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Towards a Model of Safety Climate Measurement

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*In this study, a survey instrument was developed to measure safety climate. A review of the scientific literature as well as consultation with an expert panel was used to determine the survey's dimensions. Next, the survey was administered, first as a pilot study (*n *= 15) and then as a full scale study (*n *= 229), to employees of the City of Cincinnati Department of Public Works. The psychometric integrity of the survey was assessed according to validity, reliability and utility criteria. Results are presented and discussed.*

safety climate model   safety surveillance

1. INTRODUCTION

In recent years, safety analysis measures have shifted from a focus purely based on retrospective data (e.g., man hours lost, direct costs of accidents, accident and fatality rates) toward proactive safety intervention tools (e.g., safety audits or safety climate surveys). A safety climate survey provides management with data from which to form a strategy to evaluate, correct and monitor work system conditions. Self-administered surveys can provide early warning signals to basic safety problems before they emerge as accidents and injuries [1]. The concept of safety climate can be considered as an alternative performance indicator [2]. However, although many safety climate surveys have been developed, few research studies have addressed the psychometric integrity of the instrument.

1.1. Safety Climate Versus Safety Culture

A distinction should first be made between safety climate and safety culture since the two terms are mutually related but distinguishable. Safety culture expresses itself through safety climate [2]. Furthermore, safety climate is regarded as the features of the safety culture that can be

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discerned from workers' attitudes and perceptions [3, 4]. Although both terms are used sometimes interchangeably in the scientific literature, in this article we define safety climate as the set of work system conditions and practices which result from safety culture.

Reviews of safety research literature for the past 20 years identified 15 studies related to safety measurement. Eleven used the term safety climate [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15] and four used the term safety culture [16, 17, 18, 19]. As the aim of this study is to characterize the attitudes, practices and conditions that affect safety in the work system, the subject of measurement will be defined as "safety climate".

1.2. Current Measures of Safety Climate

A literature search identified 15 published studies of safety climate surveys. These research studies were conducted in different organizations—eight in industrial sectors [5, 6, 7, 9, 10, 14, 16, 18], two in construction [8, 11], two in energy [17, 19], one in an airport [13] and two in health care [12, 15]. Guldenmund [2] summarizes these studies in Table 1.

To evaluate the merit of a scientific instrument, evidence of its validity, reliability and utility must be provided [20, 21]. Shoaf et al. [22] discussed these criteria with respect to job analysis assessment techniques. Flin et al. [23] stated that a set of basic safety climate factors must be established so that it can be shown to be reliable, valid, sufficiently comprehensive and theoretically justifiable. As this study regards the evaluation of psychometric criteria as essential in the development of a survey instrument, the scientific literature is reviewed with respect to these criteria.

Table 1 shows little agreement on the dimensions that should be included in a safety climate model among the referenced studies. Many of the reviewed instruments describe a specific content domain in great detail yet only loosely characterize other domains or even omit some domains altogether. Validity is the psychometric criterion that describes the extent to which the measuring instrument measures what it is intended to measure [20]. Content validity (i.e., evidence that the method's content adequately addresses all dimensions which constitute the safety climate), lacks established guidelines for assessment; however, is regarded as essential [24]. The varying number as well as the content of the dimensions considered in the reviewed surveys demonstrates that there is little agreement on the underlying constructs of the safety climate concept. The number of dimensions found differs considerably, ranging from two [8] to 19 [19].

A possible explanation for the variance of dimensions may be due to the fact that the surveys were carried out in different types of work organizations (i.e., industry, construction, energy, airports, and health care). Flin et al. [23] argues that safety climate dimensions are variable and are likely to be industry or even company specific, and that instruments developed in one domain may not generalize to others [4]. Niskanen [11] noted that there has been little cross matching of data from previous studies to develop a concept of safety climate. Indeed, few researchers have investigated the issue of content validity.

Criterion validity (i.e., predictive validity) compares the prediction of the measure in question with another well-accepted measure (i.e., direct indicator or standard). The degree of criterion validity depends on the correlation level between the measure under examination and the criterion standard. For example, the score on a written driving test could be correlated with the actual driving test performance (i.e., direct indicator). A safety climate survey can be correlated with the number of sick days or injury rates. In this manner, the number of sick days or injury rate data serves to act as the direct indicator in the criterion validity test.

While the importance of the data obtained from the safety climate survey is often emphasized, very few researchers have attempted to report evidence of validity.

TABLE 1. Overview of Number of Questions, Surveyed Population and Dimensions of Safety Culture and Climate Research

Reference	No. of Questions/Instrument	Population	Climate/Culture Dimensions
Zohar [5]	40, questions administered during interview	20 Israeli industrial organizations (steel, food processing and textile industry); 400 respondents	1. Importance of safety training programs 2. Management attitude towards safety 3. Effects of safe conduct on promotion 4. Level of risk at work place 5. Effects of required work pace on safety 6. Status of safety officer 7. Effects of safe conduct on social status 8. Status of safety committee
Glennon [6]	68, SAQ	Line managers from 8 Australian companies (bauxite, mining, sawmill and logging, metal refining, petroleum refining, cement manufacturing and general engineering and manufacturing); 198 respondents	1. Perceived influence of safety and health legislation 2. Perceived corporate attitude to safety and health 3. Perceived organization status of safety advisor officer 4. Perceived importance of safety and health training 5. Perceived effectiveness of encouragement (vs. disciple) in promoting safety 6. Perceived effect of department/section safety record on promotion 7. Perceived risk level of workplaces 8. Perceived status of safety targets relative to production pressures
Brown and Holmes [7]	40, SAQ	10 American manufacturing and produce companies; 425 respondents	1. Employee perception of how concerned management is with their well-being 2. Employee perception of how active management is in responding to this concern 3. Employee physical risk perception
Cox and Cox [16]	18 (+ 4), SAQ	Employees of a European company involved in the production and distribution of industrial gasses; 630 respondents	1. Personal skepticism 2. Individual responsibility 3. Safeness of work environment 4. Effectiveness of arrangement for safety 5. Personal immunity
DeDobbeleer and Béland [8]	9, SAQ	9 construction sites; 272 respondents	1. Management commitment to safety 2. Worker's involvement in safety

TABLE 1. (*continued*)

Reference	No. of Questions/Instrument	Population	Climate/Culture Dimensions
Ostrom et al. [17]	88, SAQ	Employees of the Department of Energy in Idaho, USA, and its 8 contractors; 4,000 administered	1. Safety awareness 2. Team work 3. Pride and commitment 4. Excellence 5. Honesty 6. Communications 7. Leadership and supervision 8. Innovation 9. Training 10. Customer 11. Procedure compliance 12. Safety effectiveness 13. Facilities
Cooper and Philips [9]	50, SAQ	Personnel of packaging production plant; (pre) and 187 (post) respondents	1. Management attitude toward safety 2. Perceived level of risk 3. Effects of work pace 4. Management actions toward safety 5. Status of safety officer and committee 6. Importance of safety training 7. Social status of safety and promotion
Coyle et al. [12]	30 (organization 1) and 32 (organization 2)	Workforce of 2 organizations involved in the provision of health care and social services to the elderly; 340 (organization 1), 540 (organization 2)	Organization 1: 1. Maintenance and management issues 2. Company policy 3. Accountability 4. Training and management issues 5. Work environment 6. Policy/procedures 7. Personal authority Organization 2: 1. Work environment 2. Personal authority 3. Training and enforcement of policy

TABLE 1. *(continued)*

Reference	No. of Questions/Instrument	Population	Climate/Culture Dimensions
Berends [18]	34, SAQ	3 industrial organizations (2 chemical process industries and 1 steel company); a total of 343 respondents	1. Confidence in the arrangement for safety 2. Compliance with safe working practices 3. Perceived priority given to safety 4. Own active effort put in safety matters 5. Communication about safety
Williamson et al. [14]	67, SAQ	7 workplaces, covering heavy and light industry and outdoor workers; a total of 660 respondents	1. Personal motivation for safety 2. Positive safety-practice 3. Risk justification- fatalism 4. Optimism
Hayes et al. [15]	50, SAQ	Patients seen at a medical consulting firm; 787 respondents (group 1), 879 respondents (group 2)	1. Job safety 2. Coworker safety 3. Supervisor safety 4. Management attitude towards safety practices 5. Safety program (policies)

Notes. SAQ—self-administered questionnaire.

Most efforts have not progressed beyond the stage of face validity, that is, the concept has not advanced beyond its first developmental stages [2]. Coyle et al. [12] stated that the relationship between safety climate analysis and other occupational safety and health performance indicators has not been reported and is a major area for future research.

While the validity aspects of an instrument's quality pertain to theoretical goodness, reliability aspects pertain to empirical goodness. Reliability refers to the extent to which the measurement is consistent—whether the instrument yields the same results on repeated trials. Dedobbelear and Beland [8] attempted to replicate the results of a safety climate questionnaire in two different industries and were unsuccessful. Williamson et al. [14] used the Cronbach alpha test to demonstrate an internal consistency value of .60 (n = 588, 17 items). However, most research being focused on establishing a basic set of items for assessment has not progressed to the stage which considers reliability.

Utility analysis is particularly important because it conveys information about the acceptability of such a tool by practitioners. If a tool is not easy to administer or takes too much time to finish, it will not be used in industry. Furthermore, the results must prove useful to management. Few researchers have commented on this aspect in the development of a safety climate measure. However, Williamson et al. [14] did consider utility and noted that a lengthy questionnaire is likely to affect response rate and worked to optimize questionnaire length.

Although the concept of safety climate is widely discussed in the scientific literature, no explicit, theoretical model of safety climate that has demonstrated psychometric integrity through validity, reliability and utility criteria exists. Guldenmund [2] concluded that research should now focus on proving scientific validity. Furthermore, there is no survey instrument that has gained acceptance within the scientific community as a standard instrument among a given type of industry or among different types of work organizations. At present, there is no overall satisfying model of safety climate [2].

1.3. Study Objective

The purpose of the present study is to (a) develop and validate an instrument to measure the perception of work safety climate, (b) apply the developed instrument to assess a work safety climate in an industrial setting, and (c) to evaluate the instrument's psychometric integrity.

2. METHODS AND DESIGN

2.1. Description of Client Organization

This research was conducted as a field study in cooperation with the management and workers of the City of Cincinnati Department of Public Works (CDPW). There are approximately 1,000 total employees working in the six divisions of CDPW. The six CDPW divisions and their respective objectives are:

- Highway maintenance: to maintain the public right-of-way, including streets, bridges, viaducts and walls in a safe condition;
- Sanitation: to provide solid waste collection, street cleaning, special collections and community cleanup services;
- Traffic engineering: to enhance safety and convenience to the general public through effective traffic control devices;
- Facilities management: to maintain, operate, renovate and improve all facilities, to provide comfortable working environment for city employees and citizens who utilize city services;
- Engineering: to provide high level and cost-effective construction management and quality control experience for division projects and projects for other city agencies;
- Administration: to handle administrative and clerical assignments.

2.2. Description of Subject Population

The instrument was first pilot tested on a total of 15 field employees selected at random from four divisions of CDPW. Due to differences in the number of workers employed in each division (see Table 2), the sample contained 5 subjects from highway maintenance, 6 from sanitation, 2 from facilities management and 2 from traffic engineering, resulting in a sample size of 15 (n = 15). The remaining two divisions, engineering and administrative, were not sampled in the study as most of the work involves administrative types of assignments and its employees are not participants in the same type of environment as the employees in the other four divisions.

A larger sample was then selected, composed of subjects from three worker-groups (managers, supervisors, and field employees) of four divisions of CDPW (highway maintenance, sanitation, facilities management, and traffic engineering). All managers and supervisors participated from each of the four divisions. The sample contained n = 258 workers, 26% of the total workforce (see Table 2). From this sample, 229 completed the survey for a response rate of 89%. Approximately 79% of the sample was male, nearly 30% attended some college and the average length of employment was 14 years (SD = 7.1).

TABLE 2. Sample Selected to Participate in the Study (n = 258, City of Cincinnati Department of Public Works)

Worker Group	Highway Maintenance	Sanitation	Traffic Engineering	Facilities Management	Total
Managers	6	3	1	1	11
Supervisors	23	12	6	3	44
Employees	56	70	52	25	203
Total	85	85	59	29	N = 258

2.3. Definition and Assessment of Safety Climate Dimensions

Items generated under each safety climate dimension were guided by a review of the scientific literature, including research articles dealing directly with safety climate measures (Table 1) and studies dealing with different aspects of work safety, including quality of safety programs and safety management [25, 26]. From previous research, a small set of common denominators was used to classify comparable dimensions into major headings. For example, all dimensions relating to management attitude towards safety efforts are classified as "management's safety activity". When the dimensions are renamed according to a common classification system, the total number of dimensions is significantly reduced [2].

The extent to which employees follow safety precautions has been shown to be related to employees' perceptions of management attitude towards safety [27]. It has been strongly argued that many safety problems have their origins in the poor attitude of management toward safety climate. The quality of management practice toward safety is also suggested to affect human's safety behavior [25]. Williamson et al. [14] reviewed six studies that assessed safety climate [5, 7, 8, 10, 11, 16] and found that management attitude towards safety is one dimension that runs across all six studies. A safety climate model should include assessment of the process of management attitude towards safety practice which appears to be a major influential factor in the success or failure of any safety system [7, 8].

Flin et al. (2000) [23] reviewed 16 studies of safety climate surveys [5, 7, 8, 10, 11, 16, 17, 28, 29, 30, 31, 32, 33, 34, 35, 36] and concluded that there is a common feature appeared in two thirds of the surveys, it was labeled "safety system" and included the organization's safety plan, safety inspection practices and safety equipment. In a similar review of safety climate surveys [2], using 15 studies (11 mentioned by Flin et al., 2000) [23], found that the most frequently measured dimension which appeared in all the surveys was related to safety system. Based on such extensive research, a third dimension labeled "safety surveillance process" was added as an integral part of the safety climate model.

Based on the reviewed safety climate literature (see Table 1) a model was developed which characterizes three content domains of work safety (Figure 1):

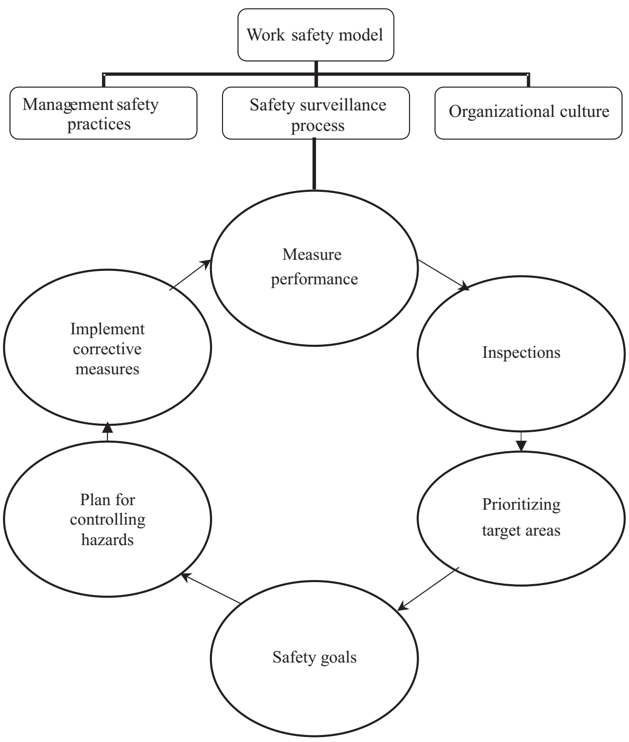

Figure 1. Work safety model.

- Management attitude towards safety practices: management's demonstrated interest in the safety of its employees;
- Organizational culture: organizational values and guiding beliefs;
- Safety surveillance process: the practices and procedure through which safety is monitored as described through the following six-step process:

  1. Performance measurement: where do we stand now? What have we done so far to promote safety?
  2. Inspections: hazard evaluation of unsafe acts and conditions (routine and scheduled inspections);
  3. Prioritizing target areas: priorities for correcting unsafe acts and conditions are set;
  4. Safety goals: a time-plan is in place to eliminate hazards and reduce injuries;
  5. Plan for controlling hazards: a work plan is developed to eliminate hazards and reduce injuries;
  6. Implement corrective measures: apply control measures (engineering controls, administrative controls, PPE) to promote safety.

A total of 31 items were included in the instrument (see Table 3). Items were rated using a modified version of the Borg category scale of physical exertion [37]. The scale used in this study deviates slightly from the Borg model, in that it is bipolar (Figure 2). Research has shown a significant improvement of perception when using bipolar scales [38].

TABLE 3. Items Within Each Dimension in the Safety Climate Model

I. Management attitude towards safety practices:
1. Workers are involved in setting safety goals
2. Workers' safety suggestions are encouraged
3. Rewards are given for safety performance
4. Violations are disciplined
5. Safety rules are enforced
6. Supervisors are adequately trained to inform employees about safety issues

II. Organizational culture:
1. Safety goals align with corporate goals (safety is given the same attention as other responsibilities such as productivity, cost, quality)
2. The organization cares for workers safety

III. Safety surveillance process:
1. Measure performance:
   a. Safety policy posted
   b. Accidents investigated
   c. Recordable accidents posted
2. Inspections:
   a. Safe practices inspected (use of head protection, eye protection, etc.)
   b. Equipment/tools inspected (machine guards, labels, safety devices, etc.)
   c. Emergency systems inspected (fire alarms, fire equipment, exit signs, etc.)
   d. Workplace housekeeping inspected (trash, floor conditions, toilets, etc.)
   e. Environmental conditions inspected (fumes, noise, lighting, radiation)
3. Prioritizing target areas:
   From the outcome of safety inspections, priorities to reduce injuries and workplace hazards are set:
   a. Before accidents or complaints occur
   b. After accidents or complaints occur

TABLE 3. (*continued*)

4. Safety goals:
   Safety goals (e.g., to reduce injures and eliminate hazards) are set every:
   a. 3 months or less (short-term)
   b. 3 months–1 year (intermediate-term)
   c. 1 year or more (long-term)
5. Plan for controlling hazards:
   a. Plan provided for awareness training (recognize visible/audio alarms, take caution when working with chemicals)
   b. Plan provided for training in the care and use of personal protective equipment
   c. Plan provided for machine design assessment (employ guards, signs, signals, use interlocks, etc.)
   d. Plan provided for reporting (report unsafe acts of fellow workers, report unsafe workplace and equipment conditions, etc.)
6. Corrective measures implemented:
   a. Orientation for safety is provided for new employee and transferee
   b. Safety meetings are provided
   c. Machine guards, shields, warnings/tags are placed where needed
   d. Needed personal protective equipment is provided
   e. Medical and first-aid facilities are available
   f. Employee complaints are corrected immediately once they are reported

7	*very strongly agree*
6	
5	*strongly agree*
4	
3	*moderately agree*
2	*weakly agree*
1	*very weakly agree*
0	*not sure*
–1	*very weakly disagree*
–2	*weakly disagree*
–3	*moderately disagree*
–4	
–5	*strongly disagree*
–6	
–7	*very strongly disagree*

Figure 2. Safety climate survey scale.

2.4. Data Collection Procedure

A cover letter explaining the nature of the survey was prepared by CDPW's safety specialist and sent to each of the four division heads requesting participation on the survey from those field employees who were randomly selected. For the pilot sample (n = 15), a meeting was scheduled with all participants present. The investigator and CDPW's safety specialist were present to administer the survey. The purpose of the survey was explained to participants. They were informed that participation was voluntary and their identity would remain anonymous. All agreed to participate. Participants were instructed to read each item carefully and indicate their perception toward safety at work. Participants were offered assistance in clarifying any areas in the survey that were unclear and were encouraged to ask questions. Respondents took approximately 20 min to complete the survey. At the end of the session, participants were asked to comment about the length, content and interpretation of items of the survey instrument.

For the large sample (n = 229), a cover letter was also prepared by CDPW's safety specialist. Cover letters were sent to each of the four division heads requesting participation on the survey from those workers (i.e., managers, supervisors, and field employees) who were randomly selected. Data collection was completed in approximately 8 weeks. Survey administration was scheduled early morning before the start of the workday at each division separately. The investigator was present only during the first sessions for each division. CDPW's safety specialist was instructed on survey administration during the first session. The CDPW safety specialist collected all data for the remaining sessions.

3. RESULTS

3.1. Validity

Content validity of the safety climate model was established through a two-part process. First, to determine the model's dimensions, a thorough review of the scientific literature was conducted. Through this review, the initial draft of the model's structure and content domains was formed. Secondly, discussions were held with the three experts—an ergonomist, an industrial hygienist and an occupational safety consultant. Each expert independently evaluated the structure of the safety climate model, its dimensions and survey items. Feedback from the experts was incorporated to finalize the safety model structure and its contents by removing ambiguity, poly-interpretability and the lack of clarity of long sentences that may threaten the validity of the outcome. After content validity was achieved, administration of the survey instrument was conducted as a pilot study on a sample of 15 field employees from CDPW.

Criterion validity of the safety climate survey was assessed after the large scale study was conducted. Aggregate injury data for 5 years (1991–1995) was collected from Occupational Safety and Health Administration (OSHA) 200 logs. This data served as the direct indicator against which the survey data was measured. Injury frequency was measured by the number of recordable injuries (RI) while injury severity was measured by the number of lost work days (Days). Correlation analysis was used to determine the relationship between injury data and safety climate dimensions. Thus, this comparison was used as a test of criterion validity. Table 4 presents the inter-correlation among safety climate dimensions and injury variables for each of the four divisions of public works. As seen in the table, the highway division's RI was negatively correlated

TABLE 4. Intercorrelation Matrix Between Safety Climate Dimensions and Injury Data (1991–1995)

		RI	Days	Management Safety	Organiza-tional Culture	Measure Performance	Inspections	Prioritize Target Areas	Safety Goals	Plan	Corrective Measures
Highway	RI	1	.755	–.587	–.341	–.075	–.171	–.152	–.175	–.184	–.258
Maintenance	Days		1	.063	.226	.336	.395	.295	.277	.297	.266
Sanitation	RI			.052	.169	.088	.172	.165	.145	.071	.128
	Days			.528	.771	.573	.577	.534	.522	.525	.573
Traffic	RI			–.287	–.238	–.398	–.339	–.334	–.321	–.331	–.342
Engineering	Days			–.492	–.405	–.708	–.596	–.566	–.574	–.655	–.621
Facilities	RI			.447	.439	.397	.473	.442	.431	.449	.458
Management	Days			–.553	–.574	–.659	–.336	–.223	–.353	–.151	–.512

Notes. RI—recordable injuries, days—lost work days, management safety—management attitude towards safety practices, plan—plan for controlling hazards, corrective measures—corrective measures implemented.

with "management attitude towards safety" ($r = -.587$). This finding supports the survey results such that the highway division scored the least on this measure in contrast to the other divisions. For the traffic engineering division, RI was negatively correlated with "performance measurement" ($r = -.398$). Survey results support this finding such that this division scored the least on this measure in contrast to the other divisions.

3.2. Reliability

Reliability of the safety climate instrument was assessed using the Cronbach alpha test. Cronbach's alpha provides a conservative estimate of a measure's reliability using the average inter-item correlation and the number of items in the scale. The average inter-item correlation is calculated constructing a correlation matrix, summing all item correlation values (i.e., the degree to which an item is related to another) and dividing this sum by the total number of item correlation values. Alpha can be interpreted as the expected correlation between an actual test and a hypothetical alternative form of the same length [20]. Alpha, the estimate of a measure's reliability, can be expressed as

$$\alpha = N\,þ/[1 + þ\,(N - 1)]$$

where N—number of items and þ—mean inter-item correlation. Alpha can vary between 0 and 1 with 0 being interpreted as *wholly unreliable* and 1 as *perfectly reliable*. For widely used scales, reliability should not be below .80 [20].

Cronbach's alpha was used to estimate the internal consistency of the items under each dimension of the safety climate model. Cronbach's alpha test was used both on the pilot sample data (n = 15) and the larger main sample (n = 229). A reliability check was tested on the scores of the survey (n = 15) to determine the degree of consistency and repeatability of scores. All dimensions of the safety climate model achieved acceptable coefficient alphas (Table 5). With all 31 items included for assessment, the obtained Cronbach's alpha was .96.

The model reliability check was calculated for the large sample and yielded a Cronbach's alpha of .93 (n = 229, 32 items including the extra item added to management attitude towards safety dimension). In addition, the inter-correlations among the safety climate dimensions were low relative to the internal consistency estimates, suggesting that model dimensions measure empirically distinct constructs. Next, stepwise discriminant analysis was performed, as a follow-up procedure to determine which of these dimensions and items is significantly different.

3.3. Utility

Model utility, the usefulness of the model in practical application, can be evaluated through

TABLE 5. Reliability Coefficients for the Safety Climate Model

Model Dimensions	Number of Items	Coefficient Alpha	*M*	*SD*
I. Management attitude towards safety practices	4	.66	3.2	1.7
II. Organizational culture	2	.91	1.4	3.7
III. Safety surveillance process:				
1. Measure performance	4	.76	3.0	2.7
2. Inspections	6	.92	3.4	3.2
3. Prioritizing target areas	2	0	4.2	2.1
4. Safety goals	3	0	4.1	2.3
5. Plan for controlling hazards	4	.96	3.7	3.3
6. Corrective measures implemented	6	.89	4.2	2.3
Total Model	31	.96		

the feedback of model users. By definition, utility analysis incorporates measures of preferences [21]. To assess the utility safety climate survey, information was solicited from the participants after they had completed the survey. Managers were also asked for feedback of the survey's usefulness following the distribution of the analysis. The following questions served as the basis for utility evaluation.

1. Was this instrument acceptable in assisting you in the assessment of your safety climate?
2. What are the limitations you experienced with this instrument?
3. Would you recommend its use to other organizations? Why?

Feedback from respondents demonstrated that the instrument was easy to understand and completed in a reasonable period of time. Based on feedback from participants in the pilot study, one item "supervisors are adequately trained to inform employees about safety issues" was added to "management attitude towards safety practices" dimension because of participants' inquiry about the adequacy of their supervisors' level of training. Further utility evaluation will be ongoing as the model is applied in larger populations as well as in diverse industries. The utility evaluation database will therefore serve as the source from which to direct model refinement.

3.4. Comparison of Safety Climate Dimensions Among Different Groups

Responses on the instrument from the main sample were then analyzed to identify total workforce (managers, supervisors, and field employees) perceptions toward their safety climate. Results were analyzed using a three-by-four factorial MANOVA (three worker categories and four divisions) to determine the linear combinations of variables (i.e., dimensions) and the items within these variables that differentiated between worker and division responses. Responses on the instrument ($n = 229$) were analyzed to examine the joint effect of workers (managers, supervisors, field employees) and divisions (highway maintenance, sanitation, traffic engineering, facilities management) on safety climate dimensions. Results revealed that the two dimensions—"management attitude towards safety practices" and "organizational culture"—significantly differentiated between worker responses (worker main effect). Specifically, field employees and supervisors scored much lower than managers on "management attitude towards safety practices" dimension. For the "organizational culture" dimension, field employees were less satisfied (*weakly agreed*) in contrast to supervisors (*moderately agreed*) and managers (*strongly agreed*). Table 6 presents MANOVA and discriminant results for the safety climate dimensions. Table 7 presents detailed results of the significant items within each safety climate dimension that differentiated between worker and/or division responses.

TABLE 6. MANOVA and Discriminant Analysis for Safety Climate Model Dimensions

Source of Violation	Variable	*MS* Between	Uni-variate *F*	*P* <	*SDFC*
Worker Differences	Management attitude towards safety practices	35.02	4.51	.011*	–.696
	Organizational culture	137.32	8.26	.000*	.878
	Safety surveillance process	35.36	5.42	.005	.252

Notes. SDFC—standardized discriminant function coefficient. Multivariate $F = .88$, $p < .28$.

TABLE 7. Results of Discriminant Analysis Showing Significant Items Within Each Safety Climate Dimension Which Discriminated Between Worker or Division Responses

Dimension	Significant Items	Source of Variation
I. Management attitude towards safety practices	1. Workers are involved in setting safety goals 2. Violations are disciplined	Division differences
II. Organizational culture	1. This organization cares for workers safety, health and welfare	Worker differences
III. Safety surveillance process		
a. Measure performance	No significant items detected	N/A
b. Inspections	1. Safe practices inspected (use of head protection, eye protection, etc.) 2. Workplace housekeeping inspected (trash, floor conditions, toilets, etc.)	Division differences
c.Prioritizing target areas	No significant items detected	N/A
d. Safety goals	1. 3 months or less (short-term) 2. 3 months–1 year (intermediate-term) 3. 1 year or more (long-term)	Division differences and worker differences
e. Plan for controlling hazards	No significant items detected	N/A
f. Corrective Measure Implemented	Needed personal protective equipment is provided	Worker differences

4. DISCUSSION

In this paper, we have focused our efforts to develop a safety climate measure, apply it in an industrial setting and report evidence of its psychometric integrity. The next logical step in the implementation of our approach is to consider the overall utility of the results the safety climate measure provides. In other words, how are the safety climate measure's results to be used?

Overtly, a safety climate survey serves to characterize safety attitudes of a work organization. The level of scores on specific items or clusters of items can indicate strengths and weaknesses of the aspects they represent. However, the greater power of the safety climate survey is to assess the work system, predict possible future accident occurrences and therefore enable a proactive improvement and monitoring program. Indeed, quantification of an organization's "health" with respect to safety provides a data-driven indicator for diagnosis and treatment in a business environment where currently most corrective action programs are conducted in retrospect after a material, physical or monetary loss has occurred.

In our study, the highway division's RI was negatively correlated with "management attitude towards safety" (r = –.587) and "organizational culture" (r = –.341). As management sets the corporate goals and determines the policies, it is not surprising that these two closely related areas were both negatively correlated with RI. The results were presented to CDPW and then used to guide improvement efforts within the highway division.

The presence of these two negatively correlated inter-related assessment areas strongly indicated the need for CDPW management to re-consider their position on safety and how that position is effectively communicated to the workers. This quantification identified a weakness in the health of the work system. Management was then able to design an improvement strategy to better align safety goals with corporate goals, set and enforce safety rules and reward or discipline resulting actions fairly. If successful, these interventions will reduce the incidence of RI in the future.

5. CONCLUDING REMARKS

A review of the scientific literature relating to the measurement of safety climate identified numerous diverse instruments that were applied in an array of industrial settings. Some models reported preliminary evidence of a specific criterion (e.g., validity or utility); however, no model was identified as adequate in terms of content completeness (i.e., content validity), criterion validity, reliability, and utility. As the evaluation of psychometric integrity through validity, reliability and utility criteria are paramount to the development of a scientific survey instrument, this research sought to establish and apply a psychometrically sound measure of safety climate in the work system. In contrast to prior efforts, this research regarded the establishment of psychometric goodness as an integral part of the safety climate model development process. As such, the plan for evaluation of these criteria provided the structure for our study.

The safety climate model was formulated following the guidelines to establish content validity. The scientific literature was reviewed to determine the complete domain of essential dimensions to characterize safety climate. A panel of experts was convened to cross-validate these dimensions and clarify the survey items. Then, the model was tested on a large population (n = 229) of workers randomly selected from the city of Cincinnati Department of Public Works. Reliability from field testing of the model was calculated, resulting in Cronbach's alpha = .93. Criterion validity was demonstrated via a strong correlation with recordable injury and lost work day data. Additional feedback on utility was favorable. Therefore, the safety climate model has demonstrated goodness as a scientific instrument and can be recommended for use in future studies.

REFERENCES

1. Peterson D. Techniques of safety management: a systems approach. New York, NY, USA: Professional and Academic; 1989.
2. Guldenmund F. (2000). The nature of safety culture: a review of theory and research. Saf Sci 2000;34(1–3);215–57.
3. Schneider B, Gunnarson S, Niles-Jolly K. Creating the climate and culture of success. Organ Dyn 1994;23(1):17–29.
4. Cox S, Flin R. Safety culture: philosopher's stone or man of straw? Work Stress 1998; 12:189–201.
5. Zohar D. Safety climate in industrial organizations: theoretical and applied implications. J Appl Psychol 1980;65(1): 96–101.
6. Glennon DP. Safety climate in organizations. In: Ergonomics and Occupational Health. Proceedings of the 19th Annual Conference of the Ergonomics Society of Australia and New Zealand; 1982. p. 17–31.
7. Brown R, Holmes H. The use of factor-analysis procedure for assessing the validity of an employee safety climate model. Accid Anal Prev 1986;18:445–70.
8. Dedobbelear N, Beland F. A safety climate measure for construction sites. J Safety Res 1991;22:97–103.
9. Cooper MD, Phillips RA. Validation of a safety climate measure. Annual Occupational Psychology Conference of the British Psychological Society, Birmingham, UK, January 3–5. Journal of Organizational Behavior 1994;9:23–7.
10. Donald IJ, Canter DV. Employee attitudes and safety in the chemical industry. Journal

of Loss Prevention in the Process Industry 1994;7(3):203–8.

11. Niskanen T. Safety climate in the road administration. Saf Sci 1994;17:237–55.
12. Coyle I, Sleeman S, Adams D. Safety climate. J Safety Res 1995;22:247–54.
13. Cabrera D, Isla R, Vilela L. An evaluation of safety climate in ground handling activities. In: Soekkha HM, editor. Aviation safety, Proceedings of the IASC-97 International Aviation Safety Conference. La Laguna, Tenerife, Spain: University of La Laguna; 1997. p. 255–68.
14. Williamson A, Feyer A, Cairns D, Biancotti D. The development of a measure of safety climate: the role of safety perceptions and attitudes. Saf Sci 1997;25:15–27.
15. Hayes B, Perander J, Smecko J, Trask, J. Measuring perceptions of workplace safety: development and validation of the work safety scale. J Safety Res 1998;29(3): 145–61.
16. Cox S, Cox T. The structure of employee attitudes to safety: a European example. Work Stress 1991;5:93–106.
17. Ostrom L, Wilhelmsen C, Kaplan B. Assessing safety culture. Nuclear Safety 1993;34(2):163–72.
18. Berends J. On the measurement of safety culture [unpublished report]. Eindhoven, The Netherlands: Eindhoven University of Technology; 1996.
19. Lee T. Perceptions, attitudes and behavior: the vital elements of a safety culture. Health and Safety 1996;October:1–15.
20. Carmines EG, Zeller RA. Reliablity and validity assessment. London, UK: Sage; 1979.
21. Petitti DB. Meta-analysis, decision analysis and cost-effectiveness analysis. New York, NY, USA: Oxford University Press; 1994.
22. Shoaf C, Genaidy A, Shell R. A perspective on work system analysis: classification and evaluation of methods. Ergonomics 1998;41(6):881–98.
23. Flin R, Mearns K, O'Connor P, Bryden R. Measuring safety climate: identifying the common features. Saf Sci 2000;34:177–92.
24. Lynn M. Determination and quantification of content validity. Nurs Res 1986;35: 382–5.
25. Bailey C, Peterson D. Using perception surveys to assess safety system effectiveness. Prof Saf 1989;34(2):22–6.
26. Brauer R. Safety and health for engineers. New York, NY, USA: Van Nostrand Reinhold; 1990.
27. Murphy L, Sturdivant K, Gershon R. Organizational and employee characteristics predict compliance with universal precautions [paper presented at the Annual Meeting of the American Psychological Society, Chicago, IL, USA]; 1993.
28. Phillips R, Cooper D, Sutherland V, Makin P. A question of safety climate: measuring perceptions of the working environment. In: Annual Conference of the British Health and Safety Society, Birmingham, UK; 1993. p. 74–81.
29. Alexander M, Cox S, Cheyne A. (1995). The concept of safety culture within an UK offshore organization. In: Collected papers of the Understanding Risk Perception Conference. Aberdeen, UK; 1995. p. 119–23.
30. Janssens M, Brett J, Smith F. Confirmatory cross-cultural research: Testing the viability of a corporation-wide safety policy. Acad Manage J 1995;38:364–82.
31. Diaz R, Cabrera D. Safety climate and attitude as evaluation measures of organizational safety. Accid Anal Prev 1996;29(5):643–50.
32. Budworth N. The development and evaluation of a safety climate measure as a diagnostic tool in safety management. IOSH Journal 1997;1:19–29.

33. Health and Safety Executive (HSE). Safety climate measurement tool. Sudbury, Suffolk, UK: HSE; 1997.
34. Mearns K, Flin R, Fleming M, Gordon R. Human and organizational factors in offshore safety. (Report OTH 543). Offshore Safety Division. Sudbury, Suffolk, UK: Health and Safety Executive; 1997.
35. Carroll J. Safety culture as an ongoing process: culture surveys as opportunities for enquiry and change. Work and Stress 1998;12:272–84.
36. Lee T. Assessment of safety culture at a nuclear reprocessing plant. Work Stress 1998;12:217–37.
37. Borg G. Psychophysical bases of perceived exertion. Med Sci Sports Exerc 1982;14(5): 377–81.
38. Hernandez L, Alhemood A, Genaidy A, Karwowski W. Evaluation of different scales for measurement of perceived physical strain during performance of manual tasks. International Journal of Occupational Safety and Ergonomics (JOSE) 2002;8(4):413–32.