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Comparisons of Subthreshold Versus Full Posttraumatic Stress Disorder Distinguished by Subjective Functional Impairment Among Train Drivers: A Population-Based Nationwide Study in South Korea

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Objective Subthreshold posttraumatic stress disorder (SPTSD), a condition that meets the full symptomatic criteria of posttraumatic stress disorder (PTSD) without subjective functional impairment, has yet to be fully investigated. In this study, we aimed to determine the prevalence and characteristics of SPTSD.

Methods The web-based survey including psychiatric diagnosis and experience of human error was conducted in actively working train drivers in South Korea.

Results Of the 4,634 subjects, 103 (2.23%) were categorized as full PTSD and 322 (6.96%) were categorized as having SPTSD. Individuals with full PTSD showed higher impulsivity and anxiety compared to those with SPTSD and those without PTSD, while those with SPTSD had more frequent clinically meaningful depression, posttraumatic stress, and alcohol and nicotine dependence and significant human error.

Conclusion Despite not qualifying as a subjective functional disability, SPTSD still had significant psychiatric symptoms. More clinical attentions need to be given to the diagnosis and treatment of SPTSD.

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Key Words PTSD, Subthreshold, Human error, Train driver.

INTRODUCTION

Posttraumatic stress disorder (PTSD) is a devastating condition that includes significant adjustment problems in occupational and social settings. Individuals with PTSD have high suicide risk¹ and functional impairment² that require intensive psychiatric intervention. In a trauma-prone occupational setting, much effort is needed to prevent and detect PTSD at earlier stages.³

The DSM-IV⁴ and the DSM-5⁵ diagnostic criteria for PTSD

both require 1) meeting full symptomatic criteria of several different categories (re-experience, avoidance and hyperarousal in DSM-IV-TR; intrusion, avoidance, negative alterations in cognition and mood, and alteration in arousal and activity in DSM-5); 2) after exposure to trauma; 3) for more than one month; and 4) with significant functional impairment or distress. The functional impairment or distress, however, depends on subjective judgment of the patient and may be overcompensated by subjects, so it may be underestimated or underreported.

Previous studies on subthreshold PTSD (SPTSD) have focused on individuals who did not meet the full symptomatic criteria.⁶⁻¹¹ In fact, the significant functional impairment criterion affects the prevalence rates of PTSD most prominently.¹² However, several studies have shown that the significant functional impairment criterion fails to discriminate between populations who need more psychiatric help.¹³⁻¹⁶

The criterion of significant functional impairment can de-

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crease false positives on some occasions, but it can also increase false negatives because functional impairment is not a clear-cut criterion.¹⁷ Individuals with symptoms of PTSD who do not meet this criterion are less likely to be diagnosed due to a lack of noticeable impairment or distress. Further, Korean populations use fewer psychiatric services than Western populations because of a strong stigma against psychiatric illnesses,¹⁸ so subjects with significant psychiatric symptoms might try to deny unconsciously the fact that they experience the significant clinical distress or minimize the significant functional impairment for fear that they might lose their jobs.

In this study, we defined SPTSD as meeting the full symptomatic and durational criteria for PTSD but not the criterion of significant functional impairment. This means that individuals with SPTSD experience clinically significant distress that meet the symptomatic criteria for PTSD, but do not experience any significant impairment at functioning. We aimed to determine the prevalence and characteristics of SPTSD in Korean train drivers. We explored the effects of SPTSD on the train drivers' psychological distress, alcohol and nicotine use, and human errors at work and compared these indicators between subjects with full PTSD and those without PTSD (i.e., those who did not meet the criteria for full PTSD or for SPTSD).

METHODS

Study population

The data were obtained from the Human Error Study for Korean Train Drivers, a nationwide survey for the prevention of human errors among train drivers. Details of this study have been published elsewhere.¹⁹ This study was based on all of the 5,480 Korean train drivers who were currently driving trains during the study period. A pilot study was conducted on 40 train drivers with face-to-face interviews by two psychologists in May to June in 2012 before beginning the main survey to evaluate the validity of the questionnaire. No significant difference was observed in terms of prevalence rate of each psychiatric disease. Data were collected from July to August of 2012, using the web-based survey system of Samsung Medical Center. All subjects were fully informed about the aims and methods of the study prior to completing the survey and informed consent was obtained prior to participation. In order to ensure the confidentiality of responses, the study researchers constructed a new web site using the external server system of Samsung Medical Center, with higher security and data encryption, and neither personal identification nor data were given to the Korean National Railroad Corporation (KORAIL). All study procedures were approved by the Institutional Review Board of the Samsung Medical Center.

The data were collected anonymously, and we let participants

know about this before starting the survey. Demographic characteristics (age, education years, gender, and marital status) and duration of train driving career were obtained from the survey. Ultimately, 4,634 train drivers completed the interview (response rate 84.56%). The mean age of the subjects who completed the survey was 45.34 years old [standard deviation (SD)=9.38], with an average of 12.98 years of education (SD=3.71). The study sample was 99.2% males, and 92.2% married. The mean train driver career duration was 17.42 years (SD=8.64).

Psychiatric diagnostic evaluation and definition of SPTSD

Participants' psychiatric evaluations were done using a web-based interview. During the interview, participants were required to respond again in the case of response errors or omissions. The Korean version of the Mini International Neuropsychiatric Interview's (MINI)²⁰ was used for the diagnostic evaluation. In the Korean version of the MINI, the Cohen's kappa value, a measure of the inter-rater reliability, of the PTSD module was 0.66.²¹

Respondents who satisfied all PTSD criteria were diagnosed with "full PTSD," and those who met the DSM-IV-TR PTSD symptomatic criteria (re-experience, avoidance and hyperarousal) and duration criterion of at least one month, but failed to meet the significant functional disability criterion (representing a significant functional disability in occupational or social situations) were diagnosed with SPTSD.

Other psychological evaluations

The Center for Epidemiologic Studies Depression Scale (CES-D)²² was applied to evaluate the severity of depression. This is a 20-item questionnaire with a five-point scale used for assessing depressive symptomatology in the general population. Its Korean version has shown high reliability (Cronbach's $\alpha=0.893$) and test-retest reliability (Pearson's r coefficient=0.68; $p<0.001$).²³ A CES-D score ≥ 21 is considered to represent clinically meaningful depression.²³

The Barratt Impulsivity Scale (BIS)²⁴ was used to evaluate the severity of impulsivity. The BIS is a self-report questionnaire to assess the personality construct of impulsivity with 30 questions, which are scored on a four point Likert scale. Total impulsivity is calculated as the sum of all items. Questions are divided into three sub-traits, i.e., motor impulsivity (e.g., "I do things without thinking"), attentional impulsivity (e.g., "I concentrate easily"), and non-planning impulsivity (e.g., "I plan tasks carefully"). Higher scores on the BIS indicate greater impulsivity. The Korean version of the BIS has shown high reliability and test-retest reliability.²⁵ The BIS was initially designed to measure impulsivity as a lifetime trait, however, recent study

showed that it also had an affective state-dependent factor.²⁶

The Impact of Event Scale-Revised (IES-R)²⁷ was applied to measure posttraumatic stress in each individual's lifetime. This is a 22-item self-rating scale of trauma-related symptoms including hyperarousal. The Korean version has shown high reliability and validity for the assessment of PTSD symptom severity (data not shown), and scores of 25 points or more indicate a serious trauma experience.²⁸ The cutoff score for clinically significant PTSD symptoms was defined as ≥ 21 .²⁸

The State-Trait Anxiety Inventory (STAI),²⁹ which is a 20-item self-report questionnaire developed to assess levels of situation-related state anxiety (STAI-S) and trait anxiety (STAI-T), was applied to measure the severity of anxiety.

Smokers were defined as individuals identifying themselves as current smokers. Nicotine dependence was measured using the Fagerstrom Test for Nicotine Dependence (FTND), which contains six items regarding nicotine craving. The sum of the individual item scores is associated with biological nicotine dependence.³⁰ We defined nicotine dependence as having the FTND score of 4 or higher.³¹ The Korean version of the FTND has been shown to have high reliability (Cronbach's $\alpha=0.72$).³²

Alcohol dependence was evaluated using the Korean version of the Alcohol Use Disorders Identification Test (AUDIT).³³ The AUDIT is a screening questionnaire that uses 10 sub-items to identify persons with hazardous and harmful patterns of alcohol consumption. Alcohol dependence was defined as a sum of individual item scores ≥ 20 . The Korean version of the AUDIT is standardized and widely used in the epidemiological setting, with high reliability (Cronbach's $\alpha=0.8$).³³

Measure of human error

Human error is defined as 'any deviation from expected human performance and not intended by the actor'. Human errors of the train drivers in this study included derailment,

station passing failure, and mishandling failure, and did not include accidents involving railway deaths and injuries since we focus on human error that is inevitable and an expected part of anyone's work. Two questions were applied to assess the human errors of train drivers: "Have you experienced an accident?" and "How many times have you experienced things such as derailment, station passing failure, and mishandling failure while driving a train, except for railway death and injury?"¹⁹ The length of each individual's career as a train driver was identified by one's answer to the following question: "How long has your career as a train driver been?" The mean rate of human errors per year, calculated from the number of human errors divided by the length of the individual's career, was regarded as significant human error if its value was ≥ 0.02 /year.

Statistical analysis

Subjects were categorized into three groups; individuals with full PTSD, individuals with SPTSD, and individuals without PTSD (i.e., those who did not meet the criteria for full PTSD or SPTSD). Categorical data were compared using chi-square tests and continuous data were compared using one-way analysis of variance (ANOVA). The presence of significant human error was compared between the groups using a chi-square analysis.

Multiple logistic regression analysis was done to find factors that distinguished PTSD and SPTSD. Diagnostic groups (i.e., PTSD, SPTSD, and without PTSD) were entered as the dependent variables. Independent variables included the type of trauma individuals experienced (i.e., serious accident, being threatened by others, witnessing death, combat, and natural disaster), clinically meaningful depression (defined as CES-D ≥ 21), alcohol dependence and nicotine dependence.

Statistical analysis was performed by using SPSS 20.0, and the level of significance was set at $p < 0.05$.

Table 1. Sociodemographic characteristics of train drivers

Variables	PTSD ^a (N=103)	Subthreshold PTSD ^{b*} (N=322)	No PTSD ^c (N=4199)	Statistics	
				F or χ^2	p
Age (mean, SD)	45.40 (7.37)	47.66 (6.55)	45.20 (9.61)	10.25	<0.0001†
Onset of PTSD (years ago)	9.78 (9.45)	8.78 (7.96)	-	0.66	0.51
Education years (mean, SD)	12.66 (3.94)	12.72 (3.62)	12.99 (3.71)	1.19	0.30
Years of length of career (mean, SD)	18.63 (8.68)	20.79 (8.49)	17.19 (8.60)	27.27	<0.0001‡
Male gender (%)	101 (98.1)	317 (98.4)	4168 (99.3)	FE	0.080
Marital status (%)					
Married	98 (95.1)	298 (92.5)	3880 (92.4)	FE	0.770
Unmarried	4 (3.9)	16 (5.0)	268 (6.4)		
Divorced/separated/widowed	1 (1.0)	8 (2.5)	51 (1.2)		

*fulfill other DSM-IV PTSD criteria without disability, clinically significant distress, or impairment in social, occupational, or other important areas of functioning, †pair-wise comparison was done using LSD a vs. c, a vs. b < 0.001, b vs. c > 0.05, ‡pair-wise comparison was done using Bonferroni correction a vs. c < 0.003, a vs. b 0.021, b vs. c > 0.05. PTSD: post-traumatic stress disorder; SD: standard deviation

Table 2. Comparison of train drivers with PTSD, subthreshold PTSD, and neither

Variables	PTSD ^a (N=103)	Subthreshold PTSD ^b (N=322)	No PTSD ^c (N=4199)	Statistics				
				F or χ^2	p	a vs. b	a vs. c	b vs. c
Depression (CES-D)	3 (2.9%)	54 (16.8%)	142 (3.4%)	130.66	<0.001	<0.003	1.000	<0.003
Impulsivity (BIS-11)								
Attention	16.08 (3.32)	13.61 (2.99)	13.69 (2.92)	33.65	<0.001	<0.001	<0.001	0.624
Motor	20.23 (3.85)	18.96 (3.61)	19.01 (3.42)	6.46	0.002	0.001	<0.001	0.798
Non-planning	26.66 (4.37)	24.73 (4.67)	25.09 (4.31)	7.88	<0.001	<0.001	<0.001	0.157
Total score	62.97 (9.13)	57.30 (8.60)	57.78 (8.33)	20.12	<0.001	<0.001	<0.001	0.313
Posttraumatic stress (IES-R)	14 (13.6%)	182 (56.5%)	399 (9.5%)	589.77	<0.001	<0.003	0.492	<0.003
State anxiety (STAI-T)	46.79 (10.39)	34.61 (8.72)	34.49 (8.87)	96.12	<0.001	<0.001	<0.001	0.877
Trait anxiety (STAI-S)	48.36 (10.43)	35.02 (8.86)	35.10 (9.14)	105.77	<0.001	<0.001	<0.001	0.818
Nicotine dependence (FTND)	3 (2.9%)	24 (7.5%)	130 (3.1%)	FE	<0.001	0.327	1.000	<0.003
Alcohol dependence (AUDIT-K)	9 (8.7%)	41 (12.7%)	174 (4.1%)	51.33	<0.001	0.719	0.066	<0.003

Covariates: age, gender, presence of any psychiatric illnesses, the length of each individual's career as a train driver. Fulfill other DSM-IV PTSD criteria without disability, clinically significant distress, or impairment in social, occupational, or other important areas of functioning. A CES-D score ≥ 21 is considered to represent clinically meaningful depression; a IESR score ≥ 21 was defined as significant post-traumatic stress symptoms; nicotine dependence was defined as having the FTND score ≥ 4 ; alcohol dependence was defined as the AUDIT-K score ≥ 20 . PTSD: post-traumatic stress disorder, CES-D: center for epidemiologic studies depression scale, BIS-11: Baratt Impulsivity Scale, IESR: impact of event scale-revised, STAI-S: State-Trait Anxiety Inventory-State, STAI-T: State-Trait Anxiety Inventory-Trait, FTND: Fagerstrom Test for Nicotine Dependence, AUDIT-K: Alcohol Use Disorders Identification Test in Korea

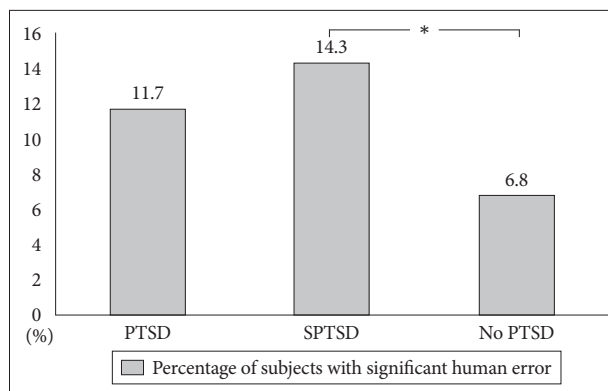


Figure 1. Comparison of human errors among the PTSD, subthreshold PTSD, and neither groups. Significant human error was defined as having human error ≥ 0.02 /year. * $p < 0.05$. PTSD: post-traumatic stress disorder, SPTSD: subthreshold PTSD.

RESULTS

Of 4,624 subjects, 103 (2.23%) were placed in the full PTSD group and 322 (6.96%) were categorized in the SPTSD group. Individuals with SPTSD were older than those with full PTSD and those without PTSD (Table 1). Those with SPTSD also had a longer career than the others. No other significant differences were observed among the three groups.

Individuals with PTSD showed higher scores in impulsivity, state anxiety, and trait anxiety compared to those with SPTSD and those without PTSD (Table 2). Those with PTSD had higher impulsivity scores in all domains including attention, motor, and non-planning domains. Those with SPTSD showed

similar scores in impulsivity, state anxiety, and trait anxiety to those with no PTSD. Clinically significant depression, significant posttraumatic stress, alcohol dependence and nicotine dependence were more frequently observed in individuals with SPTSD compared to those with PTSD and those without PTSD.

Individuals with SPTSD had significant human errors (≥ 0.02 /year) more frequently compared to those with no PTSD (14.3% vs. 6.8%, $\chi^2 = 26.20$, $p < 0.001$; post-hoc test between SPTSD vs. no PTSD $p < 0.003$) (Figure 1). Those with PTSD showed an intermediate frequency of significant human error (11.7%), but no statistically significant difference was observed from the other two groups.

We conducted a multiple logistic regression analysis to find factors that distinguished between PTSD and SPTSD (Table 3). Experiencing a serious accident, witnessing a death, natural disasters as well as the presence of depression, and alcohol dependence all predicted having SPTSD as opposed to not having PTSD. Alcohol dependence predicted PTSD as opposed to not having PTSD.

DISCUSSION

In our study, we explored the prevalence and characteristics of SPTSD in a sample of Korean train drivers. Individuals with SPTSD were shown to have more frequent alcohol dependence, nicotine dependence, clinically meaningful depression, and posttraumatic stress, while those with PTSD showed

Table 3. Multiple logistic regression analysis of the PTSD and subthreshold PTSD groups

Variables	PTSD			Subthreshold PTSD		
	N	% ^a	AOR (95% CI)	N	% ^a	AOR (95% CI)
Serious accident	332	78.1%	0.72 (0.47–1.10)	290	90.1%	10.41 (7.08–15.31)***
Threatened by others	18	4.2%	1.67 (0.49–5.68)	15	4.7%	0.97 (0.51–2.73)
Witnessed a death	77	18.1%	0.89 (0.41–1.97)	68	21.1%	1.93 (1.38–2.70)***
Combat	62	14.6%	1.11 (0.50–2.46)	53	16.5%	1.27 (0.88–1.83)
Natural disaster	15	3.5%	-	15	4.7%	6.44 (3.16–13.13)***
Depression (CES-D \geq 25)	57	13.4%	0.54 (0.16–1.79)	54	16.8%	3.67 (2.47–5.45)***
Alcohol dependence (AUDIT)	50	11.8%	2.26 (1.08–4.72) ^{*0.030}	41	12.7%	2.11 (1.37–3.26)***
Nicotine dependence (FIND)	27	6.4%	0.75 (0.23–2.47)	24	7.5%	1.46 (0.87–2.45)

Adjusted for age, sex, education years, and all variables above. * $p < 0.05$, *** $p < 0.001$, ^a% of each independent variable among those who have PTSD or subthreshold PTSD. PTSD: post-traumatic stress disorder

greater impulsivity and anxiety. Those with SPTSD committed significant human error more frequently than those with no PTSD.

In their profession, train drivers are at a heightened risk of experiencing accidents that may involve death, i.e., witnessing suicide attempts or accidental falls of passengers. Such events could increase these individuals' chances of having trauma-associated psychological distress.³⁴ The exposure to trauma and associated psychological distress, in turn, could affect the drivers' occupational adjustment, potentially causing secondary tragedies.

This is the first study to evaluate the characteristics of SPTSD that meets the full symptomatic DSM-IV criteria with no functional disability. As in previous studies,^{12,13,15,16} we found the rate of SPTSD to be higher than that of PTSD. The prevalence of PTSD in our study was relatively low compared to that of Western countries,^{10,35} but was similar to that of a Korean epidemiological study.³⁶ Higher rates of SPTSD could be due to train drivers with PTSD symptoms either trying to minimize the clinical significance due to the stigma attached to mental illness or not recognizing the effects of the symptoms in daily life. Individuals with PTSD reported higher impulsivity and anxiety as compared with the other two groups. Previous studies reported increased impulsivity in individuals with PTSD, yet mixed reports exist on the causal relationship. Some suggest increased impulsivity contributed to the development,³⁷ maintenance, and exacerbation³⁸ of PTSD. Others proposed certain PTSD symptoms could increase impulsivity.³⁹ PTSD individuals with predominant anxiety symptoms were reported to have more severe clinical symptoms.⁴⁰ Impulsivity and anxiety might contribute to the subjective distress of individuals with PTSD symptoms, eventually leading to significant functional problems and satisfying the functional impairment criterion.

It is notable that individuals with SPTSD suffered signifi-

cant psychiatric symptoms. In particular, they experienced clinically meaningful depression more frequently than the other two groups. Narrow et al.¹⁴ suggested functional disability criterion had little importance in survey study. It seems that the significant functional impairment criterion did not discriminate between psychiatric conditions that needed clinical help. The rate of alcohol dependence and nicotine dependence might reflect these individuals' efforts to self-medicate their depression due to a lack of clinical attention, which is a commonly observed phenomenon in the relevant epidemiological study.⁴¹

More importantly, individuals with SPTSD had higher rates of significant human error than the other two groups. Harmful alcohol use might contribute to the higher incidence of significant human errors. Increased clinical attention for SPTSD is needed, as a lack of treatment could result in human errors, which could cause secondary catastrophic accidents. Efforts to increase public awareness of mental illness and to decrease the stigma of psychiatric treatment are also warranted. Previous epidemiological studies consistently show that increased awareness of mental illnesses increases their prevalence in the general population.

In a social situations where there is a strong stigma related to mental illness and psychiatric treatment, workers can be reluctant to seek psychiatric treatment due to concerns that it might cause disadvantages in their career. They may also not realize that early intervention is important. Along with efforts to decrease stigma attached to having a mental illness, a more systematic approach including public education is needed for occupations that have a great risk of traumatic accidents. This is because, if only those individuals who recognize significant functional impairment obtain necessary help, individuals with SPTSD will continue to suffer from their symptoms, and their higher rates of human error will remain.

The findings from this study need to be interpreted within

the context of the study design. First, this is a cross-sectional web-based survey. Recall bias might affect the subjects' responses and web-based MINI might generate different results from the face-to-face interview, but it was inevitable since we wanted to explore all train drivers in South Korea. The pilot study conducted prior to the survey showed high construct validity with the face-to-face MINI interview. Second, false negatives in the results of the questionnaires may have underestimated the real rates of human errors and posttraumatic stress. Thus, it is possible that these data underestimate the number of human errors, as information about the number of human errors was obtained through self-reporting rather than from the train company's database. Third, the results could have been impacted by those that opted not to respond to the interview, as it has been reported that non-respondents have higher rates of mental disorders than respondents.^{42,43} Fourth, it should be noted that our subjects with SPTSD and PTSD may have had these conditions secondary to non-work related traumas, so we cannot make too many inferences about human errors as being due to previous work-related problems. Likewise, we were not able to determine temporal association between human error and the trauma experience. Fifth, we were not able to compare our findings to those from other studies with SPTSD due to differences of the criteria applied. Sixth, although the BIS have components to determine an affective state-dependent impulsivity, it also reflected individuals' lifetime trait impulsivity. Finally, because the sample was Korean, the results cannot necessarily be generalized to other populations.

Notwithstanding these limitations, this study provides a novel exploration of the rate and characteristics of SPTSD, as defined by full PTSD symptoms without a functional disability. SPTSD appears to occur more frequently than PTSD, and is more frequently associated with clinically meaningful depression and alcohol and nicotine dependence. SPTSD was also significantly associated with significant human error. In our study population of train drivers, the increase in human error rates could lead to secondary catastrophic train accidents. Increased clinical attention needs to be paid to SPTSD in order to prevent such accidents.

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