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Ageing and performance in professional bus driving – A case study from Chile

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ABSTRACT

The influence of age on driving is of great concern worldwide. Also, older people who are involved in traffic are more vulnerable than younger people, thus in the event of a traffic accident, they are at greater risk of dying. The purpose of this article is to explore the association between age and driving performance of professional bus drivers. A negative binomial regression model and the incidence rate ratio was used to explore the association between variables. The population studied consisted of the company records from 2005 to 2021, with 515 professional bus drivers. We found that the age of professional bus drivers was related to a statistically significant 4 % decrease in self-report of replacement requests. Also, we found that the incidence rate ratio of speeding in professional bus drivers aged 45–59 years and 60–77 years was 1.41 and 1.8 times the incidence of bus drivers aged 28–44 years. Bus drivers' age was related to a statistically significant 2 % increase in the incidence of minor accidents. Finally, results show a 1 % decrease in incidence of accidents for every one year of age in the group of professional drivers. However, that association was not statistically significant. Older drivers are more likely to engage in minor accidents and speeding-related violations than younger drivers. Additionally, an infrequent use of the fatigue management tool by older drivers was confirmed during the analyzed period. Thus, we concluded that education and training are needed to decrease the observed trends.

1. Introduction

Population ageing is one of the greatest challenges of the twenty-first century. Reductions in adult fertility and mortality rates lead demographic change towards an increase in the population average age (Ross, 2010; United Nations, 2019). According to United Nations projections for 2050, the population of people aged over 65 years are expected to be 15.9 % of the total global population, and 19 % of Latin America and the Caribbean population (United Nations, 2019). Given that, initiatives have emerged to face the population ageing, such as the Decade of Healthy Ageing 2020–2030, placing older people as the central axis to improve the quality of life of this age group (World Health Organization, 2020), which is based on previous guidelines (United Nations, 2002; World Health Organization, 2016; United Nations, 2015).

Ageing not only refers to the chronological passage of time but also to the physiological changes in sensory, motor and cognitive functions, which are critical for driving vehicles. Loss of sensory function as visual acuity, contrast sensitivity, glare sensitivity (Peelle, 2020), and peripheral field restriction (Haegerstrom-Portnoy et al., 1999; Karthaus and Falkenstein, 2016) are relevant since 80 %–90 % of vehicular traffic information is perceived through vision (Karthaus and Falkenstein, 2016); and commonly these losses are linked to collision accidents involving older drivers (Rolison et al., 2018). Loss of motor function such as flexibility, coordination, strength, and muscle power as a result of ageing may also impact the driving performance (Anstey et al., 2005; Karthaus and Falkenstein, 2016). For example, restricted neck rotation might impair the driver's ability to turn their head and see important stimuli on the periphery while driving in complex traffic situations, and when changing lanes (Anstey et al., 2005). Loss of cognitive function such as attention, executive functions, memory and psychomotor skills (Tinella et al., 2021), as a result of ageing impact the driving

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performance, and drivers make mistakes more frequently (Anstey and Wood, 2011). Research has associated visual, cognitive, and mobility impairment with collisions involving older drivers (Korner-Bitensky et al., 2009; Petridou and Moustaki, 2000; Rolison et al., 2018). Also, the systematic literature review performed by Jakobsen et al. (2022) shows that the risk of being involved in road crashes was higher for young, novice drivers and for older drivers, compared with middle-aged drivers and therefore an indication of a U-shaped risk factor curve.

Scientific literature confirms that older people who are involved in traffic are more vulnerable than younger people, thus in the event of a traffic accident, they are at greater risk of dying (Ang et al., 2017; Bravo et al., 2020; Lavallière et al., 2020). In the occupational field, the same trend is observed, and when older workers have accidents at work, these events tend to be more serious or fatal (Bravo et al., 2022; Peng and Chan, 2019). Thus, there is a major interest in studying the influence of age on driving. In the general population, older drivers have been reported to engage in self-regulatory behaviors for a safer driving performance, such as choosing less complex routes, making fewer mistakes, and making fewer lane changes (Mazer et al., 2021). A simulator-based study showed that older drivers have shorter time to react, control speed better, drive at a slower speed, have more difficulty in keeping distance with other vehicles, and get involved in a greater number of collisions (Doroudgar et al., 2017). However, driving at a slower speed as a self-regulatory strategy is controversial because there is no consensus on the results, since different naturalistic observation studies have shown that older drivers often drive above speed limits when driving at 30–60 km/h (Choukou et al., 2014; Cull et al., 2020). Finally, it should be noted that much of the research on driving and ageing has been placed in a non-occupational context. However, driving performance between professional and non-professional drivers is different (Chen et al., 2019; Chen et al., 2021; Dias et al., 2022). It has been observed through video analysis that professional drivers tend to behave more aggressively compared to general drivers. In addition, it has been found that characteristics such as the size of the vehicle can influence in the same way, in which drivers of heavy vehicles such as trucks or buses tend to behave more aggressively compared to drivers of lighter vehicles (Dias et al., 2022). Other important findings to mention are those presented using simulators, which show that older professional drivers tend to adopt more effective compensatory strategies than non-professional drivers (Chen et al., 2019; Chen et al., 2021). Thus, the following study aims to explore the association between age and driving performance in a bus driver company.

2. Methods

This research is based on a retrospective cohort study design and is part of the project called “Factors that influence the healthy and safe permanence of older drivers in the workforce”, which complies with all the ethical standards for the development of research in human beings. The research was submitted to and approved by the ethics committee of the Mutual de Seguridad de la Cámara Chilena de la Construcción.

2.1. Population studied

The population studied consisted of the company records between the years 2005 to 2021 of a company employing 515 bus drivers, located in Región de O’Higgins, Chile. Since the entire population was studied, a sample size calculation was not carried out.

2.2. Variables

The variables that will be used in the following study are presented in 3 groups. It is important to note that these variables were selected based on the data present in the company studied.

2.2.1. Independent variable

Age: In the study, workers’ age is the independent variable. Age was analyzed consecutively and categorized in three groups aged 28–44, 45–59, and 60–77 years. It is important to mention that the definition of older worker is usually associated with a cut-off point based on the workers’ chronological age that can vary from 40, 45, 50, 55, or 65 years (Peng and Chan, 2019). The first group is in the young workers category, and the other two groups are of older workers. The second groups aged 45–59 which can be considered as the workers closest to retirement (Bravo et al., 2022). Also, the third group matches the legal age a person is considered to be an older person in Chile (Ministry General Secretary of the Presidency, 2002). Thus in that group, people aged 60 years and older are workers and also older people. This definition of older people is used by the Inter-American Convention on the Rights of Older Persons (Organization of American States, 2015).

2.2.2. Dependent variable

Replacement request: This record is obtained when a driver reports a supervisor an inability to perform (due to drowsiness, illness or personal problems), and thus have to be replaced by another driver. Workers may activate it before starting a service or while on the road. For the latter, they are instructed to stop in a safe place and report by radio indicating C14 and wait for the replacement driver. Replacement request drills are performed to build the driver’s confidence in their reporting. From the company’s perspective, replacement requests are not punitive, quite the opposite, are considered a tool to support drivers in case they need it for ensuring their safety.

Speeding: It is the historical record of speeding over 10 km/h the maximum speed limit allowed in the area. This record is obtained per each driver by GPS measurement from the moment they join the company.

Minor accidents: Historical record of minor accidents per driver from the moment they join the company. It refers to low-energy crashes or collisions with minor consequences, which result mostly in material damages. In this case, there is no harm to people and no police personnel attend the site of the accident. The event may be reported by the driver responsible for the incident or by another driver when doing the pre-driving check.

Accidents: Historical record of accidents per driver from the moment they join the company. It refers to crashes or collisions. Unlike a minor accident, people get injured and police officers attend the site of the accident.

2.2.3. Covariates

BMI: Body Mass Index is a simple indicator of the relationship between weight and height, which is often used to screen individuals for weight categories: underweight, healthy weight, overweight, and obesity among adults. It is calculated by dividing a person’s weight in kilos by the square of their height in meters (kg/m^2).

Pathologies: The presence of pathologies in the group of bus drivers was recorded as Yes or No question. Database considered audiometric alterations, heart disease, diabetes, hypertension and optometry problems.

Type of bus: There are two types of bus, 24 and 44 seats. When joining the company, drivers start driving 24-seat buses, and later —depending on the quotas and driving performance— they are promoted to drive 44-seat buses.

Seniority: Corresponds to the number of years since the driver joined the company.

2.3. Statistical analysis

For this research, both a descriptive statistical analysis and an inferential statistical analysis were carried out. Firstly, a descriptive analysis was conducted considering all the variables included in the study. Secondly, due to all dependent variables related to driving

performance (replacement request, speeding, minor accidents and accidents) were counting variables, a negative binomial regression model was used for each of them, since this type of model allows adapting to the overdispersion of data and has previously been used in counting data to estimate of traffic accidents (Khattak et al., 2021). In addition, the incidence rate ratio (IRR) was calculated with their respective 95 % confidence intervals, the statistical significance was defined based on a p-value ≤ 0.05 and the workers aged 28–44 years was considered as a reference group. All statistical analyses were performed on STATA software, version 16.1 (StataCorp LLC, 2020). Models were adjusted for all covariates listed above.

3. Results

Table 1 shows the characteristics of the sample consisting of 515 bus drivers with an average seniority close to 8 years, and an average age close to 52 years, with more than 75 % of the sample aged 45 years or older. The average body mass index in the sample was 29 kg/m^2, and only 12 % (n = 62) of workers were categorized with a normal BMI. Regarding pathologies, 60 % of workers showed at least one pathology. On variables related to driving performance, we found that almost 70 % of the sample did not use the replacement request tool while driving; 65 % of drivers had at least one speeding event; 74 % had at least one minor accident; and only 9 % percent had at least one accident (Table 1). The entire data are not provided due to confidentiality issues.

3.1. Replacement request

When looking at the association between age and replacement request, we found that the bus drivers' age was related to a statistically significant 4 % decrease in self-report of replacement requests (IRR = 0.96; CI95: 0.94 – 0.98) (Table 2). When analyzing that association but considering the three age categories and interpreting it based on the inverse of the IRR, we found that the incidence of self-report of replacement requests of bus drivers aged 28–44 years was approximately 2.4 times the incidence of drivers aged 45–59 years (1/0.42 = 2.37) and 60–77 years (1/0.41 = 2.38). In both cases this association was statistically significant (Table 2).

Table 1
Main characteristics of the participants.

Variable	n (%) or M (SD)
Age (years)	51.68 (9.65)
Seniority (years)	8.44 (5.95)
Driver's position	
Bus 44 people	341 (66.21 %)
Bus 24 people	174 (33.79 %)
Age groups	
28–44 years	124 (24.08 %)
45–59 years	273 (53.01 %)
60–77 years	118 (22.91 %)
BMI (kg/m^2)	29.24 (3.77)
BMI categories	
Normal	61 (11.84 %)
Overweight	251 (48.74 %)
Mild obesity	167 (32.43 %)
Average obesity	34 (6.60 %)
Morbid obesity	2 (0.39 %)
Pathology	
No	208 (40.39 %)
Yes	307 (59.61 %)
Replacement request	
No	351 (68.16 %)
Yes	164 (31.84 %)
Speeding	
No	181 (35.15 %)
Yes	334 (64.85 %)
Minor accident	
No	132 (25.63 %)
Yes	383 (74.37 %)
Accidents	
No	468 (90.87 %)
Yes	47 (9.13 %)

n = number of individuals, % = percentage, M = mean, SD = standard deviation

3.2. Speeding

When analyzing the association between age and speeding, the bus drivers' age was related to a statistically significant increase in the incidence of speeding. For each year of age in the group of bus drivers, the incidence of speeding increased by 2 % (IRR = 1.02; IC95: 1.00–1) (Table 2). When analyzing this association but considering age as a categorical variable of three categories, we found that the incidence rate ratio of speeding of bus drivers aged 45–59 years and 60–77 years was 1.41 (IRR = 1.4; IC95: 0.94 – 2.11) and 1.8 (IRR = 1.77; IC95: 1.18–2.67) times the incidence of bus drivers aged 28–44, respectively. However, the association was only statistically significant in drivers aged 60–77 years (Table 2).

3.3. Minor accidents

On the one hand, in terms of the association between age and minor accidents, bus drivers' age was related to a statistically significant increase of 2 % in the incidence of minor accidents (IRR = 1.02; IC95: 1.01 – 1.03) (Table 2). On the other hand, when analyzing the three age categories, a statistically significant association was also found, in which the incidence of minor accidents in bus drivers aged 45–59 years was 1.3 times higher than in workers aged 28–44 years (IRR = 1.34; IC95: 1.03 – 1.74). While those workers aged 60 and older showed an incidence rate ratio of 1.8 times larger than the youngest reference group (IRR = 1.88; CI95: 1.42 – 2.49) (Table 2).

3.4. Accidents

Finally, by looking at the association between age and accidents, we found a 1 % decrease in the incidence of accidents for every one-year of age in the group of drivers. However, this association was not statistically significant (IRR = 0.99; IC95: 0.96 – 1.01). When analyzing the association considering age as a category, drivers aged 45–59 years had 2.3 times the incidence of accidents showed by workers aged 28–44 years (IRR = 2.27; CI95: 0.91 – 5.65). And drivers aged 60 years and older showed a lower incidence than the two younger groups (IRR = 0.97; IC95: 0.33 – 2.88). However, both associations were not statistically significant.

4. Discussion

The purpose of this study was to explore the association of age between occupational drivers and bus driving performance, assessed through speeding, replacement request, minor accidents and accidents. In general, the relationship between age and driving performance is as variable and diverse as the ageing process. Each of the variables is discussed below.

4.1. Replacement request

The replacement request while driving is a tool provided by the assessed company to take care of the workers. As mentioned above, drivers may use this tool at any time during their shift, since it is a safety-oriented tool. Becoming older proved to be significantly related to an infrequent use of this tool, which seems to be opposite to the typical literature on the subject, showing that younger drivers are more likely to keep driving despite showing drowsiness symptoms (Obst et al., 2011). However, we believe that this may have different readings. A positive reading could be that older drivers take better care of themselves, worry

Table 2
Association between age and bus driving skills.

	Speeding			Replacement request			Accident			Minor accident		
	IRR	95 %CI	P-Value	IRR	95 %CI	P-Value	IRR	95 %CI	P-Value	IRR	95 %CI	P-Value
Age (years)	**1.02**	**1.00–1.03**	**0.012**	**0.96**	**0.94–0.98**	**0.001**	0.99	0.96–1.01	0.430	**1.02**	**1.01–1.03**	**0.001**
Age Group												
18–44 years	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
45–59 years	1.41	0.94–2.11	0.095	**0.42**	**0.26–0.67**	**0.001**	2.27	0.91–5.65	0.077	**1.34**	**1.03–1.74**	**0.027**
60–77 years	**1.77**	**1.18–2.67**	**0.006**	**0.41**	**0.24–0.70**	**0.001**	0.97	0.33–2.88	0.970	**1.88**	**1.42–2.49**	**0.001**

IRR = Incidence Rate Ratio, 95 % CI = 95 % Confidence Interval. Significant P-values in bold. Models were adjusted for all covariates (BMI, Pathology, Type of bus and Seniority).

about resting before each shift, and use the replacement request tool less frequently. A negative reading could be related to some organizational aspects. The assessed company was formed entirely by male drivers, which could favor an organizational culture based on masculinity where the idea of a strong worker who does not need to be replaced is reinforced, since it could be seen as a sign of weakness among younger workers. Thus, older drivers may use to a lesser extent the replacement request to state occupational hierarchies and differentiate themselves from younger drivers, due to hegemonic masculinity. Also, regarding the organizational aspects there may be the idea of "getting signed off" by supervisors if using this tool. While the fear may be the same for all age groups, it is a fact that older people losing their jobs face greater difficulty in being re-employed. Another possible explanation for the small number of replacement requests by older drivers is that older drivers tend to overestimate their ability to drive (Huang et al., 2020) as they also tend to ignore the physical and mental deterioration caused by age. Finally, Fatigue Risk Management Systems can be categorized into predictive, proactive and reactive strategies (Sprajcer et al., 2022). The strategy used by this company on driving replacement request is a reactive one since it is based on reporting fatigue situations. The strategy favors the development of control measures to avoid fatigue-related incidents. A study on the voluntary fatigue reporting among pilots and cabin crew members of a short- and medium-haul flights airline, monthly reports identified fatigue-related hazards for eventual improving measures (Houston et al., 2012).

4.2. Speeding

On the one hand, contrary to the expectations by observing the general population, older drivers exceeded speed limits more than younger drivers. This was observed by analyzing age consecutively and per age groups. In the first case, an increase of 2 % was shown for each year. And in the second case, there was a pattern in which drivers aged 45–59 and 60–77 years showed higher rates than drivers aged 28–44 years. The results are in line with previous studies based on naturalistic observations, which have shown that older drivers drive above-established speed limits (Choukou et al., 2014; Cull et al., 2020). On the other hand, it seems to differ from those studies reporting a decrease in speed as a compensatory driving strategy taken by older drivers (Cantin et al., 2009). A study by Debnath et al. (2021) asked drivers to indicate the speeds at which they would choose to drive at 12 work zone sites. They found that young and middle-aged drivers reported higher speeds compared to older drivers. While in the study by Doroudgar et al. (2017), based on a driving simulator, found old drivers drive at a slower speed. The differences between both studies may be due to factors such as different methodologies and population samples of non-professional drivers. Thus, we believe that there was no decrease in speeding along with ageing in the current study, since professional drivers may not require as much compensatory strategies because they do not show difficulties when driving compared to other non-occupational older drivers. The study by Chen et al., 2021) shows that the adaptive behavior of professional drivers is different from non-professional drivers' behavior. They found that older non-professional drivers drove at a slower speed than young non-professional drivers. However, that association was not found in professional drivers. Also the vehicle type is something that should be considered, as it has been seen that truck or bus drivers tend to behave more aggressively compared to drivers of smaller vehicles (Dias et al., 2022).

4.3. Minor accidents

In this research, we found that age is related to an increase in minor accidents. However, there are no studies to compare these results, due to the fact that the "minor accident" category only considers minor damages to buses and does not consider harm to people or damage to other vehicles. A relevant aspect on the recording of minor accidents is that drivers must report the incidents. In addition, the bus is checked on a daily basis at the end of each shift, which decreases the risk of bias regarding unreported incidents.

An alternative to deal with these minor accidents are mixed interventions, that are combination of interventions based on education plus training on the road or simulator. Although these have been evaluated in a population of non-professional drivers, they offer a great opportunity to deal with the driving difficulties presented by the elderly (Castellucci et al., 2020).

4.4. Accidents

Similarly to some previous studies (Hamido et al., 2021; Newnam et al., 2018), our findings show that there are no statistically significant differences in accident reporting related to drivers aged 45–59 years. However, there is some data supporting a association, such as the study performed by Duke et al. (2010), in which they mention that younger drivers of heavy vehicles show higher rates of engaging in accidents, decreasing to the age of 63 years, to increase again. Similar results have been found in the general population regarding an improvement in driving as drivers get older (and get more driving experience), and a relapse passed a certain age (65 +) (Mayhew et al., 2003; Zhang et al., 1998).

4.5. Limitations

Some of the limitations of this research are, firstly, using a cross-sectional design, so causal relationships should not be established based on the findings of this study. Secondly, regarding variables related to driving performance, neither knowledge nor documentation was found on the reasons leading to driving replacement requests, speeding-violation zones, and type and cause of accidents. Knowing the reasons for driving replacement requests could lead to a better fatigue management, as in the Houston et al. (2012) study, which defined five patterns for fatigue: shifts assignment (shift-related effects), operational disruption (flight delays), layover accommodation (hotel issues), domestic matters (childcare), and other without an obvious cause. In terms of speeding, knowing the speed-violation zones is needed because, according to the data available, older people drive above the legal speed limits (Choukou et al., 2014). However, this could vary depending on

the speed limits of each zone and built environment (Ahmad et al., 2021). Identifying the type and cause of accidents could lead to a better understanding on why drivers aged 60 years and older get involved in a larger number of minor accidents but fewer accidents than drivers aged 28–44 years. Thirdly, extrapolating the research findings should be done carefully, since the study was performed on a population of professional drivers aged over 28 years old, and extrapolating the results to the general population would be a mistake. One of the strengths of this study is the use of GPS as a naturalistic driving research method for speeding assessment (Singh and Kathuria, 2021), enabling the analysis of actual conditions without interfering with drivers' behavior, considering that the use of GPS is part of the culture of the company assessed in this research.

4.6. Future research

Future research should consider longitudinal designs to explore the association between age and driving performance in an occupational setting. Also, a supporting alternative for future studies is the use of videography data, as it could allow further analysis by providing context to speeding events, incidents, and accidents (Arvin and Khattak, 2020). Finally, other variables such as gender and personality factors should be considered in future research.

5. Conclusion

This research based on recorded data for the management of occupational safety and health confirms that age affects bus driving performance. In the case of speeding and minor accidents, we found that older drivers are more likely to engage in these types of incidents. While in terms of age and accidents, it was not possible to establish a statistically significant association. Finally, infrequent use of the fatigue control tool by older drivers was confirmed, which may be explained by positive or negative reasons, depending on the interpretation provided.

CRediT authorship contribution statement

G. Bravo: Writing – original draft, Methodology, Formal analysis, Conceptualization. **H.I. Castellucci:** Writing – original draft, Project administration, Methodology, Funding acquisition, Formal analysis. **M. Lavallière:** Writing – review & editing, Visualization, Validation. **A. Campos:** Writing – review & editing, Visualization, Validation. **M. Martínez:** Visualization, Resources. **Imán Dianat:** Writing – review & editing, Visualization, Validation.

Declaration of competing interest

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

Data availability

The data that has been used is confidential.

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