



CLINICAL RESEARCH ARTICLE



Employee safety perception following workplace terrorism: a longitudinal study

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ABSTRACT

Terrorism at the workplace represents an extreme form of workplace violence potentially affecting large numbers of individuals. Evidence suggests that workplace violence adversely affects employees' health and work functioning by increasing perceived threat and decreasing perceived safety.

The objective of this study was to explore longitudinal associations between perceived safety at work among employees exposed to a workplace terrorist attack and their views on security measures and emergency preparedness.

The study comprised a three-wave follow-up of earlier cross-sectional studies on perceived safety at work in ministerial employees exposed to a terrorist attack in Oslo, Norway, in 2011 ($N = 3065$). Linear mixed-effects modelling was used to explore how perceived safety at work was associated with employees' perceptions on the prioritization of security measures at work, their knowledge of evacuation procedures, and the extent of escape and evacuation training.

The more employees believed security measures were sufficiently prioritized at work and the better their knowledge of evacuation procedures, the higher they rated perceived safety at work. These findings applied both across employees (between-subject effects) and within employees across time (within-subject effects). Employees' views on the extent of escape and evacuation training were not strongly associated with perceived safety at work. Secondary analysis showed that post-traumatic stress reactions were negatively associated with perceived safety at work, and that the positive association between knowledge of evacuation procedures and perceived safety at work was weaker in women and more educated employees.

In conclusion, following terrorism at the workplace, employees' perceived safety at work might be increased if employers prioritize security measures and provide good information on evacuation procedures. For employees with high levels of post-traumatic stress reactions, adequate treatment of these reactions will be likely to lead to enhanced perceived safety at work.

La percepción de la seguridad del empleado después del terrorismo en el lugar de trabajo: Un estudio longitudinal

Antecedentes: El terrorismo en el lugar de trabajo representa una forma extrema de violencia en el lugar de trabajo y puede, potencialmente, afectar a un gran número de personas. La evidencia sugiere que la violencia en el lugar de trabajo afecta negativamente la salud y el funcionamiento laboral de los empleados al aumentar la amenaza percibida y disminuir la seguridad percibida.

Objetivo: Explorar las asociaciones longitudinales entre la seguridad percibida en el trabajo de los empleados expuestos a un ataque terrorista en el lugar de trabajo y sus puntos de vista sobre las medidas de seguridad y la preparación para emergencias.

Método: Seguimiento de tres momentos de estudios transversales anteriores sobre la seguridad percibida en el trabajo en empleados ministeriales expuestos a un ataque terrorista en Oslo, Noruega, 2011 ($N = 3065$). El modelado lineal de efectos mixtos se utilizó para explorar cómo la seguridad percibida en el trabajo estaba asociada con las percepciones de los empleados sobre (i) la priorización de las medidas de seguridad en el trabajo; (ii) sus conocimientos de los procedimientos de evacuación; y (iii) el grado de entrenamiento de escape y evacuación.

Resultados: Cuanto más los empleados creyeron que las medidas de seguridad se priorizaron suficientemente en el trabajo y cuanto mejor conocían los procedimientos de evacuación, más alto calificaban la seguridad percibida en el trabajo. Estos hallazgos se aplicaron tanto entre los empleados (efectos entre sujetos) como dentro de los mismos empleados a lo largo del tiempo (efectos dentro del sujeto). Los puntos de vista de los empleados sobre el alcance del entrenamiento de escape y evacuación no estaban fuertemente asociados con la percepción de seguridad en el trabajo. El análisis secundario mostró

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PALABRAS CLAVE

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关键词

安全感; 安全和安全措施; 逃生和撤离; 创伤后应激; 恐怖主义

HIGHLIGHTS

- Perceived safety at work in terror-exposed employees appears to be linked to their views on security measures and emergency preparedness: the more employees believe security measures are sufficiently prioritized and the better their knowledge of evacuations procedures, the higher their perceived safety.
- Employees' views on the extent of escape and evacuation training were not linked to perceived safety at work.
- Post-traumatic stress reactions were negatively associated with employees' perceived safety at work.

que las reacciones de estrés postraumático se asociaron negativamente con la percepción de seguridad en el trabajo, y que la asociación positiva entre el conocimiento de los procedimientos de evacuación y la seguridad percibida en el trabajo fue más débil en las mujeres y los empleados con más educación.

Conclusión: Tras el terrorismo en el lugar de trabajo, la seguridad percibida de los empleados en el trabajo podría aumentar si los empleadores priorizan las medidas de seguridad y aseguran buena información sobre los procedimientos de evacuación. Para empleados con altos niveles de reacciones de estrés postraumático, el tratamiento adecuado de estas reacciones probablemente conducirá a una mayor seguridad percibida en el trabajo.

职场恐怖主义下的员工安全感 —— 一个纵向研究

背景: 工作场所的恐怖事件是工作场所暴力的极端形式, 可能影响到大量的个人。有证据表明, 工作场所暴力通过增加威胁感和降低安全感来对员工的健康和工作能力产生负面影响。

目标: 探讨经历过工作场所恐怖袭击的雇员的工作安全感与他们对安全措施和应急准备的想法之间的纵向联系。

方法: 对2011年在挪威奥斯陆遭受恐怖袭击的部长级员工的工作安全感的早期横断研究的基础上, 进行了三波后续追踪 (N = 3065)。使用线性混合效应模型来研究工作中的安全感与员工对以下几点认识的相关性 (i) 工作安全措施优先级; (ii) 他们对撤离程序的了解; 和 (iii) 逃生和疏散培训的范围。

结果: 越来越多的员工认为安全措施在工作中具有足够的优先级, 并且他们对撤离程序的了解越多, 他们评估的安全感就越高。这些发现适用于跨员工 (被试间效应) 和员工自身跨时间 (被试内效应)。员工对逃生和疏散培训程度的看法与工作中的安全感没有强关联。二级分析显示, 创伤后应激反应与工作安全感呈负相关, 而且在工作中, 疏散程序知识与工作安全感之间的正相关在女性和受过更好教育的员工中较弱。

结论: 在工作场所发生恐怖事件后, 如果雇主优先考虑安全措施并确保疏散程序被理解, 那么员工在工作中的安全感可能会增加。对于有高水平的创伤后应激反应的员工来说, 对这些反应进行适当的治疗可能会提高工作中的安全感。

1. Introduction

Exposure to violence at the workplace has been shown to adversely affect employees' somatic, psychological and emotional health, impair work functioning and increase turnover intentions (Hogh & Viitasara, 2005; Lanctôt & Guay, 2014; Rogers & Kelloway, 1997). Evidence, mostly from studies on nurses and emergency department staff exposed to verbal and/or physical abuse and violence by patients, family members or visitors, suggests that these negative consequences are at least partly mediated by an increased sense of fear of future violence and a decreased sense of safety at work (Gates, Ross, & McQueen, 2006; May & Grubbs, 2002; Shiao et al., 2010). The importance of perceived threat and safety in mediating negative health reactions following traumatic exposure at work is also suggested by a study on bank employees exposed to robberies at work, which found low perceived safety after the robbery to be a strong predictor of acute stress disorder (Hansen & Elklit, 2011; Rogers & Kelloway, 1997), and by a study on customer service representatives in a large financial institution exposed to verbal or physical assaults (Rogers & Kelloway, 1997).

An elevated sense of current threat and reduced sense of safety are fundamental in Ehlers and Clark's cognitive model of post-traumatic stress disorder (PTSD) and thought to arise as early symptoms in the disorder, later accompanied by re-experiencing, avoidance and hyperarousal (Ehlers & Clark, 2000). It has also been suggested that perceived safety may

be the essential component in turning a chronic stress response off (Brosschot, 2017). In this theory, the stress response seen in an individual with PTSD could be viewed as the 'default response' in the individual whenever and for as long as there is an absence of perceived safety. That is, the individual will remain stressed until he or she feels safe and will automatically return to being stressed once the perceived safe surroundings are removed. Reduced perceived safety and elevated threat, therefore, may be viewed as key elements in both the development and maintenance of PTSD. This is reflected in the latest version of the Diagnostic and Statistical Manual of Mental Disorders (Fifth Edition, DSM-5), with the addition of a fourth symptom cluster encompassing 'negative alterations in cognition and mood' as a criterion for PTSD (American Psychiatric Association, 2013). One part of the added symptom cluster is persistent (and often distorted) negative beliefs and expectations about oneself or the world, exemplified by statements such as 'I am bad' and 'The world is completely dangerous'. In a prior cross-sectional study by our group, we found empirical support for the new DSM-5 D-criterion for PTSD and the role played by perceived threat and safety in the disorder (Nissen, Birkeland Nielsen, Solberg, Bang Hansen, & Heir, 2015).

Workplace terrorism represents a special and extreme form of workplace violence, possibly affecting large numbers of individuals. Limited research to date has explored the perception of fear and safety at work

among terror-exposed workers (Fullerton, Ursano, Reeves, Shigemura, & Grieger, 2006; Grieger, Fullerton, & Ursano, 2004; Grieger, Fullerton, Ursano, & Reeves, 2003). Terrorism tends to push both societal attention and resources towards security- and safety-related policies and interventions (Archick, Ek, Gallis, Miko, & Woehrel, 2006; Davis et al., 2010; Hobijn & Sager, 2007). The main goal is to enhance actual or objective safety; however, there is weak evidence that security measures are cost-effective in increasing objective safety (Akhtar, Bjørnskau, & Veisten, 2010; LaFree & Dugan, 2009; Lum, Kennedy, & Sherley, 2006; Stewart, 2008; Stewart & Mueller, 2008). It has been claimed that many counter-terrorism measures may in fact have a stronger impact on the feeling of safety than on actual safety (Schneier, 2008), although evidence for this is also scant. Prior studies give some reason to believe that security measures installed at airports since 11 September 2001 have increased people's feeling of safety at airports (Chen & Noriega, 2004); that screening of passengers and luggage as well as explosive detection canines are viewed as more effective security measures than, for example, citizen watching and email monitoring (Sanquist, Mahy, & Morris, 2008); and that security checks and police presence may increase perceived safety at sporting venues (Taylor & Toohey, 2006). Apart from an earlier cross-sectional study by our group, we know of no research that has explored the association of perceived safety with knowledge and views on escape and evacuation training in connection to terrorism. Research on safety climate and safety culture within the field of occupational health has indicated that employee perceived safety at work is related to both safety training and knowledge (e.g. Leiter, Zanaletti, & Argentero, 2009; Rundmo, 1992). Similarly, occupational health research has shown that management commitment to safety is important for how employees view safety at work (O'Toole, 2002). Importantly, though, since this research mostly concerns risk perception in connection to accidents in the workplace, findings cannot necessarily be transferred to the setting of terrorism because terrorist acts are caused by people and highly intentional, in contrast to accidents. Given the hypothesized role of perceived fear and safety as mediators of negative health outcomes following workplace violence, one may argue that a prioritized goal in the aftermath of workplace terrorism should be to ensure that employees' level of perceived safety returns to normal or near-normal levels.

The present prospective three-wave study expands on two earlier cross-sectional studies investigating safety perception at work among Norwegian ministerial employees exposed to a car-bomb terrorist attack at their workplace (Nissen et al., 2015; Nissen & Heir, 2016). Eight people were killed in the attack,

about 200 more were wounded, and the explosion caused massive damage to infrastructure in the government quarter in Oslo, Norway. Various security measures were put in place in the months and years following the attack (e.g. roadblocks, high-security entrances, bullet-proof glass and ID-card controlled access to sections within buildings). Ministries also arranged educational meetings on escape and evacuation, and conducted training sessions at regular intervals. There was substantial variation between ministries in terms of the choice, extent and timing of implemented measures and escape and evacuation education and training.

The aim of the present study was to longitudinally examine previous cross-sectional findings linking employees' perceived safety at work to their views on security measures and emergency preparedness. Specifically, the study aimed to examine whether the following three predictors are longitudinally associated with employees' level of perceived safety at work: (1) whether employees believe that security measures are sufficiently prioritized at work; (2) whether employees believe that there has been sufficient escape and evacuation training; and (3) whether employees know what to do in the event of an emergency evacuation. Secondary aims were to investigate the association between post-traumatic stress reactions and perceived safety at work across time; and whether gender and education modified the assumed longitudinal association between employees' knowledge of emergency procedures and perceived safety at work.

2. Methods

2.1. Design and participants

The present longitudinal design study was based on three waves of data collected 1 year (T1), 2 years (T2) and 3 years (T3) after a major terrorist attack on 22 July 2011 in Oslo, Norway. Eligible participants included all employees in the 17 Norwegian ministries at the time of the attack who remained employed in the ministerial system throughout the study period. Eligible participants were informed about the study through their respective ministries and given the opportunity to withdraw. A study invitation letter containing a unique log-in code to access the study's online questionnaire was then sent out to eligible participants, and they had about 4 weeks to complete the questionnaire. All participants received a project ID based on their social security number, and this project ID enabled us to follow participants longitudinally. The key to match project IDs to social security numbers was stored by an independent security expert. The researchers were blind to the identity of participants. Procedures were repeated

for all three data-collection points. Further details on design and participants can be found in a separate longitudinal article by our research group (Hansen et al., 2017). The study was approved by the Regional Ethics Committee in Norway.

2.2. Variables

The outcome, *Perceived safety at work*, was measured with the statement *I feel safe when I am at work*, scored on a five-point Likert scale ranging from 1 = disagree to 5 = agree. The item originates from the Safety Perception Scale used by Grieger and colleagues in their studies on safety perception among Pentagon employees after the 11 September attacks (Grieger et al., 2003).

The three main predictors were also statements similarly scored on a five-point Likert scale ranging from 1 = disagree to 5 = agree. The three predictor statements were:

- (1) *Security measures are not given sufficiently high priority at work.* The statement was taken from research on safety climate by Cox and Cheyne (2000), and showed a factor loading of 0.59 for the concept: Priority of safety at the workplace. For ease of readability, the predictor is abbreviated to *priority* (in the text) or *Security measures given sufficient priority* (in the tables) and the scoring reversed (i.e. a higher score indicates a more positive opinion on the priority of security measures).
- (2) *I know what to do in the event of an evacuation situation.* The statement is a modified version of a statement used in the research project Trends and risk levels – Norwegian shelf, by the Norwegian Petroleum Safety Authority (Tharaldsen, Olsen, & Rundmo, 2008). The predictor is abbreviated to *knowledge* or *Know evacuation procedures* in the text and tables.
- (3) *There has been insufficient escape and evacuation training.* The statement stems from research by Williamson, Feyer, Cairns, and Biancotti (1997) on safety climate in the workplace. The original question loaded 0.74 for the factor: Positive safety practice at workplace. The predictor is abbreviated to *training* or *Sufficient escape and evacuation training* and its scoring reversed in the text and tables (i.e. a higher score indicates a more positive opinion on the extent of escape and evacuation training).

The outcome and primary predictor variables were all part of the same segment in the questionnaire presented to participants as *Security and safety at your workplace*. The total number of questions in this segment was eight (T1), six (T2) and 13 (T3).

The outcome questions (*safety*) preceded the questions on the predictors (*priority, knowledge and training*).

The Norwegian version of the PTSD Checklist (PCL) was used to assess symptoms of post-traumatic stress. Participants were instructed to answer questions in the checklist with reference to the terrorist attack. The Norwegian version of the scale has demonstrated good psychometric and diagnostic properties in earlier research (Hem, Hussain, Wentzel-Larsen, & Heir, 2012). The mean item score for PCL was used in analysis. Scores were only computed for participants who had answered at least 13 of the 17 items. Data on likely traumatic exposure were collected through a proxy measure by asking participants about their whereabouts at the time of the attack. The proxy measure was dichotomized in analyses to the categories: (1) in the government district (high exposure); and (2) not in the government district (low exposure).

Data on gender, age and educational level were obtained. For the mixed-effects models, age was divided by 10 (i.e. the regression coefficient for age indicates the change in perceived safety at work for every 10 year increase in age). Education was categorized into three groups: < 13 years (no studies at university level); 13–16 years (some studies at university level); and > 16 years (> 4 years of studies at university level). When testing education as an effect modifier, we dichotomized the variable into ≤ 16 years versus > 16 years.

2.3. Analysis

Chi-square and *t*-tests of age, gender, post-traumatic stress symptoms and perceived safety at T1 were used to evaluate potential selection bias. Unadjusted longitudinal developments in perceived safety at work were examined with linear mixed-effects modelling. The number of participants with missing values for a given variable can be inferred from Table 1. The five-category outcome variable was treated as continuous throughout analysis. Pearson's correlation coefficient was used to test for collinearity between the main three predictors.

The longitudinal associations between the predictors and outcome were evaluated with linear mixed-effects modelling. To investigate both between- and within-subject associations for time-varying predictors, we followed the procedures outlined by Vittinghoff, Glidden, Shiboski, and McCulloch (2012). More specifically, for each of the three predictors and for the PCL variable we generated two new variables: one equalling the mean score for the variable across the three data-collection points, the other equalling the difference between the score at a given time-point and the mean score. The first new variable therefore indicates between-subject associations, i.e. the difference in perceived safety at

Table 1. Characteristics of participating ministerial employees and summary information on study outcome (feel safe at work) and predictors under investigation across data-collection points after the 22 July 2011 terrorist attack in Oslo, Norway.

	First wave, T1 (1689 participants)	Second wave, T2 (1589 participants)	Third wave, T3 (1347 participants)
Demographics			
Gender (participants with data)	(1689)	(1589)	(1347)
Male, <i>n</i> (%)	716 (42.4)	661 (41.6)	589 (43.7)
Female	973 (57.6)	928 (58.4)	758 (56.3)
Age at study start (years) (participants with data)	(1689)	(1589)	(1347)
Mean (SD)	45.3 (10.5)	45.6 (10.3)	45.9 (10.3)
Education (participants with data)	(1683)	(1585)	(1343)
<13 years, <i>n</i> (%)	193 (11.4)	211 (13.3)	184 (13.7)
13–16 years	398 (23.7)	372 (23.5)	335 (24.9)
> 16 years	1092 (64.9)	1002 (63.2)	824 (61.4)
Outcome			
Feel safe at work (participants with data)	(1666)	(1572)	(1326)
1 = disagree, <i>n</i> (%)	67 (4.0)	52 (3.3)	27 (2.0)
2	111 (6.7)	110 (7.0)	61 (4.6)
3	217 (13.0)	238 (15.1)	138 (10.4)
4	501 (30.1)	529 (33.7)	408 (30.8)
5 = agree	770 (46.2)	643 (40.9)	692 (52.2)
Predictors			
Security measures given sufficient priority (participants with data)	(1663)	(1571)	(1318)
1 = disagree, <i>n</i> (%)	177 (10.6)	138 (8.8)	79 (6.0)
2	284 (17.1)	203 (12.9)	150 (11.4)
3	404 (24.3)	364 (23.2)	227 (17.2)
4	443 (26.6)	453 (28.8)	399 (30.3)
5 = agree	355 (21.4)	413 (26.3)	463 (35.1)
Know evacuation procedures (participants with data)	(1664)	(1569)	(1325)
1 = disagree, <i>n</i> (%)	97 (5.8)	58 (3.7)	32 (2.4)
2	156 (9.4)	125 (8.0)	80 (6.0)
3	301 (18.1)	315 (20.1)	217 (16.4)
4	596 (35.8)	614 (39.1)	488 (36.8)
5 = agree	514 (30.9)	457 (29.1)	508 (38.3)
Sufficient escape and evacuation training (participants with data)	(1663)	(1571)	(1325)
1 = disagree, <i>n</i> (%)	270 (16.3)	209 (13.3)	140 (10.6)
2	368 (22.1)	336 (21.4)	231 (17.4)
3	441 (26.5)	398 (25.3)	326 (24.6)
4	318 (19.1)	357 (22.7)	319 (24.1)
5 = agree	266 (16.0)	271 (17.3)	309 (23.3)
PCL (participants with data)	(1627)	(1533)	(1292)
Mean (SD)	1.44 (0.55)	1.35 (0.54)	1.32 (0.51)

A participant was defined as an employee who answered at least parts of the questionnaire. Because of missing values, the total number of participants with data for a given variable at a given time-point does not necessarily add up to the total number of participants for that time-point. PCL, PTSD Checklist.

work between individuals who are, on average, one unit apart on a given predictor; and the second the within-subject associations, i.e. the change in perceived safety at work associated with a one-unit change in a given predictor within an individual across time. The likelihood ratio test (LRT) was used to evaluate model fit with and without random slope(s) for time-varying predictors in the different models. Age, gender, education and PCL score were added as covariates in a final model, all for *a priori* reasons given findings from earlier cross-sectional studies. The proxy variable for exposure was added to the final model as a sensitivity analysis. Participants were included in the final model if they had a complete data set for at least one time-point (i.e. no missing values on outcome, predictors or covariates).

Gender and education were explored as potential effect modifiers by splitting the sample and running the final model on the split samples. That is, one analysis was conducted on the sample split by

gender, and a subsequent analysis on the sample split by education. A *p*-value of 0.05 or less was considered as evidence of significance. Analyses were performed with Stata version 14 (STATA Corporation, College Station, TX, USA).

3. Results

3.1. Flow of participants and participant characteristics

Of the 17 invited ministries, three were excluded for procedural reasons (Hansen et al., 2017). The flow of participants through the study is summarized in Figure 1. Across all time-points, potential participants answering the questionnaire included a higher proportion of women compared to those not answering (0.58 vs 0.48, $p < 0.001$; 0.58 vs 0.48, $p < 0.001$; and 0.56 vs 0.52, $p = 0.019$ at T1, T2 and T3, respectively), and they were slightly older at T2 and T3 (45.6 vs

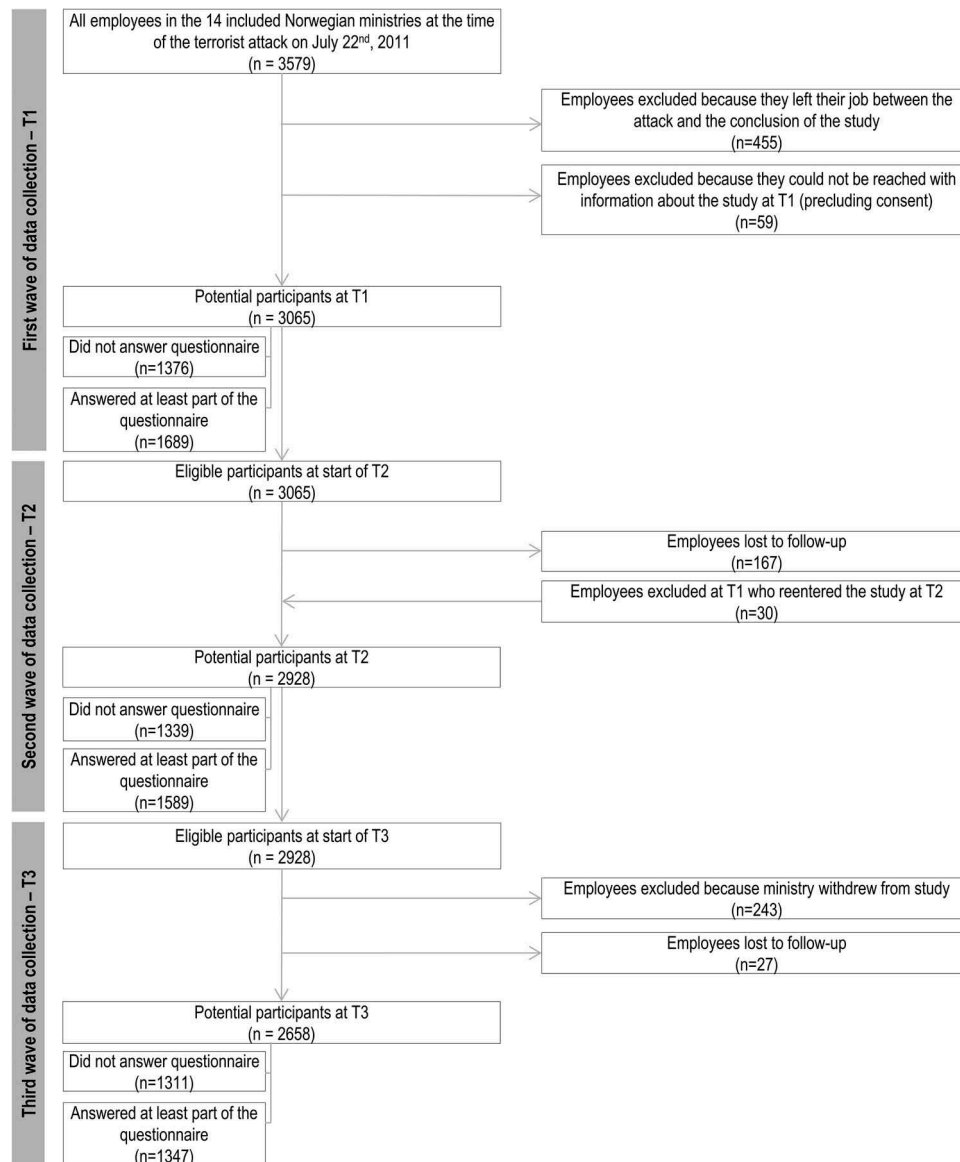


Figure 1. Flow of participants through the three waves of data collection.

44.7 years, $p = 0.030$; and 45.9 vs 44.5 years, $p < 0.001$, respectively). In total, 2108 employees were included in the final linear mixed-effects model. Of these, 526 contributed data at only one time-point whereas 1582 contributed data at more than one time-point. Only data from the latter group were used when calculating within-subject associations, and this group was older (45.7 vs 43.6 years, $p < 0.001$), had a higher proportion of females (0.58 vs 0.52, $p = 0.011$) and had higher PCL mean-item score at T1 (1.46 vs 1.35, $p = 0.003$) compared to the group of 526 contributing data at only one time-point.

3.2. Main results

There was no significant change in the unadjusted level of perceived safety at work from T1 to T2, but there was a significant increase from T1 to T3 ($p < 0.001$) (Table 1). There was also a trend for

employees overall to rate the three predictors on security measures and emergency preparedness more positively over time. That is, when comparing T2 and T3 to the baseline levels (T1), a higher proportion of employees believed that security measures were given sufficient priority at work, knew evacuation procedures and believed that there had been sufficient escape and evacuation training. The level of post-traumatic stress reactions decreased from T1 to T2 and decreased further from T2 to T3. The latter decrease was small but statistically significant (results not shown).

3.2.1. Unadjusted analysis (Model 1)

Univariable linear mixed-effects analysis showed strong evidence of between- and within-subject associations of all three predictors with perceived safety at work (Model 1, Table 2). The more employees believed security measures were sufficiently prioritized at work, the better their knowledge of

Table 2. Unadjusted (univariable), predictor adjusted and full linear mixed-effects model of perceived safety at work among ministerial employees after the 22 July 2011 terrorist attack in Oslo, Norway.

	Model 1 (univariable)		Model 2 (predictor adjusted)		Model 3 ^a (full model)	
	Reg. coefficient (95% CI)	<i>p</i>	Reg. coefficient (95% CI)	<i>p</i>	Reg. coefficient (95% CI)	<i>p</i>
Security measures given sufficient priority ^b						
Between-subject	0.40 (0.37 to 0.43)	< 0.001	0.36 (0.32 to 0.39)	< 0.001	0.30 (0.27 to 0.34)	< 0.001
Within-subject	0.14 (0.10 to 0.18)	< 0.001	0.13 (0.09 to 0.17)	< 0.001	0.11 (0.08 to 0.15)	< 0.001
Know evacuation procedures ^b						
Between-subject	0.34 (0.30 to 0.38)	< 0.001	0.19 (0.15 to 0.23)	< 0.001	0.18 (0.14 to 0.21)	< 0.001
Within-subject	0.14 (0.09 to 0.19)	< 0.001	0.12 (0.07 to 0.17)	< 0.001	0.10 (0.05 to 0.15)	< 0.001
Sufficient escape and evacuation training ^b						
Between-subject	0.24 (0.21 to 0.28)	< 0.001	-0.03 (-0.07 to 0.01)	0.140	-0.03 (-0.07 to 0.00)	0.053
Within-subject	0.04 (0.00 to 0.07)	0.028	-0.01 (-0.05 to 0.02)	0.407	-0.01 (-0.04 to 0.02)	0.474
PCL (mean item score)						
Between-subject					-0.52 (-0.58 to -0.45)	< 0.001
Within-subject					-0.43 (-0.54 to -0.32)	< 0.001
Gender (male baseline)						
Female					-0.04 (-0.10 to 0.03)	0.269
Age (increase of 10 years)					-0.04 (-0.08 to -0.01)	0.004
Education (< 13 years baseline)						
13–16 years					0.12 (0.02 to 0.23)	0.024
> 16 years					0.20 (0.10 to 0.30)	< 0.001

All regression coefficients are unstandardized. The outcome variable was a statement *I feel safe when I am at work* scored on a Likert scale ranging from 1 (disagree) to 5 (agree). The unadjusted univariable model (Model 1) includes random slopes for each of the respective within-subject associations. The predictor adjusted model (Model 2) and the full model (Model 3) include random slopes for the within-subject association for the two first predictors only, i.e. *Security measures given sufficient priority* and *Know evacuation procedures*.

^a The number of participants contributing data to at least one time-point for the final model was 2108. Of these, 874 contributed data to all three time-points, 708 contributed to two time-points and 526 contributed to one time-point.

^b The three main predictors of interest were all statements scored on a Likert scale ranging from 1 (disagree) to 5 (agree). The between-subject coefficients indicate the difference in perceived safety at work between employees who are, on average, one unit apart on a given predictor. The within-subject coefficients indicate the change in perceived safety at work associated with a one-unit change in a given predictor within an individual across time (see Methods section for further explanation).

PCL, PTSD Checklist; CI, confidence interval.

evacuation procedures; and the more they believed there had been sufficient escape and evacuation training, the higher they rated perceived safety at work. These findings applied both across individuals (between-subject association) and across time within individuals (within-subject association). The between-subject associations were comparatively larger than the within-subject associations across all predictors, although within-subject associations were also highly significant for the predictors *priority* and *knowledge*.

3.2.2. Predictor adjusted analysis (Model 2)

When the three main predictors were entered into one model (Model 2, Table 2), the between- and within-subject associations of the predictor *priority* were slightly reduced, although they remained highly significant ($p < 0.001$). The between-subject association of the predictor *knowledge* was reduced by about 40%, whereas the within-subject association was only slightly reduced. Both between- and within-subject associations were highly significant ($p < 0.001$). The between- and within-subject associations of the last predictor, *training*, were not significant. LRT indicated that the best overall model was obtained by including random slopes for the within-subject components for the predictors *priority* and *knowledge*, but not for *training*. In terms of collinearity, all Pearson's correlation coefficients between the three main

predictors were below 0.5 except for the predictors *priority* and *training* at T1, where the correlation was 0.52. We concluded that collinearity was unlikely to be a problem in our models.

3.2.3. Predictor and confounder adjusted analysis: full model (Model 3)

When the covariates PCL score, gender, age and education were added to the model (Model 3, Table 2), the between- and within-subject associations of the two predictors *priority* and *knowledge* with perceived safety at work were slightly attenuated compared to the predictor-only model (Model 2), although the evidence remained very strong ($p < 0.001$). The within-subject associations for both predictors were markedly smaller than the between-subject associations.

Both between- and within-subject associations of PCL score with perceived safety were negative and highly significant ($p < 0.001$). That is, lower levels of post-traumatic stress symptoms were associated with higher levels of perceived safety at work across employees (between-subject association), and employees who experienced fewer symptoms of post-traumatic stress over time rated perceived safety at work to be higher over time (within-subject association). For PCL score, the between- and within-subject associations were comparable in size. The LRT indicated that the best model was obtained by including random slopes for the

predictors *priority* and *knowledge*. Adding the proxy variable for exposure to the final model as a sensitivity analysis had minimal impact on the six regression coefficients of primary interest (five were unchanged and one changed by about 5%, without a meaningful change in the *p*-value).

3.2.4. Effect modification by gender and education

When the sample was split by gender (917 males and 1191 females), both between- and within-subject associations of the predictor *knowledge* were more than twice as large for males than for females. Similarly, when the sample was split according to level of education, into ≤ 16 years ($n = 797$) and > 16 years of education ($n = 1311$), both between- and within-subject associations of the predictor *knowledge* were greater for the lower educated group than for the higher educated group.

4. Discussion

4.1. Summary of main findings

In the present longitudinal study of employees following a workplace terrorist attack, the overall level of perceived safety at work did not change significantly from the first to the second wave of data collection; however, there was a significant increase in the third wave compared to the first wave. There was very strong evidence that the more employees believed security measures were sufficiently prioritized at work (*priority*) and the better their knowledge of evacuation procedures (*knowledge*), the higher they rated perceived safety at work. This finding applied when comparisons were made across employees (between-subject association) as well as when comparisons were made within employees across time (within-subject association). Similarly, lower levels of perceived safety at work were strongly associated with higher levels of post-traumatic stress symptoms. There was some evidence to suggest that both gender and education modified the positive association between *knowledge* and perceived safety at work, with a weaker association in women and higher educated employees.

4.2. Interpretation of main findings

Our main findings were broadly consistent with similar research (Chen & Noriega, 2004; Sanquist et al., 2008; Taylor & Toohey, 2006), and mirrored results from earlier cross-sectional studies on the same population (Nissen & Heir, 2016). The importance of an employer's commitment to safety in reducing work injuries by affecting workers' safety perception has also been suggested in research on occupational safety (O'Toole, 2002). The present study arguably adds another layer to current knowledge by

decomposing associations into between-subject and within-subject associations, moving one step closer to answering whether changes in the level of perceived safety at work within employees over time are associated with changes in their views on security measures and emergency preparedness over time. Longitudinal analyses showed that almost all between-subject associations were larger than within-subject associations, indicating that earlier cross-sectional estimates of associations were somewhat inflated. Nonetheless, the within-subject associations of *priority* and *knowledge* with perceived safety at work were still significant in longitudinal analyses, i.e. employees who rated *priority* and *knowledge* higher across time also rated perceived safety at work higher across time.

There was only moderate evidence of a within-subject association between believing there had been sufficient escape and evacuation training (*training*) and perceived safety at work in univariable analysis. In contrast, our earlier cross-sectional study found very strong evidence of an association between *training* and perceived safety at work in univariable analysis (Nissen & Heir, 2016), but not in a multivariable model which included the other two predictors (*priority* and *knowledge*). We argued that putting all three predictors into the same model might 'incorrectly' remove a true association between *training* and perceived safety at work because the effect was mediated through the other two predictors. The much weaker evidence of an unadjusted within-subject association in the present study suggests that for a given employee, changes in perceived safety over time do not, in fact, appear to be strongly related to changes in views on *training*.

The strong between- and within-subject negative associations of post-traumatic stress symptoms with perceived safety were consistent with earlier cross-sectional findings and support the idea that safety perception is closely linked to or even an integral part of PTSD as reflected in the DSM-5 D-criterion for the disorder (American Psychiatric Association, 2013; Nissen et al., 2015). The between- and within-subject associations were comparable in magnitude. The strength of both associations appears larger than that of the three main predictors in the full model; however, coefficients are not directly comparable. Even though both symptoms of post-traumatic stress and the three main predictors were measured on a five-point scale, the variability was much smaller for data on post-traumatic stress symptoms. In other words, if coefficients were standardized, the increase in perceived safety at work associated with a one standard deviation decrease in post-traumatic stress reactions would appear comparatively smaller. It is worth noting that the PCL-scores were quite low for the group as a whole at all three time-points, with

PCL-based PTSD prevalences of 5.8%, 4.4% and 3.9% at T1, T2 and T3, respectively (Hansen et al., 2017).

The absence of a significant change in employees' overall level of perceived safety at work between the first and the second wave of data collection, but a significant increase from the first to the third wave, may be interpreted in different ways. It is possible that the effects of changing views on security measures and emergency preparedness had a delayed impact on perceived safety at work, with effects only showing in the last wave of data collection (Zapf, Dormann, & Frese, 1996). Alternatively, it could be explained by the more pronounced change in the two predictors *priority* and *knowledge* between T3 and T1 compared to between T2 and T1. There may also be other important factors driving the change in perceived safety at work that were not investigated in the study.

4.3. Limitations and strengths

An inherent difficulty in the present study is that many factors probably exerted an impact on employees' perceived safety over time and there are likely to be confounding factors that the study has not considered. In the weeks, months and years following the attack, various interventions were undertaken by the ministries; for example, added security measures were put in place; escape and evacuation training sessions were conducted; meetings addressing health- and security-related topics were held; and the governmental occupational health services offered medical evaluations, psychological first aid and referrals to specialists to all employees present at work when the bomb exploded, and aided other employees as needed. Teasing out the isolated effects of the primary predictors in our study, therefore, is rather complicated. It could be that the many actions taken by ministries are unaccounted-for confounders in our study. Furthermore, employees' views on the priority of security measures and their knowledge of evacuation procedures may be strongly correlated with the extent of actual interventions conducted by ministries in these areas and thus be considered mediating factors between interventions and perceived safety. It is also possible that employees' views are disconnected from the extent of actual interventions undertaken. Nonetheless, employees' subjective views appear to be important for their perceived safety at work, and this is valuable knowledge in and of itself.

We have no information on the level of perceived safety among employees prior to the attack and we have not found comparable studies indicating what might be considered a normal level of perceived safety in a workplace setting. Thus, it could be that the overall levels of perceived safety found at T1, T2

and T3 are all within a normal range (indeed, about three-quarters of participants were in the highest two categories of perceived safety).

Both the outcome and main predictors were assessed through single-item statements. These items were selected from questionnaires used in similar research; however, the battery of items as used in the present study is novel. We therefore have limited knowledge of the psychometric properties of the battery. All items were in the same segment of the questionnaire and very close to one another; therefore, we cannot exclude priming bias. Even though participants were asked to answer the PCL questions with reference to the terrorist attack, we cannot exclude the possibility that symptoms of post-traumatic stress due to trauma exposure unrelated to the attack affected the results.

In terms of selection bias, we know that participants answering the questionnaire were older and included a higher proportion of females compared to those not answering, across all time-points. Since gender tended to modify the association between the predictor *knowledge* and perceived safety at work with a weaker association in women, the study probably underestimated the strength of this association. There was no evidence that the group of 455 employees who left their job between the attack and the third wave of data collection differed significantly in age, gender, symptoms of post-traumatic stress or perceived safety at work at T1, making it less likely that selection bias strongly impacted the results. However, since we only had data on post-traumatic stress and perceived safety for about half of those who left their job, we cannot rule out that those without data were more severely affected by the attack (i.e. likely higher PCL scores and lower perceived safety) and the possibility that they left their job partly because of this. In other words, we cannot rule out selection bias problems. Furthermore, we do not believe that dropping three ministries at the beginning of the study resulted in selection bias as the population of primary interest was government employees exposed to a terrorist attack at their workplace and two of the three excluded ministries were located several hundred metres away from the centre of the blast. In comparison, 13 of the participating 14 ministries were located in the government headquarters where the bomb was detonated.

Longitudinal observational designs do not allow for strong interpretations of causality. Even though within-subject changes in two of the study's three predictors were significantly associated with changes in perceived safety at work, we still cannot conclude causality.

The study has several important strengths, including its large sample size, longitudinal design and fairly

high response rate among potential participants. Very few prior studies have investigated employees' perceived safety at work after a workplace terrorist attack, and none, as far as we know, has applied a longitudinal design. The study therefore adds important evidence to the current knowledge base.

4.4. Conclusions and recommendations

In light of the evidence suggesting that low perceived safety and high perceived threat at work are likely to mediate adverse health effects in workers exposed to violence, efforts to alleviate these feelings may be a prioritized goal for employers after workplace terrorism. The present study indicates that employees' perceived safety at work is positively associated with their views on the prioritization of security measures at work. As the study did not investigate specific measures implemented by the ministries, we are unable to comment on which measures were most strongly associated with employees' views. Possible effective measures may be broadly categorized into those outside government buildings (e.g. roadblocks, rules redirecting and limiting traffic), those at the building entry/lobby controlling access to the interior of the building (e.g. security guards, high-security entrance doors), and those inside the buildings and offices (e.g. ID-card controlled access to segments of buildings, bullet-proof glass in office windows). It would be premature and lacking in perspective to conclude that security measures should be implemented in the aftermath of workplace terrorism to enhance employees' perceived safety, as decisions on security measures should be made primarily based on objective risk analysis. Nonetheless, we believe it is important to add knowledge on how measures affect employees' subjective experiences, such as perceived safety, especially if these experiences impact health.

Our second main finding, that employees' perceived safety at work is positively associated with their reported knowledge of evacuation procedures, may be of more immediate value to employers. Whereas security measures are typically very expensive, educating employees on evacuation procedures is not. Employers may want to arrange meetings where evacuation procedures are presented and discussed, information on procedures could be electronically communicated through emails or employer/company web-pages, and procedures could be summarized on posters placed at strategic locations in the workspace. Further studies are needed to corroborate the findings of the present study, and to explore whether the potential gains in perceived safety resulting from the suggested interventions indeed translate into meaningful improvements in health and functioning.

Lastly, consistent with the current understanding of PTSD as set out in DSM-5, our study found that perceived safety is closely linked to symptoms of post-traumatic stress. In the cognitive model of PTSD, faulty processing of the traumatic event leads to a distorted sense of current threat and a reduced sense of safety. Individuals with PTSD or high levels of post-traumatic stress symptoms, therefore, are not likely to feel safe at work until they receive adequate treatment for the underlying disorder.

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