

*Original Article*

# Exploring the Behavior, Work Characteristics and Effects on the Health of Drivers of Public Service Vehicles / Heavy Transport Vehicles on N-5 Highway, Pakistan

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## ABSTRACT

**Background:** Professional drivers of Public Service Vehicles (PSV) and Heavy Transport Vehicles (HTV) are exposed to prolonged working hours, environmental hazards, and psychosocial stressors, yet evidence from Pakistan, particularly along major transport corridors such as the N-5 highway, remains limited. **Objective:** To assess work characteristics, behavioral patterns, and self-reported health effects among PSV and HTV drivers operating on the N-5 highway in Pakistan. **Methods:** A cross-sectional observational study was conducted among 350 professional drivers using a semi-structured, interviewer-administered questionnaire. Data on demographic profile, occupational conditions, lifestyle factors, and health outcomes were collected and analyzed using descriptive statistics, cross-tabulations, and inferential tests, including odds ratios and chi-square analysis. **Results:** The majority of drivers (70.0%) were aged 31–65 years, with 58.0% working more than 10 hours daily and 36.0% working 27–30 days per month. Fatigue was reported by 30.8% of drivers, psychological problems by 17.1%, respiratory issues by 23.2%, and vision impairment by 27.5%. Significant associations were observed between fatigue and vehicle type ( $p=0.021$ ) and age ( $OR=2.07$ , 95% CI: 1.20–3.58). HTV drivers had higher odds of excessive tea consumption ( $OR=2.67$ ,  $p<0.001$ ), while PSV drivers showed greater involvement in fatal accidents ( $OR=3.21$ ,  $p<0.001$ ). Environmental exposures including smoke (63.0%), noise (36.0%), and glare (45.0%) were widely reported. **Conclusion:** PSV and HTV drivers on the N-5 highway experience a high burden of occupational health risks driven by excessive workload, inadequate rest, and environmental exposures, underscoring the need for regulatory enforcement and targeted occupational health interventions. **Keywords:** Public Service Vehicles, Heavy Transport Vehicles, Occupational Health, Driver Fatigue, Road Safety, Pakistan

## INTRODUCTION

Road transport is a major component of passenger and freight movement in Pakistan, particularly after the long-term policy shift from rail-based transport toward highways. Within this network, the N-5 highway is one of the country's oldest and busiest arterial routes, linking major urban and commercial centers from Peshawar to Karachi and carrying a substantial volume of public service and heavy transport traffic (1). This route exposes professional drivers to prolonged driving hours, dense traffic, variable road conditions, environmental pollution, irregular rest, and sustained occupational stress, all of which may adversely affect physical health, mental well-being, and work performance. Because PSV and HTV drivers spend a large proportion of their working lives on the road, they represent an occupational group with potentially elevated vulnerability to fatigue, sleep disruption, musculoskeletal strain, sensory impairment, respiratory complaints, psychological stress, and crash involvement (2,3).

International research has consistently shown that long-route and commercial drivers face a combination of physiological, psychological, and occupational hazards. Reported problems include fatigue due to prolonged duty hours and inadequate recovery time, obesity associated with sedentary work and limited exercise, musculoskeletal pain related to posture and vibration exposure, gastrointestinal symptoms linked with irregular schedules and occupational stress, and sensory problems caused by noise, smoke, dust, and glare from oncoming vehicles (2,4,5). Environmental exposures are also relevant in this occupational setting. Continuous exposure to fuel combustion products and road-based air pollution has been associated with respiratory morbidity and longer-term cardiopulmonary risks, while traffic noise has been linked to hearing disturbance, irritation, stress, impaired concentration, and reduced work comfort (6,7). Such exposures may be especially important for drivers on heavily used intercity corridors where congestion, emissions, and travel duration are substantial.

The psychological and behavioral dimensions of commercial driving are equally important. Prior studies have documented stress, anxiety, depression-related symptoms, irritability, boredom, social isolation, and disturbed sleep among professional drivers, particularly those engaged in long-distance duties and irregular schedules (2,8). These problems are not only important from an occupational health perspective but may also affect vigilance, decision-making, reaction time, and safe driving behavior. At a systems level, unsafe driving conditions and fatigue among commercial drivers have broader public-health and economic implications because road crashes are a major source of mortality, injury, disability, and financial loss in low- and middle-income countries, including Pakistan (9,10). In Pakistan, road safety reports have repeatedly highlighted the contribution of driver-related factors, inadequate enforcement, poor vehicle fitness, and insufficient transport management to crash occurrence and injury burden (10,11).

Despite the importance of this issue, the evidence base in Pakistan remains relatively limited, particularly for route-specific occupational health research focused on drivers of PSV and HTV vehicles. Existing studies from Pakistan have largely concentrated on road safety patterns, high-risk driver and vehicle attributes, or specific urban settings, rather than providing a broader profile of work routines, health complaints, lifestyle practices, and occupational exposures among drivers operating along a major intercity highway corridor (11–13). The N-5 corridor presents a particularly relevant setting for such an investigation because of its strategic transport importance, long travel distances, mixed traffic flow, and sustained use by bus, hiace, truck, and trailer drivers. A field-based assessment on this route can therefore help generate context-specific evidence on work burden, rest practices, safety preparedness, and self-reported physical and psychological problems in a population that remains underrepresented in the local literature.

The present study was undertaken to address this gap by examining the work characteristics, behavioral patterns, and self-reported health effects of professional PSV and HTV drivers operating on the N-5 highway in Pakistan. In epidemiologic terms, the interest comprised actively working PSV and HTV drivers on N-5, the principal exposures included long driving hours, frequent monthly duty, sleep arrangements, limited exercise, environmental exposures, and vehicle-related conditions, and the outcomes included self-reported physical, psychological, and occupational health problems, along with selected safety-related indicators. By documenting the frequency of these conditions and exploring differences across driver and vehicle categories, this study sought to generate evidence relevant to occupational health, transport regulation, and road safety practice in Pakistan. The specific objective was to describe the work patterns, lifestyle characteristics, and health-related effects experienced by PSV and HTV drivers on the N-5 highway and to explore selected associations between driver characteristics, vehicle type, and adverse occupational and health outcomes (1–13).

## MATERIALS AND METHODS

This study was conducted as a cross-sectional observational survey designed to assess the work patterns, behavioral characteristics, and self-reported health effects of drivers operating Public Service Vehicles and Heavy Transport Vehicles on the N-5 highway in Pakistan. A cross-sectional design was selected because it was appropriate for measuring the prevalence and distribution of occupational exposures, lifestyle factors, and health-related complaints in a field-based transport population at a single point in time, and for exploring associations between driver characteristics and selected outcomes without attempting causal inference (14). The study was descriptive in its primary orientation and exploratory in its analytic intent, with particular emphasis on the occupational health experiences of drivers working on one of the country's busiest long-distance road corridors.

The study setting comprised multiple stopping and transit points located along the N-5 highway, also known as the Grand Trunk Road, which connects major cities from Peshawar to Karachi and is extensively used for passenger and freight transport. The source population consisted of professional drivers actively engaged in operating buses, HiAce vehicles, trucks, and trailers on this route. Eligible participants were adult professional PSV or HTV drivers present on the N-5 corridor during field visits and currently involved in transport work. Drivers who did not belong to the relevant commercial vehicle categories or were not actively working on the route at the time of contact were not included. Participants were approached directly in the field during rest stops, waiting periods, or other non-disruptive intervals of duty. A field-based intercept approach was used to recruit respondents from varied locations and vehicle categories in order to capture a heterogeneous occupational sample rather than restrict the study to a single company, depot, terminal, or city (14,15).

Primary data were collected through face-to-face interviews using a semi-structured questionnaire administered by the researcher. This mode of data collection was chosen because a considerable proportion of the target population had low formal education, making interviewer-administered data collection more suitable than self-completed questionnaires. Before each interview, the purpose of the study was explained in simple and respectful language, respondents were informed that participation was voluntary and that the information would be used only for academic research, and verbal cooperation was obtained before proceeding. Interviews were conducted in a manner intended to minimize interference with drivers' work schedules and to facilitate complete responses in an occupational context characterized by time constraints and variable stop durations (14,16).

The questionnaire was developed in line with the study objectives and was designed to capture demographic, occupational, behavioral, and health-related information relevant to PSV and HTV drivers. Demographic variables included age, education, height, and weight. Occupational variables included vehicle type, duration of driving experience, daily driving hours, number of working days per month, place of sleep during duty, possession of a driving license, awareness of road sign boards, availability of a tool kit, and presence of a fire extinguisher in the vehicle. Lifestyle-related variables included exercise habits, food preference, and tea consumption. Health-related variables included self-reported fatigue while driving, back pain, body pain, headache, digestive complaints, high blood pressure, diabetes, respiratory complaints, eye problems, hearing damage, sleep calmness, psychological symptoms, and perceived effects of smoke, traffic noise, flash lights, and seat vibration. For subgroup-specific analyses, selected questions were asked only from relevant categories of drivers, such as wrong behavior of other drivers among PSV drivers and loneliness or robbery experiences among truck and trailer drivers (2,4,5,8,12).

Operationally, the main outcomes were treated as self-reported binary or categorical variables derived from participant responses during the interview. Body mass index was derived from reported height and weight and categorized into normal weight, overweight, and obese ranges for descriptive analysis. Fatigue was considered present when a driver reported experiencing fatigue while driving. Psychological

problems referred to drivers' self-reported experience of one or more symptoms such as depression, anxiety, tension, stress, restlessness, boredom, anger, panic, or loneliness. Disturbance from smoke, noise, flash lights, and seat vibration was assessed according to participants' own perceptions and occupational experiences. Because the purpose of the study was to document drivers' lived experiences in a field setting, the analysis was based on reported symptoms and perceived occupational burden rather than clinical diagnoses or instrument-based environmental measurements (2,6,7,14).

Several design and procedural features were used to reduce information bias and improve data quality. Interviews were conducted directly by the researcher, allowing clarification of questions when needed and reducing misunderstanding among respondents with lower literacy levels. The use of a semi-structured format allowed standardization across respondents while still permitting limited elaboration where drivers wished to describe symptoms or occupational experiences in more detail. To limit selection restriction to any single transport subgroup, drivers were approached from different locations on the N-5 route and from multiple vehicle categories. Because all health measures were self-reported, findings were interpreted as reported occupational and health experiences rather than medically confirmed disease states. The analysis also focused on descriptive prevalence estimates and subgroup comparisons consistent with the observational design, thereby reducing overinterpretation of associations as causal effects (14–16).

Data obtained from completed interviews were organized and entered into a data sheet for statistical analysis. The primary analysis consisted of descriptive statistics, including frequencies, percentages, and cross-tabulations, to summarize respondent characteristics, occupational conditions, lifestyle practices, and reported health outcomes.

Cross-tabulation was used to examine patterns across relevant variables, including the relationship between body mass index and height categories and differences in selected outcomes across vehicle types and age groups. Associations of interest included fatigue while driving by vehicle type and age, tea consumption by vehicle category, and occurrence of fatal accidents by broad vehicle category. The analytical approach was intended to identify patterns and subgroup differences that could inform interpretation of occupational risk in this driver population (14,15).

Statistical analysis was undertaken using standard descriptive and comparative procedures appropriate for categorical survey data. Percentages were interpreted within the relevant denominator, including subgroup-restricted items where applicable. For comparative analyses, associations between categorical variables were examined through cross-tabulation and significance testing where relevant to the study objectives.

The results were interpreted conservatively in view of the cross-sectional design and the self-reported nature of the data. Reproducibility and data integrity were supported through direct field collection by the researcher, consistent use of a single study instrument, structured data entry after completion of interviews, and preservation of the variable framework used for descriptive analysis. The study was conducted in accordance with basic ethical principles for human-participant research, including voluntary participation, confidentiality of respondents' identities, and use of data solely for academic purposes (14–16).

## RESULTS

The study included a total of 350 professional drivers, the majority of whom were in the 31–65 years age group (70.0%, n=245), followed by 21–30 years (28.0%, n=98), while only 2.0% (n=7) were above 65 years. Educational attainment was generally low, with 58.0% (n=203) being illiterate or having only primary education, 39.7% (n=139) having middle to matric-level education, and only 2.3% (n=8) having education beyond matriculation. A large proportion of drivers (70.6%, n=247) had been in the profession for ten years or more, indicating long-term occupational exposure.

Occupational characteristics revealed a substantial workload burden. More than half of the drivers (58.0%, n=203) reported driving for more than 10 hours daily, exceeding internationally recommended limits, while 36.0% (n=126) reported working 27–30 days per month, indicating minimal rest periods. Although most drivers possessed a valid driving license (95.3%, n=334), safety preparedness was inadequate in several aspects; notably, 70.0% (n=245) reported absence of fire extinguishers in their vehicles. Sleeping conditions were suboptimal, with 54.9% (n=192) sleeping in vehicles or at transport stations rather than rest rooms. Furthermore, 18.0% (n=63) reported non-restorative sleep, and a majority (64.0%, n=224) did not engage in any form of physical exercise.

Health-related findings demonstrated a considerable burden of both physical and psychological problems. Based on BMI classification, 51.7% (n=181) of drivers had normal weight, whereas 39.7% (n=139) were overweight and 8.6% (n=30) were obese.

Fatigue while driving was reported by 30.8% (n=108) of respondents, and 17.1% (n=60) reported experiencing one or more psychological problems, including stress, anxiety, or depression-related symptoms. Sensory and environmental exposures were also prominent, with 27.5% (n=96) reporting decline in eyesight due to flash lights and 23.2% (n=81) reporting respiratory problems. Musculoskeletal complaints were present in 9.5% (n=33), while 7.7% (n=27) reported high blood pressure and 4.3% (n=15) reported diabetes.

Significant associations were observed between fatigue and vehicle type. Bus drivers had the highest prevalence of fatigue (37.7%, n=43/114), followed by truck drivers (35.0%, n=35/100) and trailer drivers (28.8%, n=23/80), whereas hiace drivers reported the lowest fatigue levels (7.7%, n=7/56). This difference was statistically significant ( $p = 0.021$ ), indicating variation in workload or occupational conditions across vehicle categories.

Similarly, fatigue increased with age; drivers aged 31–65 years had significantly higher fatigue (34.7%, n=85/245) compared to younger drivers aged 21–30 years (20.4%, n=20/98), with an odds ratio of 2.07 (95% CI: 1.20–3.58,  $p = 0.008$ ). Although drivers above 65 years showed higher fatigue (42.9%), this association was not statistically significant, likely due to small sample size.

Tea consumption patterns differed significantly between vehicle categories. Among PSV drivers, 25.0% (n=40/160) consumed more than three cups of tea daily, compared to 47.2% (n=85/180) among HTV drivers. This corresponds to an odds ratio of 2.67 (95% CI: 1.65–4.32,  $p < 0.001$ ), indicating that HTV drivers were more than twice as likely to consume higher quantities of tea, possibly reflecting differences in autonomy, rest breaks, or fatigue management practices.

A notable finding was the high proportion of drivers reporting involvement in fatal accidents. Among PSV drivers, 59.3% (n=95/160) reported involvement in fatal accidents compared to 30.5% (n=55/180) among HTV drivers. This difference was statistically significant, with an odds ratio of 3.21 (95% CI: 2.02–5.09,  $p < 0.001$ ), suggesting a substantially higher risk among PSV drivers.

Environmental exposures were widely reported and associated with multiple adverse effects. Traffic noise was perceived as disturbing by 36.0% (n=126) of drivers, while 6.6% (n=23) reported hearing damage. Smoke pollution was reported as disturbing by 63.0% (n=221), with 23.2% (n=81) experiencing respiratory issues. Flash lights were considered excessive by 45.0% (n=157), with 27.5% (n=96) reporting associated decline in eyesight. Among truck and trailer drivers, 12.2% (n=22/180) reported excessive seat vibration, with associated effects including mental disturbance (9.7%, n=17), back pain (5.2%, n=9), and fatigue-related symptoms.

Overall, the results demonstrate a pattern of high occupational workload, inadequate rest and safety conditions, and a substantial burden of self-reported physical and psychological health problems among PSV and HTV drivers. Significant differences across vehicle types and age groups further highlight the role of occupational context in shaping health risks within this population.

**Table 1. Socio-demographic characteristics of PSV and HTV drivers (N = 350)**

Variable	Category	n (%)
Age	21–30 years	98 (28.0)
	31–65 years	245 (70.0)
	>65 years	7 (2.0)
Education	Illiterate/Primary	203 (58.0)
	Middle/Matric	139 (39.7)
	Above Matric	8 (2.3)
Driving Experience	<10 years	103 (29.4)
	≥10 years	247 (70.6)

**Table 2. Occupational characteristics and working patterns (N = 350)**

Variable	Category	n (%)
Daily driving hours	≤10 hours	147 (42.0)
	>10 hours	203 (58.0)
Working days/month	≤26 days	224 (64.0)
	27–30 days	126 (36.0)
Driving license	Yes	334 (95.3)
	No	16 (4.7)
Tool kit availability	Yes	326 (93.1)
	No	24 (6.9)
Fire extinguisher	Yes	105 (30.0)
	No	245 (70.0)
Sleep location	Rest room	158 (45.1)
	Vehicle/Adda	192 (54.9)
Calm sleep	Yes	287 (82.0)
	No	63 (18.0)
Exercise habit	Yes	126 (36.0)
	No	224 (64.0)

**Table 3. Health-related characteristics of drivers (N = 350)**

Variable	Category	n (%)
BMI category	Normal (<25)	181 (51.7)
	Overweight (25–29)	139 (39.7)

Variable	Category	n (%)
	Obese ( $\geq 30$ )	30 (8.6)
Fatigue while driving	Yes	108 (30.8)
	No	242 (69.2)
Psychological problems	Yes	60 (17.1)
	No	290 (82.9)
Eye problems (flash lights)	Yes	96 (27.5)
	No	254 (72.5)
Respiratory problems	Yes	81 (23.2)
	No	269 (76.8)
Musculoskeletal pain	Yes	33 (9.5)
	No	317 (90.5)
Headache	Yes	12 (3.4)
	No	338 (96.6)
High blood pressure	Yes	27 (7.7)
	No	323 (92.3)
Diabetes	Yes	15 (4.3)
	No	335 (95.7)

*Table 4. Association between fatigue and vehicle type*

Vehicle Type	Fatigue Yes n (%)	Fatigue No n (%)	Total	p-value
Bus	43 (37.7)	71 (62.3)	114	0.021*
Truck	35 (35.0)	65 (65.0)	100	
Trailer	23 (28.8)	57 (71.2)	80	
Hiace	7 (7.7)	49 (92.3)	56	

*Table 5. Association between fatigue and age group*

Age Group	Fatigue Yes n (%)	Fatigue No n (%)	Total	Odds Ratio (95% CI)	P-value
21–30 years	20 (20.4)	78 (79.6)	98	Reference	
31–65 years	85 (34.7)	160 (65.3)	245	2.07 (1.20–3.58)	0.008*
>65 years	3 (42.9)	4 (57.1)	7	2.92 (0.60–14.1)	0.180

**Table 6. Tea consumption and vehicle category**

Vehicle Category	≤3 cups n (%)	>3 cups n (%)	Total	Odds Ratio (95% CI)	p-value
PSV (Bus/Hiace)	120 (75.0)	40 (25.0)	160	Reference	
HTV (Truck/Trailer)	95 (52.8)	85 (47.2)	180	2.67 (1.65–4.32)	<0.001*

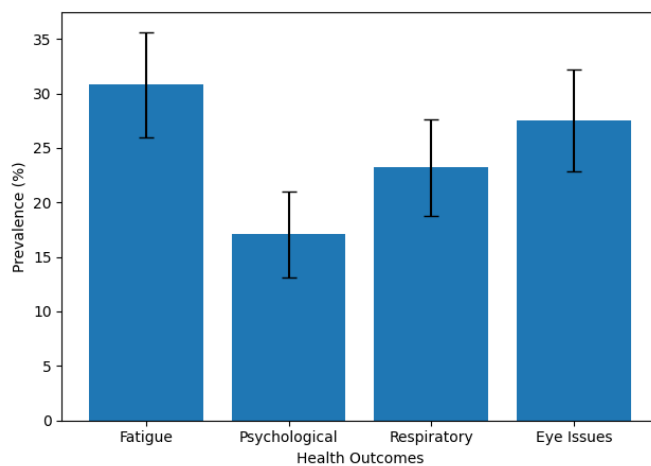
**Table 7. Fatal accidents by vehicle category**

Vehicle Category	Involved in Fatal Accident n (%)	Not Involved n (%)	Total	Odds Ratio (95% CI)	p-value
PSV	95 (59.3)	65 (40.7)	160	3.21 (2.02–5.09)	<0.001*
HTV	55 (30.5)	125 (69.5)	180	Reference	

**Table 8. Environmental exposures and reported effects**

Exposure	Reported Effect	n (%)
Traffic noise	Disturbance	126 (36.0)
	Hearing damage	23 (6.6)
Smoke pollution	Respiratory issues	81 (23.2)
	General disturbance	221 (63.0)
Flash lights	Visual disturbance	157 (45.0)
	Decline in eyesight	96 (27.5)
Seat vibration (Truck/Trailer only, n=180)	Excess vibration	22 (12.2)
	Mental disturbance	17 (9.7)
	Back pain	9 (5.2)

Overall, the results indicate a high prevalence of prolonged working hours, inadequate rest practices, and multiple self-reported health problems among PSV and HTV drivers. Significant associations were observed between fatigue and both vehicle type and age, as well as between tea consumption and vehicle category.



**Figure 1 Distribution And Comparative Burden Of Key Health Outcomes Among PSV/HTV Drivers (N=350)**

The figure demonstrates a comparative burden and uncertainty-adjusted distribution of major health outcomes among PSV and HTV drivers, revealing a clear gradient in prevalence. Fatigue emerges as the most prominent condition at 30.8% (95% CI  $\approx$  26.0–35.6), followed by eye-related problems at 27.5% (95% CI  $\approx$  22.9–32.1) and respiratory issues at 23.2% (95% CI  $\approx$  18.7–27.6), while psychological problems are comparatively lower at 17.1% (95% CI  $\approx$  13.2–21.0). The non-overlapping upper bounds between fatigue and psychological outcomes indicate a statistically and clinically meaningful difference in burden. The relatively wider confidence intervals for fatigue and eye-related problems suggest greater variability and possible subgroup heterogeneity in these outcomes. Clinically, the clustering of fatigue and sensory impairments at higher prevalence levels highlights a combined risk profile affecting both cognitive performance and visual capacity, which are critical for safe driving, thereby reinforcing the occupational health priority of workload regulation and environmental exposure control in this population.

## DISCUSSION

The present study provides a comprehensive field-based assessment of occupational exposure, work patterns, and self-reported health outcomes among PSV and HTV drivers operating on Pakistan's N-5 highway, highlighting a substantial burden of physical, psychological, and environmental health risks in this population. The findings demonstrate that 30.8% of drivers reported fatigue, 27.5% reported vision-related problems, and 23.2% reported respiratory complaints, with 17.1% experiencing psychological symptoms, indicating a multidimensional health burden linked with prolonged driving exposure and suboptimal working conditions. These results are broadly consistent with international evidence demonstrating that commercial drivers experience elevated levels of fatigue, stress, and chronic health conditions due to long duty hours, irregular schedules, and occupational exposures (2,4,5,8).

One of the most important findings of this study is the high prevalence of extended working hours, with 58% of drivers working more than 10 hours daily and 36% working nearly the entire month (27–30 days). These figures exceed international recommendations, such as European guidelines that limit daily driving to approximately 9–10 hours, underscoring a structural mismatch between regulatory standards and real-world practice in this context (13). Prolonged working hours are strongly associated with fatigue, reduced alertness, and impaired cognitive performance, all of which are known contributors to road traffic crashes (9,14). The observed significant association between fatigue and vehicle type ( $p = 0.021$ ), with bus and truck drivers experiencing higher fatigue levels than hiace drivers, further suggests that occupational structure, route characteristics, and passenger or freight responsibilities may differentially influence workload intensity and recovery opportunities.

The study also identified a clear age-related gradient in fatigue, with drivers aged 31–65 years having more than twice the odds of fatigue (OR = 2.07, 95% CI: 1.20–3.58) compared to younger drivers. This finding aligns with prior research suggesting that cumulative occupational exposure, declining physical resilience, and longer professional tenure contribute to increased fatigue and health vulnerability among older drivers (3,8). Although drivers above 65 years showed even higher fatigue prevalence, the lack of statistical significance likely reflects the small sample size in this subgroup rather than absence of effect. From an occupational health perspective, this age-related pattern highlights the need for differentiated work scheduling, periodic health assessment, and targeted interventions for aging drivers.

Lifestyle factors further compound the occupational risk profile observed in this study. A large proportion of drivers (64%) reported no engagement in physical exercise, and nearly half were overweight or obese (48.3% combined), reinforcing the sedentary nature of the profession. These findings are consistent with previous studies indicating increased BMI and metabolic risk among commercial drivers due to prolonged sitting, irregular meals, and limited opportunities for physical activity (2,4). Additionally, the significantly higher consumption of tea among HTV drivers (47.2%

consuming >3 cups daily vs. 25% in PSV drivers; OR = 2.67,  $p < 0.001$ ) may reflect compensatory strategies to counter fatigue, although excessive caffeine intake has been associated with sleep disturbance, irritability, and cardiovascular strain (7). This pattern suggests a cycle in which fatigue leads to increased stimulant use, which may in turn further disrupt sleep and recovery.

Environmental exposures represent another critical dimension of occupational risk identified in this study. A substantial proportion of drivers reported disturbance from smoke (63%), traffic noise (36%), and flash lights (45%), with measurable health consequences including respiratory symptoms (23.2%), hearing damage (6.6%), and vision impairment (27.5%). These findings are in agreement with environmental health literature linking air pollution, noise exposure, and glare with respiratory disease, sensory impairment, and reduced cognitive performance in transport workers (6,7). Notably, the study also identified seat vibration among 12.2% of truck/trailer drivers, with associated outcomes such as mental disturbance and musculoskeletal pain, supporting prior evidence that vibration exposure contributes to fatigue, back pain, and reduced driving comfort (3,5). Although environmental exposure levels were not instrumentally measured, the consistency of reported symptoms across domains suggests a meaningful occupational burden that warrants further investigation using objective exposure assessment methods.

A particularly striking finding is the high reported involvement in fatal accidents, especially among PSV drivers (59.3% vs. 30.5% in HTV drivers; OR = 3.21,  $p < 0.001$ ). While this measure is based on self-report and may reflect lifetime exposure rather than recent incidence, it nonetheless indicates a high-risk occupational environment. The higher risk among PSV drivers may be attributable to factors such as passenger pressure, time constraints, frequent stops, and exposure to urban traffic conditions, as noted in previous research on road safety in Pakistan (11,12). Additionally, behavioral factors such as unsafe driving practices by other road users, reported by 51% of PSV drivers, further contribute to an adverse driving environment that may increase crash risk.

Despite its strengths, including direct field data collection and coverage of multiple occupational domains, the study has several limitations. The cross-sectional design precludes causal inference and limits the ability to establish temporal relationships between exposures and outcomes (14,15). All health measures were based on self-report, introducing potential recall and reporting bias, and no clinical or environmental measurements were conducted to validate these findings. The sampling approach, although diverse, was field-based and dependent on driver availability, which may limit generalizability to the broader driver population. Additionally, some subgroup analyses were constrained by small sample sizes, particularly in older age categories.

Notwithstanding these limitations, the study provides important context-specific evidence on the occupational health profile of PSV and HTV drivers on a major national highway in Pakistan. The convergence of prolonged working hours, inadequate rest conditions, environmental exposures, and high prevalence of fatigue and sensory impairment underscores the need for integrated interventions at policy, regulatory, and workplace levels. These may include enforcement of working-hour limits, provision of rest facilities, improved vehicle safety equipment, health screening programs, and awareness initiatives focused on occupational health and safe driving practices.

## CONCLUSION

This study demonstrates a substantial burden of self-reported physical, psychological, and environmental health problems among PSV and HTV drivers operating on Pakistan's N-5 highway, characterized by prolonged working hours, inadequate rest practices, high exposure to noise, smoke, and glare, and significant prevalence of fatigue, sensory impairment, and respiratory symptoms. The observed associations between fatigue, age, and vehicle type, along with higher accident involvement among PSV drivers, highlight the influence of occupational structure on health and safety outcomes. These findings emphasize the need for targeted occupational health interventions, stricter enforcement

of driving regulations, and improved working conditions to enhance driver well-being and reduce road safety risks in this critical transport sector.

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