

1 **DF-8: Specific scale for assessing work fatigue in professional drivers**

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3

4 **Abstract**

5

6 The study objective is to create a scale specifically for measuring driver fatigue and to  
7 analyze the scale's psychometric properties. The participants were 518 Spanish drivers. We  
8 carried out an exploratory factor analysis (EFA) and the first subsample obtained a single  
9 item solution (8 items). We then performed a confirmatory factor analysis (CFA) with a  
10 second subsample. The results were RMSEA=0.05, CFI=0.94 and TLI=0.92, which  
11 corroborates the previous results and maintains the same number of elements. The resulting  
12 dimension shows good reliability. The scale scores were then related to several external  
13 correlates and other scales and showed good convergence and criteria validity. The results  
14 indicate that the scale for assessing work fatigue specifically in professional drivers (Driver  
15 Fatigue (DF-8)) is a reliable and valid instrument.

16

17 **Keywords:** Fatigue; Transportation, Traffic safety; Professional Drivers; Scale.

18

## 19 **1. Introduction**

20           Driving fatigue is one of the most common risk factors related to traffic accidents (1–  
21 5). Its main cause is driving for too long without resting, in addition to other variables,  
22 including the characteristics of the vehicle, the driver, and the environment. Fatigue is usually  
23 considered to be a subjective complaint that can indicate tiredness, weakness, lack of energy,  
24 an intense desire to sleep, inability to concentrate, muscle weakness and even dyspnea.  
25 Philips (6) compiles the different available definitions of fatigue and proposes a new  
26 definition: “Fatigue is a suboptimal psychophysiological condition caused by exertion. The  
27 degree and dimensional character of the condition depends on the form, dynamics and  
28 context of exertion. The context of exertion is described by the value and meaning of  
29 performance to the individual; rest and sleep history; circadian effects; psychosocial factors  
30 spanning work and home life; individual traits; diet; health, fitness and other individual  
31 states; and environmental conditions. The fatigue condition results in changes in strategies or  
32 resource use such that original levels of mental processing or physical activity are maintained  
33 or reduced” (pp. 53).

34           We must keep in mind that people may have different thresholds for perceiving  
35 fatigue. Depending on the context, it can be related to the time spent working, studying,  
36 sleeping, etc. Therefore, fatigue can be considered as the changes an organism experiences  
37 when they go over their own limit of effort, which can occur in extreme conditions when  
38 doing a task for too long, not being used to doing a task, or to the specific intensity of doing a  
39 task (7).

40           Its characteristics are: 1) it results in a decrease in the person's capacity to respond or  
41 act; 2) it is a multicausal phenomenon, although its origin may be one specific factor; 3) it  
42 affects, to varying degrees, the organism as a whole (physical and psychic), each person  
43 perceives it in a different way in regard to the form and intensity in which it is expressed, and

44 situational factors and personal characteristics are also influential; 4) the feeling of fatigue is  
45 a bodily mechanism of great adaptive value since it indicates the need to rest (8).

46 Some authors highlight that fatigue is a complex sensation because it picks up  
47 physical and psychic symptoms, locating the person on a continuum that ranges from feeling  
48 good to feeling exhausted (9). This is very important to consider in a system that evaluates  
49 individual integrity, and it is also a determining factor in a person's willingness to do a task.  
50 This makes it especially important for assessing vehicle drivers. Davidović, Pešić and Antić  
51 (10) determined three factors that influence fatigue: 1) work factors, such as working long  
52 hours without having time to recover; 2) sleep factors, such as the alteration of circadian  
53 rhythms (driving at times when you usually sleep or vice versa), as well as the number of  
54 hours slept; and 3) other health factors such as sleep, health or lifestyle problems.

55 Fatigue monitoring systems have been developed (11,12) and the working conditions  
56 of professional drivers studied (13) with the aim of preventing the traffic accidents caused by  
57 fatigue.

58 There are health questionnaires that assess fatigue (14), but there are no specific scales  
59 for assessing the fatigue of professional drivers. Therefore, some authors quantify fatigue  
60 using scales of exercise intensity perception and relate the degree of fatigue to the intensity of  
61 the effort made (15,16). Nevertheless, and because the literature reviewed does not have a  
62 specific scale for professional drivers, we consider it necessary to develop a new instrument.  
63 Therefore, the objective of this study is to analyze the factorial structure and the  
64 psychometric properties of the Driver Fatigue scale (DF-8) for evaluating fatigue in  
65 professional drivers.

66

## 67 **2. Method**

### 68 *2.1. Participants*

69 A total of 518 professional drivers in the transport sector participated in the study. At  
70 the time of data collection, the participants were active, employed, or self-employed in different  
71 types of transport activities, such as transport of common goods, hazardous goods, specials,  
72 transport, urban passenger transport, regular, discretionary, sanitary, assistance and taxi lines,  
73 among others. Demographic characteristics are described in Table 1.

74

75 **INSERT TABLE 1 HERE**

76

## 77 *2.2. Instruments*

78 The DF-8 scale is a newly created scale for specifically assessing fatigue in  
79 professional drivers in the transport sector. First, we reviewed and analyzed the related  
80 literature. Second, a team of psychologists with experience in occupational risk prevention  
81 determined the range and variables to be measured (17–20), taking into account the context  
82 and the target population (the road transport sector). Brainstorming (21,22) and focus groups  
83 were used to (23) generate ideas for items (24), and create a bank of items (17,25). This was  
84 reduced to 30 items, which were used in the present study. The response format of the items  
85 was a Likert-type scale of one to five (1 = *never* to 5 = *always*).

86 The *Attitudes Toward Safety Regulations Scale* (ATSRS) (26) is a scale that measures  
87 drivers' attitudes towards safety rules, which has an impact on compliance with the  
88 regulations established for safe circulation. It consists of 13 items and measures three  
89 dimensions of drivers' attitudes towards safety rules: F1 (ENF, *Effectiveness of Enforcement*)  
90 consists of 5 items ( $\alpha = 0.81$ ; e.g.: "2. The authorities in charge of safety take dangerous  
91 drivers out of the way") and refers to the drivers' perceptions of the effectiveness of applying  
92 regulations that penalize drivers who do not obey road safety laws; F2 (ATT, *General*  
93 *Regulatory Attitudes*) consists of 4 items ( $\alpha = 0.80$ ; e.g.: "9. Safety standards in general have

94 become too strict in recent years"). This refers to the drivers' attitudes towards safety  
95 regulations and the influence that these attitudes have on obeying these laws. The third factor,  
96 F3 (EFF, *Regulatory Effectiveness*), consists in 4 items ( $\alpha = 0.70$ ; e.g.: "12. Regulations for  
97 driver health standards improve road safety"). This measures the drivers' perceptions of the  
98 effectiveness of the regulatory standards they must obey. The items in this scale are answered  
99 with a Likert-type scale from one to seven (1 = *completely disagree* to 7 = *completely agree*).

100 The Burnout scale (MBI-GS) (27) evaluates burnout and is comprised of 15 items (3  
101 subscales). The subscale of "Exhaustion ( $\alpha = 0.87$ )" includes 5 items (example: "6.-I'm  
102 'burned out' by work"). The subscale "Cynicism ( $\alpha = .85$ )" consists of 5 items (example, "9.-  
103 I've lost enthusiasm for my work"), and the subscale of "Professional efficiency ( $\alpha = 0.78$ )"  
104 includes 6 items (example: "12.- I have achieved many valuable things in this position"), with  
105 7-point Likert responses ranging from 0 = *Never / no time* to 6 = *Always / every day*.

106 The TRANS-18 Scale (28) for detecting safety behaviors (personal and in the vehicle)  
107 and psychophysiological disorders is made up of 18 items (3 subscales). "F1.  
108 Psychophysiological Disorders" of the driver ( $\alpha = 0.81$ ) relates to things that the driver may  
109 suffer from, such as anxiety, stress, depression, hypertension and digestive and  
110 musculoskeletal disorders (e.g., "8. My job has at some time caused me digestive problems  
111 (e.g. constipation)). "F2. Personal safety behaviors" ( $\alpha = 0.80$ ) refers to abstaining from  
112 driving after drinking alcohol or having a big meal as well as not eating and/or drinking while  
113 driving (e.g., "13. I don't eat a sandwich or cake, etc. while driving"). "F3.-Vehicle safety  
114 behaviors" ( $\alpha = 0.70$ ) refers to putting on work gloves to perform job tasks, knowing how to  
115 use extinguishers, being alert whilst driving and resting for the mandatory hours (e.g., "18.- I  
116 take a rest after every 4 hours of driving.").

117 The *Swedish Occupational Fatigue Inventory* (SOFI) (29) is used for  
118 multidimensional evaluation of work-related fatigue. The Spanish version (30) is composed

119 of five factors with 3 items each: "F1. Lack of Energy", which describes the general feelings  
120 of decreased strength,  $\alpha = 0.92$ ; e.g. 12. Exhausted (for example, having low energy). "F2.  
121 Physical Tiredness" describes bodily sensations that may be the result of dynamic work and,  
122 to some extent, a sign of metabolic depletion,  $\alpha = 0.87$ ; e.g. 15. Breathing with difficulty (for  
123 example, it is difficult to inhale and exhale). "F3. Physical Discomfort" represents the most  
124 local bodily sensations that may result from the static or isometric workload,  $\alpha = 0.81$ ; e.g. 8.  
125 having stiff joints (for example elbows, knees, etc.). "F4. Lack of motivation" describes the  
126 feeling of not being implicated or excited,  $\alpha = 0.92$ ; e.g. 10. Indifferent (for example, it does  
127 not matter if there is one thing or another). And "F5. Drowsiness" describes feelings of  
128 tiredness,  $\alpha = 0.89$ ; e.g. 13. Sleepy (for example, feeling heaviness and being clumsy due to  
129 tiredness). Items on this scale are answered in a Likert-type scale from zero to ten (0 =  
130 *nothing at all* to 10 = *a lot*).

131 Finally, a set of correlates such as age, level of academic training, etc. were used.

132

### 133 2.3. Procedure

134 We used non-probabilistic sampling (31), also called random-accidental sampling  
135 (32), to obtain the sample. Participants answered voluntarily without receiving any economic  
136 or other compensation. Participants were selected through the social and business network.  
137 Participants were informed that the data obtained are completely confidential and  
138 anonymous. A protocol was prepared for participants and they answered it in their usual  
139 workplace. This protocol included a cover letter, informed consent, and response  
140 questionnaires.

141

### 142 2.4. Data Analysis

143

144 Data were analyzed as follows: First, using the program FACTOR 8.2 (33),  
145 Exploratory Factor Analysis (EFA) was performed with polychoric correlation matrices,  
146 which allow parallel analysis (34). The program also makes it possible to evaluate the  
147 internal consistency of the scales used in this research. Second, the Mplus program (Version  
148 6.12) was used for confirmatory factor analysis (CFA). Therefore, the results obtained by the  
149 EFA were validated with the AFC (35). Third, the SPSS program (25.0) was used to calculate  
150 the validity evidence through Pearson's correlations.

151

### 152 **3. Results**

153

#### 154 *3.1. Exploratory Factor Analysis*

155 The results of the Bartlett sphericity test ( $\chi^2$ ,  $df=20 = 55.224$ ;  $p = 0.00$ ) show that the  
156 AFE is appropriate (36). The sample adequacy is 0.918. Parallel analysis (34,37) and the  
157 “minimum partial partial” criterion of Velicer (1976) confirmed that the eight item  
158 unifactorial solution is adequate (Table 2). The Promin rotation method was used to establish  
159 the EFA (39). The variance explained was 46.00%.

160

161 **INSERT TABLE 2 HERE**

162

#### 163 *3.2. Confirmatory Factor Analysis*

164

165 A CFA was applied (Figure 1) to check the adequacy of the unifactorial structure,  
166 taking the previous EFA as a reference. We use the following goodness of fit indicators:  
167 Tucker-Lewis Index (TLI) (40), Comparative Fit Index (CFI) (40) and Root Mean Square  
168 Error of Approximation (RMSEA) (41). Thus, there is a certain unanimity in which values  
169 equal to or greater than 0.90 in the TLI and CFI are acceptable. They are considered excellent  
170 when they exceed the value of 0.95 (40). The RMSEA is considered acceptable when it is

171 less than 0.08 and excellent when it is equal to or less than 0.05 (42,43). In addition, all  
172 saturations range between 0.77 and 0.68. The results obtained (RMSEA = 0.05; CFI = 0.94;  
173 TLI = 0.92) indicate a good fit of the unifactorial model.

174

175 **INSERT FIGURE 1 HERE**

176

### 177 *3.3. Reliability*

178 Table 3 shows the average of the scale if the element is deleted, the total correlation  
179 of elements corrected, and Cronbach's  $\alpha$  if the element has been deleted. The total reliability  
180 of the scale in sample 1 is 0.88, with a confidence interval of 0.85 and 0.90. In sample 2 the  
181 total reliability is 0.84, with a confidence interval of 0.81-0.86. The values are therefore  
182 higher than the recommended value of 0.70 (44).

183

184 **INSERT TABLE 3 HERE**

185

### 186 *3.4. Validity Evidence*

187 The evidence of validity was calculated using the correlations between the scale (DF-  
188 8), several external correlates and the four contrast scales used (Table 4). For sample 1 we  
189 found nineteen correlations that are significant, of which there are eighteen positive  
190 correlations. The following positive correlations stand out: Exhaustion ( $r = 0.74, p < 0.01$ )  
191 and Lack of energy ( $r = 0.73, p < 0.01$ ). The one negative association was for the safety  
192 behaviors in the vehicle ( $r = -0.19, p < 0.05$ ). In sample 2, we found twenty-two significant  
193 correlations. Among the seventeen positive correlations, the following stand out: Exhaustion  
194 ( $r = 0.65, p < 0.01$ ) and Lack of energy ( $r = 0.67, p < 0.01$ ). Of the five negative correlations

195 found, we can highlight personal efficacy ( $r = -0.19, p < 0.01$ ) and number of children ( $r = -$   
196  $0.19, p < 0.01$ ).

197

198 **INSERT TABLE 4 HERE**

199

#### 200 **4. Discussion**

201 In the present study we have developed the Fatigue in Professional Drivers (FD) scale  
202 and examined its psychometric properties. This instrument makes it possible to specifically  
203 assess the degree of fatigue in professional vehicle drivers quickly.

204 The scale has been validated in two samples ( $n_1 = 246$  and  $n_2 = 272$ ). The results  
205 obtained confirm our objectives and indicate that: 1) The internal structure is unifactorial.  
206 The internal structure was analyzed with CFA, obtaining an RMSEA = 0.05, CFI = 0.94 and  
207 TLI = 0.92. Therefore, the objective is fulfilled, as the factor structure was the best we have  
208 obtained. 2) The scale has optimal reliability (0.88 and 0.84). 3) The scale shows adequate  
209 evidence of validity, measured through external indicators, in both samples. The results  
210 demonstrate that the analyzed scale correlates significantly with other scales and with other  
211 external correlates.

212 In conclusion, the statistical analyses performed indicate that the Fatigue in  
213 Professionals Drivers (FD-8) scale has a unifactorial structure and determines appropriate  
214 statistical indexes (45). This short instrument is easy, quick, and agile to apply. It is also easy  
215 to interpret and understand.

216

#### 217 **5. Implications**

218 This scale allows fatigue in professional drivers to be evaluated. Since the scale has  
219 good psychometric properties, the results provide important practical information about the

220 driver's state. Human resources can manage this information strategically to improve the  
221 occupational health of this group of workers and prevent accidents. In addition, the scale  
222 allows prevention professionals to obtain reliable data through evaluations based on scientific  
223 evidence. Addressing this factor may greatly help to identify factors that help workers to  
224 improve their health and companies to reduce the number of collisions and traffic violations.

225         The limitations include that the use of self-reports can be a source of errors, such as  
226 social desirability (46). We also found that in the studied population there were very few  
227 women who drive professionally; therefore, it would be convenient to conduct a study in a  
228 sample with a higher representation of the female gender.

229

230 **References**

- 231
- 232 1. Li MK, Yu JJ, Ma L, Zhang W. Modeling and mitigating fatigue-related accident risk  
233 of taxi drivers. *Accid Anal Prev* [Internet]. 2019 [cited 2019 Jun 13];123:79–87.  
234 Available from: <https://doi.org/10.1016/j.aap.2018.11.001>
- 235 2. Li Y, Yamamoto T, Zhang G. Understanding factors associated with misclassification  
236 of fatigue-related accidents in police record. *J Safety Res*. 2018 Feb 1;64:155–62.
- 237 3. Neisa CM, Rojas YA. Fatiga Laboral , Accidentes e Incidentes Laborales en los  
238 Conductores de Carga Pesada de una Empresa Transportista de la ciudad de Yopal  
239 [Accidents and Occupational Incidents in Heavy Cargo Drivers of a Transport  
240 Company in the city of Yopal]. *Cuad Hispanoam Psicol*. 2009;10(1):7–21.
- 241 4. Useche SA, Cendales BE, Gómez V. Measuring Fatigue and its Associations with Job  
242 Stress, Health and Traffic Accidents in Professional Drivers: The Case of BRT  
243 Operators. *EC Neurol*. 2017;4(4):103–18.
- 244 5. Zhang G, Yau KKW, Zhang X, Li Y. Traffic accidents involving fatigue driving and  
245 their extent of casualties. *Accid Anal Prev* [Internet]. 2016 [cited 2019 Jun 13];87:34–  
246 42. Available from: <http://dx.doi.org/10.1016/j.aap.2015.10.033>
- 247 6. Phillips RO. A review of definitions of fatigue - And a step towards a whole definition.  
248 *Transp Res Part F Traffic Psychol Behav*. 2015;29:48–56.
- 249 7. Muchinsky P. *Psicología aplicada al trabajo*. México, DF: International Thomson  
250 Editores SA; 2002.
- 251 8. Norman R. *Psicología Industrial* [Industrial Psychology]. Madrid, ESP: Rialp, S.A.;  
252 1999.
- 253 9. Barrientos-Gutiérrez T, Martínez-Alcántara S, Méndez-Ramírez I. Construct validity,  
254 reliability, and cutoff point of the Subjective Symptoms of Fatigue Test in Mexican  
255 workers. *Salud Publica Mex*. 2004 Dec;46(6):516–23.

- 256 10. Davidović J, Pešić D, Antić B. Professional drivers' fatigue as a problem of the  
257 modern era. *Transp Res Part F Traffic Psychol Behav* [Internet]. 2018 [cited 2020 May  
258 11];55:199–209. Available from: <https://doi.org/10.1016/j.trf.2018.03.010>
- 259 11. Barr L, Howarth H, Popkin S, Carroll RJ. A review and evaluation of emerging driver  
260 fatigue detection measures and technologies [Internet]. US Department of  
261 Transportation, Washington. United States. Federal Motor Carrier Safety  
262 Administration; 2005 Jun [cited 2019 Jun 13]. Available from:  
263 <https://rosap.ntl.bts.gov/view/dot/34394>
- 264 12. Stern HS, Blower D, Cohen ML, Czeisler CA, Dinges DF, Greenhouse JB, et al. Data  
265 and methods for studying commercial motor vehicle driver fatigue, highway safety and  
266 long-term driver health. *Accid Anal Prev* [Internet]. 2019 May 1 [cited 2019 Jun  
267 13];126:37–42. Available from:  
268 <https://www.sciencedirect.com/science/article/pii/S0001457518300836>
- 269 13. Makowiec-Dąbrowska T, Gadzicka E, Siedlecka J, Szyjkowska A, Viebig P, Kozak P,  
270 et al. Climate conditions and work-related fatigue among professional drivers. *Int J*  
271 *Biometeorol* [Internet]. 2019 Feb 8 [cited 2019 Jun 13];63(2):121–8. Available from:  
272 <http://link.springer.com/10.1007/s00484-018-1643-y>
- 273 14. Dittner AJ, Wessely SC, Brown RG. The assessment of fatigue: A practical guide for  
274 clinicians and researchers. *J Psychosom Res* [Internet]. 2004 Feb 1 [cited 2020 Jun  
275 13];56(2):157–70. Available from:  
276 <https://www.sciencedirect.com/science/article/abs/pii/S0022399903003714?via%3Dihub>  
277 ub
- 278 15. Gil-Moreno-De-Mora G, Palmi-Guerrero J, Prat-Subirana JA. Valoración de la  
279 percepción subjetiva de la fatiga en motoristas de competición Rally-Raid Dakar  
280 [Assessment of the Subjective Perception of Fatigue in Competition Motorcyclists

- 281 Rally-Raid Dakar]. *Acción Psicológica* [Internet]. 2017 [cited 2020 Jun 13];14(1):93.  
282 Available from: <http://dx.doi.org/10.5944/ap.14.1.19265>
- 283 16. Marcora SM, Staiano W, Manning V. Mental fatigue impairs physical performance in  
284 humans. *J Appl Physiol* [Internet]. 2009 Mar [cited 2020 Sep 13];106(3):857–64.  
285 Available from: <http://www.physiology.org/doi/10.1152/jappphysiol.91324.2008>
- 286 17. Haladyna TM. *Developing and Validating Test Items*. Developing and Validating Test  
287 Items. New York: Taylor & Francis Group; 2014.
- 288 18. Martínez M, Moreno R, Muñiz J. Construcción de los ítems [Construction of items].  
289 In: Muñiz J, Fidalgo MA, García-Cueto E, Martínez R, Moreno R, editors. *Análisis de*  
290 *los ítems* [Item analysis]. Madrid, SP: La Muralla; 2005. p. 9–52.
- 291 19. Morales P, Urosa B, Blanco AB. Construcción de escalas de actitudes tipo Likert  
292 [Construction of Likert-type attitude scales]. Madrid, SP: La Muralla; 2003.
- 293 20. Wilson M. *Constructing measures: An item response modeling approach*. Constructing  
294 *Measures: An Item Response Modeling Approach*. New York: Routledge; 2004. 1–213  
295 p.
- 296 21. Canto JM. *Dinámica de grupos: aspectos técnicos, ámbitos de intervención y*  
297 *fundamentos teóricos* [Group dynamics: technical aspects, areas of intervention and  
298 *theoretical foundations*]. Aljibe, editor. Málaga, SP; 2000.
- 299 22. Gil F. *Técnicas para generar ideas y para solucionar problemas* [Techniques for  
300 *generating ideas and solving problems*]. In: *Técnicas grupales en contextos*  
301 *organizacionales* [Group techniques in organizational contexts]. Madrid, SP: Pirámide;  
302 2004. p. 145–70.
- 303 23. Morgan DL. *The Focus Group Guidebook*. Focus Group Kit 1. Thousand Oaks, Ca:  
304 Sage; 1998.
- 305 24. Crotty M. *The foundations of social research: meaning and perspective in the research*

- 306 process. St. Leonards, NSW: Allen and Unwin; 1998. 248 p.
- 307 25. Schmeiser CB, Welch C. Test development. In: Brennan RL, editor. Educational  
308 measurement. Westport, CT: American Council on Education / Praeger; 2006. p. 307–  
309 53.
- 310 26. Douglas MA, Swartz SM. A multi- dimensional construct of commercial motor  
311 vehicle operators' attitudes toward safety regulations. *Int J Logist Manag* [Internet].  
312 2009 Aug 14 [cited 2020 Feb 20];20(2):278–93. Available from:  
313 <https://www.emerald.com/insight/content/doi/10.1108/09574090910981341/full/html>
- 314 27. Salanova M, Schaufeli WB, Llorens S, Peiró JM, Grau R. Desde el "burnout" al  
315 "Engagement" ¿una nueva perspectiva? [From the 'Burnout' to 'Engagement', a new  
316 perspective?]. *J Work Organ Psychol*. 2000;16(2):117–34.
- 317 28. Boada-Grau J, Sánchez-García JC, Prizmic-Kuzmica AJ, Vigil-Colet A. Health and  
318 Safety at Work in the Transport Industry (TRANS-18): Factorial Structure, Reliability  
319 and Validity. *Span J Psychol*. 2012 Mar 10;15(1):357–66.
- 320 29. Åhsberg E, Gamberale F, Kjellberg A. Perceived quality of fatigue during different  
321 occupational tasks: Development of a questionnaire. *Int J Ind Ergon* [Internet]. 1997  
322 Aug 1 [cited 2019 Oct 7];20(2):121–35. Available from:  
323 <https://www.sciencedirect.com/science/article/abs/pii/S0169814196000443>
- 324 30. González-Gutiérrez JL, Moreno-Jiménez B, Garrosa E, López A. Spanish version of  
325 the Swedish Occupational Fatigue Inventory (SOFI): Factorial replication, reliability  
326 and validity. *Int J Ind Ergon* [Internet]. 2005 Aug 1 [cited 2019 Jun 20];35(8):737–46.  
327 Available from:  
328 <https://www.sciencedirect.com/science/article/abs/pii/S0169814105000442>
- 329 31. Hernández R, Fernández C, Baptista P. Metodología de la Investigación [Investigation  
330 methodology]. México: McGraw-Hill Interamericana; 2004.

- 331 32. Kerlinger FN, Lee HB. Investigación del Comportamiento. Métodos de investigación  
332 en ciencias sociales [Behavioral research: Methods of research in the social sciences].  
333 4th ed. México, DF: McGraw-Hill Interamericana; 2002.
- 334 33. Lorenzo-Seva U, Ferrando PJ. FACTOR: A computer program to fit the exploratory  
335 factor analysis model. Behav Res Methods [Internet]. 2006 [cited 2018 Sep 10];38:88–  
336 91. Available from: <http://www.springerlink.com/index/10.3758/BF03192753>
- 337 34. Timmerman ME, Lorenzo-Seva U. Dimensionality assessment of ordered polytomous  
338 items with parallel analysis. Psychol Methods [Internet]. 2011 [cited 2018 Sep  
339 10];16:209–20. Available from: <http://doi.apa.org/getdoi.cfm?doi=10.1037/a0023353>
- 340 35. Pérez-Gil JA, Chacón-Moscoso S, Moreno-Rodríguez R. Validez de constructo: El uso  
341 de análisis factorial exploratorio-confirmatorio para obtener evidencias de validez  
342 [Construct validity: The use of exploratory-confirmatory factor analysis to obtain  
343 evidence of validity]. Psicothema. 2000;12(2):442–6.
- 344 36. Kaiser HF. An index of factorial simplicity. Psychometrika [Internet]. 1974 Mar [cited  
345 2018 Sep 11];39:31–6. Available from: <http://link.springer.com/10.1007/BF02291575>
- 346 37. Lattin J, Carroll J, Green P. Analyzing multivariate data. Pacific Grove, CA: Duxbury  
347 Press; 2003.
- 348 38. Velicer WF. Determining the number of components from the matrix of partial  
349 correlations. Psychometrika [Internet]. 1976 [cited 2018 Sep 10];41:321–7. Available  
350 from: <http://link.springer.com/10.1007/BF02293557>
- 351 39. Lorenzo-Seva U. Promin: A method for oblique factor rotation. Multivariate Behav  
352 Res [Internet]. 1999 [cited 2018 Sep 10];34:347–65. Available from:  
353 [http://www.tandfonline.com/doi/abs/10.1207/S15327906MBR3403\\_3](http://www.tandfonline.com/doi/abs/10.1207/S15327906MBR3403_3)
- 354 40. Lévy-Mangin J-P, Varela-Mallou J. Modelización con estructuras de covarianzas en  
355 ciencias sociales : temas esenciales, avanzados y aportaciones especiales [Modeling

- 356 with covariance structures in social sciences: essential, advanced topics and special  
357 contributions]. Coruña, Spain: Gesbiblo, S.L.; 2006. 119 p.
- 358 41. Fan X, Sivo SA. Sensitivity of fit indices to model misspecification and model types.  
359 *Multivariate Behav Res* [Internet]. 2007 [cited 2018 Sep 17];42:509–29. Available  
360 from: <https://www.tandfonline.com/doi/full/10.1080/00273170701382864>
- 361 42. Bentler PM. Comparative fit indexes in structural models. *Psychol Bull* [Internet].  
362 1990 [cited 2018 Sep 17];107:238–46. Available from:  
363 <http://doi.apa.org/getdoi.cfm?doi=10.1037/0033-2909.107.2.238>
- 364 43. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis:  
365 Conventional criteria versus new alternatives. *Struct Equ Model* [Internet]. 1999 [cited  
366 2018 Sep 17];6:1–55. Available from:  
367 <http://www.tandfonline.com/doi/abs/10.1080/10705519909540118>
- 368 44. Nunnally JC, Bernstein IH. *Psychometric Theory* (McGraw-Hill Series in  
369 Psychology). New York: McGraw-Hill; 1994. 583 p.
- 370 45. Tabachnick BG, Fidell LS. *Using multivariate statistics*, 5th ed. [Internet]. Using  
371 multivariate statistics, 5th ed. Boston, MA: Allyn & Bacon/Pearson Education.; 2007  
372 [cited 2018 Sep 17]. 980 p. Available from: [http://psycnet.apa.org/record/2006-03883-](http://psycnet.apa.org/record/2006-03883-000)  
373 000
- 374 46. Ferrando PJ, Chico E. Adaptación y análisis psicométrico de la escala de deseabilidad  
375 social de Marlowe y Crowne [Adaptation and psychometric analysis of the Marlowe  
376 and Crowne social desirability scale]. *Psicothema* [Internet]. 2000 [cited 2018 Sep  
377 10];12:383–9. Available from: <http://www.redalyc.org/articulo.oa?id=72712309>
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380 Table 1.

381

382 *Summary of the sociodemographic variables of the participants in the two subsamples.*

| Variable                                    |   | (n <sub>1</sub> =246) | (n <sub>2</sub> =272) |
|---|---|-----------------------|-----------------------|
| <b>Gender (%)</b>                           | Men   | 90.7                  | 91.5                  |
|   | Women   | 9.3                   | 8.5                   |
| <b>Age (years)</b>                          |   | M=41.42 (SD=13.93)    | M=40.37 (SD=12.44)    |
| <b>Marital status (%)</b>                   | Married   | 60.2                  | 59.3                  |
|   | Single  | 10.6                  | 10.4                  |
|   | Widowed   | 18.7                  | 22.6                  |
|   | De-facto union                                      | 9.8                   | 6.3                   |
|   | Divorced / Separated                                | 0.8                   | 1.5                   |
| <b>Children (number)</b>                    |   | M=1.40 (SD=1.06)      | M=1.29 (SD=1.14)      |
| <b>Educational level</b>                    | Without studies.                                    | 4.9                   | 2.6                   |
|   | Completed primary education                         | 19.9                  | 18.9                  |
|   | Completed secondary education                       | 52.8                  | 48.1                  |
|   | Finished university studies                         | 17.5                  | 23.0                  |
| <b>Professional group</b>                   | Transport of common goods                           | 39.8                  | 42.6                  |
|   | Transportation of dangerous goods                   | 5.7                   | 4.1                   |
|   | Transportation of special merchandise               | 2.8                   | 3.0                   |
|   | Crane transport                                     | 3.7                   | 1.1                   |
|   | Urban passenger transport                           | 8.5                   | 9.3                   |
|   | Intercity passenger transport                       | 8.5                   | 7.4                   |
|   | Discretionary passenger transport (trips, charters) | 4.9                   | 3.0                   |
|   | Health transport                                    | 8.9                   | 5.6                   |
|   | Transportation assistance                           | 0.8                   | 0.7                   |
|   | Taxi  | 11.4                  | 14.1                  |
|   | Others  | 4.9                   | 9.3                   |
| <b>Distance from home to workplace (km)</b> |   | M=19.71 (SD=52.27)    | 23.52 (SD=71.83)      |
| <b>Weekly work (hours)</b>                  |   | M=45.23 (SD=17.59)    | 45.28 (SD=16.39)      |
| <b>Action ratio (%)</b>                     | International-Europe                                | 14.2                  | 14.1                  |
|   | Spain   | 26.4                  | 34.4                  |
|   | Catalonia (region)                                  | 26.8                  | 19.3                  |
|   | Province  | 32.5                  | 32.2                  |

383

Table 2

*Saturation matrix of the factors in the Driver Fatigue Scale DF-8 (n<sub>1</sub>=246) and other aspects.*

| Content Item   | SD    | F1    | Media | Variance | Skewness | Kurtosis<br>(Zero centered) |
|--|-------|-------|-------|----------|----------|-----------------------------|
| 1. Me deja cansado (exhausto) repartir mercancías o llevar a la gente a su destino. [It makes me tired (exhausted) to distribute goods or take people to their destination].                               | 0.141 | 0.773 | 2.134 | 0.998    | 0.492    | -0.622                      |
| 2. Me siento débil cuando termino de conducir el autobús, camión, combi, furgoneta, taxi, etc. [I feel weak when I finish driving the bus, truck, combi, van, taxi, etc.].                                 | 0.138 | 0.768 | 1.711 | 0.655    | 1.079    | 0.978                       |
| 3. Los nervios conduciendo me provocan malestar físico. [Driving nerves cause me physical discomfort].   | 0.092 | 0.733 | 1.955 | 1.071    | 1.019    | 0.589                       |
| 4. Cuando conduzco el vehículo tengo los músculos tensos y siento malestar. [When I drive the vehicle, my muscles are tense and I feel uncomfortable].   | 0.099 | 0.704 | 1.907 | 0.942    | 0.993    | 0.618                       |
| 5. Me siento cansado nada más empezar la jornada de trabajo en el autobús, camión, combi, furgoneta, taxi, etc. [I feel tired as soon as I start the workday on the bus, truck, combi, van, taxi, etc.].   | 0.202 | 0.703 | 1.711 | 0.655    | 1.079    | 0.978                       |
| 6. Me agota el ritmo de trabajo cuando conduzco en exceso. [The pace exhausts me when I drive too much].   | 0.149 | 0.695 | 2.659 | 1.352    | 0.253    | -0.755                      |
| 7. Me noto muy cansado cuando despierto. [I feel very tired when I wake up].   | 0.131 | 0.686 | 2.280 | 1.027    | 0.479    | -0.288                      |
| 8. Necesito tomar café u otro tipo de estimulante para poder estar más despierto al conducir el vehículo. [I need to drink coffee or another type of stimulant to be more awake when driving the vehicle]. | 0.117 | 0.686 | 2.415 | 1.452    | 0.468    | -0.682                      |
| Variance Explained (46.00 %)   |       |       |       |          |          |                             |

Table 3.

*DF-8: Reliability (Item and factor) for the two subsamples.*

| Items                          | <i>(n<sub>1</sub>=246)</i> |            |            | <i>(n<sub>2</sub>=272)</i> |            |            |
|--------------------------------|----------------------------|------------|------------|----------------------------|------------|------------|
|                                | <i>(a)</i>                 | <i>(b)</i> | <i>(c)</i> | <i>(a)</i>                 | <i>(b)</i> | <i>(c)</i> |
| 1                              | 14.96                      | 0.69       | 0.86       | 14.98                      | 0.636      | 0.814      |
| 2                              | 15.06                      | 0.68       | 0.86       | 15.13                      | 0.649      | 0.812      |
| 3                              | 15.14                      | 0.67       | 0.86       | 15.39                      | 0.636      | 0.815      |
| 4                              | 15.19                      | 0.65       | 0.86       | 15.37                      | 0.510      | 0.829      |
| 5                              | 15.39                      | 0.60       | 0.87       | 15.45                      | 0.561      | 0.824      |
| 6                              | 14.44                      | 0.61       | 0.86       | 14.54                      | 0.524      | 0.828      |
| 7                              | 14.82                      | 0.64       | 0.86       | 14.77                      | 0.573      | 0.822      |
| 8                              | 14.68                      | 0.61       | 0.87       | 14.76                      | 0.529      | 0.830      |
| <i>M Scale</i>                 |                            | 17.10      |            |                            | 17.20      |            |
| <i>SD Scale</i>                |                            | 6.07       |            |                            | 5.54       |            |
| Total reliability of the scale |                            | 0.88       |            |                            | 0.84       |            |
| Confidence interval            |                            | 0.85-0.90  |            |                            | 0.81-0.86  |            |

- 385 (a) M scale if element is deleted.  
386 (b) Total correlation of corrected elements.  
387 (c) Cronbach's  $\alpha$  if the item has been deleted.  
388

Table 4.

*DF-8: Indications of validity of the scale with external correlates and contrast scales (ATRS, MBI-GS, TRANS-18, SOFI) of the two samples (n1 = 246 and n2 = 272).*

|                               |  | <i>n</i> <sub>1</sub> =246            | <i>n</i> <sub>2</sub> =272 |               |
|-------------------------------|--|---------------------------------------|----------------------------|---------------|
|                               |  | F1                                    | F1                         |               |
| Socio-demographic             | Age (years).   | -0.01                                 | <b>-0.17**</b>             |               |
|                               | Number of children   | 0.06                                  | <b>-0.19**</b>             |               |
| Correlates External           | Number of minutes you are sitting when you work.   | <b>0.13*</b>                          | 0.09                       |               |
|                               | Number of minutes you walk when you work.  | -0.01                                 | 0.17                       |               |
|                               | Number of partners with whom you interact.   | -0.5                                  | -0.08                      |               |
|                               | Number of orders received by your supervisor.  | 0.2                                   | <b>0.13*</b>               |               |
|                               | How many days have you felt tired or without energy during the past week?  | 0.10                                  | <b>-0.27**</b>             |               |
|                               | How many times have you felt tired or without energy for more than 3 hours on any day last week?                     | <b>0.35**</b>                         | <b>0.27**</b>              |               |
|                               | How many times have you felt so tired to the point that you had to force yourself to do things during the past week? | <b>0.18**</b>                         | <b>0.28**</b>              |               |
|                               | How many times have you felt tired or without energy doing things you enjoy during the last week?                    | <b>0.30**</b>                         | <b>0.19**</b>              |               |
|                               | How many complaints from suppliers, passengers and users have you received?  | <b>0.16**</b>                         | 0.05                       |               |
|                               | How many days have you missed work because you were sick?  | -0.02                                 | -0.01                      |               |
|                               | How many days have you been to work while sick?  | <b>0.24**</b>                         | <b>0.15**</b>              |               |
|                               | How many times have the police made you obey the traffic or transit regulations?                                     | 0.09                                  | <b>0.18**</b>              |               |
|                               | How many times have you miscalculated the size of your vehicle and damaged it?                                       | <b>0.16**</b>                         | 0.01                       |               |
|                               | How many times have you taken a wrong road or route when driving due to lack of attention?                           | <b>0.19**</b>                         | <b>0.20**</b>              |               |
|                               | How many times have you driven so distracted that you almost crashed?  | <b>0.28**</b>                         | <b>0.15*</b>               |               |
|                               | <b>ATRS</b>  | F1.- Effectiveness of the application | -0.05                      | -0.04         |
|                               |  | F2.- General regulatory attitudes     | <b>0.18**</b>              | <b>0.17**</b> |
| F3.- Regulatory effectiveness |  | 0.01                                  | 0.08                       |               |
| <b>MBI-GS</b>                 | Exhaustion   | <b>0.74**</b>                         | <b>0.65**</b>              |               |
|                               | Cynicism   | <b>0.52**</b>                         | <b>0.44**</b>              |               |
|                               | Personal effectiveness   | -0.09                                 | <b>-0.19**</b>             |               |
| <b>TRANS-18</b>               | F1.-Psychophysiological disorders  | <b>0.64**</b>                         | <b>0.53**</b>              |               |
|                               | F2.-Personal safety behaviors  | -0.02                                 | -0.00                      |               |
|                               | F3.-Safety behaviors in the vehicle  | <b>-0.19*</b>                         | <b>-0.14*</b>              |               |
| <b>SOFI</b>                   | F1.-Lack of Energy   | <b>0.73**</b>                         | <b>0.67**</b>              |               |
|                               | F2.-Physical Tiredness   | <b>0.57**</b>                         | <b>0.48**</b>              |               |
|                               | F3.-Physical Discomfort  | <b>0.69**</b>                         | <b>0.61**</b>              |               |
|                               | F4.-Lack of motivation   | <b>0.57**</b>                         | <b>0.61**</b>              |               |
|                               | F5.-Drowsiness   | <b>0.57**</b>                         | <b>0.58**</b>              |               |

\*\* p < 0.01; \* p < 0.05

390 Note: ATRS. Attitudes Toward Safety Regulations Scale  
 391 DF-8. Driver Fatigue  
 392 MBI-GS. Maslach Burnout Inventory-General Survey  
 393 SOFI. Swedish Occupational Fatigue Inventory  
 394 TRANS-18. Scale to detect safe behaviors  
 395

396 *Figure 1.* DF-8 ( $n_2=272$ ): Confirmatory factor analysis of the scale ( $\chi^2 =$   
397 55.224;  $df = 20$ ;  $P\text{-value}=0.0000$ ; TLI= 0.92; CFI= 0.94; RMSEA= 0.05).