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Development and validation of safety climate scales for lone workers using truck drivers as exemplar

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A B S T R A C T

The purpose of this study was to develop and test the reliability and validity of a new scale designed for measuring safety climate among lone workers, using truck drivers as exemplar. The new scale employs perceived safety priority as the metric of safety climate and a multilevel framework, separating the measurement of organization- and group-level safety climate. The second purpose of this study was to compare the predictive power of generic items with trucking industry-specific ones. Three dimensions for each of the two levels of safety climate were drawn from the results. The organization-level safety climate dimensions were proactive practices, driver safety priority, and supervisory care promotion. The group-level safety climate dimensions were safety promotion, delivery limits, and cell phone disapproval. Predictive validity of both generic and industry-specific items was supported, but the industry-specific items provided a stronger predictive value. Results showed that the scale is a reliable and valid instrument to measure the essential elements of safety climate for truck drivers in the lone working situation.

1. Introduction

1.1. Safety climate

Safety climate refers to workers' shared perception of their organization's policies, procedures, and practices as they relate to the value and importance of safety within the organization (Griffin & Neal, 2000; Zohar, 1980, 2000, 2011, in press). Characterized by shared perceptions of employees, safety climate can be seen as an organization's temporal "state of safety" at a discrete point in time (Cheyne, Cox, Oliver, & Tomas, 1998). Safety climate is often confused with safety culture and, while they are similar concepts, they are distinguished in the literature. Safety culture has been described as shared values and beliefs that interact with an organization's structures and control systems to produce behavioral norms (Reason, 1998; Thompson et al., 1996; Utall, 1983). As just stated, safety climate refers to the workers' shared perceptions of the organization's policies, procedures, and practices as they relate to the value and importance of safety within the organization. In short, safety climate is the measurable aspect of safety culture. The practical and theoretical significance of safety climate as a construct stems from its ability to predict safety behavior and safety-related outcomes (e.g., accidents and injuries)

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in a wide variety of settings, as evidenced by diverse samples, in both Western and Eastern cultures (e.g., Cooper & Phillips, 2004; Dedobbeleer & Beland, 1991; Griffin & Neal, 2000; Hofmann & Stetzer, 1996; Mearns, Whitaker, & Flin, 2003; Niskanen, 1994; Oliver, Cheyne, Tomas, & Cox, 2002; Siu, Phillips, & Leung, 2004; Zohar, 1980, 2000). The results of several recent meta-analysis studies covering up to 202 published studies (Beus, Payne, Bergman, & Arthur, 2010; Christian, Bradley, Wallace, & Burke, 2009; Nahrgang, Morgeson, & Hofmann, 2011) indicate that safety climate is among the strongest predictors of safety behaviors and injury data in both workgroups and entire companies.

1.2. The need for studying safety climate for lone workers using truck drivers as exemplar

1.2.1. Lone workers

A lone worker is an employee who works alone and who performs an activity that is intended to be carried out in isolation from other workers, without close or direct supervision (BSIA, 2010, Hughes & Ferrett, 2009). There is no single definition that encompasses those who may face lone working situations. The National Health Service in the United Kingdom (NHS, 2005) defines lone working as: "any situation or location in which someone works without a colleague nearby; or when someone is working out of sight or earshot of another colleague." The term "lone worker" can describe a wide variety of staff who work, either regularly or occasionally, on their own, without access to immediate support from work colleagues, managers, or others (e.g., telecommuters, truck drivers, travelling salesmen, health visitors; NHS, 2005).

While the number of studies on safety climate has increased dramatically in recent years (Huang, Chen, & Grosch, 2010), most have focused on traditional work environments, in which supervisors and workers interact under the same roof throughout the day. Little research has been done to examine how a company's safety climate influences lone workers. Given that lone working is becoming more and more prevalent across a variety of industries (e.g., truck drivers, utility workers, teleworkers), it is important to conceptualize the effect of this work environment on organizational climate emergence.

1.2.2. High accident rate in trucking industry

The truck accident/crash rate is high. The Bureau of Labor Statistics' Census of Fatal Occupational Injuries (BLS, 2012) reported 396 fatalities in truck transportation in 2010 with a rate of 31.8 per 100,000 workers. This accounts for nearly 8.7% of all work-related fatalities and occurs at an incidence rate much higher than the 3.6 per 100,000 workers seen for all industries. The non-fatal injury rate in 2010 was 5.3 per 100 full-time workers for truck transportation, compared to a rate of 2.9 for all private industries (BLS, 2012). The workers in the transportation industry in the US experience some of the highest numbers and rates of fatal and non-fatal injuries. Moreover, the accidents or crashes not only involve trucks but also passenger or other commercial vehicles. The National Highway Traffic Safety Administration (NHTSA) of the United States Department of Transportation reported a total of 3380 fatalities and 74,000 injuries involving large trucks in 2009 (NHTSA, 2010). This study conducted research with lone workers using truck drivers as exemplar.

1.2.3. Safety climate issues in trucking industry

Individual workers and their supervisors must make daily decisions about safety at work because it influences or competes with other performance facets of the job. These can be related to the task itself (e.g., safety vs. on-time delivery or productivity), or to the worker performing the task (e.g., safety vs. personal discomfort or extra effort). This situation is especially evident in industries like transportation/trucking in which employees spend much of their time away from home base. Truck drivers, who drive alone for long periods on the road, often face competing demands on safe driving, such as on-time demands vs. taking time to address fatigue, challenging weather conditions, hours of service regulations, proper vehicle maintenance, and speed limits and other traffic rules. This type of worker rarely has contact with other company drivers and often lacks direct supervisory interaction, other than through electronic technology. This would seem to make shared perspectives on company safety climate difficult to achieve and its existence worth studying.

From the safety climate literature, research shows that individuals are able to form relatively homogenous perceptions from the vast array of stimuli present in the work environment. Schneider and Reichers (1983) described three approaches in terms of the etiology of climates (*structural approach*, *attraction–selection–attrition approach*, and *symbolic interactionist approach*), which could find application in the lone-worker situation.

The structural approach to the etiology of climates (Payne & Pugh, 1976) focuses on objective aspects of the work context affecting workers' attitudes, values, and perceptions of safety. Examples of objective aspects related to safety include a company's training programs, the power/authority of safety managers, types of technology (in-vehicle computers, equipment, and maintenance) used, and the degree to which safety rules and policies constrain individual behavior. Considering this approach, the work context may influence individuals' safety climate perceptions. In a lone-worker situation, truck drivers in this case may form their safety climate perception based on objective aspects of the company (e.g., whether good safety training is provided, how well the truck is maintained).

From the perspective of the "attraction–selection–attrition" approach (Schneider, 1987), workers are similar to each other and therefore share similar perceptions and interpretations regarding safety (Schneider, 1975). Members of one organization are relatively homogeneous as a result of organizational processes (e.g., selection into the organization) and individual processes (e.g., attraction to and attrition from the organization). Although workers may not be involved in the selection process (i.e., how trucking companies recruit drivers), it is expected that when a company really cares about and promotes safety, it will attract and retain workers who really care about safety and who will follow safety rules. Lone workers who care about

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safety may be attracted to working for particular companies because these companies have good safety reputations or, conversely, leave if safety is neglected.

The symbolic interactionist perspective (Schneider & Reichers, 1983; Zohar, 2010) suggests that climate develops as workers compare pieces of information and cues, discuss possible interpretations, and attempt to reach a consensus regarding the meaning of events, procedures and practices at the workplace. It places the focus on those meanings that arise from the interaction between people. According to Blumer (1969) and Mead (1934), verbal communication and other behaviors leading to social interactions between people are the primary ways meaning and significance come to be associated with membership in a group. Due to reduced face-to-face interactions, this approach may apply to lone workers the least, but they may still have opportunities to interact with their supervisors, trainers, and others using electronics or the telephone.

Despite the importance of safety climate, there have been only a limited number of published studies that address this issue in the trucking industry. Arboleda, Morrow, Crum, and Shelley (2003) provided insight into how accidents in the trucking industry might be reduced by a clearer understanding of how common management practices contribute to safety climate, and the extent to which perceptions of these practices differ as a function of hierarchical level within trucking firms. The authors developed a four-item scale to estimate safety climate; however, no validity information was provided for the scale, and no injury/safety outcomes were examined in the study. They assumed that implementation of a stronger safety climate should result in fewer accidents, but empirical evidence supporting their assumption was not presented. Wills, Watson, and Biggs (2006) examined the relationship between safety climate and self-reported driving behaviors. The six safety climate dimensions studied (i.e., communication and procedures, work pressures, relationships, safety rules, driver training, and management commitment) were significantly associated with the four aspects of self-reported driving outcomes (i.e., traffic violations, driver error, driving while distracted, and pre-trip vehicle maintenance). However, the focus of their study was on drivers who needed to drive a motor vehicle at least once during the course of their average work week, not on truck drivers in the lone working situation.

Unlike traditional studies in the transportation industry that focus on equipment and driver behavior, the current study extends the safety climate literature to examine the organizational impact (safety climate) on both subjective and objective safety outcomes for truck drivers (e.g., driving safety, near misses, and road injury). Specifically, this study focuses on commercial truck drivers who constitute a unique group of lone workers as they drive alone for long periods of time. As Zohar (2010) suggested, development of industry-specific climate scales should be encouraged as it is likely to identify new, context-dependent targets of climate perception in respective industries. The identification of concrete climate indicators in each industry should offer opportunities for developing and testing hypotheses regarding processes underlying climate emergence (Zohar, 2010). It can also be anticipated that the results would provide more actionable and specific suggestions for future intervention because these scales are grounded in a particular context. Therefore, the first objective of this study was to develop and test the reliability and validity of a new scale designed for measuring safety climate among lone workers, using truck drivers as exemplar.

1.3. The conceptual framework of safety climate measure

Following three decades of safety climate research, Zohar (2008, 2010) introduced several propositions for future safety climate study. Development of the new safety climate scale in the current study was based on three propositions: safety priority as the requisite referent or target of safety climate perceptions, a multi-level framework for safety climate perceptions, and organizational climate as socially shared perceptions (Christian et al., 2009; Zohar, 2010). The latter proposition was subjected to test in this study, given that the context of lone work was expected to impede or obstruct emergence of socially shared cognitions, giving rise to individual-level climate perceptions.

The Social Ecological Model (Bronfenbrenner, 1977, 1979) can be applicable to this study because it is a multi-level theoretical framework that posits there are different spheres of influence. Those spheres include the microsystem, in which individuals are shaped by their environment and the people with whom they interact. Like the social interactionist perspective used in the etiology of climate, social interactions occurring within microsystems have an effect on people. The mesosystem involves the influence of organizational factors (e.g., policies and rules) on the environment in which individuals live and work. The examination of mesosystems through the perception of employees is the basis of safety climate research.

1.3.1. Relative priority and multi-level framework for safety climate

Zohar (2008) offers a concise description about relative priority of safety as a target of safety climate perceptions as follows: “Given that safety issues often compete with other operational issues such as speed or flow of production, it follows that (enforced) safety policies and procedures can be construed in terms of the relative priorities of safety and the other production goals” (p. 377). Methodologically, such a framework suggests that measures of safety climate ought to include items referring to situations presenting competing operational demands involving safety (e.g., safety vs. speed, flow, schedules, profitability), because such situations offer the clearest indication of priorities at the workplace.

Zohar (2008, 2010) also proposed that safety climate should be understood within a multi-level framework that identifies organization- and group-level safety climates as distinct perceptions having different referent objects. To reduce conceptual ambiguity stemming from the fact that current definitions and measures fail to discriminate between the priorities of senior management and those of group supervisors, both organization- and group-level items need to be assessed to attain a comprehensive understanding of safety climate. A multi-level framework and related data indicate that employees discriminate

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between priorities at the top and those of their own unit, resulting in the emergence of two concurrent safety climates. Therefore, perceptions must be measured separately for the organization- and group-level safety climates. The organization-level safety climate refers to perceptions about the instituted company procedures and top-management actions for promotion of safety, whereas the group-level safety climate involves perceptions about the direct supervisory and work-group practices for safety. These two different levels of safety climate can be quite independent (i.e., high organization-level safety climate with low group-level safety climate or vice versa), though they are likely to be related to one another in many cases. In line with these two propositions, the new scale developed in the current study employs perceived safety priority as the metric of safety climate and a multi-level framework, separating the measurement of organization- and group-level safety climate by differentiating items into two sub-scales.

1.3.2. Shared safety climate perception

Christian et al. (2009) categorized safety climate perceptions into two levels of analysis, resulting in shared group-level safety climate and individual/psychological safety climate. They summarized the literature (e.g., James, Hater, Gent, & Bruni, 1978; James & Sells, 1981; Jermier, Gaines, & McIntosh, 1989; Young, 2010) and defined psychological safety climate as individual perceptions about safety-related policies, practices, and procedures pertaining to safety matters that affect personal well-being at work. A shared group-level safety climate emerges when individual worker's perceptions are shared and consensus forms within a particular work environment (e.g., James, James, & Ashe, 1990; Young, 2010). Thus, shared group-level safety climate can be defined as shared perceptions about the work environment and characteristics as they are related to safety matters that may affect a group of individuals (e.g., Griffin & Neal, 2000; Young, 2010; Zohar & Luria, 2005). Due to the fact that this study involved lone workers who rarely interact with other co-workers, we tested the homogeneity of safety climate perceptions to determine whether it should be analyzed at the group/work unit or individual levels of analysis.

1.4. The predictive power of generic vs. industry-specific items

The development of the safety climate scales in this study began with a number of generic items from Zohar and Luria (2005) that can be applied across industries and are relevant to key safety issues of the lone worker (e.g., trucking industry). Additionally, new items tailored specifically to the trucking industry were developed and included in the overall safety climate scales. As Zohar (2010) stated, although it is possible to use generic safety climate scales across industries, focusing on the core themes of managerial commitment and safety management, the identification of concrete climate indicators in each industry should offer opportunities for eliciting and testing hypotheses regarding processes underlying climate emergence. Therefore, the second objective of this study was to compare the predictive power of generic items with industry-specific ones, constituting the new Trucking Safety Climate scale. The construct and predictive validities of the newly developed safety climate scales for the trucking industry were tested. Specifically, incremental predictive validity of the trucking industry-specific items over the generic safety climate scale items was examined.

2. Study design/methodology

Both qualitative and quantitative methods were employed to design the safety climate scales for the trucking industry. Target participants were corporate lone truck drivers. Informed consent was prepared for each stage of the process, using specific consent forms for the individual interviews, cognitive interviews, pilot tests, and actual survey data collection stages. Study procedures at each stage were approved by the appropriate Institutional Review Board.

2.1. Initial survey question development

Initial survey questions were designed by the project team based on: (a) Review of scientific literature that led to the adoption of generic safety climate scale items from Zohar and Luria (2005) – 6 items each for organization- and group-level safety climate were included in the survey; (b) Review of accident inquiries, which included truck companies' safety performance metrics, such as injury rate, crash rate, and safety audit and risk scores; and (c) Input from subject matter experts, including truck drivers, supervisors of truck drivers, and insurance experts on the trucking industry. Fifty-three in-depth interviews were conducted with corporate lone truck drivers and their supervisors at two truck stops and one large trucking company. Combining the information from all of the above, we decided to focus on job functions, communication patterns, work priorities, supervisory interactions, and related workplace safety practices. Initial survey development followed and a draft of potential safety climate items was compiled. A draft of 100 items (61 items for the organization- and 39 items for the supervisor/group-level safety climate scales) was developed.

2.2. Pre-testing process

2.2.1. Cognitive/think-aloud interviews

Cognitive/think-aloud interviews with 38 truck drivers were conducted to examine the meaning of the items (for clarification purposes), identify language and/or content issues while completing the questionnaire (e.g., long pauses, inconsistent answers, indications of confusion), and the extent to which these items cover all relevant safety practices. This procedure was used to improve content validity and face validity. Participants were recruited from two truck stops and one trucking company where interviews for initial item generation were held. Revisions were made for such things as item wording, presentation order in the survey, and format of the survey based on participants' comments and suggestions. The revised scales after cognitive interviews included 35 items measuring organization-level and 26 items measuring group-level safety climate. The revised scales were used for the next pre-test step.

2.2.2. Pre-test

After the cognitive interviews, the pre-test was conducted with 64 additional truck drivers who were recruited from truck stops to participate in a paper-and-pencil survey. These pre-tests were conducted to make sure the questions were clear, and the survey administration was feasible (e.g., estimating the survey completion time). After this stage, the survey was revised. A 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) was used for all safety climate items.

2.3. Survey implementation at pilot trucking company

The revised version of the survey (i.e., 35 items to measure organization-level and 26 items to measure group-level safety climate) was completed by drivers working for the pilot company, resulting in 2030 completed surveys. With official permission from the company, the procedure was as follows: when the pilot company held its regular winter training, which was a 15-min web-based course required for every truck driver of the company, the survey was offered in conjunction with this program. At the end of the training session, drivers were invited to participate in this survey. Any driver who agreed to participate had to click the link to enter into a third-party website, which hosted the survey. Consent was given by the drivers during the recruitment. Their participation in the survey was double-blinded; the company did not know who participated and did not have access to the survey data. In order to link the survey information to future driving outcomes, participants were asked to enter their company ID to be used as an identifier. Average time for completion of the survey was 18 min. Five $100 gift cards were provided through a random drawing as an incentive to encourage participation. For this, the respondents who wished to join the drawing were asked to provide contact information (e.g., e-mail) at the end of the survey and were assured of their confidentiality again.

Six months after survey completion, performance data from all company drivers were provided to us from the pilot company to serve as criteria for validating the survey. No names were provided and only the employee IDs were used to link the information. The survey results were matched with performance data at the individual level. Once this was done, a new set of identification numbers was assigned to replace the employee IDs, which were then dropped out of the dataset to ensure the confidentiality of survey participants.

2.4. Survey implementation at seven additional companies

After data collection from the pilot company, seven additional trucking companies were recruited and data were collected from them. A total of 8095 truck drivers took the survey from the eight companies. One company used a paper-and-pencil survey (the response rate could not be calculated), while the other seven companies used a web-based survey. Response rates ranged from 34% to 73% with a mean around 45%. Table 1 shows the response rates and other descriptive information about the eight companies that was acquired from trucking company representatives and trucking websites. Five companies were classified as "Truckloads." That is, they generally contract an entire trailer load to a single customer, as opposite to "Less-than truckload" which generally mixes freight from several customers in each trailer (see Table 1). Only one of the eight companies was unionized. The percentage of female truckers was as low as .5% and as high as 15% across the eight companies. The speed limit policy differed across the eight companies from 55 to 68 miles per hour. Individual surveys with more than 50% missing values in the safety climate scale items were deleted; accordingly, 7466 questionnaires were used for analysis, including the pilot company data (n = 1998).

Table 1
Descriptive information of the eight trucking companies.

Company	A[a]	B	C	D	E	F	G	H
Number of respondents	2030	248	461	290	4003	235	270	558
Response rate (web-based survey)	34%	73%	37%	58%	51%	40%	N/A	55%
Descriptive information[b]								
Truckload or Less-than truckload[c]	TL	LTL	TL	LTL	TL	TL	LTL	TL
Union (U) or Non-Union (N)	N	N	N	N	N	N	U	N
% Female	7%	.5%	8%	3%	3%	15%	.4%	2%
Speeding policy	60 mph	Local	60 mph	65 mph	63 mph	55 mph	68 mph	63 mph

[a] Pilot company used to aid in developing and testing of survey.
[b] Information collected from company representatives and trucking websites.
[c] TL = Truckload, which generally contracts an entire trailer load to a single customer. LTL = Less-than truckload, which generally mixes freight from several customers in each trailer.

2.5. Final survey items based on reliability and validity analyses

All responses for items with negative wordings were reversely coded. Both Exploratory Factor Analysis (EFA; with the data collected from the pilot company) and Confirmatory Factor Analysis (CFA; first with the pilot company, then the full merged dataset from all eight companies) were performed to provide information for the factorial validity.

The EFA was performed only with the data collected from the pilot company to explore the factorial structure of the newly developed Trucking Safety Climate scales, which also included generic items. Out of 2030 participants, 1998 questionnaires with no more than 50% missing values on the safety climate scales were used. The EFA addresses research questions that include the following: (a) How many first-order factors exist in organization- and group-level safety climate scales? (b) Do "within factor" items cluster well together while discriminating between items of different factors? and (c) Which features are most important in the classification of a group of items? (DeCoster, 1998). Based on the findings from the EFA, the initial item set was trimmed down and refined to form both organization- and group-level safety climate scales.

Internal consistency among items associated with each of the obtained factors was assessed based on Cronbach's α estimates. Items that decreased sub-scale reliability were dropped. After the EFA and reliability test on internal consistency, 20 items to measure organization-level and 20 items to measure supervisor/group-level safety climate were chosen as the final scale items.

The CFA came after to confirm the construct validity of the safety climate scales. A series of CFAs were performed first with the data collected from the pilot company and then with the data from all eight trucking companies to assure factor structure validity of the safety climate scales. The quality of the model fit was examined based on comparative fit index (CFI), Tucker–Lewis index (TLI), and root mean square error of approximation (RMSEA). For CFI and TLI, .95 or greater is interpreted as evidence of appropriate fit (Hu & Bentler, 1999). The guidelines for interpreting RMSEA are as follows: RMSEA < .05 indicates a good model fit; .05 < RMSEA < .08 indicates a reasonable model fit; and RMSEA > .10 indicates a poor model fit (Browne & Cudeck, 1993; Hair, Anderson, Tatham, & Black, 1998).

2.6. Examining shared safety climate perception

Within-group agreement and reliability indices such as r_{wgj}, Intra-class Correlation Coefficient ICC(1) and ICC(2) (Bartko, 1976; Bliese, 2000; James, Demaree, & Wolf, 1984, 1993) were calculated to examine employees' shared perceptions at the same work unit level. The criteria for individual-level data aggregation to create group-level variables were as follows:

(1) *ICC(1):* The ICC(1) indicates the extent to which individuals within the same organization assign the same psychological meaning to, or agree in their perceptions of, an organizational characteristic (Ostroff & Schmitt, 1993). There are no definitive guidelines on acceptable ICC(1) values. In past research, ICC(1) values have ranged from 0 to 0.50, with a median of 0.12 (James, 1982; Ostroff & Schmitt, 1993). Perhaps the most widely accepted criterion for ICC(1) is over 0.10, which indicates ICC(1) with medium effect size (Murphy & Myors, 1998).

(2) *ICC(2):* The ICC(2) assesses the relative status of between and within variability using the average ratings of respondents within each unit (Bartko, 1976). It indicates reliability at the aggregate level, or the reliability of means (Ostroff & Schmitt, 1993). There is no strict standard of acceptability of ICC(2) values. Glick (1985) recommended an ICC(2) minimum cutoff of 0.60. Schneider, White, and Paul (1998) suggested that a moderate value of ICC(2) coupled with an acceptable r_{wgj} score is sufficient grounds for aggregation. The average ICC(2) value for their study was 0.47. LeBreton and Senter (2008) suggested that, depending on the quality of the measures being used in the multi-level analysis, researchers will probably want to choose values between 0.70 and 0.85 to justify aggregation. One of the most widely accepted criterion for ICC(2) is over 0.70 (LeBreton & Senter, 2008; Ostroff & Schmitt, 1993).

(3) r_{wgj}: The r_{wgj} is an assessment of within-group inter-rater agreement (James et al., 1993). It measures agreement among raters' assessments of a single target. A median of r_{wgj} larger than 0.70 was used as the criterion.

2.7. Measure of safety criteria

Both subjective and objective safety criteria were obtained to test whether the safety climate scores were associated with the self-reported driving safety behavior and the objective safety outcomes collected.

2.7.1. Subjective safety criterion

To evaluate the participating truck drivers' self-reported driving safety behavior, six items adapted from Huang, Roetting, McDevitt, Melton, and Smith (2005) were included in the survey: "I always comply with the posted speed limits," "I occasionally jump to get out of my truck quickly," "I occasionally drive without getting enough sleep," "I sometimes find myself in a difficult situation without having a way out," "I always use my log book legally," and "When I'm tired or rushed, I sometimes skip the daily vehicle inspection." The items were all on a 5-point Likert scale; Cronbach's α for these six items was 0.66 with data from all eight trucking companies ($n = 7466$). The average score of these six items was used as the indicator of this construct. Univariate and multiple regressions were used to investigate the safety climate and safety behavior relationship.

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2.7.2. Objective safety criteria

Since the measure of driving safety behavior was based on respondents' self-reports, a socially desirable response tendency could be expected and this might compromise the validity of the measure. To address this concern, objective safety data were collected to serve as criteria for predictive validity testing. Hard-braking and road injury were the two objective safety criteria. The frequency of hard-braking for individual drivers was collected because it can presumably represent the frequency of near misses for truck drivers. Hard-braking is very dangerous as it can be a major cause of collisions and jackknifing (the folding of an articulated vehicle such as a truck with a trailer). Another objective safety criterion, road injury, was operationalized as lost work days due to injury and was measured 6 months after the survey implementation. One notable advantage of using the road injury variable is that it can convey comprehensive information about safety outcomes unlike simple accident or injury frequency, which does not take into account the severity, fatality, or overall cost of incidents. Since an ordinary least-square regression cannot address count variables as dependent variables, a Poisson log-link generalized linear modeling (GLM) approach was used to estimate the model of safety climate score(s) as independent variable(s) and an objective performance metric as a dependent variable that was a count variable.

3. Results

Of the total 8095 data points, 7466 responses (92.3%) with no more than 50% missing values on safety climate scales were retained for further analyses. This included 1998 samples from the pilot company. Only one company provided the hard-braking frequency data for its participants (3233 participants out of 3578 participant surveys used for analysis, 90.4%), while road injury data were collected from five companies (5534 participants out of 6346 participant surveys used for analysis, 87.2%).

3.1. Construct validity

The EFA with a varimax rotation yielded three factors each for the organization- and group-level safety climate scales (i.e., *proactive practices*, *driver safety priority*, and *supervisory care promotion* for the organization-level safety climate scale; *safety promotion*, *delivery limits*, and *cell phone disapproval* for the group-level safety climate scale). Although we anticipated these potential factors to be somehow correlated, we also assumed that these factors would stand independently; therefore, we chose varimax rotation. Based on the factor structure, factor loading, and content validity, 20 items for each of the organization- and group-level scales were selected. Items with multiple loading and relatively weak factor loading (less than 0.45) were dropped out. At the same time, theoretical and practical aspects of the items were also considered. For instance, the item "My supervisor expects me to answer the cell phone even while I'm driving" from the group-level safety climate scale was loaded on both the *delivery limits* factor with $\lambda = 0.58$ and the *cell phone disapproval* factor with $\lambda = 0.51$. However, as the content of this item is apparently related to the cell phone use while driving, the item was retained in the *cell phone disapproval* factor. The EFA results are presented in Tables 2A and B. Descriptive statistics and internal consistency of the organization-level safety climate scale and group-level safety climate scale along with factor inter-correlations are shown in Table 3. Internal consistency statistics of Cronbach's alphas ranging from .67 to .94 were acceptable.

The 20-item three-factor structures of the organization- and group-level safety climate scales were confirmed by CFAs. CFAs were conducted first for the pilot trucking company ($n = 1998$). Three different types of factor structures were tested: (a) correlated three-factor model, (b) overall single-factor model, and (c) the 2nd order hierarchical model including both the three factors and a single second-order factor above them. The first model was based purely on the three-factor solution from the EFA. Correlations among these three factors were estimated. The second model ruled out the three sub-factors for parsimony of the construct and assumed that the 20 items loaded on a single overall factor. The final model included the three sub-factors and also an upper-level overall factor hypothesized to cause the three sub-factors. It was based on a theoretical consideration that safety climate should be able to be represented by various sub-dimensions of the safety climate. As presented in Table 4, all three CFA models fit the data well. CFIs and TLIs were over 0.95, and RMSEAs were not greater than 0.10. The correlated three-factor model and the 2nd order hierarchical model equally showed better fit compared to the single-factor model ($\Delta\chi^2 = 679.89$ with $\Delta df = 3$ for the organization-level safety climate scale; $\Delta\chi^2 = 1612.30$ with $\Delta df = 3$ for the group-level safety climate scale; both were significant at $p < 0.01$). Considering high inter-correlations among the three factors (0.71–0.84), the 2nd order hierarchical factor model was more appropriate in capturing the nature of the safety climate measure than the three-factor or overall single-factor models. The results all together indicated that the best use of the safety climate scale would be with the consideration of the three sub-factors drawn from the EFA that were closely related to each other and these three sub-factors need to be understood in regard to one general higher factor, safety climate. The construct validity evidence was also provided by the same CFAs performed with data from eight trucking companies ($n = 7466$), which included the cases from the pilot company (Table 5). Consistent with the CFAs run with only the pilot company data, all the different factor models reported acceptable model fit while the best fitting models were both the correlated three-factor model and the 2nd order hierarchical model.

The findings from the EFAs and CFAs provided support for the construct validity of the level-specific organization- and group-level safety climate scales that take into account safety priority over competing demands.

Table 2A
Exploratory factor analysis (EFA) results for organization-level safety climate (OSC) scale (with pilot company data, $n = 1998$).

		Factor		
		F1	F2	F3
F1: Proactive practices				
[a]X1:	Uses any available information to improve existing safety rules	**.73**	.21	.23
[a]X2:	Tries to continually improve safety levels in each department	**.72**	.20	.30
[a]X3:	Invests a lot in safety training for workers	**.69**	.18	.08
X4:	Creates programs to improve drivers' health and wellness (e.g., diet, exercise)	**.65**	.05	.22
[a]X5:	Listens carefully to our ideas about improving safety	**.65**	.06	.47
X6:	Cares more about my safety than on-time delivery	**.64**	.32	.20
X7:	Allows drivers to change their schedules when they are getting too tired	**.62**	.25	.19
X8:	Provides enough hands-on training to help new drivers be safe	**.62**	.06	.34
X9:	Gives safety a higher priority compared to other truck companies	**.62**	.29	.04
[a]X10:	Reacts quickly to solve the problem when told about safety concerns	**.58**	.18	.27
[a]X11:	Is strict about working safely when delivery falls behind schedule	**.55**	.39	−.17
X12:	Gives drivers enough time to deliver loads safely	**.55**	.29	.20
X13:	Fixes truck/equipment problems in a timely manner	**.53**	.00	.49
F2: Driver safety priority				
X14:	Will overlook log discrepancies if I deliver on time	.07	**.79**	.11
X15:	Makes it clear that, regardless of safety, I must pick up/deliver on time	.19	**.71**	.06
X16:	Expects me to sometimes bend safety rules for important customers	.33	**.62**	.30
X17:	Turns a blind eye when we use hand-held cell phones while driving	.20	**.46**	.29
F3: Supervisory care promotion				
X18:	Assigns too many drivers to each supervisor, making it hard for us to get help	.10	.19	**.73**
X19:	Hires supervisors who don't care about drivers	.30	.21	**.69**
X20:	Turns a blind eye when a supervisor bends some safety rules	.31	.47	**.51**
	Eigenvalues	8.11	1.43	1.11
	Percentage variance	40.55	7.15	5.54
	Cumulative variance	40.55	47.70	53.24

Note. All responses for items with negative wordings were reversely coded.
Bolded values indicate factor loadings > 0.40 that are appropriate for a particular factor.
[a] Generic safety climate scale items for lone workers adopted from Zohar and Luria (2005).

Table 2B
Exploratory factor analysis (EFA) results for group-level safety climate (GSC) scale (with pilot company data, $n = 1998$).

		Factor		
		F1	F2	F3
F1: Safety promotion				
[a]Y1:	Compliments employees who pay special attention to safety	**.78**	.11	.25
Y2:	Provides me with feedback to improve my safety performance	**.78**	.20	.30
Y3:	Respects me as a professional driver	**.75**	.36	.00
[a]Y4:	Frequently talks about safety issues throughout the work week	**.74**	.05	.36
[a]Y5:	Discusses with us how to improve safety	**.73**	.18	.35
[a]Y6:	Uses explanations (not just compliance) to get us to act safely	**.72**	.14	.27
Y7:	Is supportive if I ask for help with personal problems or issues	**.67**	.30	−.08
Y8:	Is an effective mediator/trouble-shooter between the customer and me	**.67**	.33	.10
[a]Y9:	Is strict about working safely even when we are tired or stressed	**.64**	.24	.26
Y10:	Gives higher priority to my safety than on-time delivery	**.64**	.42	.11
Y11:	Would like me to take care of serious equipment problems first before delivering	**.63**	.38	.14
Y12:	Gives me the freedom to change my schedule when I see safety problems	**.56**	.46	.14
Y13:	Makes me feel like I'm bothering him/her when I call	**.53**	.51	−.13
F2: Delivery limits				
Y14:	Encourages us to go faster when deadheading (going for a new load)	.12	**.76**	.17
Y15:	Expects me to sometimes bend driving safety rules for important customers	.22	**.76**	.23
Y16:	Sometimes turns a blind eye with rules when deliveries fall behind schedule	.29	**.70**	.29
Y17:	Pushes me to keep driving even when I call in to say I feel too sick or tired	.39	**.61**	.14
F3: Cell phone disapproval				
Y18:	Expects me to answer the cell phone even while I'm driving	.21	.58	**.51**
Y19:	Stops talking to me on the phone if he/she hears that I am driving	.26	.19	**.74**
Y20:	Turns a blind eye when we use hand-held cell phones while driving	.16	.47	**.62**
	Eigenvalues	9.71	1.68	1.00
	Percentage variance	48.55	8.39	5.02
	Cumulative variance	48.55	56.94	61.96

Note. All responses for items with negative wordings were reversely coded.
Bolded values indicate factor loadings > 0.40 that are appropriate for a particular factor.
[a] Generic safety climate scale items for lone workers adopted from Zohar and Luria (2005). Generic item "Refuses to ignore safety rules when work falls behind schedule" dropped after exploratory factor analysis.

Table 3
Descriptive statistics and internal consistency of the safety climate scale along with factor inter-correlations (with pilot company data, $n = 1998$).

	1	2	3	4	5	6	7	8
1. OSC factor 1	–							
2. OSC factor 2	.55	–						
3. OSC factor 3	.62	.54	–					
4. Total OSC	**.96**	**.73**	**.76**	–				
5. GSC factor 1	.70	.45	.58	.71	–			
6. GSC factor 2	.55	.61	.52	.63	.66	–		
7. GSC factor 3	.46	.53	.43	.54	.58	.65	–	
8. Total GSC	**.70**	**.55**	**.61**	**.74**	**.97**	**.80**	**.73**	–
Mean	4.00	4.31	3.68	4.02	4.00	4.44	4.30	4.13
SD	.72	.78	.92	.67	.82	.75	.81	.73
Cronbach's α	.90	.68	.67	.92	.94	.81	.73	.94

Note. OSC: Organization-level safety climate. OSC factor 1: Proactive practices. OSC factor 2: Driver safety priority. OSC factor 3: Supervisory care promotion. GSC: Group-level safety climate. GSC factor 1: Safety promotion. GSC factor 2: Delivery limits. GSC factor 3: Cell phone disapproval. All the correlation coefficients were statistically significant at $p < .01$.

Table 4
Confirmatory factor analysis (CFA) results (with pilot company data, $n = 1998$).

Models	Fit indexes			
	X^2 (*df*)	CFI	TLI	RMSEA (90% CI)
A. Organization-level safety climate[a]				
Model 1: Three-factor	1394.80 (167)	.99	.99	.062 (.059–.065)
Model 2: One-factor	2074.69 (170)	.98	.98	.077 (.074–.080)
Model 3: 2nd order hierarchical	1394.80 (167)	.99	.99	.062 (.059–.065)
B. Group-level safety climate[b]				
Model 1: Three-factor	1797.26 (167)	.99	.98	.072 (.069–.075)
Model 2: One-factor	3409.56 (170)	.97	.97	.100 (.097–.103)
Model 3: 2nd order hierarchical	1797.26 (167)	.99	.98	.072 (.069–.075)

[a] Model 1: a structural model with three factors (proactive practices, driver safety priority, and supervisory care promotion). Model 2: a structural model with one overall factor for total 20 items. Model 3: a structural model with one overall 2nd order factor of safety climate with three sub-factors (proactive practices, driver safety priority, and Supervisory care promotion).
[b] Model 1: a structural model with three factors (safety promotion, delivery limits, and cell phone disapproval). Model 2: a structural model with one overall factor for total 20 items. Model 3: a structural model with one overall 2nd order factor of safety climate with three sub-factors (safety promotion, delivery limits, and cell phone disapproval).

Table 5
Confirmatory factor analysis (CFA) results (with eight trucking companies, $n = 7466$).

Models	Fit indexes			
	X^2 (*df*)	CFI	TLI	RMSEA (90% CI)
A. Organization-level safety climate[a]				
Model 1: Three-factor	4500.90 (167)	.99	.99	.059 (.057–.060)
Model 2: One-factor	7621.56 (170)	.98	.98	.077 (.075–.078)
Model 3: 2nd order hierarchical	4500.90 (167)	.99	.99	.059 (.057–.060)
B. Group-level safety climate[b]				
Model 1: Three-factor	6268.43 (167)	.99	.98	.070 (.068–.071)
Model 2: One-factor	12440.72 (170)	.97	.97	.098 (.097–.100)
Model 3: 2nd order hierarchical	6268.43 (167)	.99	.98	.070 (.068–.071)

[a] Model 1: a structural model with three factors (proactive practices, driver safety priority, and supervisory care promotion). Model 2: a structural model with one overall factor for total 20 items. Model 3: a structural model with one overall 2nd order factor of safety climate with three sub-factors (proactive practices, driver safety priority, and supervisory care promotion).
[b] Model 1: a structural model with three factors (safety promotion, delivery limits, and cell phone disapproval). Model 2: a structural model with one overall factor for total 20 items. Model 3: a structural model with one overall 2nd order factor of safety climate with three sub-factors (safety promotion, delivery limits, and cell phone disapproval).

3.2. Results for examining shared safety climate perception

Prior to the evaluation of the effect of the safety climate scores on safety behavior and the safety outcome variables, the level of within-group agreement and between-group variance was examined. For this, r_{wgj} and intra-class correlations ICC(1) and ICC(2) were calculated based on the pilot company data, which had 66 groups encompassing 1998 truck drivers. The grouping was made based on a sub-unit of the company, and each group was operationalized by a direct supervisor.

Although good within-group agreement was observed with median r_{wgj} values .94 and .95 for the organization- and group-level safety climate scales, respectively, between-group variance did not reach the satisfactory level for ICC(1) ranging from 0.02 to 0.06 and ICC(2) ranging from 0.12 to 0.36 (see Table 6). Considering that the generally accepted criteria for ICC(1) and ICC(2) are, respectively, greater than 0.10 (LeBreton & Senter, 2008; Ostroff & Schmitt, 1993) and greater than 0.70 (Bliese, 2000), the results failed to justify the aggregation of individual/psychological safety climate scores to form shared safety climate perception for their work groups.

One more company (company B in Table 6) provided information for grouping based on work units. A similar pattern was observed for the data. Median r_{wgj} values were 0.93 for both organization- and group-level safety climates. ICC(1) ranged from 0.03 to 0.08 while ICC(2) ranged from 0.27 to 0.50, suggesting the between-group variance was not enough to create group/unit-level aggression data. Therefore, the following analyses were based on individual/psychological safety climate scores instead of aggregated shared safety climate perception scores of the work units.

Although there was a lack of reliability within work unit-level (based on supervisor group), shared safety climate perception was observed at the company as the unit for all eight companies with median r_{wgj} = 0.89 and 0.88, ICC(1) = 0.12 and 0.11, and ICC(2) = 0.99 and 0.99, respectively, for the organization- and group-level safety climate scores. Since the number of participating companies was limited (n = 8), no shared safety climate perceptions for the companies were aggregated for further analyses.

3.3. Criterion-related validity

3.3.1. Overall safety climate scores and safety behavior

For the following analyses, aimed at testing the predictive validity of the newly developed organization- and group-level safety climate scales, the data collected from all eight trucking companies (n = 7466) that participated in this study were used for the regression analyses. The regression analyses showed that the overall scores of organization- and group-level safety climate (20 items each) were all significantly related to self-reported driving safety behavior with B = 0.37 (SE = 0.01, 95% confidence interval = [0.35, 0.38], $p < 0.01$) and 0.33 (SE = 0.01, 95% confidence interval = [0.32, 0.35], $p < 0.01$), respectively. R^2 statistics showed that the organization-level safety climate score explained 19% of the variance for driving safety behavior while the group-level safety climate score accounted for 20% of the variance (Table 7).

3.3.2. Overall safety climate scores and objective safety performance measures

For the generalized linear modeling (GLM) analyses, data from five companies that provided the road injury variable (n = 5534) were used. According to the GLM analyses, the organization- and group-level safety climate scores also significantly predicted road injury with B = −0.56 (SE = 0.03, 95% confidence interval = [−0.61, −0.50], Wald χ^2 = 380.49,

Table 6
Shared safety climate perception examination for pilot company and one additional company.

	r_{wgj} [a]	ICC(1)	ICC(2)	ANOVA (F)
A. Company 1 (pilot company, n = 1998)				
1. OSC factor 1	.93 (.00–1.00)	.02	.16	1.19
2. OSC factor 2	.77 (.00–1.00)	.02	.12	1.13
3. OSC factor 3	.63 (.00–1.00)	.02	.14	1.16
4. Total OSC	**.94 (100–1.00)**	**.02**	**.16**	**1.19**
5. GSC factor 1	.93 (.00–1.00)	.03	.22	1.28*
6. GSC factor 2	.87 (.00–1.00)	.04	.25	1.34**
7. GSC factor 3	.79 (.00–1.00)	.06	.36	1.56*
8. Total GSC	**.95 (.00–1.00)**	**.04**	**.23**	**1.30***
B. Company 2 (n = 2620)				
1. OSC factor 1	.91 (.00–1.00)	.04	.32	1.47**
2. OSC factor 2	.69 (.00–1.00)	.03	.27	1.38**
3. OSC factor 3	.52 (.00–1.00)	.04	.34	1.52**
4. Total OSC	**.93 (.00–1.00)**	**.04**	**.33**	**1.48****
5. GSC factor 1	.90 (.00–1.00)	.07	47	1.88**
6. GSC factor 2	.82 (.00–1.00)	.05	.40	1.66**
7. GSC factor 3	.75 (.00–1.00)	.08	.50	1.99**
8. Total GSC	**.93 (.00–1.00)**	**.07**	**.48**	**1.94****

Note. OSC: Organization-level safety climate. OSC factor 1: Proactive practices. OSC factor 2: Driver safety priority. OSC factor 3: Supervisory care promotion. GSC: Group-level safety climate. GSC factor 1: Safety promotion. GSC factor 2: Delivery limits. GSC factor 3: Cell phone disapproval. Criteria for acceptable homogeneity tests are the following: a median of r_{wgj} > .70 (James et al., 1993); ICC(1) > .10 (LeBreton & Senter, 2008; Murphy & Myors, 1998; Ostroff & Schmitt, 1993) and ICC(2) > .70 (Bliese, 2000; LeBreton & Senter, 2008).

[a] r_{wgj} statistics are mean values with ranges within bracket.

* $p < .05$.

** $p < .01$.

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$p < 0.01$) and −0.46 ($SE = 0.02$, 95% confidence interval = [−0.51, −0.41], Wald $\chi^2 = 346.85$, $p < 0.01$), respectively (Table 8). These findings indicate that, as the raw score of organization-level safety climate increases from 1 to 5, the overall number of lost days due to road injury would drop from 2.01 to 0.02 days. For the group-level safety climate scale, as the raw score increases from 1 to 5, the number of lost days would decrease from 1.61 to 0.25 days.

One company provided the frequency of hard-braking information for their employees ($n = 3233$). The variable was regressed by GLM with the organization- and group-level safety climate scale scores. The overall organization-level safety climate score could predict the hard-braking variable significantly (intercept = 0.68, $B = -0.08$, $SE = 0.02$, 95% confidence interval: [−0.13, −0.04], $p < .01$) while the overall group-level safety climate score could not (intercept = 0.45, $B = -0.02$, $SE = 0.02$, 95% confidence interval: [−0.06, 0.02], $p = 0.25$). However, when the driving safety behavior variable was included as a mediator, both organization- and group-level safety climate had significant indirect effects on the hard-braking frequency with coefficients −0.02 ($SE = 0.01$, 95% confidence interval: [-0.03, -0.08×10^{-2}], $p < 0.05$) and −0.01 ($SE = 0.01$, 95% confidence interval: [-0.02, -0.05×10^{-2}], $p < 0.05$), respectively. These findings supported the predictive validity of the safety climate scales. In summary, criterion-related validity of the developed safety scales was supported.

3.3.3. Incremental predictive validity of the trucking industry-specific items

With an attempt to examine the value of including industry-specific items in addition to generic items in terms of criterion-related validity, the previous regression and GLM analyses were repeated separately for the generic items and the full safety climate scales, which included both the generic and industry-specific items. To test multiple-predictor models with the regression and GLM analyses, mean centered variables were used to reduce the effect of multicollinearity caused by high correlation between the two predictors (i.e., the generic item scores and the full safety climate scales).

The regression analyses showed that the generic items of the organization- and group-level safety climate scales could independently predict driving safety behavior significantly with $B = 0.28$ ($SE = 0.01$, 95% confidence interval = [0.26, 0.29], $p < 0.01$) and 0.22 ($SE = 0.01$, 95% confidence interval = [0.20, 0.23], $p < 0.01$), respectively (Table 7). When the driving safety behavior was regressed on both the generic item score and the full safety climate scale together, only the full safety climate scale was a significant predictor with a positive coefficient. Although the score from only the generic items was a significant predictor in the multiple regression, it negatively predicted driving safety behavior, which was contrary to the simple regression in which the driving safety behavior was regressed by the score from the generic items independently. The organization-level generic items accounted for 14% of the dependent variable variance ($B = -0.11$, $SE = 0.02$, 95% confidence interval = [−0.15, −0.07], $p < 0.01$), while the full organization-level safety climate scale could explain an additional 6% of the variance ($B = 0.48$, $SE = 0.02$, 95% confidence interval = [0.44, 0.52], $p < 0.01$), with total $R^2 = 0.20$. Ten percent of the dependent variable variance could be accounted for by the group-level generic item score ($B = -0.17$, $SE = 0.01$, 95% confidence interval = [−0.20, −0.14], $p < 0.01$), while an additional 11% of the variance could be explained by the full (generic + industry-specific items) group-level safety climate scale ($B = 0.49$, $SE = 0.02$, 95% confidence interval = [0.46, 0.52], $p < 0.01$), with total $R^2 = 0.21$.

Results from the GLM are presented in Table 8. In the single-predictor models, scores from only the generic items could predict road injury significantly ($p < 0.01$). Unstandardized coefficient B values of the generic item scores for the organization- and group-level safety climate scales were, respectively, −0.31 ($SE = 0.03$, 95% confidence interval = [−0.36, −0.26], Wald $\chi^2 = 149.75$) and −0.21 ($SE = 0.02$, 95% confidence interval = [−0.26, −0.17], Wald $\chi^2 = 79.56$). However, in the multiple-predictor models, which included both the score from generic items and the score from the full safety climate scale (generic + industry-specific items) together to predict road injury, only the full safety climate scale showed a significant

Table 7
Regression analyses in prediction of self-report driving safety behavior with total organization-level safety climate (OSC) and group-level safety climate (GSC) scores and their generic item scores and full safety climate scale scores ($n = 7466$ from all eight companies).

DV: driving safety	R^2	Intercept (SE)	B^a (SE)	95% CI	
				Lower	Upper
Simple regression					
OSC generic items	.14	3.27 (.03)	.28 (.01)	.26	.29
Full OSC	.19	2.92 (.04)	.37 (.01)	.35	.38
GSC generic items	.10	3.56 (.03)	.22 (.01)	.20	.23
Full GSC	.20	3.04 (.03)	.33 (.01)	.32	.35
Multiple regression					
OSC generic items	.14	–	−.11 (.02)	−.15	−.07
Full OSC	.06	–	.48 (.02)	.44	.52
(OSC generic items + Full OSC)	.20	4.36 (.01)	–	–	–
GSC generic items	.10	–	−.17 (.01)	−.20	−.14
Full GSC	.11	–	.49 (.02)	.46	.52
(GSC generic items + Full GSC)	.21	4.36 (.01)	–	–	–

Note. OSC: Organization-level safety climate. GSC: Group-level safety climate.
[a] All B values were statistically significant at $p < .01$.

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Table 8
Generalized linear modeling with Poisson log-link function results in prediction of road injury (lost working days) with the generic item score and full organization-level safety climate (OSC) scale and group-level safety climate (GSC) scale (n = 5534 from five companies that provided injury information).

DV: road injury	Intercept (SE)	B^a (SE)	95% CI		Wald χ^2
			Lower	Upper	
Single-predictor model					
OSC generic items	.35 (.10)	−.31 (.03)	−.36	−.26	149.75
Full OSC	1.28 (.11)	−.56 (.03)	−.61	−.50	380.49
GSC generic items	−.09 (.09)	−.21 (.02)	−.26	−.17	79.56
Full GSC	.94 (.10)	−.46 (.02)	−.51	−.41	346.85
Multiple-predictor model					
OSC generic items	–	.67 (.06)	.56	.78	141.73
Full OSC	–	−1.25 (.06)	−1.37	−1.12	379
(OSC generic items + Full OSC)	−.92 (.02)	–	–	–	–
GSC generic items	–	.58 (.05)	.49	.67	157.25
Full GSC	–	−1.00 (.05)	−1.09	−.90	413.67
(GSC generic items + Full GSC)	−.93 (.02)	–	–	–	–

Note. OSC: Organization-level safety climate. GSC: Group-level safety climate.
[a] All B values were statistically significant at $p < .01$.

($p < 0.01$) and negative relationship with the dependent variable with $B = -0.87$ (SE = 0.04, 95% confidence interval = [−0.96, −0.78], Wald χ^2 = 378.49) and −0.73 (SE = 0.04, 95% CI = [−0.80, −0.65], Wald χ^2 = 354.47), respectively, for the organization- and group-level scales. The generic item scores had positive B statistics in the prediction of the road injury variable when the effect of the full safety climate scale on the road injury variable was controlled for, even when significant. It was contrary to the negative B statistics of the generic item scores in the single-predictor GLM models.

The predictive directions of the generic item scores for driving safety and road injury were reversed after the full safety climate scales' effects were ruled out. This suggested a multicollinearity problem, as expected. High correlations were observed between the generic item score and full safety climate scale with r = 0.91 and 0.86 (both were significant at $p < 0.01$), respectively, for the organization- and group-level safety climate scales. These findings showed that the generic items and the full safety climate scales have a large common portion in the prediction of driving safety behavior and road injury, with the full safety climate scales that included items specifically tailored to the trucking industry demonstrating stronger predictive validity. Criterion-related validity testing results supported the overall predictive utility of the safety climate scales and also showed the significant incremental predictive validity of the industry-specific items over the generic items.

4. Discussion

The first objective of this study was to develop and test the reliability and validity of a new scale designed for measuring safety climate among lone workers, using truck drivers as exemplar. The new scale employs perceived safety priority as the metric of safety climate. Furthermore, it employs a multi-level framework, separating the measurement of organization- and group-level safety climate by differentiating items into two sub-scales. The second objective of this study was to compare the predictive power of generic items with industry-specific ones, constituting the new Trucking Safety Climate scale.

Results showed that three-factor solutions drawn from EFAs and CFAs confirmed the organization- and group-level safety climate scales' construct validity. A series of homogeneity testing did not reveal a shared perception unique to work unit, but organization-level shared perception was observed for these eight participating companies. Criterion-related validity of the safety climate scales in terms of the relationship between safety climate scores and driving safety behavior/road injury was supported by regression and GLM analyses. These findings were consistent with previous studies such as Griffin and Neal (2000), Mueller, DaSilva, Townsend, and Tetrick (1999), and Zohar (2003).

This study has several theoretical and practical implications. First of all, a safety climate measurement tool suited for the trucking/transportation industry had not been introduced before the current study. Also, the focus of this study was placed on the trucking industry where safety issues, such as high accident rates, need to be addressed. The target participants included in the study were mobile lone workers who drive trucks for long periods of time away from home, with a lack of face-to-face supervisory oversight. Safety climate can be very important for this unique population because safety climate can act as a frame of reference that guides normative safety behavior, such that employees develop coherent sets of perceptions and expectations regarding safety behavior-outcome contingencies. Employees, thus, behave accordingly when strong safety climate exists, even in lone working situations. Furthermore, the findings from this study consistently showed that safety climate can be a strong indicator of safe driving behavior and objective safety outcomes in the trucking industry.

Second, this study provided ample empirical evidence to support the theoretical suggestions from Zohar (2008, 2010). This study highlighted two different levels of perception regarding safety climate in the trucking industry, which led to the development of the organization- and group-level safety climate scales. This is closely related to the process of safety climate formation and transfer from organizational level to individual employee level via work group. In this regard, future studies about safety climate in the trucking industry would benefit from the use of the newly developed level-specific safety climate scales. Moreover, these safety climate scales include items regarding safety priority over competing operational and safety demands. Specifically, the *driver safety priority* and *supervisory care promotion* factors from the organization-level safety climate scale and the *delivery limits* and *cell phone disapproval* factors from the group-level safety climate scale items were, for the most part, about priority issues, such as safety over-time, productivity, and supervisory oversight.

As Zohar (2010) suggested, development of industry-specific climate scales should be encouraged as it is likely to identify new, context-dependent targets of climate perception in respective industries. In the current study, a reliable and valid safety climate scale specific for the trucking industry was developed. The industry-specific scales incorporate various factors and items pertaining to the trucking industry, which could be used among trucking companies to show where improvements can be made and, as such, may offer a valuable starting point for future safety interventions and have actionable plan.

Christian et al. (2009) categorized safety climate perceptions into two levels of analysis, resulting in shared group-level safety climate and individual/psychological safety climate. Our study results showed that for lone workers, individual/psychological safety climate perceptions were significant predictors for safety outcomes; however, there were no shared safety climate perceptions among working groups. As lone workers generally lack the opportunity to interact with other co-workers, so it is reasonable that there were no shared safety climate perceptions among working groups. A chance to talk together is important for symbolic interaction (Schneider & Reichers, 1983; Zohar, 2010) in order to form group consensus, which places the focus on meanings that arise within the interactions between people. This suggests that companies may consider providing more opportunity for verbal communication and other interaction behaviors between lone workers and other employees (e.g., more frequent group meetings, using technology to increase communication) in order to form shared safety climate perception among groups.

This study also investigated the relationship between safety climate scores and an objective safety outcome variable, the number of lost working days due to injury measured 6 months after the scale implementation, and clearly reconfirmed previous findings about the organizational effect of safety climate on safety outcomes (Beus et al., 2010; Christian et al., 2009; Nahrgang et al., 2011). The organization- and group-level safety climate scores can be a valid indicator not only for driving safety behavior but also for future road injury in the trucking industry. The implementation of the safety climate scales, which assess multiple dimensions unique to organization and group levels, would provide managers and employees with rich feedback regarding the relative strengths and weaknesses in safety policies and practice in their particular company.

Finally, the large sample size and objective performance metrics used in this study strengthened the psychometric property and utility of the newly developed safety climate scales. The sample size of over 7000 mobile lone workers from major trucking companies enhanced not only the uniqueness of the study population but also the sound reliability and external validity of this study.

There are several potential limitations as well. Regardless of the fairly large sample size, the number of trucking companies that participated in this study was only eight. The findings from eight trucking companies may not be exactly consistent across many other companies that were not included in this study because different trucking companies are likely to have different managerial styles, attitudes toward safety issues, and levels of quality of the supervisor–employee relationship. Also, truck drivers' job experience and average distance of daily driving may vary across different companies. Hence, a selection bias could have affected the results as some trucking companies who were asked but did not participate in the study may have had poor safety records and felt reluctant to participate. Future studies should diversify the sampling sources by including more companies with different organizational conditions to ensure the reliability of the Trucking Safety Climate scale scores and predictive validity.

In conclusion, the present study showed that even though truck drivers work alone, they are able to perceive the safety priorities of their companies, and these perceptions can be used to predict safe working behavior and actual injury outcomes. It is expected that the development and validation of organization- and group-level safety climate scales specific to the trucking industry would contribute to future studies about safety climate and safety outcomes in the trucking industry.

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