

ORIGINAL

Peritraumatic reactions, PTSD symptoms, and pain : A study of train disasters in Japan

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Abstract : *Objective :* The purpose of this study was to examine the relationship between peritraumatic reactions, posttraumatic stress disorder (PTSD) symptoms, and pain in people injured in train disasters. *Methods :* The participants were injured in a train crash in Japan that left more than 100 dead. There were 218 participants in the analysis, with a mean age of 37.50 ± 14.67 years. Peritraumatic reactions were assessed using the Peritraumatic Distress Inventory. PTSD symptoms were evaluated using the Impact of Event Scale-Revised Japanese-language version. Pain was measured using the Visual Analog Scale. *Results :* Peritraumatic reactions did not directly affect PTSD symptoms but were found to be associated via latent variables. Regarding pain and PTSD symptoms, intrusive memories were more associated with pain than other symptoms were. There was an associative path from intrusion to pain, but no such path from pain to intrusion. *Conclusions :* Our results suggest that a therapeutic approach to intrusion may be effective in ameliorating the pain caused by injury. Future research should examine integrated treatment approaches for both PTSD and pain, rather than just for aspects of PTSD. *J. Med. Invest.* 68:85-89, February, 2021

Keywords : train disaster, peritraumatic reactions, PTSD symptoms, pain

INTRODUCTION

Background

The physical and mental effects of transportation disasters have been well established. A railroad accident in the early 19th century injured a large number of people, opening the public's eyes and evoking society's interest in traumatic disasters (1). This event led to a number of findings about disease, anniversary reactions after the accident, and a tendency for symptoms to be prolonged due to a lack of social support (2); the presence of intrusive memories, nightmares, and avoidance symptoms, more pronounced in cases of life-threatening situations (3); and physical and mental disease that may persist nearly 20 years later (4).

In Japan, railroads were first built in 1872. Since then, many serious accidents have occurred, commencing with the train derailment at Shimbashi Station in 1874 (5). However, there are a number of problems in conducting surveys about railway disasters. Passengers live across a wide area, which makes it extremely difficult to ascertain the post-accident comings and goings of survivors. Further, the limited number of victims and bereaved families who can cooperate with the survey results in a low collection rate of questionnaires and a high dropout rate, and there are few actual reports (6).

The Current Study

On April 25, 2005, around 9:18 a.m., an accident occurred on the JR West Fukuchiyama Line between Tsukaguchi Station and Amagasaki Station in Japan. The first to fifth cars of the seven-car train derailed, and the first and second cars crashed

into the first floor of a condominium on the east side of the track. The number of direct fatalities from the accident was 106 passengers and a driver, and 562 people were injured (7).

Two days after the accident, a counseling system was set up, coordinated by the Hyogo Prefectural Government. This counseling system was publicized through newspapers, television, and websites. Counseling activities were conducted from 9:00 a.m. to 5:00 p.m., including weekends and holidays, by phone, visits to counseling organizations, and home visits. Service providers considered support for systematic visits to bereaved families and injured people, but information such as name and place of residence was not available. In contrast to natural disasters, there was no basis for government agencies to obtain information on the victims, and because the Act on the Protection of Personal Information was in full force immediately before the accident, it was impossible to gain information from the companies or medical institutions concerned. Therefore, the Hyogo Prefectural Government made repeated requests to the company in question, and the company complied.

Based on the information obtained, outreach activities such as visit support to applicants began, and at the same time, the Hyogo Institute for Traumatic Stress (HITS) started a survey about physical and mental health conditions. An investigation conducted six months after the accident gave a basic summary of conditions at that time (8). Afterwards, the reliability and validity of the scale used were confirmed, and we decided to re-analyze the data in the present study.

Our research specifically examined the relationship between peritraumatic reactions in the immediate aftermath of the accident, and the pain that often results from traffic accidents, as well as typical PTSD symptoms (intrusive memories, avoidance, and changes in physical and emotional reactions); based on the diagnostic criteria (DSM-IV-TR) at the time of this survey. We examined fear and helplessness during the peritraumatic phase, diagnostic criteria A2 for PTSD in the DSM-IV that were removed in the DSM-5 revision. One reason for the deletion was

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research on cases in which the trauma experience and the core symptom criteria of PTSD were met, but the A2 criteria may not have been met (9, 10). Those investigations covered a wide range of traumatic experiences—not only accidents, but also assault and rape. In studies that limited traumatic experiences to motor vehicle accidents (11) or the emergency medical team personnel deployed after the Great East Japan Earthquake (12), A2 was reported to be a predictor of PTSD. Because our study focused only on train accident injuries, we examined peritraumatic reactions and PTSD symptoms based on the results of Nishi *et al.* (11).

Many studies have investigated the comorbidity of PTSD and chronic pain. Based on those results, researchers have proposed theoretical models for the comorbidity of PTSD and chronic pain. The Mutual Maintenance Model (13) describes the interplay of PTSD and chronic pain in seven processes, and the Shared Vulnerability Model (14) states that anxiety susceptibility affects the development of both disorders. The Fear-Avoidance Model (15-17) explains how fear and avoidance behaviors are related to the development and maintenance of chronic pain in light of the physiological arousal response. The Triple Vulnerability Model points out that there are three common vulnerabilities in the development of disease has been applied to PTSD and chronic pain comorbidities (18). Other case reports suggest that pain experienced after traumatic experience may be a flashback (19, 20). Our study examined the relationship between each symptom of PTSD and pain in order to identify which symptoms are more associated with pain.

METHODS

Participants and Procedure

Among those injured in the accident, 550 people who were on the company's list at the time were included in the original investigation. The self-administered questionnaire was sent in late October or early November 2005, approximately six months after the accident. By January 5th, 2006, 243 people had responded to the survey (44% response rate). Of the respondents, 218, excluding those with missing values in the analysis scale, were analyzed.

Ethical considerations

The purpose of the original survey, the voluntary nature of participation in the survey, data management methods, and the protection of personal information at the time of publication of the results were explained in writing, in compliance with the Declaration of Helsinki. A response was requested only if consent was granted.

Measures

We asked about participants' basic attributes, information related to the accident (e.g., their purpose in boarding the train; which car they were in; the predictability of the danger), personal damage caused by the accident (e.g., whether or not they were hospitalized; the number of days in the hospital), and the impact of the accident on their lives. The following scales were used in this analysis:

Impact of Event Scale-Revised, Japanese-language version (IES-R-J)

The IES-R-J is a Japanese version of a self-administered questionnaire developed by Weiss *et al.* (21) to measure traumatic stress symptoms (22). The 22 total items ask about intrusion (8 items), avoidance (8 items), and hyperarousal (6 items) in the past week. Reliability and validity were tested in cases such as the Tokyo Metro sarin attack and the Great Hanshin-Awaji Earthquake. Spearman's rank correlation was

$r = 0.86$ ($p = 0.0001$), and internal consistency (Cronbach's α) was established for intrusion ($\alpha = 0.88-0.91$), avoidance ($\alpha = 0.81-0.90$), hyperarousal ($\alpha = 0.80-0.86$), and all items ($\alpha = 0.92-0.95$), depending on the case in question. For each item, participants were asked to rate the intensity of their symptoms on a 5-point scale ranging from 0 (*not at all*) to 4 (*extremely true*). The higher the total score (out of 88), the stronger the PTSD symptoms. The cutoff point for extracting a likely diagnostic group was a total score of 24/25 points.

Peritraumatic distress inventory (PDI)

This is a self-administered questionnaire created by Brunet *et al.* (23) to measure distress, including fear and helplessness, during and immediately after a critical incident. The inventory consists of 13 items rated on a 5-point scale from 0 (*not at all*) to 4 (*extremely true*). According to Nishi *et al.* (24), who tested the reliability and validity of the Japanese version among traffic accident injury victims, there was sufficient internal consistency ($\alpha = 0.83$). A higher total score (out of 52 points) indicates a stronger reaction. In the original survey, we asked for the information to be filled in after recalling the situation immediately after the accident.

Visual Analog Scale (VAS)

The VAS is a visual scale showing the degree of pain at the time of the survey. A straight 10 cm line has one end indicating *no pain at all* (0 points) and the other end indicating *unbearable pain* (10 points). The result is the pain score, measured by the distance past the *no pain* point 0. The minimum value is 0, the maximum 10.

Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics Version 23 and Amos Version 23 for Windows (Japan IBM, Tokyo, Japan). For all tests, significance was set at $\alpha = 0.05$ (two-tailed).

RESULTS

Descriptive statistics and preliminary analyses

Attributes of the analysis target

Details of the demographics of the analyzed participants are shown in Table 1. More than 80% of the participants were on board to commute to work or school, indicating that the accident occurred on the route they used daily. Approximately 60% of participants were in the first three cars, which held the fatalities. About half of the respondents escaped from the car on their own, and about 70% exited the car within 30 minutes. Over 80% of the participants were transported to hospitals, but about 30% of the participants were hospitalized. About 24% of respondents said their daily lives had not recovered at the time of the survey.

Relationships between variables

The mean value and SD of each variable and the Pearson product-moment correlation coefficient between each variable were calculated (Table 2). The results showed a significant moderate positive correlation between the PDI and all subscales of the IES-R-J. In addition, there was a significant moderate positive correlation between intrusion, hyperarousal, and the VAS, and a significant weak positive correlation between the PDI, avoidance, and the VAS. For the IES-R-J, 45% of the participants had a cutoff value of 25 or higher, indicating likely PTSD. *Association between peritraumatic reactions, PTSD symptoms, and pain*

The purpose of this study was to verify that PDI directly affected each symptom of PTSD and to identify those PTSD symptoms that were more associated with pain. We performed path analysis by structural equation modeling for verification. The

Table 1. Demographic characteristics of participants

Characteristics	<i>n</i>	%
Sex, Age		
Male (years)	84 (39.24 ± 15.02)	38.5
Female (years ; 2 persons of unknown age)	134 (36.39 ± 14.39)	61.5
Overall (years)	218 (37.50 ± 14.67)	100.0
Occupation category		
Employed Full-time	78	35.8
Employed Part-time	28	12.8
Self-employed	9	4.1
Homemaker	7	3.2
Student	42	19.3
On leave of absence (before accident)	2	0.9
On leave of absence (after accident)	22	10.1
Unemployed	15	6.9
Others	12	5.5
Unknown	3	1.4
Marital status		
Married	107	49.1
Unmarried	98	45.0
Bereaved	4	1.8
Divorced	7	3.2
Unknown	2	0.9
Purpose of the train ride		
Commuting	180	82.6
Shopping, Hospital visit, Visitation, etc.	13	6.0
Leisure, Recreation	5	2.3
Others	19	8.7
Unknown	1	0.5
Car No		
No.1	23	10.6
No.2	35	16.1
No.3	69	31.7
No.4	33	15.1
No.5	24	11.0
No.6	18	8.3
No.7	14	6.4
Unknown	2	0.9
Means of escape		
Self	109	50.0
Other passengers	29	13.3
Neighbors	25	11.5
Rescue team, Police	34	15.6
No recollection	11	5.0
Others	10	4.6
Escape time		
Within 10 minutes	85	39.0
10 -30 minutes	72	33.0
30 -60 minutes	13	6.0
More than an hour	9	4.1
No recollection	24	11.0
Others	15	6.9
Transport to hospital		
Yes	185	84.9
No	33	15.1
Hospitalization		
Yes	72	33.0
No	146	67.0
Recovery of daily life		
Within a few days	17	7.8
Within a week	6	2.8
Within 2 weeks	6	2.8
Within one month	34	15.6
Within 2 months	22	10.1
Within 3-4 months	50	22.9
Within six months	26	11.9
Not yet	52	23.9
Unknown	5	2.3

Table 2. Psychometric data

Psychometric data		CORRELATION COEFFICIENT									
		M	SD	Min.	Max.	IES-R-J			PDI	VAS	
total	Intrusion					Avoidance	Hyperarousal				
IES-R-J	total	24.74	17.13	0	77	—	.883**	.859**	.895**	.634**	.436**
	Intrusion	8.54	6.66	0	32	—	—	.564**	.795**	.596**	.473**
	Avoidance	9.66	7.69	0	31	—	—	—	.632**	.489**	.282**
	Hyperarousal	6.54	5.18	0	23	—	—	—	—	.604**	.415**
PDI		22.75	10.53	0	48					—	.275**
Pain(Visual Analogue Scale:VAS)		2.48	2.59	0	9						—

**p<.01

maximum likelihood method was used to estimate the parameters. We examined the bidirectional causality between each of the PTSD symptoms and VAS, and the final results based on the Akaike's Information Criterion (AIC) are shown in Figure 1. The goodness of fit index was $\chi^2(4)=3.217$ ($p = 0.522$), GFI = 0.994, AGFI = 0.978, CFI = 1.000, RMSEA < 0.001 (90% CI : 0.000-0.093), and AIC = 25.217. After examining the bidirectional causality between avoidance and pain, we found the fit index to be $\chi^2(4) = 8.013$ ($p = 0.091$), GFI = 0.986, AGFI = 0.947, CFI = 0.992, RMSEA=0.068 (90% CI : 0.000-0.137), and AIC = 30.013. After examining the bidirectional causality between hyperarousal and pain, we found the goodness of fit index to be $\chi^2(4) = 7.836$ ($p = 0.098$), GFI = 0.986, AGFI = 0.946, CFI = 0.992, RMSEA = 0.066 (90% CI : 0.000-0.135), and AIC = 29.836.

For the adopted model, at first, peritraumatic reactions did not directly indicate a positive path for each PTSD symptom. However, through the latent variables, a positive path was shown between each of the symptoms. Among the symptoms, the effect on hyperarousal was particularly strong. For intrusion and pain, there was a positive path from intrusion to pain, but no significant path from pain to intrusion. Therefore, PDI influenced each PTSD symptom, not directly, but through the mediation of certain factors. Although intrusion was more related to pain than other PTSD symptoms were, physical pain was not related to intrusion symptoms.

DISCUSSION

The purpose of this study was to examine whether the strength of response during the peritraumatic phase predicted the intensity of each PTSD symptom, and which PTSD symptoms were more associated with pain. The results revealed that the strength of the peritraumatic reaction intensified each PTSD symptom, not directly, but through the mediation of another variable. In addition, out of all PTSD symptoms, intrusion was shown to be most associated with pain. In addition to peritraumatic reactions, pre-traumatic and post-traumatic factors are believed to cause PTSD. In this study, another variable cannot be examined because neither pre-traumatic factors nor post-traumatic factors were obtained. However, it should be noted that some post-traumatic factors can raise PTSD symptoms, especially hyperarousal, after a railroad accident.

Pain was associated more with intrusion than with hyperarousal and avoidance. However, while intrusion accentuated pain, pain did not accentuate intrusion symptoms. This result did not fully support the third process of the Mutual Maintenance Model (13), where chronic pain is seen as a flashback or a recurrence of trauma, maintaining the link between bodily sensations and trauma. The survey used in our study did not focus solely on patients and did not conduct clinical diagnostic interviews on PTSD and pain. Moreover, we found that the average value of pain was $2.48 \pm 2.59/10$ points, indicating that there were not many patients with severe pain. Therefore, we concluded that pain had no effect on intrusion. Furthermore, in a questionnaire survey such as this one, the trigger for intrusion and the specific content of the flashback were not clarified. To discover that information, it would be necessary to create a separate survey item to consider whether pain triggers intrusion or whether pain itself is a physical flashback and, thus, intrusion.

Since both pain and PTSD symptoms consist of multidimensional components (13), intrusion is not the only factor associated with pain, nor is pain the only factor associated with intrusion. However, a therapeutic approach to intrusion might prevent pain from becoming more serious. In particular, the efficacy of prolonged exposure therapy and cognitive processing therapy has been shown to be effective against PTSD and other comorbidities. In addition, in recent years, the effectiveness of integrated treatment approaches for both diseases (PATRIOT; Pain and Trauma Intensive Outpatient Treatment) has been examined, not from the aspect of PTSD (25). In a traffic disaster like this one, it is not uncommon for pain from injuries to remain after physical treatment. In the future, further investigation of the above approaches for both chronic pain and PTSD would be beneficial.

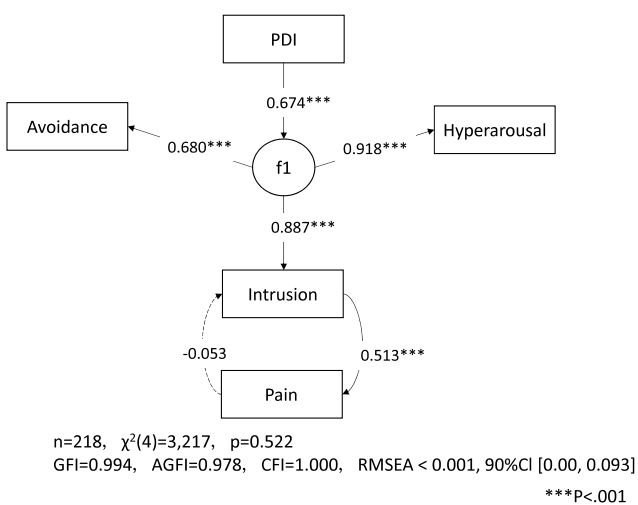


Figure 1. The association between peritraumatic reactions, PTSD symptoms and pain

LIMITATIONS

In this study, the detailed mechanism by which chronic pain and PTSD coexist could not be investigated. In the future, it will be necessary to consider anxiety, which is thought to influence the development or maintenance of both chronic pain and PTSD. Further, attention bias is thought to be related to the maintenance of symptoms of both diseases, as are coping strategies such as avoidance, depression, and pain catastrophizing, which refers to the chronicity of pain due to catastrophic thinking. In addition, since the instrument used was a self-administered questionnaire, there may have been a large variation among individual responses. The impact of the accident will need to be assessed along with the results of structured interviews such as the Clinician-Administered PTSD Scale.

CONCLUSIONS

The results of this study revealed that peritraumatic reactions indirectly intensified PTSD symptoms; the effect on hyperarousal was particularly strong. Among the PTSD symptoms, intrusion was found to affect pain. For the participants in the current study, we suggest that an approach to intrusion would be effective when PTSD symptoms and pain coexist, even in the midst of daily life.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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