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Accidents Will Happen. Do Safety Systems Improve Warehouse Safety Performance?

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ACCIDENTS WILL HAPPEN. DO SAFETY SYSTEMS IMPROVE WAREHOUSE SAFETY PERFORMANCE?

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Abstract

Safety is becoming more and more an issue in warehouses. In the literature, effective measures leading to increased occupational health and safety have hardly been researched. Most research focuses on the impact of perceived safety-related leadership of managers and worker safety consciousness on 'safety climate' and workers' safe behavior. We have carried out exploratory research into which measures really improve the safety performance of a warehouse. We particularly focus on the effects of (1) safety-related work procedures, (2) safety leadership, and (3) workers' safety consciousness. Based on a survey we show that safety leadership and safety-related work procedures significantly drive worker safety consciousness, which in turn positively impacts safety performance.

1 Introduction

Safety and security are becoming more and more important. Not only in society but also for companies. In a small country like the Netherlands the number of occupational accidents leading to injury and absence of work was 219,000 in 2007. The number of occupational deaths varied between 87 and 147 annually in the period 2000-2007 [16]. For those occupational accidents that led to treatment at a first aid department in a hospital, the direct medical costs amounted €94 million in 2007 with an additional €220 million costs of absence [16]. There is also a tendency to put more claims on employers when unsafe working circumstances may have caused accidents.

In warehouses, most accidents are related to the use of forklift trucks. According to www.logistiek.nl, the year 2008 counted 1700 serious injuries in the Netherlands in warehouses due to forklifts. Traffic in warehouses is often heavy, forklifts and workers on foot work in close proximity, and the work is often under time pressure (due times must be realized, regardless of the order volume to be handled). Youtube shows many movies with serious forklift-related accidents. Many companies therefore have invested

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in improving occupational safety. Well-organized warehouses are clean, well-lit, personnel is properly trained for the job and for safety, they have floor markings to indicate where loads should be stored or buffered, have forklift flows separated from manual flows, and pay attention to safe working. They may also use a variety of specific safety enhancing systems such as dock-locks (to prevent docked trucks from slithering), globe mirrors, safety signals, anti-collision devices, and personal protection equipment like helmets, gloves and shoes. A company like Scania has integrated Safety in its Scania Production System (SPS, derived from the Toyota Production System) as the first of four key elements. Occupational safety is integrated in their procedures and comes first every time an investment is made. They may even invest in safety measures that might reduce efficiency. Still, even in well-organized warehouses, accidents will happen. The question is then which measures really help to improve the safety performance in a warehouse.

This question is important as occupational safety measures cost time, compete for managerial attention and often also cost money. There may also be a trade-off with productivity. Unfortunately, literature does not offer much help in answering the question. The amount of occupational safety research over the last decades has been extremely low, with less than 1% of the organizational research publications in top journals being related to this subject [2]. It follows that Karen Brown's [3] call for workplace safety research has been left largely unanswered [6].

In order to fill this void we started researching this question, in cooperation with the Dutch organization of manufacturers and importers of material handling equipment (BMWT). We are particularly interested in the relation between safety performance (that is, the absence of personal accidents) and hazard reducing systems: system-related elements introduced by the management with the objective to improve safety in the warehouse. From the literature we know that self-reported safety events and injuries are significantly influenced by the management leadership style and safety consciousness [2], [8]. However, the impact on the number of accidents and the impact of hazard reducing systems has not yet been researched. Our contribution therefore is: (1) defining the new construct Hazard Reducing Systems (HRS) and making it measurable, (2) defining safety performance, and (3) exploring the relationships between these constructs.

2 Literature

Occupational safety is not a well-researched construct. Still, some researchers have attempted to shed light on this topic. We review the relevant literature in this section, focusing on individual personality and group traits, leadership and leadership styles, and hazard reducing systems.

2.1 Individual personality and group traits

Much of the research in safety focuses on leadership, perceptions between leaders and subordinates and individual/group characteristics. Miller et al. [11] aim to integrate the

personality construct “conscientiousness” with the behavioral construct “contextual performance” in the organizational health framework by studying a group of 104 public sector employees who had an average length of service of 3.99 years. Conscientiousness was found to have an influence on “task performance” (the more technical aspects of the job), and also on “contextual performance” behaviors which maintain the work environment in which the task takes place [11], [12]. Neal and Griffin [13] find that “supportive leadership” has a lagged effect on safety climate and conscientiousness has a lagged effect on safety motivation/ compliance and participation.

Based on samples of workers of two different industries Wallace & Vodanovich [19] claim that people with jobs that have a high level of task automation are more prone to distractions and are therefore more prone to accidents. Colbert and Witt [5] use trait activation theory to point out the role that “Goal focused leadership” (GFL) and “Person-organization goal congruence” have on the interaction between conscientiousness and job performance. This study was conducted among 390 employees and 41 supervisors of a private sector document processing company. The study showed that GFL moderates the relationship between conscientiousness and job performance.

2.2 Leadership and leadership styles

One of the earliest studies linking leadership and workers’ safety consciousness was carried out by Dunbar [7]. In a study among two groups of fork lift operators under two different leaders and leadership styles, it appears that safety consciousness depends on the perception of the manager being interested in the workers’ general welfare. Krause [10] finds that, out of 7 different approaches to motivate employees (motivational speakers, slogans/posters/signs, kick-in-the-rear, disciplinary action, gain sharing programs, contests and award incentives, and employee engagement), employee engagement is the best method for management to improve safety success. In addition, a study conducted by Zohar [20] among 36 section managers and 381 line workers at a regional safety center finds that improved supervisory safety practices, emphasizing safety as a performance goal, leads to an improvement in the overall safety of the company, measured by safety records, safety climate, and improved ear-plug use.

Barling et al. [2] and Kelloway et al. [8] research the leadership profile and label it as “transformational leadership” and “safety specific transformational leadership” (SSTL), respectively. Barling et al. [2] show that transformational leadership has a positive effect on safety related events and injuries through variables such as “safety consciousness” and “perceived safety climate” in a study conducted among 174 participants with an average of 3.1 years of experience in restaurants and fast food outlets. Safety consciousness is defined as an individuals’ own awareness of safety issues. Occupational injuries include eight different categories, such as strains, burns, and lacerations, specific to the restaurant industry. The result of this study proves that safety consciousness and safety climate fully mediate the outcomes. Kelloway et al. [8] expand the model and show that safety specific passive leadership (the opposite of SSTL) does not have a null effect, but actually

contributes to a higher number of safety incidents. Participants of this study were 158 employed undergraduate students that worked on average 27.35 hours per week in restaurants.

2.3 Hazard reducing systems

Several researchers, such as Deming and Herzberg (according to Krause [10]), Shannon et al. [15], and Wallace and Vodanovich [19] have suggested that systems have influence on individuals at the shop floor. Wallace and Vodanovich [19] in particular suggest that accidents are more prone to happen in automated environments. Both Brown et al. [3], [4] and Prussia et al. [14] study and empirically prove the interaction between social factors at the individual worker level and technical factors at the systems level, focusing mainly on physical safety hazards at the shop floor, work pressure, and perceived safety climate. Kjellén [9] studies safety at oil rigs and argues that safety performance at these platforms results from the integration of safety management in the governance process. Safety is incorporated at every main decision point. Vincent et al. [18] suggest that paying great attention to the design and ergonomic aspects of equipment and implementation of safety devices also have an effect on fatigue and cognitive overload in surgical quality and safety.

Summarizing, the literature review suggests that safety incidents in a company may be impacted by safety leadership, workers' safety consciousness, and hazard reducing systems. However, the precise impact of these factors on safety incidents, and in particular the impacts systems may have, is still far from clear.

3 Research model

In this study we explore the impact of hazard reducing systems on safety performance. Safety performance will be primarily measured by the absence of accidents involving people. However, other factors play a role as well. According to [2] and [8] safety-specific transformational leadership (SSTL) influences injuries, an effect which is mediated by safety consciousness. We therefore hypothesize:

Hypothesis 1. Safety-specific transformational leadership (SSTL) positively influences safety consciousness (SC).
Hypothesis 2. Safety consciousness (SC) positively influences Safety performance

SSTL is defined as a manager's ability to inspire employees, challenge employees on the intellectual level, engage employees in ensuring the overall safety of the work floor and pro-active management of safety issues [2] [8]. This is assessed using the 10 items developed by [2] and [8]. The statements were originally developed to be asked from employees to get information about their managers. We additionally use reformulated

statements in the managerial version of our survey. A 5-point scale response format is used ranging from 1 (disagree strongly) to 5 (agree strongly).

Following [2], Safety consciousness (SC) is defined as an individual's own awareness of safety issues and measured by 7 items on a 5-point scale ranging from 1 (disagree strongly) to 5 (agree strongly). We modified three questions slightly to emphasize safety consciousness rather than safety behavior. In addition, we modified the 7 resulting items and included them in the managerial version of the questionnaire in order to measure the safety consciousness of the warehouse personnel as perceived by the manager.

Hazard reducing systems (HRS), defined as the systematic use and implementation of procedures, rules, and systems with prime objective to increase occupational safety, will have a positive effect on both safety consciousness and safety performance. We therefore hypothesize:

Hypothesis 3. Hazard-reducing systems (HRS) positively influence safety consciousness.
Hypothesis 4. Hazard-reducing systems (HRS) positively influence safety performance.

HRS is, however, not a validated construct. We therefore had to devise our own measurement tool. In practice, warehouse managers use an array of measures to enhance safety. In order to make the construct measurable we have relied on a recently published occupational safety handbook resulting from a joint effort of the BMWT (organization of manufacturers and importers of material handling equipment), the VeLA (organization of logistics consultants), and the Dutch Ministry of Social Affairs [1]. This 395-page handbook contains a large list of safety enhancing measures and procedures (warehouse) companies might take to increase occupational health and safety. More than 300 measures are mentioned divided in four categories: human factors, equipment factors, organizational factors, and environmental factors. A grouped sample of these factors is presented in Table 1.

We used a total set of 72 HRS-related questions, 69 of which were measured on a 5-point scale and 3 open questions. This set was checked for face validity with the managing director of the BMWT and the chairman of the Safest Warehouse of the Year award.

The dependent variable Safety performance is also not a validated construct. Actually we measured its inverse: the weighted number of accidents during 3.5 years per warehouse full time equivalent (fte) (ACC). We used the following five accident categories, as described in [1]:

1. Near occupational accidents
2. Occupational accidents resulting in injury but not leading to absence;
3. Occupational accidents resulting in injury and minimal absence from work of 1 day;
4. Occupational accidents resulting in hospital admission after a visit to the Emergency Department of a Dutch hospital;

5. Fatal occupational accidents.

Casualties in the three most serious categories have to be reported to the Ministry of Social Affairs. In order to take into account the exponentially increasing severity of the accident categories we summed the numbers of accidents per category over the period Jan 2006-August 2009, using as weights 0, 1, 2, 4, and 8, respectively.

Table 1. Four categories of hazard reducing measures with some subcategories

Human factors (HF) • Training • Competencies • Knowledge/Experience	**Equipment factors (EF)** • Certification of equipment • Maintenance of equipment • Use and goodness of fit • Ergonomics of equipment use
Organizational Factors (OF) • General safety procedures • Specific safety procedures • Safety monitoring and feedback • Work pressure	**Environmental factors (ENV)** • Flow separation • Storage separation • Waste removal & handling, active cleaning • (day)Light (ergonomics) • Personal Protective equipment • Noise (ergonomics) • Floor quality • Air quality/ active ventilation • Safety signs/ indicators, and equipment • Security and theft prevention • Fire prevention/ escapes

4 The survey

In order to minimize the risk of bias from coincidental accidents, we focus on larger warehouses, i.e. those with at least 5 warehouse workers (full time equivalents). Furthermore we exclude warehouses where primarily dangerous goods are handled and stored, as these warehouses legally have very far-going safety measures and are as such not representative. No organisation maintains a complete list of warehouse operations in the Netherlands, not even Statistics Netherlands, because companies in all sectors operate warehouses. We used a list of contact persons of the BMWT. This list consists of all contact persons involved in the use, sales, or consultancy of material handling systems, obtained through BMWT's member companies. As all warehouses use some form of material handling system like storage racks or pallet trucks (and usually both), we believe this is probably the best list available on warehouses and their contact persons in the Netherlands. The file contains 13,000 records. After cleaning the list of material handling suppliers, consultants and, in several cases, multiple contact persons per company, the list reduced to about 6,000 unique warehouses. In the second half of 2009

we approached 1,400 randomly selected companies from this list by email asking their willingness to participate in the survey. 170 companies (12.1%) could not be reached due to an incorrect or no longer existing email address. From the remaining 1230 companies 169 (13.7%) indicated they were not willing to participate in the study. Main reasons for this were lack of interest, too small size, other priorities (e.g. laying off people, implementing a new warehouse management system), and lack of time (e.g. Christmas season coming up). The overall response was 78 (6.3%), of which 75 cases could be used. In 3 cases the warehouse appeared to be too small or either the manager or the worker questionnaires were missing. A total of 983 (79.9%) companies did not respond at all. In an investigation of a sample (5%) of the non-respondents we did not find an overpopulation of one industry or type of firm. Within each company up to about 20 workers were surveyed with respect to SSTL and SC, depending on the number of workers present. Companies were instructed to use a representative subset of workers, by selecting workers at different positions (including supervisors, foremen), different contract forms (fixed and variable contracts), gender, and nationality. Sample descriptives have been included in the tables below.

Table 2. Warehouse descriptives

	#employees	**(%)**	**Participating Industries**	**(%)**
Warehouses	5 – 25	36.0	(Other)	29.5
N = 75	26 – 50	25.3	Automotive	16.7
	51 – 100	8.0	Food & Beverages	14.8
	101 – 200	6.7	Computer/ Electronics	11.1
	201+	18.7	Pharmaceuticals	9.3
	average=84.2		(Petro) Chemical	7.4
			Electro-Technical	5.6
			Logistics Service Provider	5.6

Table 3. Manager descriptives

	Gender	**Age**	**Highest education**	**Employment duration**
Managers	94.4%: M	30.2%: 30 - 40	36.5%: < Polytech.	7.5%: < 1 Year
N = 75	5.6%: F	50.9%: 40 - 50	55.8%: Polytechnic	13.3%: 1 -3 Years
		18.9%: 50 – 62	7.7%: University	79.2%: > 3 Years

The total number of (direct) warehouse employees that filled in the questionnaire amounted to 1000, or 13.9 per company on average. The response rate varied from 1.3% (13 out of 1030 employees working in 5 shifts) to 94.7% (17 out of 19 employees), with an average of 32%. All listed sectors have a reasonable representation, and in view of the average number of workers per company (84.2) the sample may represent the medium and larger warehouses. The sample may be somewhat biased, however, towards the safer warehouses, as unsafe warehouses will not be inclined to participate in the survey,

particularly not because a representative sample of employees must fill out questionnaires.

5 Results

An exploratory Principal Components factor analysis was conducted using Varimax rotation on the set of 69 questions measuring HRS. We used a factor load coefficient break-off point of 0.45. Furthermore, only factors that had an eigenvalue of 1 or larger were allowed to enter. In order to prevent a large number of very small factors we limited their number to 5. This reduced the number of questions to 32, which cumulatively explain 33.4% of the variance in the data.

Table 4. Factor Analysis (Principal Components Method)

Factor	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1 ST	10.319	14.956	14.956	5.471	7.930	7.930
2 SP-*a*	4.141	6.001	20.956	5.226	7.574	15.504
3 CTH	3.581	5.190	26.147	5.188	7.520	23.023
4 SPB	2.842	4.119	30.265	3.774	5.470	28.493
5 SS	2.139	3.101	33.366	3.362	4.873	33.366

The factors were all given a category name in accordance with the topic that the questions entailed: 1. Safe traffic measures (ST); 2. Safety training, inspection, signals and general safety procedures ('Safety procedures', SP-*a*); 3. Cleanliness, tidiness, hazard procedures (CTH); 4. Safe parking and work-load balancing procedures (SPB); 5. Safe storage and use of proper material handling systems (SS). We additionally included the frequency of safety training (SP-*b*), which was inversely measured on a 5-point scale ranging from 1 (more than once a year) to 5 (less than once every 10 years) and averaged over all employees.

All are multiple-item factors with Cronbach alphas (of standardized items) of .79, .58, .93, .75, and .74, respectively. Cronbach alpha values for Safety leadership (SSTL) and Safety consciousness (SC) were also measured per company over all worker questionnaires. These values range between 0.70 and 0.95, i.e. sufficiently large for each company involved. We conclude that the measures are sufficiently reliable for exploratory research. For each company the average score of SSTL and SC is taken (averaged over the workers).

Correlations between the different independent variables and ACC (=1/Safety performance) were measured. The most important significant correlations are given in Table 5.

Table 5. Pearson correlations

	SSTL	SSTL (CV)	SC	SC (CV)	LAR	ST	SP-a	CTH	SPB	SS	% female	Ave. age	Education	labor retainment	SP-b
ACC	-.447**	.492**	-.274*	.284*	.338**	-.153	-.113	-.134	.027	-.065	-.216	.015	-.194	.048	.179
SSTL	1	-.912**	.662**	-.628**	-.324**	.115	.269*	.049	-.035	-.024	.010	.087	.069	.040	-.403**
SSTL (CV)		1	-.573**	.584**	.234*	-.095	-.196	.037	.025	.020	-.017	-.019	-.090	-.014	.380**
SC			1	-.930**	-.312**	.114	.342**	.058	.089	.045	-.193	.257*	.079	.252*	-.527**
SC (CV)				1	.196	-.038	-.210	-.075	-.073	.000	.232*	-.159	-.123	-.178	.511**
LAR					1	-.314**	-.550**	-.370**	.034	-.060	-.159	-.220	.040	-.242*	.160
ST						1	.582**	.287*	.086	.312**	-.116	.106	-.090	.089	-.161
SP-a							1	.307**	.040	.215	-.229*	.233*	-.048	.227*	-.390**
CTH								1	.159	.307**	-.027	.003	-.066	.139	-.044
SPB									1	.725**	.081	-.051	.079	-.045	-.104
SS										1	.023	-.124	.048	-.151	-.105
%Female											1	.037	.164	-.048	.126
Ave. age												1	-.405**	.716**	-.069
Education													1	-.247*	-.244*
labor retainment														1	-.147

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The categorical variable ‘Lack of accident registration’ (LAR) is measured on a 3-point scale, from 1 (both non-compulsory accident categories are measured) to 3 (non-compulsory accident categories are not measured). This table shows that the average number of weighted accidents per fte (ACC) strongly negatively correlates with SSTL (r=-.447, p<.01), the coefficient of variation of SSTL (r=.492, p<.01), Safety consciousness (SC, r=-.274, p<.01) and the coefficient of variation of SC (r=.284, p<.01). Apparently, more relative variation in the workers’ opinion on their safety consciousness or their manager’s safety leadership implies a larger number of weighted accidents per fte. Also, the better the warehouse registers the non-compulsory accident categories (the lower the LAR value), the fewer accidents occur. Obviously, in order to prevent accidents from happening, a manager must also have knowledge of near and minor accidents. ACC does not significantly correlate with other main variables, although the percentage of female direct warehouse employees has a borderline positive influence on ACC (r=-.216, p=0.068) and there is borderline positive impact of the average workers’ education level (r=-.194, p=0.10). We see further a strong correlation (r=.662, p<.001) between Safety leadership (SSTL) and Safety consciousness (SC) and between the means and coefficients of variation of SC and SSTL. Safety procedures (SP-*a* and SP-*b* frequency of

training) do not directly impact ACC, however, they significantly impact the workers' safety consciousness, implying that more safety procedures and training lead to a higher level of Safety consciousness. SP-*a* and SP-*b* also correlate strongly with safety leadership ($r=.269$, $p<0.05$ and $r=-.403$, $p<0.05$, respectively). This implies that, although SP does not directly impact ACC, it does improve the workers' safety consciousness, thereby partly supporting hypothesis 3.

In addition we have carried out a full regression analysis (excluding strongly mutually correlating independent variables, to prevent multicollinearity), and including further control variables, which shows the most important variables are SSTL (CV) and Lack of accident registration. Safety consciousness has strong impact on ACC as a mediating variable, influenced by both safety leadership and Safety procedures (SP-*a* and SP-*b*).

5 Conclusions and outlook

Based on these results we conclude that hypotheses 1 and 2 are supported by the data, but hypothesis 4 is not supported. Prime factor influencing Safety performance (=1/ACC) are the manager's Safety transformational leadership (CV), Lack of accident registration, and Safety procedures (SP). The workers' Safety consciousness also plays an important role as it correlates strongly with ACC. Safety consciousness in turn, is determined by SSTL and Safety procedures, which partly supports hypothesis 3.

In further research we will focus on increasing the response and carrying out additional analyses.

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