



Developing effective professional bus driver health programs: An investigation of self-rated health

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ABSTRACT

The health of professional bus drivers is a critical factor in their driving performance; any impairment may lead to undesired consequences. In an attempt to develop and prioritize health and wellness programs, this study investigates the factors significantly affecting the health conditions of professional bus drivers, as well as the strength of these factors. This study uses self-rated health as the examination measurement. This simple assessment is an inclusive measure of health status for judging health trajectory, and is highly associated with changes in functional ability, including perceived control over driving. This study evaluates driver responses of self-rated health with ordered response models that consider factors such as the driver reported health problems, physical and psychological conditions, demographic factors, driving experience, and working environment. Analysis of a sample of 785 drivers shows that age, body mass index, depression, daily working hours, perceived company safety culture, and health problems are the factors significantly affecting self-rated health. Depression has the greatest effect among all factors except health problems. Unlike the linear relationships for the other factors, the relationships between depression levels and perceived health are S-shaped. The results of ordered response models suggest that these influential factors have distinct effects on the self-rated health of individual drivers and on the different levels of self-rated health.

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1. Introduction

Professional drivers have a tremendous effect on public safety. In particular, the physical and psychological health of professional drivers is critical factors in driving performance. Any impairment may lead to undesirable consequences for drivers, passengers, and operators alike. Even today, when technologies, such as auto brake systems in railroad transportation, have been developed to reduce the adverse effects of professional drivers being suddenly incapacitated, professional drivers are classified as safety critical workers or high level safety workers (National Transport Commission of Australia, 2004). Their health conditions may lead to serious incidents affecting the public or the transport network. Professional bus drivers, who have less help from advanced technologies than train operators and pilots, require more cautious health management. This is why bus drivers are the subject of this study.

Due to their working environment and job characteristics, professional bus drivers are vulnerable to specific health problems.

Continuous whole-body vibration, sedentary nature of driving, fatigue, tight timetables, irregular shift schedules, and various stressors from the driving environment (such as customer complaints and heavy traffic) make bus drivers more likely to suffer from musculoskeletal problems, cardiovascular diseases, and gastrointestinal complaints. Bus drivers also have a higher level of work-related stress than individuals in other occupations (Kompier and Dimartino, 1995; Magnusson et al., 1996; Tse et al., 2007; Tuchsien and Endahl, 1999; Wang and Lin, 2001). Professional bus drivers sometimes experience trauma at work, including injuries or deaths due to traffic accidents. This trauma can induce post-trauma stress disorder (PTSD), and might consequently lead to physical health problems, work burnout, and substance abuse (Chen and Cunradi, 2008; Issever et al., 2002; Vedantham et al., 1999).

The vulnerability of professional bus driver health and its importance to driving performance have prompted governments and companies to provide various health and wellness programs that typically involve regular health examinations. Health examinations can provide valuable information about the examinee's current health condition. However, health examinations do not capture the complete state of physical, mental, and social well being of examinees due to the restrictions and limitations of examination time, budgets, procedures, and equipment (Idler and Benyamini, 1997). The field of psychosocial epidemiology has attempted to develop

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other measurements to investigate the health condition of individuals in addition to health examinations. Relevant measurements include smoking, alcohol use, overweight, and perceived health.

This study measures perceived health, or self-rated health, by asking respondents to rate their overall health as being excellent, good, fair, or poor. While health self-rating provides a global and simple assessment, previous studies have shown that this measure is an inclusive and accurate measure of health status and health risk factors for judging trends, and not only the current level of health (Idler and Benyamini, 1997). Self-rated health is also a reliable predictor of mortality, is highly associated with changes in functional ability (such as perceived control over driving), and possesses satisfactory validity and reliability (Idler and Benyamini, 1997; Idler and Kasl, 1995; Kaplan and Camacho, 1983; Windsor et al., 2008). Accordingly, this study uses perceived health as a tool to investigate professional bus driver health.

The aim of this study is to investigate the perceived health conditions of professional bus drivers and explores factors significantly affecting perceived health. Identifying these significant factors and how their strengths are associated with self-rated health could allow companies and governments to develop and prioritize health and wellness programs for professional bus drivers. The considered factors include professional bus driver health problems, physical and psychological conditions, demographic factors, and working environment. A sample of 785 professional bus drivers was collected in a national survey in Taiwan. The collected responses of self-rated health formed an ordinal variable that is analyzed using four types of ordered response models: the conventional ordered logit model and three other ordered response models considering the heterogeneity of individual respondents and the heterogeneous effects of factors on different levels of perceived health.

The remainder of this paper is organized as follows. Section 2 introduces the survey plan, the selected variables and associated measures, and the applied ordered response models. Section 3 presents the analysis results, followed by discussions in Section 4.

2. Methodology

2.1. Survey

The dataset in this study comes from a government research project, a preliminary study aiming at exploring the relationships between the health conditions of professional driver and their driving safety in Taiwan (Wong, 2009). The survey was conducted from October to November 2009, with a response rate of 87.1%. The participants were randomly chosen from driver lists acquired by the government, and asked about their health conditions, physical and psychological statuses, socio-demographic conditions, driving experience, and working environment. The anonymous questionnaires were mailed with self-addressed envelopes enclosed. The completed questionnaires were returned directly to the research team.

2.2. Selected variables and associated measures

This study has one dependent variable, perceived health, and adopts three types of explanatory variables: the physical and psychological conditions of drivers, demographic factors, and driving experience and working environment, as detailed below.

2.2.1. Perceived health

Researchers have proposed different ways to ask respondents regarding their self-rated health. However, previous studies have shown that the concept of self-rated health is relatively insensitive to the semantic variations in the questions eliciting the self-rating

(Idler and Benyamini, 1997). This study asks professional drivers to compare their health to that of others of the same age to dismiss age-related conditions. The question is stated as follows: "How is your health, compared with others your age? Is it better, same, or worse?" Other studies have also used similar questions (Ho, 1991; Jagger and Clarke, 1988).

2.2.2. Physical and psychological conditions

This study considers indicators representing the physical and psychological conditions of professional drivers, including reported health problems (RHP), depression levels, stress levels, sleep quality, and burnout. The RHP variable is coded as 1 if respondents had experienced any health problems in the previous year. Note that reported health problems include not only problems diagnosed by medical specialists, but also general discomfort and pains.

The depression level is measured using the Taiwanese depression scale. This scale is designed specifically for Taiwanese people aged 18 or above, and has satisfactory reliability and validity (Chen et al., 2010). The scale consists of 18 items with a four-point Likert scale coded from 0 to 3. The global score ranges from 0 to 54; a score of 19 or above suggests the possibility of depression, and a score of 29 or above indicates a need for professional medical treatment.

Stress is measured using Siegrist's effort/reward imbalance model. This model postulates that psychological strain results from the interaction between job demands and job control. The combination of low control and high demands produces job strain; this undesired property is a condition experienced by professional bus drivers (Tse et al., 2006). The adopted scale consists of 17 items; the first six items measure a participant's efforts, followed by 11 items measuring the rewards (Tseng and Cheng, 2002). The items are rated on a five-point Likert scale coded from 1 to 5. The global score is calculated as the sum of effort scores divided by the sum of reward scores with adjustment of the number of items. A score of 1 represents a balance between effort and reward, while a score above 1 indicates disproportionate effort.

Sleep quality is measured using the Pittsburg sleep quality index (PSQI), representing the professional driver sleep quality and disturbance retrospectively over a one-month period based on self-reports (de Pinho et al., 2006; Sabbagh-Ehrlich et al., 2005). The PSQI produces a global score between 0 and 21. The inventory consists of seven components, including sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. A participant scoring higher than 5.0 is typically classified as having poor sleep quality.

Burnout level is measured using the Copenhagen burnout inventory (CBI) developed by Kristensen et al. (2005). The adopted inventory (Chang et al., 2007; Yeh et al., 2007) consists of 19 items, seven of which are specifically for work-related burnout, the focus of this study. Each item is recorded on a five-point scale, with responses ranging from always (score 100) to never (0), or very seriously (100) to very slightly (0). The global score represents the average of these seven items.

2.2.3. Demographic factors

The demographic factors concerned in this study include professional driver age, gender, and body mass index (BMI). The BMI is computed as the weight (kilogram) divided by the square of height (square of centimeter). According to the Department of Health, Taiwan, a BMI value equal to or greater than 24 is considered overweight.

2.2.4. Driving experience and working environment

This study considers five variables for driving experience and working environment, including driving experience, years of service, daily driving hours, daily working hours, and perceived company safety culture. The driving experience variable measures

Table 1
Variables and definitions.

Definition (label)	Definition or measure	Category (coding) or range
Perceived health condition	Perceived level compared with same generation	Worse (0), similar (1), better (2)
Reported health problems	Health problems in the previous year	No (0), yes (1)
Depression level	Taiwan depression scale	0–54
Stress level	Effort/reward imbalance model	Nonnegative
Sleep quality	Pittsburg sleep quality index	0–21
Burnout level	Copenhagen burnout inventory	0–100
Age	Years	
Gender	Male or female	Male (1), female (0)
Body mass index	Weight (kg)/Height ² (m ²)	
Driving experience	No. of years driving buses	
Years of service	No. of years servicing in the current company	
Daily driving time	Average driving hours per day	
Daily working time	Average working hours per day	
Safety culture	Global aviation network scale	25–125

the number of years that respondents have been driving large passenger buses (ten seats or more, or 3.5 Tons or heavier). The years of service variable represents the number of years that a respondent has been with the current company. The daily driving hours and working hours refer to the average hours that a respondent drives and works during a typical day.

Finally, the perceived company safety culture is measured using a scale developed by the Global aviation network (GAIN, 2001). This scale is a general, and less activity-specific, safety culture survey. By adopting this scale, this study can compare various types of organizations and activities, including bus companies (Bjornskau and Longva, 2009). The scale consists of 25 items covering various safety-relevant issues: management attitude and focus on safety, the attitude and focus on safety among employees, culture of reporting, and reactions to reported errors and incidents. These items are measured with a five-point Likert scale ranging from 1 (disagree completely) to 5 (agree completely). The global score is computed as the sum of the 25 items, ranging from 25 to 125. A global score of 92 or above indicates good safety culture.

Table 1 summarizes the selected variables and their definitions and associated measures.

2.3. Ordered response models

This study uses ordered response models to investigate self-rated health, which is an ordered response variable in this study. Ordered logit and ordered probit models are the most conventional ordered response models, and usually yield similar results. The difference between these two models is their specified distribution for the disturbance: the ordered logit model specifies it as a logistic distribution, while the ordered probit model specifies it as a normal distribution. Assuming that the perceived health condition of a professional driver is an ordered discrete variable with m categories, an ordered logit model in terms of probability can be written as:

$$Pr(y_i > j | \mathbf{X}) = g(\mathbf{X}_i \boldsymbol{\beta}'_j) = \frac{\exp(\mathbf{X}_i \boldsymbol{\beta}'_j - \phi_j)}{1 + \exp(\mathbf{X}_i \boldsymbol{\beta}'_j - \phi_j)}, \quad j = 1, \dots, m - 1 \tag{1}$$

where \mathbf{X}_i is a $k \times 1$ vector of observed explanatory variables, $\boldsymbol{\beta}$ is a $k \times 1$ vector of unknown parameters to be estimated, and m is the number of categories of the ordinal dependent variable. The parameters of the model ($\boldsymbol{\beta}$) and the cut points (the ϕ_j s) are estimated using the method of maximum likelihood (Quddus et al., 2010).

The model presented in Eq. (1) assumes that the effects of explanatory variables on perceived health are fixed across observations. However, this may not be true. Researchers have proposed different approaches to deal with this problem. This study focuses on two approaches: the first approach is to release the assumption that the unknown parameters, the elements in $\boldsymbol{\beta}$, are invariant

across all outcome groups. This is typically referred as the proportional odds assumption, or the parallel regression assumption. The improved model is called a generalized ordered logit model, and can be written as follows:

$$Pr(y_i > j | \mathbf{X}) = g(\mathbf{X}_i \boldsymbol{\beta}'_j) = \frac{\exp(\mathbf{X}_i \boldsymbol{\beta}'_j - \phi_j)}{1 + \exp(\mathbf{X}_i \boldsymbol{\beta}'_j - \phi_j)}, \quad j = 1, \dots, m - 1 \tag{2}$$

The difference between Eqs. (1) and (2) is the subscript of the unknown parameter vector ($\boldsymbol{\beta}$), j , which represents the distinct effect on the different levels of perceived health. While the generalized ordered logit model is extremely flexible, some elements in $\boldsymbol{\beta}$ may not need to vary. To balance the flexibility and succinctness of the model, Williams (2006) proposed a partial proportional odds model in which only a subset of coefficients are constrained across different categories of the dependent variable. This model can be written as follows:

$$Pr(y_i > j | \mathbf{X}) = g(\mathbf{X}_i \boldsymbol{\beta}'_j) = \frac{\exp(\mathbf{X}_{1i} \boldsymbol{\beta}'_{1j} + \mathbf{X}_{2i} \boldsymbol{\beta}'_2 - \phi_j)}{1 + \exp(\mathbf{X}_{1i} \boldsymbol{\beta}'_{1j} + \mathbf{X}_{2i} \boldsymbol{\beta}'_2 - \phi_j)}, \tag{3}$$

$$j = 1, \dots, m - 1$$

where \mathbf{X}_{1i} represents the vector containing the variables with distinct effect across the categories of the dependent variable, and $\boldsymbol{\beta}'_{1j}$ is the associated vector of unknown parameters. By contrast, \mathbf{X}_{2i} represents the vector containing the variables with fixed effects across the categories of the dependent variable, and $\boldsymbol{\beta}'_2$ is the associated vector of fixed effects.

The second approach to improving the conventional ordered logit model is to release the assumption of fixed variation across all respondents, i.e., the homoskedasticity assumption. This improved model is a location-scale model, or heterogeneous choice model. A model form presented by Williams (2009) can be written as follows:

$$Pr(y_i > j | \mathbf{X}) = g\left(\frac{\mathbf{X}_i \boldsymbol{\beta}'_j}{\sigma_i}\right) = \frac{\exp((\mathbf{X}_i \boldsymbol{\beta}'_j / \sigma_i) - \phi_j)}{1 + \exp((\mathbf{X}_i \boldsymbol{\beta}'_j / \sigma_i) - \phi_j)}, \tag{4}$$

$$j = 1, \dots, m - 1$$

where σ_i refers to the variance corresponding to respondent i .

3. Results

3.1. Characteristics of professional bus drivers

The dataset in this study included the responses of 785 professional bus drivers. Approximately 60% of them reported their perceived health as being similar to others their age, while one-

Table 2
Characteristics of professional bus drivers ($N = 785$).

Variable (unit)	Mean	Standard deviation
Age (years)	42.15	8.23
Gender (male percentage)	98.09%	0.14
Company service year (years)	6.44	6.10
Driving experience (years)	9.66	8.10
Daily driving time (h)	9.24	1.87
Daily working time (h)	10.58	2.50

third reported better health and 5% reported worse health. Table 2 summarizes the basic characteristics of these drivers. The average age of the respondents was 42.15 years old, with approximately 10 years of driving experience. On average, drivers had been with their current company for six years. The associated standard deviation is relatively high, indicating the widespread coverage of respondents: young and old, and novice and experienced. The majority of current professional bus drivers in Taiwan are males, as reflected by the sampled male percentage. The daily average driving time is approximately 9 h, with one more hour for other tasks, such as cleaning the bus and being on standby.

Table 3 summarizes the physical and psychological conditions and perceived company safety culture, including depression level, stress level, sleep quality, and burnout level. This study uses Cronbach's α to measure the reliability of these measurements. As Table 3 shows, most of the measurements exhibited satisfactory reliability, with Cronbach's α values exceeding the conventional threshold of 0.7. Stress level and sleep quality have two Cronbach's α values because these two measurements consist of more than one dimension of underlying concepts. The stress measurement contains two opposite concepts: effort and reward. Table 3 shows that both of these concepts have satisfactory reliability. Sleep quality, which is measured using the Pittsburgh sleep quality index, consists of seven components that reflect distinct aspects of sleep quality. Consequently, it is not uncommon for a Cronbach's α value to be below 0.7 (Carpenter and Andrykowski, 1998), as Table 3 shows. Conversely, sleep disturbance, the only component containing more than two items in PSQI, has a satisfactory Cronbach's α value of 0.83.

The average respondent had a BMI value of 25.45, depression level of 5.4, stress level of 0.44, sleep quality of 5.73, burnout level of 22.66, and perceived safety culture of 99.83. These results indicate that most individuals are overweight (value exceeds 24¹) but can adjust their emotions well, feel little stress (effort less than reward) but have insufficient sleep quality (value exceeds 5), and perceive that their company has a good safety culture (value exceeds 92).

To explore the distribution of drivers' physical and psychological conditions and perceived company safety culture further, boxplots are provided in Fig. 1. The BMI range recommended for Taiwanese people is between 18.5 and 24; BMI values over 24 and 27 are regarded as overweight and obese, respectively (Ho and Tsai, 2007). As shown in Fig. 1(a), more than half of the bus drivers have a BMI level of 25 or above; and over a quarter of bus drivers present a BMI level over 30. The result indicates that being overweight is a common issue for Taiwanese bus drivers, and a number of them have obesity problems.

Using a Taiwanese depression scale, if the score exceeds 19, professional assistance is recommended. As shown in Fig. 1(b), most bus drivers have no clear depression syndrome; however, the average score of 5.40 (std = 6.69, $n = 785$) is significantly higher than the average score of 3.26 (std = 5.92, $n = 1552$) reported in a previous

¹ The BMI range recommended for Taiwanese people is between 18.5 and 24; BMI values over 24 and 27 are considered to be overweight and obese, respectively (Ho and Tsai, 2007).

study whose subjects were general Taiwanese people (Yen et al., 2005). This result indicates a depression issue in Taiwanese bus drivers, especially those who score over 19.

The cutoff level for the stress score (the effort-reward ratio) is 1; a stress score above 1 is regarded stressful. As shown in Fig. 1(c), only approximately 6.5% of the bus drivers felt stress regarding their job. This percentage is lower than various high-stress jobs in Taiwan, such as the high-tech industry; approximately 11% of high-tech industry employees reported an imbalanced effort-reward ratio using the same scale (Tseng and Cheng, 2002). However, several outliers are observed in panel (c); these bus drivers require particular attention.

A PSQI score over 5 is regarded as poor sleep quality. As shown in Fig. 1(d), approximately half of the bus drivers have poor sleep quality. The average PSQI score of bus drivers is 5.73 (std = 2.70, $n = 785$), which is significantly worse than the average score of 4.93 (std = 2.30, $n = 120$) reported in a previous study whose subjects were Taiwanese military air pilots (Chu et al., 2004).

There is no specific cutoff level for the Copenhagen burnout index. Fig. 1(e) shows a right-skewed distribution of the burnout levels, indicating a score concentration of a relatively low level.

A safety culture score over 92 is regarded as perceiving good safety culture in the work environment. Fig. 1(f) shows three-fourths of the bus drivers perceive good safety culture, although a few bus drivers still perceive an extremely poor safety culture.

The trends shown in Table 3 indicate significant correlations between the physical and psychological conditions of respondents and their perceived safety culture. These relationships are taken into consideration when developing statistical models in the following analysis.

3.2. Estimates of ordered response models

This study uses four types of models to analyze data: ordered logit, heterogeneous choice, generalized ordered logit, and partial proportional odds models. Brant tests are conducted to determine whether the parallel lines assumption of the ordered logit model is violated (Long and Freese, 2006). If the Brant test reveals significant results, then the generalized ordered logit and partial proportional odds models should be considered. The necessity of using the heterogeneous model is tested using the stepwise procedure suggested by Williams (2009). Results show that the effect of the variable depression (DP) on the level of perceived health condition varies across the different thresholds and individuals. Therefore, this variable is considered in the variance structure for the development of heterogeneous choice models and in the release of parallel constraints for the development of partial proportional odds models.

This study develops four types of models using the aforementioned variables. The coefficient significance and goodness-of-fit indexes are used to investigate the best model for each model type based on a backward selection procedure. The final variables selected for each model type are identical, including reported health problems, age (AGE), body mass index, daily average working hour (WRK), depression level, and safety culture (SC). Table 4 summarizes the results.

The results of the ordered logit model show that professional drivers who reported health problems were less likely to perceive better health than those who did not report health problems. Older professional drivers with lower body mass indexes, shorter working hours, lower depression levels, and higher levels of perceived safety culture were more likely to perceive better health. The results of the heterogeneous choice model reveal a similar pattern. The positive coefficient of the depression level in the variance equation reveals that professional drivers who perceived a higher level of

Table 3
Reliability, mean, and correlation of drivers' physical and psychological conditions, and perceived company safety culture.

Measurement	Cronbach's α	Mean (SD)	Correlation					
			DP	ST	SP	BO	SC	
Body mass index (BMI)	N/A ^a	25.45 (3.57)	1					
Depression level (DP)	0.93	5.40 (6.69)	0.02	1				
Stress level (ST)	Effort: 0.87 Reward: 0.90	0.44 (0.35)	0.10 [*]	0.52 [*]	1			
Sleep quality (SP)	Global: 0.62 Disturbance: 0.83	5.73 (2.70)	0.02	0.37 [*]	0.32 [*]	1		
Burnout level (BO)	0.86	22.66 (16.88)	0.01	0.58 [*]	0.56 [*]	0.42 [*]	1	
Safety culture (SC)	0.98	99.83 (17.26)	-0.05	-0.31 [*]	-0.43 [*]	-0.24 [*]	-0.40 [*]	1

^a BMI is a single measurement and thereby has no Cronbach's α value.
* $p < 0.05$.

depression varied more in their perceived health than those who perceived a lower level of depression.

The generalized ordered logit models in this study produce two sets of coefficients. The left column under the generalized ordered logit model in Table 4 reveals the variable effects by comparing the "worse" and "at least similar" (i.e., including responses as "similar" and "better") levels of perceived health. The right column shows the effects by comparing the "at most similar" (i.e., including responses as "worse" and "similar") and "better" levels. These two columns exhibit coefficients with sign patterns identical to the previous two models. However, the impact strength of explanatory variables is somewhat different in these two columns. In the left column, the RHP and DP coefficients are more negative than those in the right column, indicating that having health problems and being

more depressed increases the likelihood of driver health worsening rather improving. By contrast, the more negative the BMI and WRK coefficients are, and the more positive the SC coefficients in the right column are, the more a driver's health can deteriorate as a result of higher BMI values, longer working hours, and lower safety culture levels.

This study examines the significance of these differences using Wald chi-square tests (Williams, 2006). The results of partial proportional odds model indicate that DP is the only variable having a significant effect on the various levels of self-rated health. Table 4 shows that the estimated effects of DP on the two thresholds are both negative and significant, implying a lower likelihood of perceiving better health conditions for professional bus drivers with a higher level of depression. Furthermore, the variable DP has a more

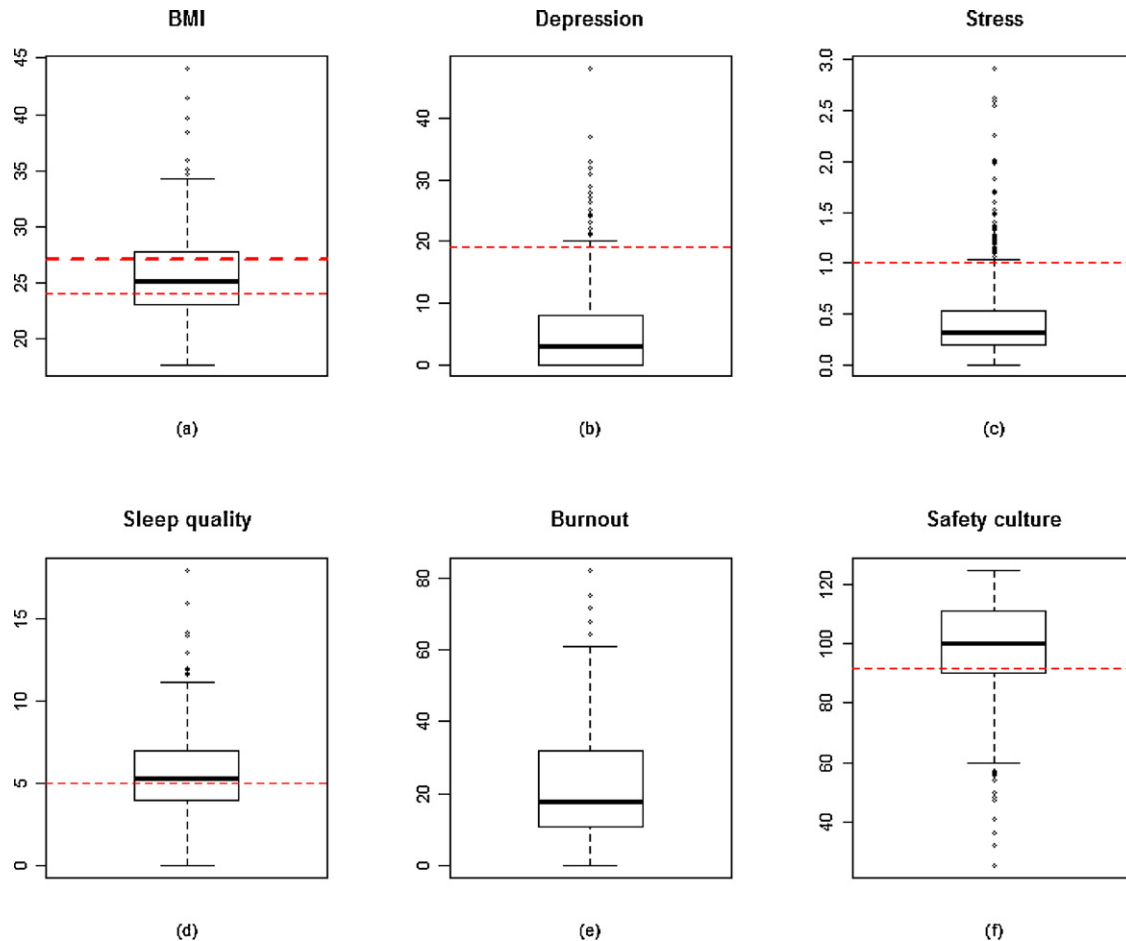


Fig. 1. Boxplots of drivers' health and wellness measurements.

Table 4
 Estimation results for the Ordered Logit, Heterogeneous Choice, Generalized Ordered Logit, and Partial Proportional Odds models.

	Models							
	Ordered logit	Heterogeneous choice	Generalized ordered logit		Partial proportional odds			
			Threshold between worse and similar	Threshold between similar and better	Effect not varying by threshold	Threshold between worse and similar	Threshold between similar and better	
Variables affecting the perceived health condition level								
Reported health problems (RHP)	−1.0434 ^{***}	−1.1464 ^{***}	−1.5740 ^{**}	−1.0086 ^{***}	−1.0557 ^{***}			
Age (AGE)	0.0261 ^{**}	0.0281 ^{**}	0.0530 [*]	0.0227 [*]	0.0262 ^{**}			
Body mass index (BMI)	−0.0541 [*]	−0.0643 ^{**}	−0.0423	−0.0566 [*]	−0.0537 [*]			
Daily average working hour (WRK)	−0.0560 [~]	−0.0563	−0.0373	−0.0566 [~]	−0.0558 [~]			
Depression level (DP)	−0.0698 ^{***}	−0.1076 ^{***}	−0.1064 ^{***}	−0.0486 ^{**}		−0.1058 ^{***}		−0.0493 ^{**}
Safety culture (SC)	0.0151 ^{**}	0.0179 ^{***}	0.0046	0.0179 ^{**}	0.0158 ^{**}			
Variables affecting the error variance								
Depression (DP)		0.0283 ^{***}						
Statistics								
Cut point 1	−3.8160	−4.9852 ^{***}	−4.0552 [~]		−4.1725 ^{***}			
Cut point 2	0.5664	0.6400	0.7319		0.7252			
Log-likelihood at convergence	−557.69	−550.53	−553.10		−554.94			
LR chi-square	139.45	153.77	148.63		144.95			
Degrees of freedom	6	7	12		7			
McFadden pseudo-Rho square	0.111	0.123	0.118		0.116			
AIC	1,131.381	1,119.066	1,134.204		1,127.885			
BIC	1,168.707	1,161.057	1,199.524		1,169.876			

[~] $p < 0.1$.

^{*} $p < 0.05$.

^{**} $p < 0.01$.

^{***} $p < 0.001$.

obvious effect on a driver's likelihood of reporting a worse health condition than a better health condition.

While these four models all provide plausible results, the goodness-of-fit indexes presented in the bottom of Table 4 indicate that the heterogeneous choice model is the best model. These results show that the heterogeneous choice model has the best fit in terms of the least negative log-likelihood at convergence, the largest LR chi-square, the best McFadden pseudo-rho square, and the smallest AIC and BIC values.

3.3. Marginal effects of explanatory variables

This study estimates the marginal effects of explanatory variables to compare the coefficients within and across different models. Marginal effects exhibit the effect of changes in one variable on the probability of each possible outcome occurring while all the other variables remain fixed at their average level. For a dichotomous explanatory variable, the marginal effect represents the effect as the variable changes from 0 to 1. For continuous variables, this study measures the instantaneous rate of change (Williams, 2009). Table 5 summarizes the marginal effects derived from the best model (the heterogeneous choice model) and the conventional ordered logit model.

Table 5 shows that the reported health problems variable exhibits the largest marginal effect among all the variables, followed by the depression level. Conversely, age and safety culture show the least marginal effects among these variables.

The signs of the marginal effects in the “worse” and “better” categories are opposite for all variables. This indicates that a variable that increases the probability of feeling worse health than that of their peers decreases the probability of perceiving better health, and vice versa. Most professional bus drivers reported their health condition as being similar to that of their peers. The middle of Table 5 demonstrates how changes of explanatory variables affect the probability of this category. Professional bus drivers who reported health problems had a higher probability of perceiving similar health. Younger drivers with a higher BMI, longer working hours, higher levels of depression, and perceiving lower levels of safety culture reported that their perceived health was similar to that of their peers.

The marginal effects for the variables RHP, AGE, BMI, WRK, and SC are similar between the ordered logit and the heterogeneous choice models. These are the five variables that are excluded in the variance equation of the heterogeneous choice model. By contrast, the DP variable is unique. While both models agree that depression has a significant negative effect on a professional bus driver's self-rated health, the marginal effect estimated in the ordered logit model is only half of that estimated in the heterogeneous model in the “worse” level of perceived health. Moreover, the marginal effect of depression is similar to the marginal effect of working hours in the “worse” level of perceived health in the ordered logit model, but four times higher in the heterogeneous choice model. This means that the conventional ordered logit model can underestimate the effect of depression on driver health. The ordered logit model also overestimates the positive and negative effects of depression in the “similar to” and “better than” health conditions. In short, the ordered logit model, which ignores the heteroskedasticity across individuals, distorts the estimated effects on the various levels of perceived health.

3.4. Conditional predicted probabilities

To better understand how changes in an explanatory variable affect the probabilities of various perceived health conditions, Fig. 2 plots the predicted probabilities against one specified explanatory variable while fixing other explanatory variables at their average

level. The red square line represents the predicted probability curve for the “better” level, while the green triangle and blue diamond lines represent the predicted probability curve for the “similar” and “worse” levels, respectively. While AGE, BMI, WRK, and SC show linear relationships with the predicted probabilities, DP exhibits non-linear relationships.

Fig. 2(a) shows how changes of professional driver age affected the predicted probabilities of the three levels of perceived health when BMI, WRK, SC, and DP are controlled at the average level and RHP is fixed at no health problems reported. At a young age, 70 of professional bus drivers would report similar health as their peers, 28% would report better health, and only a small portion would report worse health. As their age increases, more professional bus drivers would report better health and less would report similar or worse health. At age 58, the probability of reporting better health exceeds that of reporting similar health condition.

The three lines in Fig. 2(b) represent the opposite trends of those in Fig. 2(a). As the body mass index increases, the “similar” and “worse” lines go up while the “better” line goes down. This sharp downward trend in the “better” line suggests that professional bus drivers no longer feel better when their BMI value increases. By contrast, the increased rate in the “similar” curve is also high, especially at the early stages of increase in the BMI. As the BMI increases, the increased rate of the “similar” curve slows slightly.

The lines in Fig. 2(c) have similar patterns as those in Fig. 2(b). When working hours become longer, more professional bus drivers perceive similar and worse health condition, and fewer professional bus drivers perceive better health. The lines in Fig. 2(d) have similar patterns as those in Fig. 2(a). When perceiving better company safety culture, more professional bus drivers perceive better health, and fewer professional bus drivers perceive similar or worse health.

Fig. 2(e) shows the most distinct curve patterns. The “similar” curve goes up with the increase of depression level until depression reaches level 14. At this point, the curve starts descending as the depression level increases. By contrast, the “better” curve shows negative slopes with decreasing rates of change; this curve drops sharply at low levels of depression and becomes flat at high levels of depression. Even at extremely high levels of depression, approximately 20% of professional bus drivers perceived better health than their peers. Finally, the “worse” curve exhibits an S-shape: slow increases at low levels of depression, moderate increases at middle levels of depression, and slow increases at high levels of depression. Note that when the depression level exceeds 40, most professional drivers perceived their health condition to be worse than their peers.

4. Discussions

This study uses a cross-sectional survey to investigate the self-rated health of professional bus drivers, the associations between perceived health, and possible factors affecting this correlation. The collected responses of measurements regarding respondent's physical and psychological conditions exhibit satisfactory validity and reliability. The partial proportional odds model and heterogeneous choice model exhibit better goodness-of-fit than do the conventional ordered logit models. This suggests a heterogeneous relationship between individual drivers and perceived health and the heterogeneous impacts of explanatory variables on the different levels of self-rated health.

4.1. Affecting factors

Reported health problems are significant, but not the only significant variable. This suggests that factors other than health examinations could drive respondents to provide different health

Table 5
Marginal effects of the ordered logit and heterogeneous choice models.

Perceived health condition compared to peers	Variable	Model	
		Ordered logit	Heterogeneous choice
Worse	Reported health problems (RHP)	0.0293***	0.0194**
	Age (AGE)	-0.0007 [†]	-0.0004 [†]
	Body mass index (BMI)	0.0014 [†]	0.0010 [†]
	Daily average working hour (WRK)	0.0015 [~]	0.0009
	Depression level (DP)	0.0018***	0.0037***
	Safety culture (SC)	-0.0004**	-0.0003**
Similar	Reported health problems (RHP)	0.1890***	0.1800***
	Age (AGE)	-0.0049**	-0.0046 [†]
	Body mass index (BMI)	0.0102 [†]	0.0105**
	Daily average working hour (WRK)	0.0106 [~]	0.0092
	Depression level (DP)	0.0132***	0.0105**
	Safety culture (SC)	-0.0029**	-0.0029***
Better	Reported health problems (RHP)	-0.2180***	-0.2000***
	Age (AGE)	0.0056**	0.0050 [†]
	Body mass index (BMI)	-0.0116 [†]	-0.0115**
	Daily average working hour (WRK)	-0.0121 [~]	-0.0101
	Depression level (DP)	-0.0150***	-0.0142***
	Safety culture (SC)	0.0033**	0.0032***

[~] $p < 0.1$.

^{*} $p < 0.05$.

^{**} $p < 0.01$.

^{***} $p < 0.001$.

ratings. This result matches previous findings that perceived health provides health information beyond health examinations (Idler and Benyamini, 1997; Kaplan and Camacho, 1983). While this study shows that drivers who reported health problems are less likely to report better self-ratings of health, 75 drivers reporting health problems indicated that their health was better than that of their peers. By contrast, five drivers who reported no health problems responded that their health was worse than that of their peers. There could be several reasons for this. First, this study does not measure driver self-confidence: an individual with a higher level of self-confidence might overestimate their health. Second, this study uses the reported health problems as a dummy variable, and for some drivers, health problems may have little effect on self-ratings of health. Third, a cross-sectional survey is a one-time survey that may include deviations due to measurement error: even though respondents report health problems, they might not truly have a poor health condition.

The age effect on perceived health is positive, indicating that older drivers are more likely to report a better level of self-rated health than younger drivers. This does not mean that an older driver's health is better than a younger driver's health. Recall that the designed question for perceived health is to ask the respondents to report their health conditions compared with their peers. This approach precludes age-related conditions. However, individuals who have survived until an older age in a high-workload occupation such as bus driving require themselves to consistently maintain a satisfactory health condition. On the other hand, older drivers may not have reported bad health in the survey because of a fear of losing their job due to their age. To reduce such measurement errors, the questionnaires were mailed with self-addressed envelopes enclosed, and the completed questionnaires were returned directly to the research team. Moreover, the questionnaire was anonymous, which could further reduce the drivers' concern. Despite all preventative endeavors, some measurement error is inevitable.

Body mass index is a critical indicator of health. The results of this study show that professional drivers are more likely to report lower self-ratings of health with a higher BMI value. Professional bus drivers experience long-time sedentariness; the average driving time in this study was 9 h. Moreover, the irregular shift

schedules and tight timetables might prevent drivers from eating regularly. The respondents also showed a low level of perceived access to physical activity in the survey. These characteristics are all risk factors for a high BMI (Lahti-Koski et al., 2002). The average BMI in the sample is approximately 25.5, indicating the requirement for effective health programs regarding the weight management of professional drivers.

Driving and working hours are a critical safety issue for professional drivers. This study shows a significantly adverse effect of working hours on perceived health, suggesting that longer working hours may affect not only short-term fatigue or drowsiness, but also long-term health. The long hours spent on driving and working often causes back disorders for professional drivers. Irregular work schedules and low job control give professional drivers a high level of stress, and lead to social isolation (Tse et al., 2006). Taiwan, like many industrialized countries, has Hours-of-Service (HoS) regulations, specifying the driving and working hours within a reasonable length of time. However, the results of this study highlight the importance of bus companies' compliance with government regulations and supervision.

The values of safety culture used in this study are from the perspective of drivers, who reported what they perceive regarding the safety attitude and focus of management and employees, the culture of reporting, and reactions to reported errors and incidents. The significant positive results in this area suggest that when drivers perceive a better safety culture in the working environment, they tend to have a better self-rating of health. While the adopted scale (the GAIN's safety culture scale) does not consist of any items directly related to health practices, safety culture could affect employee's health through other factors. For example, previous research shows that drivers who consider following the schedule to be more important than driving safety are more likely to report higher stress levels, which consequently affect their health conditions (Oz et al., 2010). Poor safety culture is also associated with higher absences due to sickness (Bjornskau and Longva, 2009). The results of this study indicate that maintaining good safety culture is relevant to not only driving safety, but also driver health.

Depression has the most distinct property among all the variables in this study. This variable is the only variable that shows

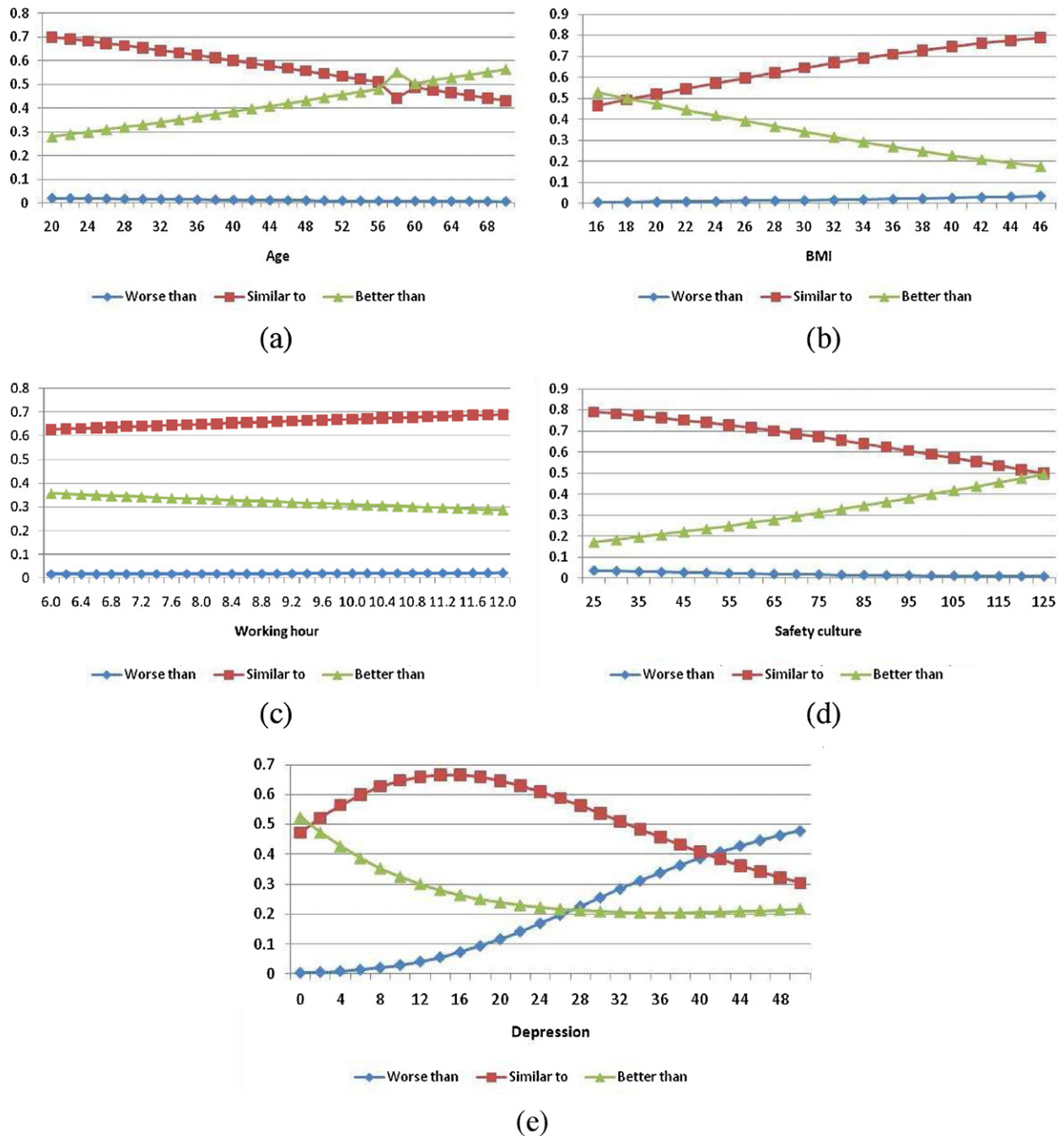


Fig. 2. Conditional predicted probability of various perceived health levels using the heterogeneous choice model.

various effects on different levels of perceived health, and is the only variable that demonstrates a trend in residual variability. The marginal effect of depression on the self-ratings of health is relatively intense, second only to that of the reported health problems, and is also the only continuous variable that may make the predicted probability of a worse level greater than those of similar and better levels. These results suggest that depression levels have a significant and complicated effect on perceived health.

The negative effects of depression on health are significantly linked to physical and psychological impairments. For example, depression can jeopardize immune systems and thus cause immune-mediated disease (Herbert and Cohen, 1993). Individuals who are depressed are also less likely to engage in healthy behaviors (Idler and Benyamini, 1997), and are more likely to have poor sleep

quality (Carpenter and Andrykowski, 1998; Chen et al., 2010). This study contributes to the literature that depression also has significant associations with perceived health, especially for professional bus drivers.

In addition to its significance, depression exhibits an S-shaped relationship with self-rated health in this study. This is unlike the linear relationships apparent in other significant variables. When their depression levels were low, only a few drivers perceived a worse level of health. However, the percentage of drivers perceiving a worse health condition increased rapidly as the depression level increased. This sharp increase suggests the importance of maintaining depression at a reasonably low level. Conversely, the “better health condition” curve decreases as depression increased. The speed of decrease gradually declined, and the probability of

reporting a better level of perceived health approaches a stable level of 0.2 when depression exceeds a level of 30; this is also the threshold for the poorest category in the Taiwanese depression scale. Depression induces immune-mediated diseases and interacts with other factors such as stress. Therefore, respondents may be highly depressed and still perceive their health as being better than that of their peers. However, further studies are required to explain this result.

Despite the aforementioned significant factors, some factors that show a significant relationship with perceived health in previous studies are not applicable to this study. For example, men and women evaluate their perceptions of health differently in different social positions (Martikainen et al., 2004). However, most professional bus drivers in Taiwan are male (over 98% of the respondents in this study are male). Though gender factor is a non-significant factor in this study, this does not mean that gender has no effect on perceived health to professional bus drivers. Moreover, this study does not consider education and income levels, which are typically controlled in evaluating perceived health (Idler and Benyamini, 1997). These two variables are not considered primarily due to their availability and low variability; i.e., most professional bus drivers have similar education levels and income levels in Taiwan. It may also be worth analyzing the frequency of incidents and accidents during the months that follow the health assessment to determine whether medical factors influence traffic safety in future studies.

This study tests the interaction effects between reported health problems and the other variables. However, the results are all non-significant, indicating that the effects of reported health problems did not depend on other variables.

4.2. Health and wellness programs

This study shows that health problems have the largest marginal effects on self-rated health for professional bus drivers, indicating the importance of uncovering health problems in daily practice. Because health conditions are dynamic and health problems may be difficult to recognize, regular health examinations are not adequate, and additional health and wellness programs are required. For example, a company can help its drivers improve their self-health management and value their own health condition. Possible strategies include informing drivers of the different effects of rotation jobs and regular jobs; possible causes and results of fatigue and burnout; importance of sleep and recovery activities during off-duty periods; possible effect of consuming caffeine or taking drugs; and importance of maintaining regular exercise.

In addition to health problems, other significant factors may require programs to manage professional bus driver health effectively. Depression management is a crucial topic. The results of this study show rapidly increasing probabilities of worsening health when depression exceeds a certain level. This indicates the importance of designing health programs to help drivers in the early stages of depression. Other programs to consider include weight management and working hour management. At least 10% and 20% of drivers no longer feel healthier than their peers when their BMI exceeds the threshold of being overweight and obesity, respectively. This highlights the importance of helping professional bus drivers maintain their BMIs within a healthy range. Furthermore, though the effect of working hours is less considerable, complying with the HoS regulation is also a priority to prevent self-rated health from deteriorating severely.

The impact of safety culture on self-rated health is the least significant among all aforementioned factors. However, results show that when perceived safety culture of professional bus drivers is not adequately positive enough (i.e., lower than 93), 10–20% of them no longer perceive their health condition as being better than that of their peers. While safety culture helps increase performance and

safety behavior in commercial transportation companies (Zohar, 2010), its positive effect on driver health should also be valued.

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