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# Training Health and Safety Committees to Use Control Banding: Lessons Learned and Opportunities for the United States

Anne L. Bracker, Timothy F. Morse, and Nancy J. Simcox

University of Connecticut Health Center, Section of Occupational and Environmental Health, Farmington, Connecticut

*Control banding (CB) is a control-focused risk management model that has received international attention. CB strategies are designed to control workplace chemical exposures after the completion of a qualitative risk assessment. Connecticut was one of the first states to provide training on how to use this control-focused tool. Joint labor/management teams and individuals from 34 workplaces attended a control banding workshop and learned how to use one CB model, the United Kingdom (UK) Health and Safety Executive's Control of Substances Hazardous to Health (COSHH) Essentials Toolkit. After the initial training program the investigators used follow-up workshops, questionnaires, site visit data, and case studies to evaluate the training curriculum and assess the utility and effectiveness of this CB strategy. We found that the model is easily learned, although several areas for improvement were identified. Participants from 10 workplaces used COSHH Essentials to evaluate at least one task. The training curriculum was effective in that the agreement between the exposure variables coded by these workplaces and one of the workshop instructors, a certified industrial hygienist (CIH), were highly concordant. The training curriculum and the model promoted a discussion of risk between workers and managers and resulted in the implementation of improvements in the work environment. The model agreed with both the CIH's and the worksites' qualitative risk assessments 65% of the time, and likely over-controlled for 71% (5/7) of the cases of nonagreement. Feedback from workshop participants benefits the current dialogue on the implications of implementing CB in the United States.*

**Keywords** chemical hazards, control banding, COSHH Essentials, Globally Harmonized System of Classification and Labeling of Chemicals (GHS), risk assessment, training

Address correspondence to: Anne L. Bracker, University of Connecticut Health Center, Section of Occupational and Environmental Health, 263 Farmington Avenue, MC-6210, Farmington, CT 06030-6210; e-mail: bracker@nso.uchc.edu.

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## INTRODUCTION

Control Banding (CB) toolkits offer employers and workers simple and accessible risk assessment strategies that can be used to target tasks that require exposure controls or professional advice. The control-focused models assign intervention categories (control bands) based on the level of risk to work tasks after the completion of a qualitative risk assessment.

In the early 1990s, building on the pharmaceutical industry's CB concepts,<sup>(1–4)</sup> occupational health experts in the United Kingdom (UK) examined the alignment between hazard classification, occupational exposure limits (OELs) and data on exposure and control systems.<sup>(5)</sup> This led to one of the first CB toolkits, Control of Substances Hazardous to Health (COSHH) Essentials.<sup>(6)</sup> The toolkit was developed to help small-to-medium sized enterprises (SMEs) comply with the UK Health and Safety Executive's (HSE) COSHH Essentials directive.<sup>(7–10)</sup> Building on COSHH Essentials' CB approach, several countries have developed their own CB models (Belgium–REGETOX, the Netherlands–Stoffenmanager and Norway–KjemiRisk as examples).<sup>(11–13)</sup> In addition, many European Union (EU) countries support using CB tools to comply with the EU's Registration, Evaluation, Authorization and Restriction of Chemical substances (REACH) regulation and health and safety experts have proposed CB models to control exposure to nanoparticles and ergonomic risk factors.<sup>(14,15)</sup>

CB models such as COSHH Essentials can be used to complement or enhance the traditional occupational exposure level (OEL) approach to risk assessment because the models capture and simplify many of the qualitative strategies industrial hygienists (IHs) learn and apply in the field to evaluate risk. For example, IHs use qualitative strategies to filter out lower risk activities so as to focus on higher risk tasks. If CB toolkits can model the thought processes that IHs use to evaluate risk, employers with limited access to IH advice can use the models to take steps to improve the health and safety conditions for their workers.<sup>(16–18)</sup>

CB represents a new paradigm, control-focused risk assessment. In the United States, widespread use requires an underlying sense of trust that the system neither over-controls nor under-controls hazards, the latter case being a more serious concern for a screening tool. This article describes a workshop-based evaluation of the utility and effectiveness of the COSHH Essentials CB model.<sup>(7-10)</sup> The COSHH Essentials generic CB model groups occupational risk control strategies into four bands based on an established hierarchy of control procedures: 1) dilution ventilation and good industrial hygiene practice, 2) engineering controls, primarily local exhaust ventilation, 3) containment and 4) seek specialist advice.<sup>(19)</sup> Substitution is recommended for chemicals with a high hazard potential regardless of the potential for exposure. The combination of a substance's inherent toxicity and its exposure potential determine the desired control band for a task. After the completion of the assessment, COSHH Essentials directs users to control guidance fact sheets. In addition, COSHH Essentials offers "direct advice" (best practice) factsheets for some industry-specific tasks, removing the interim steps of evaluating specific chemical hazards and exposure potential variables.

Much of the published research on the strengths and weaknesses of CB has focused on the COSHH Essentials CB toolkit. Russell et al.<sup>(9)</sup> found that the exposure ranges from the COSHH Essentials model were in agreement with, or more stringent than, expertly derived health-based OELs. Maidment<sup>(10)</sup> concluded that the model's control recommendations would reduce exposures to an acceptable exposure range. Although Tischer et al.<sup>(20)</sup> reported reasonably good agreement between the model's exposure predictor bands and the actual air levels of solids and organic solvents used in medium quantities, they identified under-control errors when small quantities or organic solvents (medium/high volatility) were used. Jones and Nicas<sup>(21)</sup> reported both under- and over-control errors for vapor degreasing and bag filling operations, and ACGIH's CB task force identified several deficiencies with the toolkit.<sup>(22)</sup> AIHA's and ACGIH's respective CB working groups highlight the benefits of CB models (e.g., in the absence of OELs). However, they recommend improving the COSHH Essentials toolkit and emphasize the need for additional verification and validation studies of COSHH Essentials and other CB models.<sup>(22,23)</sup>

We completed a workshop-based evaluation of the use and adequacy of the COSHH Essentials CB toolkit. Individuals and joint labor/management teams from multiple workplaces were encouraged to use the COSHH Essentials CB model following a series of CB workshops. We conducted a systematic evaluation<sup>(24)</sup> to answer the following questions, and to provide guidance for possible implementation in the United States:

1. How effective was the outreach for the training program?
2. Did the workshop participants use the COSHH Essentials CB model at their workplaces?
3. What were the perceived strengths and weaknesses of the COSHH Essentials CB model?
4. How effective was the training curriculum?
5. How effective was the COSHH Essentials CB model?

## METHODS

### Outreach and Curriculum Development

The investigators developed an interactive CB curriculum for health and safety committees with input from a workshop planning task force.<sup>(25-27)</sup> The planning task force included representatives from the business community (Connecticut Business and Industry Association-CBIA), labor (Connecticut Council for Occupational Safety and Health-ConnectiCOSH), state government (Connecticut Department of Public Health-CT DPH, Connecticut Department of Labor-Occupational Safety and Health Division (CONN-OSHA), federal government (OSHA and the National Institute for Occupational Safety and Health-NIOSH) and professional organizations such as the Society for Chemical Hazard Communication (SCHC) and the Connecticut River Valley Chapter of the American Industrial Hygiene Association (CRV-AIHA). Outreach was targeted to employers and employees from SMEs and health and safety committees.

### Workshop I Curriculum

An initial half-day interactive workshop included an overview of control banding; case study exercises based on COSHH Essentials; information on how to locate and interpret Risk Phrases (R-phrases) and a summary of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). When presenting the "pen and paper" version of the model, the instructors used the Health and Safety Executive's "Finding the Right Control Approach" wheel to illustrate the variables that are incorporated in the model.<sup>(28)</sup> An optional afternoon "on-line" session at individual computer workstations allowed participants to apply the COSHH Essentials' web tool (<http://www.coshh-essentials.org.uk/>) to sample tasks from their actual workplaces. Participants used a Likert scale to evaluate the success in meeting the workshop objectives:

- List several factors that contribute to occupational chemical exposure risk
- Identify the hazardous properties of a chemical by using R-phrases
- Complete a workplace risk assessment using COSHH Essentials
- Locate control guidance and "best practice" fact sheets

After the workshop participants were asked to apply the model to at least one task at their respective worksites. Participants were encouraged to call one of the instructors, an expert in hazard classification, if they needed help assigning R-phrases.

### Evaluation of the Training Curriculum and the COSHH Essentials CB Model

We utilized small group discussions with report back, questionnaire surveys, site visit data and case studies to evaluate the utility and effectiveness of the COSHH Essentials CB strategy and the curriculum.

### Qualitative Assessment of the CB Model-Workshop II

Ten weeks after the first workshop the participants reconvened to discuss their experiences with the model. In-depth small group discussions provided extensive qualitative information on the usefulness and potential improvements of the model. Two workplaces that had used the model presented case studies and a panel of stakeholders addressed the implications of using CB in the United States.

### Questionnaire Survey

Ten weeks after the second workshop the participants were sent a questionnaire survey to obtain information about the extent of utilization, “ease of use” of the COSHH Essentials approach, the type of tasks evaluated, obstacles in applying the model and agreement with the model’s recommended control band. Participants who did not complete the questionnaire survey were called by one of the investigators (NS) and asked to complete the survey over the phone.

### Industrial Hygiene Site Visits

After the questionnaire surveys were completed, a pilot evaluation project was performed by one of the investigators (AB), a CIH, who visited nine of the ten worksites that had evaluated tasks with COSHH Essentials. Four of the worksites were in the laboratory/pharmaceutical sector, four were in the manufacturing sector and one was in the health care sector.

The CIH reviewed 21 of the 66 tasks the worksites had evaluated. She evaluated a maximum of four tasks at each worksite. If a worksite team had evaluated a similar task multiple times, the tasks the CIH evaluated were randomly selected from a list provided by the company. The CIH and the participants completed a COSHH Essentials CB evaluation of an additional nine tasks together. Although the CIH was not always able to observe the tasks in operation, she visited most of the work areas where the tasks were completed.

The CIH’s qualitative control-focused evaluation included reviewing material safety data sheets (MSDSs), gathering information on multiple exposure potential variables (quantity, frequency, form, room size, etc.) and evaluating existing controls. A “perceived proper control strategy” was then developed for the task. While most validation studies have utilized air sampling as the “gold standard” for evaluating CB models, this pilot qualitative evaluation relied on best practices, or the expectation that a task likely would or would not exceed an OEL.

The CIH then completed a COSHH Essentials CB assessment for those tasks. The CIH also used the COSHH Essentials’ e-tool to locate control guidance and best practice factsheets. The variables (hazard group, quantity and dispersion potential) and control bands generated by the CIH were compared to the worksites’ assessments as a measure of the effectiveness of the CB training and the model. The variable “task frequency” was not assessed because the “pen and paper” model used by many of the worksites does not include it.

### Case Studies—Workshop III

The task force met again to plan the outreach and curriculum for Workshop III. The third workshop was designed primarily to present findings to the professional industrial hygiene community. Speakers from the research team, OSHA and the pharmaceutical sector addressed the topic: *Control Banding: Does the Model Work?* In addition, seven worksites that had used the CB model presented their case studies. For example, one team described using the model to identify a safer substitute for a metal cleaning task and another team discussed using the model to evaluate the factors that contributed to exposure risk in their laboratory.

### Data Management and Analysis

Data were entered and managed in SPSS v.15. Concordance between the CIH and the workshop participants was assessed by cross-tabulating results. Kappa statistics were used to evaluate the level of agreement between the variables and control bands generated by the worksites and the investigator.

## RESULTS

### How Effective was the Outreach for the Training Program?

Sixty-eight (68) participants from 34 worksites, including managers (40%), workers (29%), consultants (22%), and planning committee members (9%) attended Workshop I. Fourteen of these worksites sent teams and 20 sent individuals. Characteristics of the participants’ worksites’ are summarized in Table I. Half of the participants stayed for the optional

**TABLE I. Workshop I Participants’ Worksites**

Industry Sector	N	%
Manufacturing	27	40
Public sector/government agency	10	15
Health care	9	13
Laboratory/pharmaceutical	8	12
Consulting	8	12
Education	5	7
Other	1	1
Total	68	100

  

Size of Facility	N	%
<20	0	0
20–50	5	7
50–100	11	16
100–500	13	19
>500	19	28
Unknown	20	30
Total	68	100

**TABLE II. Participants' Feedback—Most Valuable Part of the COSHH Essentials CB Model**

- It represents a simple, uniform approach to hazard classification
- It helps identify chemicals that could be substituted with safer alternatives
- It is most useful for tasks involving chemicals with a low-medium hazard classification because tasks involving chemicals with a high hazard classification frequently resulted in the recommendation to “seek special advice”.
- It provides a system for the documentation and validation of existing controls. The documentation provided by the online e-tool is particularly attractive.
- It is relatively easy to use and could be attractive to the smaller employer
- It is a useful training tool for workers

afternoon session in the computer lab, which was the maximum capacity for the lab.

Thirty-six workers, managers and planning committee members attended Workshop II and 79 health and safety professionals, managers, workers and planning committee members attended Workshop III. Thirty-one (45%) of the participants who had attended Workshop I returned for the second workshop. Twenty four (35%) of the participants who had attended Workshop I returned for the third workshop.

#### **Did the Workshop Participants Implement the COSHH Essentials CB Model at their Workplaces?**

Forty-four (71%) of the Workshop I participants (not including planning committee members) completed the questionnaire survey. Twenty-four (54%) of the survey respondents had tried to use COSHH Essentials at their worksites. On a scale from 1 (difficult) to 10 (easy) these respondents rated the model's ease of use as 7.2 (SD = 1.5). Eighteen participants from ten workplaces used the generic COSHH Essentials model to evaluate at least one task.

Twenty (46%) of the survey respondents did not try to use COSHH Essentials at their worksites. Of these, 30% stated it was not appropriate for their setting, 25% were too busy, 10% lacked management support, 5% found using the computer application too difficult, 5% already had a risk management protocol and 25% did not respond to the question. These non-user respondents rated the model's ease-of-use as 6.1 (SD = 2.4).

#### **What were the Perceived Strengths and Weaknesses of the COSHH Essentials CB Model?**

During Workshop II participants discussed the CB activities they had launched at their workplaces. Their thoughts were summarized by the investigators. The participants' feedback on the most valuable parts of the COSHH Essentials CB model

**TABLE III. Participants' Feedback—Barriers Associated with the COSHH Essentials CB Model**

Difficulty researching R-phrases: R-phrases are inconsistent and hard to find, especially for mixtures. Chemicals without R-phrases inappropriately are classified in the least stringent hazard band, Hazard Group A.

Difficulty working with mixtures: Mixing tasks are confusing as are some exposure potential variables. For example, quantity classifications jump significantly from medium (liters) to large (cubic meters) and the model does not take all potential exposure variables into account (such as application method and distance from the process).

Difficulty locating control guidance sheets: Control guidance and direct advice fact sheets were hard to find online and they were not available for some industry sectors.

Difficulty trusting the model: For some tasks the model either over- or under-controlled.

is summarized in Table II. Their feedback on the barriers is summarized in Table III.

#### **How Effective was the Training Curriculum?**

Seventy-four percent of the participants from Workshop I completed workshop evaluation forms. These participants reported that the workshop's objectives had been met. The results (based on a scale of 1: not at all to 4: completely) were dichotomized into high (3–4) versus low (1–2) scores to assess how well participants were able to:

- List several factors that contribute to occupational chemical exposure risk (95% high)
- Identify the hazardous properties of a chemical by using R-phrases (96% high)
- Complete a workplace risk assessment using COSHH Essentials (100% high)
- Locate control guidance and “best practice” fact sheets (98% high)

The level of agreement between the variables and control bands identified by participants from nine workplaces and those identified by the CIH is shown in Table IV. Although the participants and the CIH were in agreement with the R-phrases classification only 67% of the time, they agreed with the hazard group assigned to the 21 tasks 90% of the time. In some cases the participants inappropriately used the hazard statements on their MSDSs to assign their own R-phrases to a task (i.e. interpreting “toxic”). In other cases they found inconsistent R-phrases classifications when multiple sources were consulted.

The CIH and the participants' coding of the exposure potential variables agreed in 86% of cases for the amount and 90% for dispersion. The CIH and the participants calculated the same control band 81% of the time. The CIH and the

**TABLE IV. Effectiveness of Training Curriculum: Did worksites use the model correctly? (tasks = 21)**

Variable	Worksite/ Investigator Agreement (%)	Kappa*
R- Phrase classification (100% agreement on all assigned R-phrases)	67	
Hazard Group (A-E)	90	0.87*
Amount (small, medium, large)	86	0.70*
Dispersion (low, medium, high)	90	0.81*
Control Band (1-4)	81	0.74*
Located control guidance or Direct Advice Fact Sheets (Y/N)	76	0.44

\*p < 0.01 for significance of kappa value.

participants both located control guidance sheets for 76% of the tasks.

#### How Effective was the COSHH Essentials CB Model?

The control bands generated by the model agreed with the perceived proper controls the investigator (CIH) and the worksites identified for the tasks 75% of the time for each of the paired comparisons and 65% for all three (CB model, CIH, and worksites) (Table V). Ten (33%) of the 30 tasks reviewed were classified as “seek special advice”. These tasks were removed from the analysis since by definition the recommendations of the CIH could be classified as “special advice.”

The CIH classified 3 tasks as over-controlled by the CB model, and 2 tasks as under-controlled. One task seen as under-controlled was a laboratory task involving the transfer

**TABLE V. Effectiveness of the Model: Were the control recommendations (bands) generated by the generic COSHH Essentials (using the CIH’s classification) consistent with the controls the investigator (CIH) and/or the worksites perceived as correct?**

	Percent of Tasks (n = 20)	If Disagree, Does the Model Over- or Under-Control?
Model and CIH agree	75%	3 over-control 2 under-control
Model and worksite agree	75%	4 over-control 1 under-control
Model, CIH, and worksite all agree	65%	5 over-control 2 under-control

Note: Based on CIH or worksite as comparison standard.

of small quantities of organic solvents for short durations (<15 minutes). Although it is unlikely that the OEL was exceeded with the model’s recommended control band of general ventilation, the CIH felt that best practices pointed to engineering controls (specifically a fume hood) for this task. Direct advice factsheets were not available for laboratory tasks. The CIH (and the worksites) thought the model also under-controlled when they evaluated a machining task. Because it was a liquid, the model used the coolant’s vapor pressure, not misting, to predict dispersion potential. The Metalworking Fluids guidance available under COSHH Essentials’ Direct Advice Topics was more useful because it recommended engineering controls for machining with metalworking fluids. In both under-control cases, supplemental industry specific best practice guidance would have led the investigator and the worksites to appropriate interventions, increasing the level of agreement with the model.

The CIH (and the worksites) concluded that the model over-controlled when it recommended that several laboratory tasks (mixing and transferring small to medium quantities of organic solvents) be done under containment (i.e. a glove box). They felt the existing fume hood engineering control approach was appropriate. Direct advice factsheets were not available for laboratory tasks. The CIH identified an additional task that she believed over-controlled exposures. She felt that local exhaust ventilation (vs. containment) was adequate to control exposure to a small quantity (milliliters) of toluene used for a cleaning task. There were no Direct Advice Factsheets for small scale degreasing with medium volatility chemicals. Although the worksites felt that the model over-controlled a Hazard Group D sanding task and a Hazard Group C mixing task, the CIH did not agree.

There were eight tasks for which the CB model recommended a higher level of control than was currently being used in the workplace. Because the worksites agreed with the model for these tasks, all of the worksites stated that they planned to use (or had already used) the model to justify the enhancement of existing controls.

## DISCUSSION

The participants that attended these workshops were some of the first to be trained on how to use a CB model in the United States. Our extensive outreach effort was successful – individuals and joint labor management teams from a variety of industry sectors and sizes attended the workshops.

Many EU countries approve of using CB models to comply with the EU’s REACH regulation.<sup>(14)</sup> As the “globally harmonized” occupational health initiatives move forward, CB could become an important part of U.S. policy. The feedback from the group we trained could help shape both the approach and the training models. There were several conclusions to draw from this combination of workshops and on-site evaluations of implementation which relate to the effectiveness of our training

program as well as the COSHH Essentials model specifically and CB models generally.

### **The Interactive CB Training Curriculum was Effective**

Although SMEs can be encouraged to learn about the CB model by visiting websites or requesting CB publications, participatory CB workshops represent a more effective approach to launching this model in the United States.<sup>(25,27)</sup> Toolkits, such as COSHH Essentials, are more likely to be used by employers and workers if accompanied by training programs, ideally with interactive case studies and a computer lab component. Training teams of workers and managers from the same workplace allowed for a healthy dialogue about the model. Eighteen participants from ten worksites used the model to complete a qualitative risk assessment of multiple tasks. The CB training curriculum was effective as illustrated by the high level of agreement between the variables and control bands identified by the worksites and those identified by the CIH.

### **The Strengths of COSHH Essentials and CB Models Ease of Use**

Workshop participants welcomed a simplified approach to risk assessment and they found the COSHH Essentials model relatively easy to use. The participants' positive ease-of-use responses are similar to those reported by UK chemical purchasers who had used the model.<sup>(29)</sup>

### ***A Valuable Health and Safety Training Tool***

COSHH Essentials and CB models, in general, can be used to teach health and safety committees about industrial hygiene and its concepts. The model and the training curriculum encouraged the worksite teams to discuss risk. SMEs have had difficulty identifying and characterizing workplace chemical hazards.<sup>(30)</sup> CB offers practical help. CB models encourage SMEs and workers to develop a greater appreciation for the factors that contribute to occupational exposure risk.

Workshop participants used COSHH Essentials' "pen and paper" model and the somewhat transparent online model to manipulate exposure and hazard classification variables. They used these tools to identify which variables to address when they wanted to reduce risk. When the teams agreed with the model and thought current controls were not protective, they universally planned to implement the enhanced controls.

### ***Identification of High Hazard Chemicals***

Many of the teams we trained used COSHH Essentials to highlight the need for chemical substitutes. The model directs the user to "seek special advice" when high hazard chemicals without threshold properties (carcinogens, mutagens, asthmagens) are used in the workplace. Although some of the participants were frustrated by this directive, many participants interpreted the recommendation as a "red flag" that highlighted the need for careful risk management and the exploration of

substitutes. The model would be strengthened even more if it clearly pointed to specific "safer substitutes."

### **Building on the Contributions of COSHH Essentials—Addressing the Limitations**

Although the participants had little trouble using COSHH Essentials, they identified implementation barriers (Table III). The solutions discussed below address these limitations and could enhance future CB models and training initiatives in the United States.

#### ***Promote the GHS***

CB will not take hold in the United States until SMEs are able to locate R-phrases. As the GHS moves forward, workers and managers in the United States should find it easier to locate accurate and consistent R-phrases or Hazard Statements (the GHS equivalent).

A critical element of the GHS process should be to ensure consistent hazard statements based on the strict implementation of precise internationally harmonized definitions. Current MSDSs are widely divergent in how potential health effects are described or even listed. The GHS could result in dramatically improved risk communication.

Additional efforts to explore an MSDS certification process or training for individuals who write MSDSs and assign hazard statements could also be beneficial. In the meantime, as a precautionary measure, chemicals without R-phrases or toxicological data should not be classified in Hazard Group "A"; they should be classified in Hazard Group "C."<sup>(22)</sup>

#### ***Improve the Training Materials Concerning Mixtures***

The investigators plan to improve the training materials associated with two types of mixing tasks—mixing tasks involving multiple chemicals and tasks involving mixtures that were made before starting a task.

#### ***Develop a Searchable Library of Control Guidance and Best Practice Factsheets***

Future training programs should encourage employers and workers to locate "best practice" guidance before using the generic COSHH Essentials model to identify recommended control bands. COSHH Essentials' growing library of direct advice topics (best practice resources) represents an important initiative. A central catalogue of these materials for a greater number of industries is recommended.

COSHH Essentials did not have best practice advice for many of the tasks the worksites reviewed (laboratory tasks, for example). For 25% of the tasks evaluated the model failed to capture the thought processes the CIH used to qualitatively evaluate risk. More "best practice" guidance would have resulted in more agreement between COSHH Essentials control guidance and the CIH's recommendations.

The grouping of control strategies for specific tasks into bands or "best practices," based on the combination of intrinsic hazard and conditions of use is not a new concept in the United States. For example, OSHA requires the use of a vented

enclosure when workers use crystalline silica for abrasive blasting.<sup>(31)</sup> NIOSH promotes the use of best practices for the control of metalworking fluids in machining sumps<sup>(32)</sup> and the ACGIH recommends that exposure to thermal decomposition products of rosin core solder be controlled to levels as low as possible.<sup>(33)</sup> Many exposure control strategies have been developed by the IH community—best practice CB guidance provides a means of sharing this collective knowledge.

### *Emphasize the Importance of Using CB as One Component of a Comprehensive Health and Safety Program*

Due to its generic character, there is a concern that reliability and accuracy may have been sacrificed for the sake of COSHH Essentials' simplicity and transparency.<sup>(11,21,22,34,35)</sup> Our data suggest that the generic COSHH Essentials CB model may not work as currently designed in some circumstances. The model appeared to over-control hazards for the majority of the cases of nonagreement. However, reliance on the current U.S. approach of OEL-based compliance is also imperfect. The OEL model may under-control exposures due to incomplete, inadequate, and outdated standards as well as dependence on potentially inadequate measurement strategies.<sup>(36,37)</sup>

COSHH Essentials' generic risk management model is meant to be one aspect of a comprehensive health and safety program. SMEs should be encouraged to use the model in the context of a broader discussion of risk. When the teams agreed with the model and thought current controls were not protective CB lead to the implementation of improvements in the work environment. When the teams did not agree with the model they discussed possible explanations including the model's inability to account for all exposure predictor variables. They also discussed the value of collecting air samples to supplement the model's recommendations.

SMEs and workers in the United States will be more likely to incorporate CB models into their health and safety programs after additional validation studies are completed. For example, newer CB models, such as Stoffenmanager, have additional exposure potential variables and incorporate more *a priori* validation modeling.<sup>(12,13)</sup> Although no model will be perfect, CB will help workplaces, especially those with limited access to IHS, take the important step of identifying and controlling the exposures associated with high risk tasks.

### LIMITATIONS

This study was conducted as part of a training grant and, therefore, was relatively modest in relation to scope and methodology. Conclusions on effectiveness were necessarily confounded between the CB model itself and our training approach (that is, the utility of the model was only evident if we were able to successfully train people in how to use it). We attempted to distinguish between these issues in the discussion.

Due to resource limitations, we were only able to utilize a single CIH to perform the comparative evaluations, and that CIH had considerable knowledge of the CB approach,

and potential biases in relation to the perceived utility of the model. Although many of the worksite teams had health and safety professionals, including IHS, it would be helpful in future studies to compare the CB model to the qualitative risk assessments of multiple independent experts.

### CONCLUSION

Individuals and joint labor/management teams from a cross section of workplaces attended a series of CB workshops. The investigators conducted an evaluation of the use and adequacy of the training program and the model for those participants. COSHH Essentials can be easily learned. The participatory training curriculum and the CB model promoted a discussion of risk between workers and managers and resulted in the implementation of improvements in the work environment. Participants successfully used COSHH Essentials to identify high hazard chemicals and tasks. The barriers they associated with using COSHH Essentials included difficulty with locating R-phrases, working with mixtures, finding control guidance sheets and trusting the model.

The model agreed with both the CIH's and the worksite teams' qualitative risk assessments 65% of the time, and likely over-controlled for 71% (5/7) of the cases of nonagreement. New CB models that build on the important contributions made by COSHH Essentials should include more exposure potential variables, best practice guidance and validation modeling.

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