characteristics correspond to different aberrant-driving profiles in a multi-city Pakistani sample. This evidence provides a stronger basis for targeted road-safety interventions than aggregated driver-behaviour scores alone would.

6. Recommendations

In this research, specific and context-specific interventions are implied due to the observed patterns of differentiated behaviors. Governments should institute effective behavioural education programs,

enhance graduated licensing, and increase awareness of impulse control and safe driving attitudes among young drivers who exhibit more aggressive behaviour. They must get priority on arterials and in cities where aggressive maneuvers are more likely to lead to significant crashes. Enforcement should combine educational programs, stiffer penalties for aggressive violations, and positive reinforcement of safe driving behavior. For drivers with high exposure and for middle-aged drivers who have demonstrated high-risk and distracted driving behaviors, periodic refresher training should be provided in conjunction with license renewals, through on-the-job road-safety courses, and through selective enforcement of speeding and mobile phone use. These will be placed on major streets of the city and high-traffic routes, and the policy comes-ons, such as compulsory training, enforcement activities and work-based safety bonuses, will again focus on achieving compliance. Radicalization of penalties at signalized intersections, automated penalty recognition, and increased scrutiny should be imposed on recidivists of battery, including drivers who have already developed a habit of repeating deliberate offences, such as red-light running, when renewing their licenses. These measures should be supported by points, penalties, and monitoring instruments, as well as by special behavioral programs to deter unchecked non-conformity. All of these can be used to align enforcement, education, and institutional policies with the risk profiles applied in this study, thereby improving road safety in urban Pakistan. Therefore, road-safety interventions in Punjab should be targeted according to behavioural risk profile: aggressive young drivers should be addressed through behavioural training, experienced risky drivers through refresher licensing programs, distracted drivers through mobile-phone enforcement, and repeat unlawful drivers through automated monitoring and graduated penalties.

The results of the study indicate that behavioural interventions need to be supported by engineering, enforcement,

and institutional solutions, based on the perspective of the Safe System/Vision Zero. The problem of risky driving can be addressed by controlling speed, maintaining lane control and slowing down on high-traffic urban roads. Licensing-stage behavioural training and conflict-management modules should be used to address aggressive driving among young drivers. Mobile phone enforcement and public awareness should be used to curb distracted driving, and roadside monitoring should reinforce these efforts. Automated enforcement should be used to penalise unlawful and targeted behaviours, such as red-light violations and repeated rule-breaking, with violation records incorporated into the licence renewal process. These measures would shift the policy response from general awareness to a more active approach to making the system safer, viewing driver behaviour, infrastructure, enforcement, and institutional accountability as interlinked elements in improving road safety.

CRedit contribution

Malik Muneeb Abid: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Waqas Haroon:** Supervision, Validation, Writing – review & editing. **Ashok Kumar:** Supervision, Validation, Writing – review & editing.

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Declaration of competing interests

The authors declare no conflict of interest.

Declaration of generative AI use

The authors assert that no generative AI was applied in the creation of this paper.

Ethics statement

The ethics committee of the Civil Engineering Department at the University of Sargodha, Pakistan, approved the study protocol. All participants were informed of the data collection in advance.

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The data are available from the corresponding author upon reasonable request.

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