Original article

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Development of a questionnaire to assess worker knowledge, attitudes and perceptions underlying dermal exposure

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Objectives Workers' behavior is identified as an important determinant of dermal exposure and is influenced by knowledge, attitudes, and risk perceptions. Because behavior may be a significant predictor of exposure, its assessment provides a means for examining exposure and designing strategies and incentives that encourage worker protective behavior. Currently, there are no psychosocial instruments examining worker knowledge, attitudes, and perceptions with respect to dermal hazards. Accordingly, a questionnaire was developed and tested to provide an instrument for measuring worker knowledge, attitudes, and perceptions.

Methods The questionnaire was developed on the basis of a literature review and expert consultation. Scales were constructed based on standard methods. Two worker focus groups were used to evaluate worker understanding and content validity of the KAP (knowledge, attitudes, perceptions) questionnaire. The resulting 115-item questionnaire that included scales for knowledge (N=13), attitudes (N=27), perceptions (N=15), behavior (N=8), behavioral intentions (N=15), barriers (N=13), and facilitators (N=5) was tested on 89 workers from 19 facilities.

Results The concepts identified in the focus groups included worker perception of higher risk due to a poor fit and replacement frequency for personal protective equipment and cross-contamination by workers moving into work zones. Field testing of the questionnaire (N=89) yielded Cronbach's alpha reliability scores ranging from 0.87 for the self-efficacy personal protective equipment scale to 0.92 for the overall belief scale, indicating high internal reliability.

Conclusions Although further testing and refinement is needed, this survey instrument provides an initial and conceptually unique means for evaluating behavioral determinants of worker dermal exposure.

Key terms behavior; occupational dermal exposure; survey development.

Dermal exposure in the workplace remains an underrecognized hazard with a lack of methods for assessment and occupational exposure limits. The United States National Institute for Occupational Safety and Health (NIOSH) reports that approximately 13 million workers are annually exposed to contaminants that can potentially be absorbed through the skin (unpublished data). The Bureau of Labor Statistics reports that skin disease accounted for 12% of all occupational illnesses in 2001, with an incidence rate of 4.3 per 10 000 (unpublished data). It is likely that dermal exposure resulting in skin disease represents the "tip of the iceberg" when exposures in which absorption occurs without obvious dermal effects are considered, but rather with systemic effects that are manifested years later (eg, cancer or neurotoxicity). Nonspecific guidelines exist for worker exposure protection, such as the American Conference for Governmental Industrial Hygienists' (ACGIH's) skin notations and biologically based exposure indices (BEIs®) (1). However, such information is available for only a limited number of chemicals. In addition, dermal exposures are seldom monitored, possibly due to the absence of standardized methods and means of assessment. Thus it is likely that, until better

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methods of assessment are developed, a clear picture of the extent of worker dermal exposure or its associated health threat will remain unknown.

There is a hierarchy of industrial hygiene controls available to address dermal hazards within the workplace. Industry typically relies on worker use of personal protective equipment (PPE) and less on solutions such as product substitutions and engineering controls that put less of the burden of protection on the worker (2). For worker dermal protection, Goldenhar et al (3) believe that the use of PPE as the main method of reducing worker dermal exposure requires "the greatest degree of continual and constant commitment on the part of the workers and/or management [p 21]".

Because behavior is such a critical consideration and determinant of worker dermal exposure, there is a strong rationale for studying this behavior and the knowledge, attitudes, and perceptions that underlie it. In a recent review paper, Kromhout & Vermeulen (4) found that behavioral characteristics were thought to account for most of the between-worker variability in dermal exposure. These findings were further substantiated by Rutz & Krieger (2) and Wakefield (5), who identified behavior as a dominant factor in predicting dermal exposure. The United States Environmental Protection Agency recognizes the impact that human activities have on the timing, duration, location, and routes of exposure and thus have implemented several major studies designed to collect behavioral information. These studies have included the National Human Exposure Assessment Survey (NHEXAS) and the National Human Activity Pattern Survey (NHAPS) (6–8). Incorporating the consideration of behavior into dermal exposure assessment may provide a means for not only better evaluating exposure, but also for identifying effective intervention strategies.

The psychosocial factors that underlie behavior include knowledge, attitudes, and perceptions, as illustrated in the conceptual model in figure 1. Although this conceptual model is concerned with individual-level factors, beliefs fit into a broader social and organizational context as presented by Lund & Aarø (9). Within our conceptual model, some consideration is given to ecologic-level factors such as time pressure and safety culture.

Assessments that consider the behavioral aspects that underlie exposure will enlighten mitigation strategies that emphasize worker education and training (10). Evidence in the literature suggests potential psychosocial barriers that limit worker adherence to the guidelines for PPE use. Goldenhar et al (3) stressed that, just because an intervention is implemented, it does not mean that workers will change their behavior to make that intervention a success. Some of the suspected barriers identified in the literature include time pressure (11–12), risk perception (13–14), peer acceptability (15), and negative outcome expectancy (ie, belief that the outcome will not produce the desired result) (11). Identifying the barriers that may modify worker compliance with PPE recommendations and examining the correlation of worker knowledge with protective behavior are concepts to consider in the design of training, strategies, and incentives for worker protective behavior. Ultimately, behavior can be seen as a driving factor in worker exposure, and, in turn, behavior can play an important role in exposure reduction.

Some relevant behavioral public health applications have examined the knowledge, attitudes, and perceptions of workers to address issues such as back injuries and agricultural chemical-associated risks (11–13, 16–19). However, currently, there are no specific instruments for examining psychosocial influences on worker behavior with respect to the dermal exposure of manufacturing workers. Accordingly, we conducted our study to develop, test, and evaluate a questionnaire to examine worker knowledge, attitudes, and perceptions

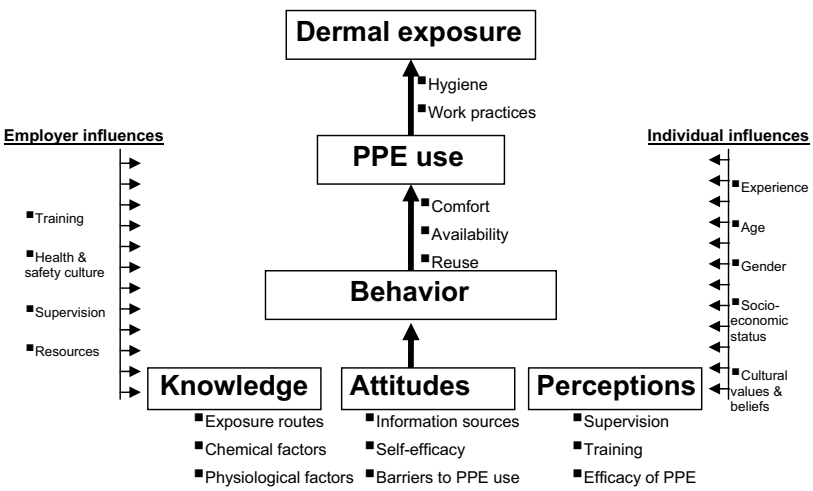

Figure 1. Conceptual framework for evaluating the psychosocial determinants of worker dermal exposure. (PPE = personal protective equipment)

(KAP) of dermal hazards within the workplace. The KAP questionnaire was developed using the health belief model, shown in figure 2, which is based on the theory that self-protective behavior is driven by the anticipation of a negative health outcome and the desire to avoid such an outcome or reduce its impact. Within this model, the perceived susceptibility to the event or likelihood of its occurrence further influences the motivation to take protective action (20–22).

Methods

The KAP questionnaire was developed in the following five phases (see figure 3): (i) a literature review, (ii) an expert panel review, (iii) focus-group testing and evaluation, (iv) field testing, and (v) validation.

In phase 1, a thorough review of the literature was conducted to ascertain the current state of knowledge concerning potential barriers and protective behavior related to worker dermal exposure. The databases accessed for the literature review included PubMed, PsycINFO, and Sociological Abstracts. The search terms included various Boolean combinations and permutations of the terms dermal exposure/hazards, survey, knowledge, attitudes, and perceptions, occupational exposure, and worker behavior. We searched the literature to see if viable instruments or scales existed for dermal exposure hazards. Vaughan (19) developed an instrument to examine risk perceptions and self-protective behavior among immigrant farm workers, while other investigators used survey-based methods to examine the attitudes and risk perceptions of farm workers handling agricultural chemicals (11–13, 16–18), all representing various levels of sophistication. However, we found that there were no specific, validated instruments that addressed dermal hazards and behavior in manufacturing; thus the development of our own instrument was necessary.

The KAP instrument was constructed to include seven subscales to measure worker knowledge, attitudes, and perceptions of workplace dermal hazards. These subscales encompass relevant concepts necessary for the understanding of worker behavior and include knowledge, information belief, behavior belief, overall belief, behavior, PPE self-efficacy, and training. The questionnaire was developed according to standard protocol for questionnaire design and testing (23–24). The topics covered in the worker KAP questionnaire are presented in table 1. The questionnaire was approved by the Johns Hopkins Committee for Human Research. It uses dichotomous and Likert-scale responses (25).

Knowledge can be defined as factual information from training or experience. The "knowledge" questions were designed to gauge worker knowledge of pathways of chemical exposure in the workplace and worker understanding of basic chemical characteristics and the conditions favorable to chemical dermal absorption.

An attitude is defined as an affect (eg, an emotion, feeling, or desire) or as the result of an evaluative process. The "attitude" questions were designed to examine worker attitudes about the adequacy of protection from dermal exposures, how workers access chemical information in the workplace, and potential facilitators and barriers of worker use of PPE.

A perception is defined as the result of a cognitive process whereby a person interprets information based on his or her understanding of that object. The "perception" questions explored concepts such as how workers perceive the adequacy and effectiveness of workplace training (including training related to PPE use), and the availability of PPE (see table 1).

Demographic information was also collected by way of a short survey with multiple-choice response options. Workers provided information on age, gender, ethnic group or groups, household income, highest educational attainment, and years of similar work experience. Prior to the field testing, the KAP questionnaire items were

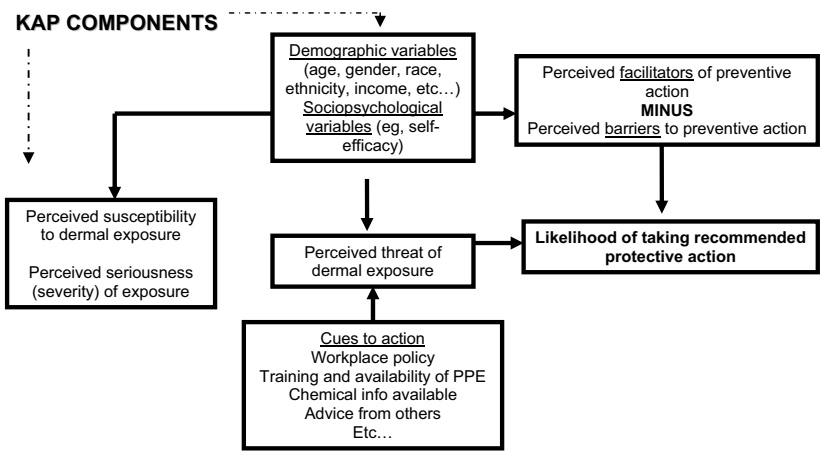

Figure 2. Elements of the health belief model adapted to the workplace dermal knowledge, attitudes, and perceptions (KAP) questionnaire. Adapted from Janz & Becker (22).

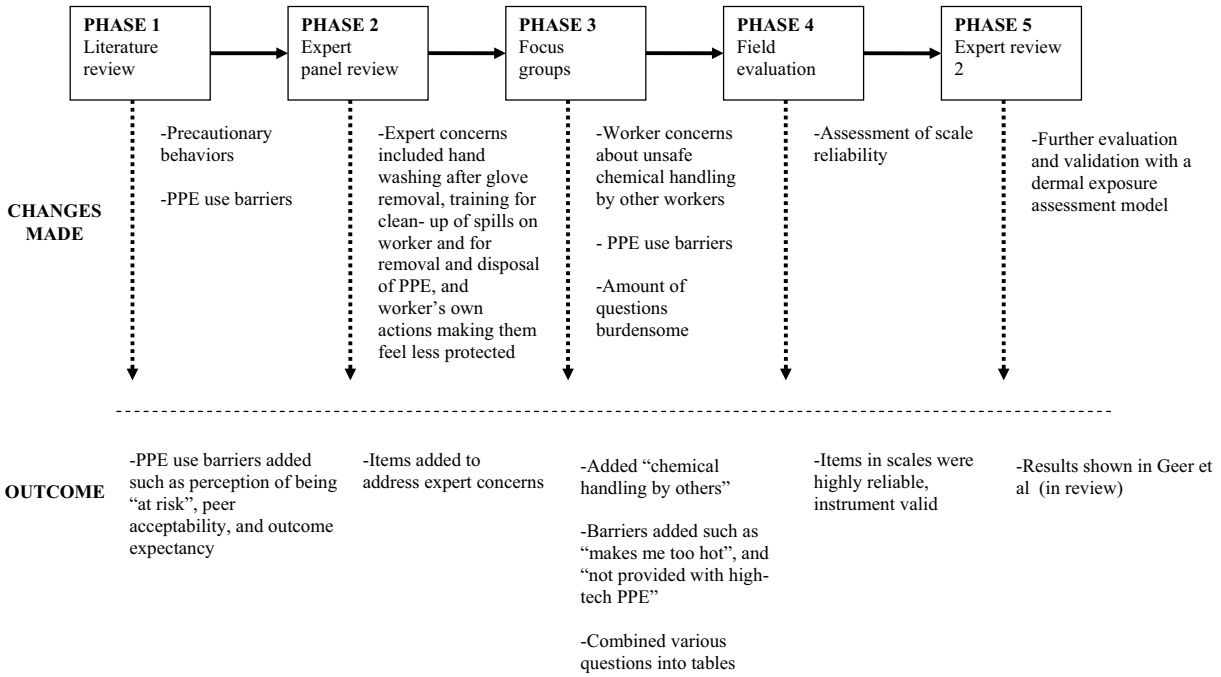

Figure 3. Phases of the study.

Table 1. Questionnaire components included in the KAP (knowledge, attitudes, and perceptions) questionnaire. (PPE = personal protection equipment)

Scale	Item	Concepts measured	Response options
True/false knowledge	1–13	Exposure routes, surface contamination, PPE use, hand washing (knowledge)	True; false; don't know
Information belief	34–36	Worker provided with information about work chemicals that can be hazardous (attitudes, beliefs)	Strongly agree; agree; disagree; strongly disagree
Behavior	44–48	Frequency with which worker engages in protective behavior (behavior)	Often; sometimes; rarely; never
PPE self-efficacy	70–76	Worker confidence in outcome of protective behavior (attitudes)	Strongly agree; agree; disagree; strongly disagree
Behavior belief	79–84	Worker provided with training and protective clothing, information necessary for worker to protect him- or herself (attitudes, beliefs)	Strongly agree; agree; disagree; strongly disagree
Overall belief	86–96	Amount and availability of information and training given, understanding of this information (beliefs, perceptions)	Strongly agree; agree; disagree; strongly disagree or poor; fair; good; excellent/ not trained
Training	97–100	Worker perception of adequacy of training (perceptions)	Poor; fair; good; excellent; not trained

reviewed for content, coverage, and clarity by four experts in industrial hygiene, personal protective equipment, and survey design.

In phase 3, the questionnaire was further developed and evaluated using two focus groups. The focus-group sessions helped to identify additional items and to verify the content validity of the initial items generated and chosen for the questionnaires. The focus-group sessions also served to test the face validity of the questionnaire and, therefore, reflected how meaningful the concepts were to the workers.

Workers were recruited from industries in which there was significant potential for dermal exposure to harmful agents, as established in concert with the site health and safety manager or supervisor. Preliminary contact was established with management at several companies located in the regions around Baltimore, Maryland, and Lancaster, Pennsylvania. Through these contacts, announcements were distributed inviting workers to participate in the focus group. Workers willing to participate indicated their interest to the company contact person for scheduling.

As suggested by Basch (26), focus-group workers were selected as a purposeful sample to compare workers' interpretations and ideas about dermal hazards with existing scientific constructs and to pilot test the questionnaire. Two focus groups were selected across six job classifications within one industry. Although the focus-group workers were selected from a single industry, their concerns are likely broadly representative of other workers facing workplace dermal hazards. However, it is also likely that specific concerns associated with more esoteric processes or work practices were not represented. One group was comprised of production workers and

the other of maintenance workers. The workers were invited to participate in the study by way of a pamphlet posted in the workplace or by nomination by the employer of workers at the greatest risk of dermal exposure. The duration of the focus-group sessions was approximately 1.5 hours. A small monetary incentive was provided for participation. Workers participating in the focus group were not eligible to participate in the later field evaluation of the questionnaire.

A standardized interview protocol guide was developed to assure that the data were collected in a consistent and reliable manner. The focus-group discussion centered on a short list of open-ended questions designed to identify worker experiences, issues, and concerns with dermal hazards and the availability and use of PPE.

After the open-ended discussion, the questionnaire was administered by field technicians to each worker within the focus groups to pretest the instrument. After the administration of the KAP questionnaire, workers were asked to discuss and interpret each questionnaire item. The sessions were audiotape-recorded so that reference could be made to the remarks of the participants in order to ascertain common themes.

The variability in worker response and the understanding of question content, or face validity, was evaluated, as well as the completeness of concept inclusion in the questionnaire, or content validity. This information was used to produce a revised final version of the questionnaire; specifically questions were added where content coverage was lacking, to be used in the larger field evaluation.

In phase 4, the questionnaire was further evaluated in a field study. Recruitment for this portion of the study was similar to that for the focus groups, as already described. Participating industries were chosen as a purposeful sample based on established relationships through site visits or graduate or internship programs with the industrial hygiene program at the Johns Hopkins Bloomberg School of Public Health and the occupational safety and environmental health program at Millersville University. Individual workers were recruited from within an industry by way of a posted flyer in the workplace and based on communication with the health and safety manager. The questionnaires were self-completed in the presence of a field technician within the workplace. The questionnaire administration took place during normal workhours over the duration of 30 minutes. The technician was available for questioning during the completion of the questionnaire. A small monetary incentive of USD10.00 was provided for participation.

Questions were coded based on a Likert-scale, on which a more desirable answer was given a higher score than a less desirable answer (ie, a higher level of self-efficacy or a positive perception of training). Missing values were replaced with the sample mean. Data were analyzed using SPSS v.8.0 (SPSS Inc, Chicago IL, USA). The frequencies of each question were calculated.

In phase 5, the reliability of each scale, defined as how well a set of items within a scale measured the same underlying construct, was determined based on the calculation of internal reliability using Cronbach's alpha coefficient (27).

Results

Literature review (phase 1)

Concepts identified in the literature review were useful in the selection of items for the questionnaire. These included behaviors relating to PPE use and potential PPE use barriers. For example, Tucker (28) reported that there is less of a likelihood that workers will partake in protective actions if the rationale for protective measures is not clearly communicated, such as the knowledge of the consequence of exposure. Arcury & Quandt (11) found that a worker's disbelief of being at risk can serve as a mechanism for disregarding risks. In addition, Quandt et al (13) found that, if workers perceive little control over exposure, they are less apt to partake in protective or preventive behavior. Other factors, such as risk perception, for example, the worker's belief in susceptibility for disease, have also been identified as necessary prerequisites for behavior change. Vaughan (19) examined the relationship between risk perceptions and self-protective behavior among immigrant farm workers chronically exposed to pesticides. The author found that self-protective behavior was more likely if workers felt informed about risks, believed that precautionary methods were effective, and had a greater perception about their own ability to control exposure. These concepts were integral to the questionnaire development and were included throughout the attitudes and perceptions sections.

The potential barriers to PPE use found in the literature included time pressure (11–12), risk perception (13–14), peer acceptability (15), and negative outcome expectancy (ie, belief that the outcome will not produce the desired result) (11). These items were added to the survey in a section relating to PPE-use facilitators and barriers.

Expert panel review (phase 2)

The questionnaire was reviewed by various experts in the field, including industrial hygienists, regulators, and industry representatives. Expert concerns included

(i) hand washing after glove removal, (ii) training for clean-up of spills on the worker, (iii) training on removal and disposal of PPE, and (iv) workers' perceptions about how their own actions make them feel about their own protection. These concerns were incorporated into the final version of the questionnaire.

Focus-group evaluation (phase 3)

The focus-group discussions were useful for determining worker opinions and attitudes, and they helped to identify the innovative concepts not found previously in the literature. These newly introduced concepts from the focus-group open-ended question and discussion sessions were included in the questionnaire. One such concept included the perception of cross-contamination as a result of a worker bringing contaminated materials into another worker's space. Other concepts included worker concerns with the use of protective equipment (including the availability of PPE and proper-fitting PPE), the lack of training for reuse of gloves and other PPE, and the adequacy of training for proper clean-up of spills and splashes.

At the end of the focus-group session, the KAP questionnaire was administered individually to each worker volunteer. The responses were used to ensure that questionnaire items were discriminating, as evidenced by varied responses. The results indicated that the questionnaire had adequate face validity; in other words, the questionnaire covered the KAP concepts and content validity and, therefore, indicated that the questionnaire covered all of the important areas and concepts. This conclusion was drawn from subjectively comparing a list of main concepts that we felt important to worker dermal exposure and protection to the concepts the workers felt were important. In the initial assessment of the focus-group item responses, the knowledge gaps included concepts of dermal absorption differences by body location, types of chemicals likely to be dermally absorbed, and effects of damaged skin on the process of chemical absorption.

Table 2. Industries participating in the study.

Facility type	Tasks observed	Agents handled
Lithography (N=1)	Mixing	Acetone/toluene
Paint manufacture (N=1)	Tank washing	Chrome yellow pigment
Automotive repair (N=3)	Cleaning and set-up	Brake solvent
Fiberglass bathtub manufacture (N=1)	Coating	Polyester resin
Aircraft engine parts manufacture (N=1)	Production	Epoxy
Chemical manufacture (N=2)	Packaging	Silicates
Detergent manufacture (N=2)	Pouring bags	Detergents
Wire screen manufacture (N=1)	Coating	Polyvinyl chloride acetate resin
Textile manufacture (N=5)	Treating fabric	Assorted chemicals
Metal sheet productions (N=1)	Coating	Solvents
Gas and electrical (N=1)	Splicing	Silicone spray

Table 3. Demographic characteristics of the workers in the study (N=89).

Demographic variable	Percentage
Gender	
Male	75.3
Female	24.7
Age	
<39 years	39.5
40–49 years	31.4
>50 years	29.1
Race	
White	76.4
Other	23.5
Household Income	
< USD 34 000	15.7
USD 35 000 to 49 000	41.6
USD 50 000 to 74 000	27.0
>USD75 000	15.7

Field implementation and validation (phases 4 and 5)

A general description of the types of facilities participating in the study, as well as the type of tasks observed and agents handled, is presented in table 2.

Nineteen industries located in areas near Baltimore, Maryland, and Lancaster, Pennsylvania, participated in the field evaluation portion of the study. A total of 89 workers, approximately 5 workers per facility, participated. All 89 workers completed the KAP questionnaire. Copies of the questionnaire are available under a Google search for "Buckley TJ" or at the following internet address: http://sph.osu.edu/divisions/ehs/ehsfacstaff/buckleyt/.

Demographic characteristics of the study sample included a majority of whites and males (75% in each category) (refer to table 3). Altogether 41% of the workers reported a total household income of USD 40 000 to USD 49000. The largest proportion of workers was in the <39-year-old age group (39%), and for most of the workers (62%) the highest level of education achieved was high school graduation or lower.

The reliability of each of the questionnaire scales was determined on the basis of the calculation of internal reliability, or the correlation of items within a scale, using Cronbach's alpha coefficient. A scale with high reliability indicates that the items within the scale all measure the same construct. The worker KAP scales resulted in Cronbach's alpha scores ranging from 0.87 for the self-efficacy PPE scale to 0.92 (N=89) for the overall belief scale, indicating high reliability (27) (table 4).

Table 4. Cronbach's alpha for the worker KAP (knowledge, attitudes, perceptions) questionnaire by scale (N=89).(PPE = personal protective equipment)

Scale	Alpha coefficient	If scale item deleted	Revised alpha coefficient
Behavior belief	0.88	No change	No change
PPE-specific	0.84	"Reuse of disposable PPE…"	0.87
Information belief	0.93	"Information about work chemicals…"	0.94
True–false knowledge	0.61	"Chemicals penetrate the skin the same no matter what the body location"	0.63
Behavior scale	0.48	No change	No change
Training scale	0.90	"The training I get to clean up spills or splashes on myself…"	0.90
Overall belief	0.92	No change	No change

Table 5. Knowledge response frequencies (N=89). (Correct responses shown in boldface)

Number of question	Knowledge items	True (%)	False (%)	Do not know (%)
1	Chemicals enter body through breathing in	**98.9**	1.1	0.0
2	Chemicals enter body through ingesting them	**96.6**	3.4	0.0
3	Chemicals cannot enter body through contact with contaminated surfaces	2.2	**91.0**	6.7
4	Chemicals enter body through contact with spills and splashes	**97.7**	2.3	0.0
5	Chemical gas and vapor in air can enter body through the skin	**69.6**	18.0	12.4
6	Chemicals in dry form do not have the potential to be absorbed through skin	15.7	**73.0**	11.2
7	Chemicals in liquid form can be absorbed through the skin	**97.7**	1.1	1.1
8	Chemicals in oil more likely to penetrate skin then chemicals in water	**27.0**	39.3	33.7
9	Chemicals penetrate the skin no matter what the body location	55.1	**30.3**	14.6
10	All types of gloves provide same level of protection	6.7	**93.2**	0.0
11	Chemicals can more easily enter the body through damaged skin	**95.5**	1.1	3.4
12	Hand washing promotes the movement of chemicals from skin into the body	16.9	**75.2**	7.9
13	If you do not wash your hands, the food that you eat could be tainted with workplace chemicals	**97.7**	0.0	2.3

Within the knowledge scale, workers had a high frequency of correct responses for most of the items (table 5). However, there were a few items for which workers had relatively lower scores; these indicated a knowledge gap. Approximately 30% of the workers responded to the following three statements incorrectly: (i) chemicals in dry form do not have the potential to be absorbed through the skin (false); (ii) chemicals in gas or vapor in air can be absorbed through the skin (true); and (iii) hand washing promotes the movement of chemicals from the skin into the body (false).

Similar to the situation with the knowledge scale, a high percentage of the workers indicated favorable attitudes about dermal hazards and protection practices (table 6). However, there were a few exceptions. Approximately 20% of the workers (N=89) felt that they were not provided with the best available PPE or given enough information about how to protect themselves.

Responses for the behavioral scale (table 7) indicated that approximately one-third of the workers reported not washing their hands before donning gloves. In contrast, after removing gloves, more than 90% of the workers indicated washing their hands at least sometimes.

Worker perceptions about dermal hazards and protection practices were generally high (table 8); however, concern in some areas was indicated. Approximately 30% of the workers (N=89) answered "poor to fair" for the following items: (i) the amount of health and safety training I get is…; (ii) the encouragement I get from other workers to wear PPE is…; (iii) the training I get for removal and disposal of PPE is…; (iv) the training I get to handle chemicals is…; and (v) the training I get to clean up spills or splashes on myself is….

A follow-up study providing further evaluation and validation of the current questionnaire via comparisons with exposure is currently under review.

Discussion

There are indications that worker dermal exposure is poorly recognized, evaluated, and controlled (unpublished data). In an effort to understand dermal exposure and its underlying behavioral determinants better, a questionnaire was developed to assess worker knowledge, attitudes, and perceptions. Although similar survey tools have been developed for worker behavioral-driven public health concerns, this is the first related to dermal exposure (11–13, 16–19). The central focus of this paper was to describe results obtained from the development and testing of the KAP questionnaire, including the use of open-ended questions to spur discussion, and from the pretesting of the questionnaire.

Table 6. Attitude response frequencies (N=89) for information and behavioral beliefs and the personal protective equipment (PPE) self-efficacy scales. [a]

Question number	Attitude items	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)
34	I am informed about work chemicals that can enter the body through the skin	38.2	49.4	6.7	5.6
35	I am told about work chemicals that can be harmful to my health	37.1	48.3	9.0	5.6
36	Information about work chemicals is easy to get at work	47.2	37.1	13.5	2.2
44	I am given the information I need to protect myself	46.1	41.6	11.2	1.1
45	I am given the gloves I need to protect myself	62.9	32.6	2.2	2.2
46	I am given other protective clothing I need to protect myself	50.6	36.0	11.2	2.2
47	I am given the training I need to protect myself	50.6	35.9	11.2	2.2
48	I am trained to use PPE properly	53.9	34.8	11.2	0.0
70	I am confident that I can use PPE properly	59.5	37.1	3.4	0.0
71	I am confident that I can protect my skin at work	41.6	55.0	3.4	0.0
72	I am given enough information of how to protect my skin	33.7	47.1	19.1	0.0
73	My supervisor goes out of his/her way to make sure I am protected	24.7	53.9	19.1	2.2
74	Reuse of disposable PPE makes me feel less protected	24.7	49.4	20.2	5.6
75	I am provided with the best available PPE	23.6	56.1	19.1	1.1
76	My supervisor goes out of his/her way to make sure I am provided with proper-fitting PPE	22.5	59.6	16.9	1.1

[a] Information belief scale = question numbers 34–36; behavior belief scale = question numbers 44–48; PPE self-efficacy scale = question numbers 70–76.

Table 7. Behavior response frequencies (N=89).

Question number	Behavior scale	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)
79	How often do you wash your hands before putting on gloves?	11.2	20.2	29.2	22.5	16.9
80	How often do you wash your hands after removing gloves?	1.1	6.7	22.5	30.3	39.3
81	How often do you use skin-related PPE when it has been recommended?	1.1	4.5	7.9	30.4	56.2
82	How often are you required to reuse PPE when it is dirty?	67.4	15.8	10.1	2.2	4.5
83	How often do you feel unprotected because other workers are not handling chemicals safely?	32.6	35.9	21.3	7.9	2.2
84	How often do your own actions make you less protected?	29.2	31.4	31.5	2.2	5.6

Table 8. Overall belief and training response frequencies (N=89). [a]

Questionaire number	Perception items	Poor (%)	Fair (%)	Good (%)	Excellent (%)	Not trained (%)
86	The supervisor's level of concern about my protection is:	1.1	15.7	50.5	32.6	0.0
87	The amount of information I get about workplace chemicals is:	4.5	21.6	43.8	30.3	0.0
88	The availability of information I get about workplace chemicals is:	6.7	13.5	46.0	33.7	0.0
89	The amount of health and safety training I get is:	6.7	23.6	37.1	32.6	0.0
90	The availability of gloves for my use is:	2.2	7.9	32.6	57.3	0.0
91	The availability of protective clothing for my use is:	5.6	11.2	46.0	37.1	0.0
92	My understanding of why to use PPE is:	1.1	3.4	48.3	47.2	0.0
93	My understanding of how to use PPE is:	1.1	5.6	43.8	49.4	0.0
94	The ability of my gloves to protect me is:	0.0	9.0	51.7	39.3	0.0
95	The ability of my protective clothing to protect me is:	1.1	15.7	58.4	24.7	0.0
96	The encouragement I get from other workers to wear PPE is:	9.0	26.4	50.5	14.6	0.0
97	The training I get for PPE use is:	2.2	22.5	44.9	28.1	2.2
98	The training I get for removal and disposal of PPE is:	6.7	23.6	46.0	20.2	3.4
99	The training I get to handle chemicals is:	11.2	15.7	43.8	27.0	2.2
100	The training I get to clean up spills or splashes on myself is:	13.5	18.0	38.2	30.3	0.0

[a] Overall belief scale = question numbers 86–96; training scale = question numbers 97–100.

The KAP questionnaire was developed systematically with reliance on the relevant dermal literature (2, 4, 10, 29, 30), industrial hygiene and expert judgment, and, ultimately, through focus groups reflecting the experience of workers. The quality and utility of the questionnaire were evaluated based on standard criteria of content and face validity, as well as on internal reliability (24, 27). For each KAP scale, the questionnaire tested very favorably. The standards of Robinson et al (23) were used to assess the strength of the Cronbach's

alpha values in this study (0.80 or higher = exemplary, 0.7–0.79 = extensive, 0.6–0.69 = moderate). The Cronbach alpha scores ranged from 0.84 to 0.92 for the majority of the KAP scales, indicating "exemplary" internal reliability.

The "knowledge" domain of the survey suggested some weaknesses in workers' understanding of the chemical characteristics that relate to skin absorption. Quandt et al (13) observed a similar phenomenon among farm workers in relation to the lack of knowledge or understanding of pesticide skin absorption. Low variability in response on the knowledge portion of the survey suggested that some revision of the questions may be required in order to provide greater discrimination within and between workers about their level of knowledge. The survey's usefulness will be optimized when it captures, with sensitivity and specificity, the true variability of knowledge across workers. The consistency of workers' correct and incorrect responses suggests the need to develop this portion of the KAP questionnaire further.

For the "perceptions" domain, the questionnaire results suggested that nearly one-third of the workers felt inadequately trained to deal with chemical hazards in the workplace, including clean-up of spills, use and disposal of PPE, and simply the handling of chemicals. This is a potential barrier to worker self-efficacy that may lead to a lessened role of workers in their own protection. The worker individual-item KAP results indicated that chemical handling and PPE-use training were also areas lacking adequate attention. These findings are supported by Perry & Bloom (12), and they suggest that increasing worker self-efficacy in these areas would likely have a positive influence on worker protective behavior. These findings are also supported in the work by Vaughan, in which self-protective behavior was more likely if workers felt informed about risks, believed that precautionary methods were effective, and had a greater perception about their own ability to control exposure (19).

Use of observational exposure surveys is a well-established method in the epidemiology and exposure literature on the assessment of inhalation and dermal exposures (29–35). Psychosocial components of behavior have been examined previously in the field of industrial hygiene to address issues such as worker pesticide exposure and worker low-back pain (11, 13, 17). However, our questionnaire is the first of its kind to incorporate self-reported psychosocial behavioral determinants of dermal exposure. Although our model is primarily concerned with individual-level influences on behavior and exposure, it is imbedded in a greater social context. A more-comprehensive model might include greater consideration of cultural factors and management commitment to prevention and intervention, as has been presented by Lund & Aarø (9). In addition, behavior and risk factors may need to be adapted to different types of industries. If this survey is used in another country, it should go through standard procedures of translation and back-translation (24, 36). It should then be tested with the native speakers using cognitive interviews to make sure that the same concepts are being measured (24).

The value in using the health belief model as a framework for this study is that it provides information about categories of concepts to be important, and it gives exact measures of concepts specific to an issue and specific to a population.

Use of the health belief model provided strength in this study due to the flexibility in its ability to fill in items for major constructs for different scenarios.

Thus the KAP questionnaire is a promising new instrument for the evaluation of worker knowledge, attitudes, and perceptions underlying behavior to identify gaps in dermal hazard knowledge (12), behavioral barriers to PPE use (11), and limitations in worker training (11). This questionnaire can be used as a normative instrument in the training of industrial hygienists and workers across industries to assess hazard knowledge proficiency. It can also be used in the identification of opportunities for training and intervention with a focus on approaches to enhance workers' attitudes and perceptions of the workplace safety climate to increase ultimately their precautionary behavior (13, 15). Because knowledge gaps and low worker attitudes have the potential to lead to higher exposure, the assessment of the KAP questionnaire in combination with exposure is a potentially novel method for not only understanding exposure, but also for identifying the means for prevention. Further development testing of the instrument is recommended for test-retest reliability, and, with a larger sample size, for construct validity.

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