- お酒の量が増加すると？
  - 肝臓に中性脂肪が蓄積され、大きな負担をかけることになります。
  - 胃や腸といった消化管の粘膜も荒れてきます。
  - 血圧が急激に高くなります。
  - 依存症になる可能性もあります。

- 結果の診断
  - 点数が0～1点だった人

    アルコールに依存している可能性は低いと思われます。今の生活を続けて下さい。

  - 点数が2～3点だった人

    アルコールに依存している可能性があります。週2日は休肝日にしたり、食べながら適量範囲でゆっくりと飲みましょう。寝つくための飲酒も避けましょう。 11頁のストレス対処法や13頁のリラックス法などを参考に、 お酒以外の方法でストレスを発散させましょう。

  - 点数が4点以上だった人

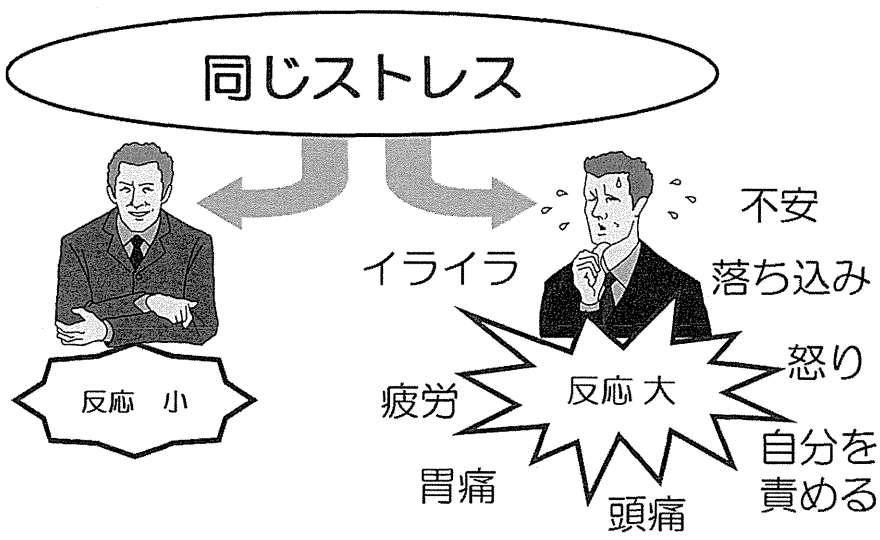
    アルコールに依存している可能性が高いと考えられます。健康管理室で相談することをお勧めします。

3．ストレス対処の方法

- ストレス対処とは、ストレスを受けても上手く対処すること、ストレス反応を大きくしないことを言います。

- 同じストレスを受けても、すべての人が同じように落ち込んだり、イライラするわけではありません。人によって、ストレスの受け止め方（認知）やストレス対処の方法が違うからです。

- まずは、次頁で自分のストレス対処のタイプを調べてみましょう。



セルフチェック

あなたのストレス対処法は？

あなたはストレスを受けた時に、どのように考え、行動しますか？
当てはまるものに○をつけて下さい。

・詳しい人から自分に必要な情報を収集する（ ） ・既に経験した人から話を聞いて参考にする（ ） ・力のある人に教えを受けて解決しようとする（ ）	情報収集型 ○の数　つ
・原因を検討し、どうするべきかを考える（ ） ・過ぎたことを反省し、次にすべきことを考える（ ） ・どのような対策をとるべきか綿密に考える（ ）	計画立案型 ○の数　つ
・悪い面ばかりでなく、良い面を見つけていく（ ） ・今後は良いこともあるだろうと考える（ ） ・悪いことばかりではないと、楽観的に考える（ ）	肯定的解釈型 ○の数　つ
・誰かに話を聞いてもらい、冷静さを取り戻す（ ） ・誰かに話を聞いてもらい、気を静めようとする（ ） ・誰かに愚痴をこぼして、気持ちをはらす（ ）	カタルシス型 ○の数　つ
・責任を他の人に押しつける（ ） ・自分は悪くないと言いのがれする（ ） ・その場を取り繕って、その状況から一時避難する（ ）	)責任転嫁型 ○の数　つ
・対処できない問題だと考え、あきらめる（ ） ・どうすることもできないと解決を先のばしする（ ） ・自分では手におえないと考え、放棄する（ ）	放棄あきらめ型 ○の数　つ
・そのことをあまり考えないようにする（ ） ・嫌なことを頭に浮かべないようにする（ ） ・無理にでも忘れようとする（ ）	回避的思考型 ○の数　つ
・友達とお酒を飲んだり、好物を食べたりする（ ） ・スポーツや旅行などで、活動的に過ごす（ ） ・散歩や音楽鑑賞などで、のんびり過ごす（ ）	気晴らし型 ○の数　つ

（1）積極的対処（○の数　つ）

●情報収集型：困った時に周囲の人に助言を求めたり、色々な情報を集める。
●計画立案型：直面している問題を積極的に解決しようとする。
●肯定解釈型：出来事の良い面をみたり、楽観的な考え方をする。
●カタルシス型：自分の抱えている悩みを誰かに聞いてもらったり、愚痴をこぼしたりすることで、心を浄化（カタルシス）する。

・ストレスになる状況や問題を避けずに、積極的に対処する方法で、ストレスを減らすことが分かっています。周囲に助言を求めたり、悩みを聞いてもらうことは、弱音をはいているわけではなく、重要な対処方法なのです。
・しかし、積極的に解決しようと頑張りすぎると燃え尽きてしまう（バーンアウト）こともありますので、気をつけましょう。

（2）消極的対処（○の数　つ）

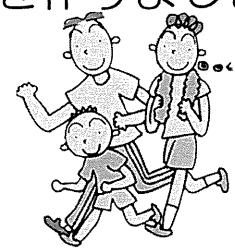
●責任転嫁型：つらい出来事や困難な状況から逃げ出したり、自分のせいにしないで眼をそらす。
●放棄あきらめ型：問題の解決を見送り、状況に身をまかせる。
●回避思考型：問題から距離をおき、思い出さないようにする。
●気晴らし型：趣味などを行い、気晴らしをする。

・ストレスになる状況や問題を避けて、消極的に対処する方法です。一時的にストレスを減らしますが、問題は解決していないため、結局ストレスは残ったままです。また職場内での責任転嫁はぎすぎすした雰囲気を引き起こします。
・しかし、長期化した問題や必要以上の負担がある場合、ストレスを一時的に減らすためには、消極的対処が役立ちます。

（1）と（2）の○の数が、
・同じくらい・・・・バランス良いストレス対処です。
・極端に差がある・・バランス良いストレス対処を心がけましょう。

あなたのリラックス法は？

- 人には、自律神経（交感神経と副交感神経）があります。交感神経の働きが高いと緊張・ストレスが高い状態、副交感神経の働きが高いとリラックスしている状態です。
- 交感神経の高い状態が続くと、心身に不調が生じます。そのため、リラックスする時間を作りましょう。



- スポーツや旅行など活動的な趣味、散歩や音楽鑑賞や園芸などのんびり過ごす趣味など、自分の好きなことに集中できる時間を確保しましょう。
- 活動的な趣味は、疲れている時はかえって疲労をためます。のんびりリラックスできる趣味も持つことを心がけましょう。

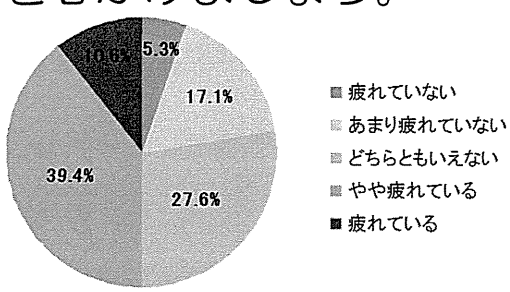


図2 勤務日の疲労感

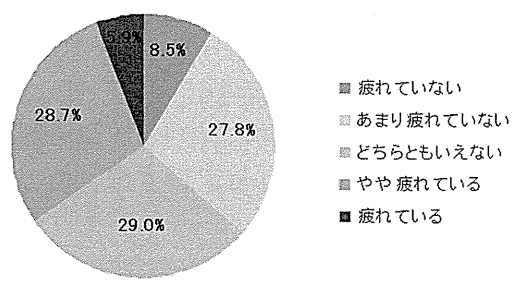


図3 休日の疲労感

- H24年の「こころの健康調査」の結果（図2、図3）では、勤務日では約半数の人が「疲れている・やや疲れている」、休日でも約3分の1の人が「疲れている・やや疲れている」と回答してます。休日でもなかなか疲労がとれないことが分かりました。

丹田呼吸法のすすめ

- リラックス方法の一つとして、大変有効な呼吸法をご紹介します。

- 自律神経は、呼吸によってのみ意識的にコントロールできます。よくある例として、緊張した時に深呼吸すると落ち着きます。

- 東洋医学的に丹田とは『気』（元気、やる気、生命力）が貯まる場所と言われています。
丹田の場所は、椅子の前に腰かけて足を投げだし、その足を上に挙げた時きに腹筋が張る箇所です（おへその下あたり）。

- 軽く両手で丹田を押さえ、丹田を意識し、「いち、にい、さん～」で鼻から息を全部吐ききります。
次に、丹田を意識し、鼻から大きく息を吸い込みます。
- 丹の田場所がわかれば、足を挙げなくてもできるので、会議中、バスや電車の中、どこでも丹田呼吸を心がけて下さい。

2012.12　ＴＬ研修での一コマ

あなたの睡眠力は？

セルフチェック

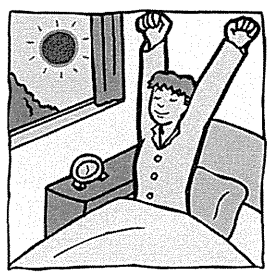
●あなたが実行していることに○、していないことに×をつけて下さい。

・毎朝決まった時刻に起きている（　）	生活習慣
・朝の光を30分浴びている（　）	●リズムと光
・昼寝をする時は30分以内 である（　）	
・規則正しい3度の食事をとっている（　）	●食事
・日中はよく体を動かしている（　）	●運動
・規則正しい運動習慣がある（　）	
・睡眠時間にはこだわらない（　）	睡眠に対する考え方
・眠くなるまで床につかない（　）	
・枕や布団は、自分にあったものである（　）	寝室の環境
・寝る環境は、静かで、照明が暗い（　）	
・寝る環境は、適当な室温・湿度である（　）	
・寝る直前に、テレビ・パソコン・携帯を見ない（　）	寝る前の過ごし方
・寝る直前に緊張を強いる仕事をしない（　）	●状態
・寝る直前の入浴はぬるめの湯（40℃前後）である（　）	
・寝る直前は、リラックスしている（　）	
・カフェインは、夕食以降はとらない（　）	●嗜好品
・アルコールは、寝る直前は飲まない（　）	
・タバコは、寝る1～2時間前は吸わない（　）	

○の数　　つ　　×の数　　つ

睡眠力向上のすすめ

- 不眠で悩む人に話を聞いてみると、寝酒、コーヒーの多飲、長時間の昼寝・・・と睡眠を妨げる習慣があります。
- ○の数が多いほど、良質な睡眠をとることができますが、×の数が多かった項目があれば、以下を参考にして、自分でできそうなことを試してみて下さい。



【生活習慣】

●リズムと光

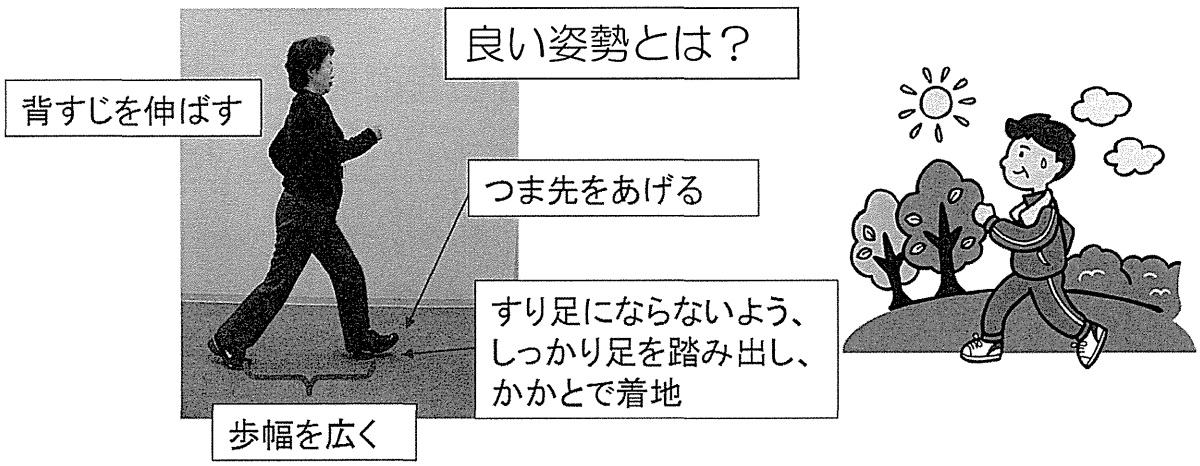
- 体のリズムは、脳と胃袋にあります。脳を刺激するために、朝6～8時の朝の光を浴びましょう。白湯やホットコーヒーで、胃袋を刺激する方法もあります。
- 休日も平日と同じ時刻に起きましょう。その分夜は早めに就寝しましょう。起きる時刻に2時間以上の差があると、夜眠れなくなり、平日の朝に起きるのが辛くなります。
- 昼寝をする場合は、15時までにとりましょう。長い昼寝はかえってぼんやりのもと。夕方以降に昼寝をすると、リズムが崩れ、身体がだるくなります。

●食事

- 特に朝食は、心と身体の目覚めに重要です。

●運動

- 歩くことは有効な運動です。
  - ポイントは、速めのスピード・姿勢良く・20～30分間歩くことです。



- ラジオ体操も有効な運動です。
  - 起床時や昼休みなど気軽にできます。ラジオ体操第一は、一般の人が行える体操、第二は働き盛りの人が体を鍛え筋力を強化する体操です。

【睡眠に対する考え方】

- 睡眠時間は、長い人や短い人がいますし、季節でも変わります。昼間に支障がなければ、あまりこだわらないようにしましょう。
- 眠ろうとする意気込みで、頭がさえてしまいます。

【寝室の環境】

- 周囲の音が気になる時は、耳栓をしてみましょう。
- 寝る前30分から温度（夏は24～26℃、冬は12～14℃）を調節しましょう。

【寝る前の過ごし方】

●環境

- 寝る前に、テレビ・パソコン・携帯を見る、仕事をすることは、頭が冴えるのでやめましょう。
- 熱いお風呂はリラックスできないので、避けてください。
- 寝る前は、激しい運動は避けましょう。腹式呼吸、ヨガ、アロマテラピーがお勧めです。

●嗜好品

- カフェインは、コーヒーだけでなく、緑茶、紅茶、コーラ、栄養ドリンク、チョコレートにも含まれるので、控えましょう。
- 寝るための飲酒（寝酒）はやめましょう。寝つきは良くなりますが、その後の睡眠が浅くなり、夜間・早朝に目が覚めます。

長い道のりを進むために大切なこと

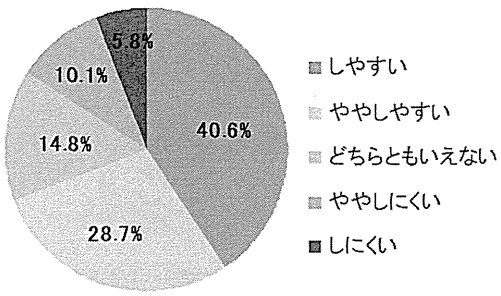


図4　休暇の取得のしやすさ

・H24年の「こころの健康調査調査」の結果（図4）では、69.3%の人が「休暇を取得しやすい・ややしやすい」と回答していました。

・一方で16.9%の人が「しにくい・ややしにくい」と回答していました。

・災害後は、「皆が大変だから、私も頑張らなくては」「もっと大変な人がいる」と思い、休むことを遠慮しがちでした。しかし、復興は長期戦です。走り続けていると燃えつきてしまいます。

・長期戦では休養・リラックスが心身の健康に必要です。

・仲間同士でいたわって下さい。気持ちをためないで下さい。

・管理職は、メンバーに声をかけましょう。必要に応じて仕事の負荷を調整しましょう。また率先して休む姿をみせて下さい（メンバーが休みやすくなるためにも）。

・家族や友人の支え合いを大切にして下さい。今回の災害で、「家族との絆」を感じたという声を多くの方々からお聞きしました。休暇を取ることは、自分のためだけでなく、家族のためにもお勧めします。

あとがき

- 本小冊子は、防衛医科大学校重村淳講師・愛媛大学谷川教授による「こころの健康調査（H23年、24年）」の結果、谷川教授による「管理職研修・TL研修」の内容などを元に、作成しました。

- 内容について、ご意見、ご質問などございましたら、以下までお問い合わせ下さい。

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with as few adverse events as treatment of hypertension with thiazides, we would support statin treatment in this group.

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Conflict of Interest Disclosures: The authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest none were reported.

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RESEARCH LETTERS

Psychological Distress in Workers at the Fukushima Nuclear Power Plants

To the Editor: A magnitude 9.0 earthquake and tsunami on March 11, 2011, triggered plant explosions and a nuclear meltdown at the Fukushima Daiichi nuclear power plant. The nearby Daini nuclear power plant also experienced damage but remained intact. Studies after the nuclear disaster at Chernobyl[1] suggest nuclear power plant workers are at risk for general psychological distress, including posttraumatic stress response (PTSR). We examined the psychological status of Fukushima workers 2 to 3 months after the disaster.

Methods. Following approval by the ethics committees of Ehime University and National Defense Medical College, we recruited all full-time nuclear power plant workers from the Daiichi (n=1053) and Daini (n=707) plants in May and June 2011. Written informed consent was obtained.

Using a self-report questionnaire, we assessed sociodemographic characteristics and disaster-related experiences (TABLE 1; coded dichotomously as "yes" or "no"), including discrimination/slurs (*sabetsu/chuushou*) because the electric company was criticized for their disaster response and the workers have been targets of discrimination.[2] General psychological distress was evaluated using the K6 scale (Japanese version),[3] including items on feeling nervous, hopeless, restless/fidgety, depressed, everything was an effort, and worthless in the last 30 days. Scores ranged from 0 to 24, with 13 or higher indicating high distress.[3] PTSR was assessed by the Japanese version of the Impact of Event Scale Revised (IES-R-J), a 22-item scale including PTSR domains of intrusion, avoidance/numbing, and hyperarousal.[4] Scores ranged from 0 to 88, with 25 or higher indicating high PTSR.[4] Cronbach α was high for K6 (0.88) and IES-R-J (0.95).

Table 1. Participant Characteristics, General Psychological Distress (GPD), and Posttraumatic Stress Responses (PTSR)

Characteristics	Total (N = 1495) No.	Total (N = 1495) % (95% CI)	Daiichi (n = 885) No.	Daiichi (n = 885) % (95% CI)	Daini (n = 610) No.	Daini (n = 610) % (95% CI)	*P* Value
Age, y							
20-39	728		429		299		
40-59	743	39.6 (11.3)[a]	446	39.6 (11.3)[a]	297	39.5 (11.3)[a]	.39
≥60	18		8		10		
Male sex[b]	1412	94.4 (93.3-95.6)	853	96.4 (95.2-97.6)	559	91.6 (89.4-93.8)	<.001
Supervisory work status	153	10.2 (8.7-11.8)	89	10.1 (8.1-12.0)	64	10.5 (8.1-12.9)	.78
Preexisting illnesses[b]	217	14.5 (12.7-16.3)	135	15.3 (12.9-17.6)	82	13.4 (10.7-16.1)	.32
Discrimination/slurs[b]	191	12.8 (11.1-14.5)	124	14.0 (11.7-16.3)	67	11.0 (8.5-13.5)	.08
Near-death experience[b]	623	41.7 (39.2-44.2)	470	53.1 (49.8-56.4)	153	25.1 (21.6-28.5)	<.001
Tsunami evacuation[b]	185	12.4 (10.7-14.0)	87	9.8 (7.9-11.8)	98	16.1 (13.2-19.0)	<.001
Witnessing of plant explosions[b]	388	26.0 (23.7-28.2)	318	35.9 (32.8-39.1)	70	11.5 (8.9-14.0)	<.001
Family member deaths	87	5.8 (4.6-7.0)	53	6.0 (4.4-7.6)	34	5.6 (3.8-7.4)	.73
Colleague deaths[b]	259	17.3 (15.4-19.2)	173	19.5 (16.9-22.2)	86	14.1 (11.3-16.9)	.007
Major property loss[b]	433	29.0 (26.7-31.3)	285	32.2 (29.1-35.3)	148	24.3 (20.9-27.7)	.001
Home evacuation[b]	999	66.8 (64.4-69.2)	617	69.7 (66.7-72.7)	382	62.6 (58.8-66.5)	.004
High GPD, K6 ≥ 13[c,d]	638	42.7 (40.2-45.2)	412	46.6 (43.3-49.8)	226	37.0 (33.2-40.9)	<.001
High PTSR, IES-R-J ≥ 25[c,e]	378	25.3 (23.1-27.5)	261	29.5 (26.5-32.5)	117	19.2 (16.1-22.3)	<.001

Abbreviations: IES-R-J, Japanese version of the Impact of Event Scale Revised; K6, Japanese version of the K6 scale.
[a] Mean (SD) values are presented.
[b] Marked variables were entered in the multivariable logistic regression model (forced entry method) as potential outcome factors.
[c] Participants with missing data were excluded from the analysis.
[d] Data were missing for 10 participants (0.7% of total; Daiichi, n=6; Daini, n=4).
[e] Data were missing for 70 participants (4.7% of total; Daiichi, n=42; Daini, n=22).

Two-tailed χ^2 tests were performed to evaluate the difference in proportions. Significant independent variables from bivariate analysis were considered potential factors of high general psychological distress and PTSR, and were entered in the multivariable logistic regression model (forced entry method). SAS version 9.2 (SAS Institute) was used. A 2-sided $P<.05$ was used to indicate significance.

Results. Of 1760 eligible workers, 1495 (85%) participated (Daiichi: n=885 [84%]; Daini: n=610 [86%]). Compared with Daini workers, Daiichi workers were more often exposed to disaster-related stressors (Table 1). Experiencing discrimination or slurs was not statistically significantly different between groups (14% vs 11%, $P=.08$).

Daiichi workers had significantly higher rates of psychological distress (n=412; 47%; 95% CI, 43%-50%; vs n=226; 37%; 95% CI, 33%-41%; $P<.001$) and PTSR (n=261; 30%; 95% CI, 27%-33%; vs n=117; 19%; 95% CI, 16%-22%; $P<.001$) (Table 1). For both groups, discrimination or slurs were associated with high psychological distress (Daiichi: adjusted odds ratio [AOR], 2.06; 95% CI, 1.34-3.16; vs Daini: AOR, 2.90; 95% CI, 1.63-5.17) and high PTSR (Daiichi: AOR, 2.17; 95% CI, 1.43-3.30; vs Daini: AOR, 2.70; 95% CI, 1.47-4.96) (TABLE 2). Other significant associations in both groups included tsunami evacuation and major property loss with psychological distress and preexisting illness and major property loss with PTSR.

Comment. We found that general psychological distress and PTSR were common in nuclear plant workers 2 to 3 months after the disaster. The prevalence was higher than in other studies (12.5% with severe or very severe psychological impairment in a review of 24 studies),[5] possibly due to the complexity of their experience. Higher rates were found among workers of Daiichi than Daini, which is concordant with their higher exposure to disaster-related stressors.

This is the first study to our knowledge to explore discrimination as a factor in postdisaster mental health. Experiencing discrimination was associated with both general psychological distress and PTSR. A similar phenomenon was observed in Vietnam War veterans; along with combat exposure, insufficient societal support and societal rejection upon homecoming were associated with posttraumatic stress disorder.[6]

Several limitations warrant discussion. Our report was cross-sectional, with neither baseline measures nor long-term outcomes. The responses were self-reported and no comparison group was available. We had no information on specific previous physical/mental illness; educational,

Table 2. Factors Associated With High General Psychological Distress (GPD) and High Posttraumatic Stress Responses (PTSR)

	Daiichi (n = 885)				Daini (n = 610)			
Mental Health Outcome Factors[a]	β	SE	Adjusted OR (95% CI)	*P* Value	β	SE	Adjusted OR (95% CI)	*P* Value
High GPD[b]								
Sex, female vs male	0.53	0.40	1.69 (0.77-3.73)	.19	0.53	0.32	1.70 (0.90-3.19)	.10
Preexisting illnesses	0.23	0.21	1.26 (0.84-1.89)	.26	0.72	0.26	2.05 (1.23-3.41)	.006
Discrimination/slurs	0.72	0.22	2.06 (1.34-3.16)	.001	1.07	0.29	2.90 (1.63-5.17)	<.001
Near-death experience	0.63	0.16	1.89 (1.39-2.56)	.001	0.21	0.22	1.24 (0.80-1.91)	.33
Tsunami evacuation	0.63	0.26	1.87 (1.13-3.09)	.015	0.59	0.25	1.80 (1.09-2.95)	.02
Witnessed plant explosion	0.03	0.16	1.03 (0.75-1.41)	.87	0.88	0.28	2.40 (1.39-4.14)	.002
Colleague deaths	0.17	0.19	1.19 (0.82-1.72)	.37	−0.11	0.27	0.90 (0.53-1.51)	.68
Major property loss	0.63	0.16	1.88 (1.38-2.58)	<.001	0.60	0.21	1.83 (1.21-2.77)	.004
Home evacuation	0.42	0.16	1.52 (1.10-2.08)	.01	0.05	0.19	1.05 (0.72-1.53)	.80
High PTSR[c]								
Sex, female vs male	0.56	0.41	1.74 (0.79-3.86)	.17	1.24	0.35	3.46 (1.76-6.81)	<.001
Preexisting illnesses	0.49	0.21	1.64 (1.08-2.48)	.02	0.79	0.29	2.20 (1.24-3.92)	.007
Discrimination/slurs	0.78	0.21	2.17 (1.43-3.30)	<.001	1.00	0.31	2.70 (1.47-4.96)	.001
Near-death experience	0.52	0.17	1.68 (1.20-2.34)	.002	0.53	0.25	1.70 (1.04-2.79)	.03
Tsunami evacuation	0.31	0.25	1.36 (0.84-2.22)	.21	0.98	0.28	2.67 (1.55-4.58)	<.001
Witnessed plant explosion	0.21	0.17	1.23 (0.89-1.72)	.21	−0.06	0.34	0.94 (0.49-1.84)	.87
Colleague deaths	0.40	0.19	1.49 (1.02-2.18)	.04	−0.11	0.33	0.89 (0.47-1.69)	.73
Major property loss	0.62	0.16	1.85 (1.34-2.56)	<.001	0.59	0.24	1.81 (1.12-2.91)	.02
Home evacuation	0.34	0.18	1.40 (0.99-1.99)	.06	−0.10	0.24	0.90 (0.57-1.44)	.67

Abbreviation: OR, odds ratio.
[a] Shown factors were entered in the multivariable logistic regression model (forced entry method).
[b] Defined according to the Japanese version of the K6 scale (≥13). Data were missing for 10 participants (0.7% of total; Daiichi, n=6; Daini, n=4).
[c] Defined according to the Japanese version of the Impact of Events Scale-Revised (≥25). Data were missing for 70 participants (4.7% of total; Daiichi, n=42; Daini, n=22).

marital, or socioeconomic status; or precise irradiation exposure, although irradiation symptoms were not reported.

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Acquisition of data: Shigemura, Tanigawa.
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Internal Radiation Exposure After the Fukushima Nuclear Power Plant Disaster

To the Editor: On March 11, 2011, an earthquake and tsunami struck Japan and led to a meltdown of the reactors at the Fukushima Daiichi nuclear power plant. Release of radioactive material into the air, water, and soil raised concern about internal radiation exposure and the long-term risk of cancer in nearby residents.[1] However, radiation exposure has not been measured.

Methods. Minamisoma is located 23 km north of the Fukushima Daiichi nuclear plant. Many residents were evacuated, but by August 2011, approximately half had returned. A voluntary screening program for levels of cesium (^{134}Cs and ^{137}Cs), known to be representative of total internal radiation exposure,[2] was conducted between September 26, 2011, and March 31, 2012, for all residents aged 6 years or older using a whole-body counter (Fastscan Model 2250) shielded to background radiation. Detection limits were 210 Bq for ^{134}Cs and 250 Bq for ^{137}Cs with a 2-minute scan. Persons without radiation exposure would have a level of 0 Bq. Cesium exposure was measured as both total body exposure and concentration by body weight (Bq/kg) and is reported as median values with ranges (minimum to maximum). Total cesium exposure was converted into committed effective dose (sievert, Sv) based on the assumption of acute cesium inhalation immediately after the disaster in adults, and on that of chronic cesium ingestion after the disaster in children. Common dose-limit recommendations for the public are 1 mSv or less.[3] χ^2 Tests were used to compare proportions of adults and children exposed, with 2-sided $P < .05$ considered statistically significant. All statistical analyses were conducted using Stata/MP version 11 (StataCorp LP). The institutional review board of the Institute of Medical Science, University of Tokyo, approved the study with a waiver of informed consent.

Results. A total of 9498 residents enrolled in the study, 24% of the registered population on August 15, 2011. The sample consisted of 1432 children (720 girls; median [range] age, 11 [6-15] years) and 8066 adults (4512 women; median [range] age, 44 [15-97] years).

A total of 3286 individuals (34.6%; 95% CI, 33.6%-35.6%) had detectable levels of cesium (FIGURE). Cesium was detected in 235 children (16.4%; 95% CI, 14.5%-18.3%), ranging from 210 to 2953 Bq (median, 590 Bq), with a concentration of 2.8 to 57.9 Bq/kg (median, 11.9 Bq/kg). In contrast, 3051 adults (37.8%; 95% CI, 36.8%-38.9%) had detectable levels of cesium, ranging from 210 to 12 771 Bq (median, 744 Bq), with a concentration of 2.3 to 196.5 Bq/kg (median, 11.4 Bq/kg). This difference in exposure risk between adults and children was statistically significant ($\chi^2 = 246.5$, $P < .001$).

Committed effective doses were less than 1 mSv in all but 1 resident (1.07 mSv).

Comment. To our knowledge, this is the first report on internal exposure to cesium radiation after the Fukushima Daiichi nuclear plant incident. In this sample, exposure levels were low in most adults and children tested and much lower than those reported in studies years after the Chernobyl incident (49 Bq/kg after 7-10 years).[4] Even the highest levels of contamination observed are below the thresh-

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Associations between Disaster Exposures, Peritraumatic Distress, and Posttraumatic Stress Responses in Fukushima Nuclear Plant Workers following the 2011 Nuclear Accident: The Fukushima NEWS Project Study

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Abstract

Background: The 2011 Fukushima Daiichi Nuclear Power Plant accident was the worst nuclear disaster since Chernobyl. The nearby Daini plant also experienced substantial damage but remained intact. Workers for the both plants experienced multiple stressors as disaster victims and workers, as well as the criticism from the public due to their company's post-disaster management. Little is known about the psychological pathway mechanism from nuclear disaster exposures, distress during and immediately after the event (peritraumatic distress; PD), to posttraumatic stress responses (PTSR).

Methods: A self-report questionnaire was administered to 1,411 plant employees (Daiichi, $n=831$; Daini, $n=580$) 2–3 months post-disaster (total response rate: 80.2%). The socio-demographic characteristics and disaster-related experiences were assessed as independent variables. PD and PTSR were measured by the Japanese versions of Peritraumatic Distress Inventory and the Impact of Event Scale-Revised, respectively. The analysis was conducted separately for the two groups. Bivariate regression analyses were performed to assess the relationships between independent variables, PD, and PTSR. Significant variables were subsequently entered in the multiple regression analyses to explore the pathway mechanism for development of PTSR.

Results: For both groups, PTSR highly associated with PD (Daiichi: adjusted β, 0.66; $p<0.001$; vs. Daini: adjusted β, 0.67; $p<0.001$). PTSR also associated with discrimination/slurs experience (Daiichi: 0.11; $p<0.001$; vs. Daini, 0.09; $p=0.005$) and presence of preexisting illness(es) (Daiichi: 0.07; $p=0.005$; vs. Daini: 0.15; $p<.0001$). Other disaster-related variables were likely to be associated with PD than PTSR.

Conclusion: Among the Fukushima nuclear plant workers, disaster exposures associated with PD. PTSR was highly affected by PD along with discrimination/slurs experience.

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Competing Interests: JS, SN, and AY provided mental health assistance to TEPCO Fukushima Daiichi and Daini nuclear power plant employees according to official requests from Daini and a Japanese government cabinet order to the Ministry of Defense. TT is a Daini part-time occupational physician. DN and YM report no conflict of interest disclosures. This does not alter the authors' adherence to all the PLOS ONE policies on sharing data and materials.

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Introduction

On March 11, 2011, a 9.0 magnitude earthquake and series of tsunami attacked the northeastern coast of Japan (the Great East Japan Earthquake). Tokyo Electric Company (TEPCO) Fukushima Daiichi Nuclear Power Plant (Daiichi) was heavily damaged, eventually leading to plant explosions, nuclear plant meltdowns, release of radioactive materials, and mandatory evacuation of the surrounding residents. It became the largest nuclear disaster since the 1986 Chernobyl accident, and only the second disaster (along with Chernobyl) to measure Level 7 severity on the International Nuclear Event Scale. Recovery efforts are expected to continue for decades.

Chernobyl mental health studies [1–3] suggest that among the affected population, plant workers are at particular risk for experiencing psychological distress. The Fukushima nuclear plant workers have been working under extremely hazardous conditions

Table 1. Comparisons of two subject groups (Daiichi vs. Daini).

			Subject groups							
			Total		Daiichi		Daini		Daiichi vs. Daini	
			n	%	*n*	%	*n*	%	χ^2	*p*
Total			1,411	100	831	100	580	100		
Sociodemographic factors	Age, years	20–29	381	25.6	227	25.7	154	25.4		
		30–39	347	23.3	202	22.9	145	23.9		
		40–49	395	26.5	235	26.6	160	26.4		
		50–59	348	23.4	211	23.9	137	22.6		
		60–69	18	1.2	8	0.9	10	1.7	2.09	0.72
	Sex	Male	1,337	94.8	804	96.8	533	91.9	15.5	<0.001***
	Supervisory work status	Yes	147	10.4	86	10.3	61	10.5	0.07	0.79
	Preexisting illness(es)	Yes	203	14.4	126	15.2	77	13.3	0.96	0.33
Disaster-related experiences	Discrimination/slurs	Yes	179	12.7	115	13.8	64	11	2.97	0.085
	Near-death experience	Yes	593	42	446	53.7	147	25.3	117	<0.001***
	Escape from tsunami	Yes	175	12.4	82	9.9	93	16	12.9	<0.001***
	Witnessing of plant explosion(s)	Yes	372	26.4	303	36.5	69	11.9	112	<0.001***
	Family member death(s)	Yes	81	5.7	50	6	31	5.3	0.11	0.74
	Colleague death(s)	Yes	249	17.6	166	20	83	14.3	7.49	0.006**
	Major property loss	Yes	408	28.9	269	32.4	139	24	11.1	0.001**
	Home evacuation	Yes	945	67	582	70	363	62.6	8.2	0.004**

**$p<0.01$.
***$p<0.001$.
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[4], and a majority of the workers have been under a multitude of stressors. In addition to workplace traumatic stress, such stressors include victim experiences, grief reactions, and the criticism from the public due to their company's post-disaster management [5].

Responses occurring at the time of a trauma and immediately after (i.e., peritraumatic responses) include emotional changes (e.g., helplessness, guilt, horror, and fear of death) and physical reactions (e.g., sweating, shaking, and bladder/bowel responses). A meta-analysis [6] has suggested that such peritraumatic distress (PD) is one of the strongest predictors of future posttraumatic stress responses (PTSR), such as intrusion, avoidance/numbing, and hyperarousal, subsequently developing posttraumatic stress disorder (PTSD) among the affected individuals.

Our previous study [7] examined the mental health outcomes of the Fukushima Daiichi and Daini workers 2–3 months post-disaster. This report suggested their enormous and complex disaster exposures resulted in high rates of general psychological distress and PTSR. As of the writing of this article, little is known about the psychological pathway mechanism from multiple nuclear disaster exposures, PD, to PTSR among the affected people. In order to explore this development pathway of PTSR, we conducted a cross-sectional study to explore this association among Fukushima nuclear plant workers post-accident.

Methods

Following approvals from the Ethics Committees of Ehime University and National Defense Medical College, full-time TEPCO employees of Fukushima Daiichi and the nearby Daini nuclear power plants (Daiichi: $n = 1{,}053$; Daini: $n = 707$) were invited to participate in the present study, 2–3 months post-disaster (May–June, 2011). Daini is located 12 km south of Daiichi, had suffered tsunami attacks, and was close to nuclear meltdown. None of the workers had reported acute radiation exposure symptoms. Written consent was obtained from subjects upon enrollment in the study.

We gathered information about respondents' socio-demographic information, disaster-related stressors, and the extent of PD using a self-report questionnaire. Disaster-related stressors were determined based on our initial on-site services [5] and dichotomously coded as "yes" or "no." We asked subjects whether they had experienced discrimination/slurs (*sabetsu/chuushou* in Japanese) because TEPCO workers were under public criticism. Our studies revealed that PTSR in workers were complex and linked to their multiple disaster experiences, including work-related trauma, disaster victim distress, grief experience, and discrimination from the public [5,7]. We assessed colleague death(s) as a potential stressor because two young Daiichi employees and a Daini contractor had died due to tsunami.

PD was measured using a Japanese version of the Peritraumatic Distress Inventory (PDI) [8,9]. The PDI is a 13-item scale quantifying fear and sense of helplessness in the period during and immediately after a traumatic experience. The response format was a five-point Likert scale ranging from 0 to 4; the total score ranged from 0 to 52, and higher scores represent higher PD. A study among motor vehicle accident survivors showed a PDI cutoff score of 22/23 to predict PTSD [10]. The scale's internal consistency is high (Cronbach's alpha = 0.86).

PTSR was quantified using a Japanese version of the Impact of Event Scale-Revised (IES-R) [11]. This is a 22-item scale measuring PTSR domains of intrusion, avoidance/numbing, and hyperarousal. The detailed explanation is available on our previous paper [7].

Table 2. Bivariate and multivariate relationships: peritraumatic stress and independent variables.

			Associations with PDI															
			Daiichi (n=831)								Daini (n=580)							
			Bivariate analysis				Multivariate analysis				Bivariate analysis				Multivariate analysis			
			B	SE	β	p	B	SE	β	p	B	SE	β	p	B	SE	β	p
Sociodemographic factors	**Age**	Years	−0.08	0.03	−0.10	0.004**	−0.04	0.03	−0.04	0.24	−0.06	0.03	−0.07	0.077				
	Sex	Male	2.93	1.83	0.06	0.11					3.32	1.31	0.11	0.012*	2.96	1.19	0.09	0.013*
	Supervisory work status	Yes	−3.16	1.06	−0.10	0.003**	−1.76	1.01	−0.06	0.08	−3.56	1.16	−0.13	0.002**	−2.73	1.06	−0.10	0.010*
	Preexisting illness(es)	Yes	0.23	0.91	0.01	0.80					2.02	1.06	0.08	0.056				
Disaster-related experiences	**Discrimination/slurs**	Yes	5.58	0.92	0.21	<0.001***	3.61	0.84	0.13	<0.001***	6.59	1.11	0.24	<0.001***	4.38	1.05	0.16	<0.001***
	Near-death experience	Yes	7.35	0.60	0.39	<0.001***	5.62	0.61	0.30	<0.001***	6.45	0.78	0.33	<0.001***	4.33	0.80	0.22	<0.001***
	Escape from tsunami	Yes	5.92	1.07	0.19	<0.001***	2.19	1.00	0.07	0.028*	5.36	0.95	0.23	<0.001***	2.98	0.93	0.13	0.001**
	Witnessing of plant explosion(s)	Yes	4.79	0.65	0.25	<0.001***	2.53	0.63	0.13	<0.001***	4.29	1.10	0.16	<0.001***	2.48	1.01	0.09	0.015*
	Family member death(s)	Yes	1.15	1.36	0.03	0.40					1.07	1.60	0.03	0.50				
	Colleague death(s)	Yes	3.93	0.80	0.17	<0.001***	1.67	0.78	0.07	0.033*	1.83	1.02	0.07	0.074				
	Major property loss	Yes	3.86	0.68	0.19	<0.001***	2.30	0.63	0.12	<0.001***	4.56	0.82	0.23	<0.001***	2.87	0.77	0.14	<0.001***
	Home evacuation	Yes	1.97	0.71	0.10	0.005**	1.20	0.64	0.06	0.059	1.38	0.74	0.08	0.062				

*p<0.05.
**p<0.01.
***p<0.001.
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Table 3. PDI scores, confirmatory factor analysis of PDI items, and associations with IES-R.

		Total (n=1,411)	Daiichi (n=831)						Daini (n=580)					
		Factor analysis[†]	Score		Associations with IES-R				Score		Associations with IES-R			
			Mean	SD	B	SE	β	t	Mean	SD	B	SE	β	t
PDI total score			19.46	9.35	1.13	0.05	0.66***	24.9	15.89	8.64	1.13	0.05	0.67***	21.5
PDI items	1. I felt helpless to do more	0.69	1.51	1.24	5.79	0.39	0.46***	14.7	1.20	1.17	6.57	0.43	0.54***	15.2
	2. I felt sadness and grief	0.75	2.06	1.29	5.94	0.38	0.48***	15.8	1.81	1.29	5.43	0.41	0.48***	13.3
	3. I felt frustrated or angry I could not do more	0.65	1.77	1.30	5.12	0.38	0.42***	13.3	1.48	1.31	4.50	0.42	0.41***	10.8
	4. I felt afraid for my safety	0.72	1.94	1.35	4.68	0.38	0.40***	12.4	1.39	1.23	4.63	0.45	0.40***	10.4
	5. I felt guilt that more was not done	0.62	1.37	1.24	5.08	0.41	0.40***	12.4	1.04	1.18	5.92	0.44	0.49***	13.4
	6. I felt ashamed of my emotional reactions	0.60	0.70	0.96	7.70	0.51	0.47***	15.1	0.57	0.86	7.32	0.63	0.44***	11.7
	7. I felt worried about the safety of others	0.44	3.21	1.04	3.70	0.53	0.24***	7.00	3.10	1.05	2.36	0.56	0.18***	4.25
	8. I had the feeling I was about to lose control of my emotions	0.68	0.91	1.15	7.07	0.41	0.52***	17.3	0.82	1.09	6.42	0.48	0.49***	13.4
	9. I had difficulty controlling my bowel and bladder	0.34	0.09	0.43	10.2	1.23	0.28***	8.26	0.07	0.33	14.0	1.71	0.32***	8.19
	10. I was horrified by what happened	0.64	2.69	1.30	4.74	0.40	0.39***	12.0	2.51	1.32	3.46	0.43	0.32***	8.08
	11. I had physical reactions like sweating, shaking and pounding heart	0.67	1.06	1.27	6.21	0.38	0.50***	16.5	0.79	1.11	7.26	0.45	0.56***	16.2
	12. I felt I might pass out	0.46	0.28	0.79	7.26	0.65	0.37***	11.2	0.17	0.54	10.39	1.00	0.40***	10.4
	13. I felt I might die	0.64	1.84	1.55	3.82	0.33	0.38***	11.6	0.91	1.26	3.85	0.45	0.34***	8.60

***$p<0.001$.

[†]One-factor solution accounted for 38.3% of the total variance.

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Table 4. Associations between posttraumatic stress responses (IES-R) and independent variables: bivariate and multiple regression analyses.

	Associations with IES-R															
	Daiichi (n=831)								Daini (n=580)							
	Bivariate regression				Multiple regression				Bivariate regression				Multiple regression			
	B	SE	β	p	B	SE	β	p	B	SE	β	p	B	SE	β	p
Sociodemographic factors																
Age, years	0.02	0.05	0.02	0.68					0.07	0.05	0.06	0.19				
Sex	4.93	2.98	0.06	0.10					6.56	2.12	0.13	0.002**	2.22	1.63	0.04	0.18
Supervisory work status	−1.26	1.86	−0.02	0.50					−1.08	1.95	−0.02	0.580				
Preexisting illness(es)	3.78	1.53	0.09	0.014*	3.23	1.16	0.07	0.005**	7.78	1.73	0.18	<0.001***	6.60	1.33	0.15	<0.001***
Disaster-related experiences																
Discrimination/slurs	10.5	1.53	0.23	<0.001***	5.03	1.23	0.11	<0.001***	10.6	1.85	0.23	<0.001***	4.11	1.46	0.09	0.005**
Near-death experience	6.34	1.07	0.20	<0.001***	−2.74	0.93	−0.09	0.003**	7.38	1.33	0.22	<0.001***	−1.31	1.12	−0.04	0.24
Escape from tsunami	7.61	1.78	0.15	<0.001***	2.20	1.42	0.04	0.12	8.23	1.58	0.21	<0.001***	2.59	1.28	0.07	0.044*
Witnessing of plant explosion(s)	4.31	1.12	0.13	<0.001***	−0.85	0.91	−0.03	0.35	3.43	1.83	0.08	0.062				
Family member death(s)	3.44	2.32	0.05	0.14					2.13	2.61	0.03	0.41				
Colleague death(s)	4.50	1.37	0.11	0.001**	0.85	1.07	0.02	0.43	−0.05	1.70	0	0.98				
Major property loss	5.66	1.16	0.17	<0.001***	1.00	0.92	0.03	0.28	6.48	1.36	0.19	<0.001***				
Home evacuation	3.50	1.18	0.10	0.003**	0.87	0.91	0.03	0.34	2.09	1.22	0.07	0.09	0.23	0.92	0.01	0.81
PDI total score	1.13	0.05	0.66	<0.001***	1.12	0.05	0.66	<0.001***	1.13	0.05	0.67	<0.001***	1.06	0.06	0.63	<0.001***

*p<0.05.
**p<0.01.
***p<0.001.
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