Harpur Hill, Buxton
Derbyshire, SK17 9JN
T: +44 (0)1298 218000
F: +44 (0)1298 218590
W: www.hsl.gov.uk

HEALTH & SAFETY LABORATORY

Systematic Review of Preventative Behavioural Interventions for Dermal and Respiratory Occupational Health Hazards

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Project Leader: **Jennifer Lunt**

Author(s): **Jennifer Lunt, Rachel Lee, Louise Carter**

Science Group: **Human Factors**

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EXECUTIVE SUMMARY

Objectives: A systematic review of occupational based behavioural interventions for non-pathogenic dermal and respiratory chemical and physical hazards was undertaken to (a) evaluate their effectiveness, and (b) identify a best practice approach for reducing exposure where this had arisen from behavioural non-compliance. It sets precedence by:

- Being amongst the first attempts to systematically evaluate the evidence base for behavioural interventions intended to reduce exposure to occupational health hazards.

- Using criteria for judging each intervention's ability to demonstrate behaviour change mechanisms.

Methods: We used a systematic review to provide a tool for developing a reliable evidence base by reducing subjectivity and bias from the literature review process. This technique includes:

- Being exhaustive and accommodating published and unpublished literature,
- Setting predetermined inclusion criteria for sifting relevant articles,
- Judging each article's ability to answer the research questions against predetermined quality criteria, and
- Incorporating inter-rater reliability checks.
- Calculating effect sizes to provide an objective indicator of intervention effectiveness.

Articles were included in the review if they:

(a) Evaluated an intervention intended to affect behavioural compliance

(b) Used before and after intervention measures and a control group comparison design to evaluate the intervention, and

(c) Directly or indirectly addressed occupational dermal or respiratory hazards, and

(d) Used behavioural-related exposure indicators. These encompassed airborne exposure measures, and secondary exposure indicators including health effects, behaviour observations, and self-reported work practices.

Pathogenic hazards were excluded to ensure a manageable volume of material. Systematic searches of 17 electronic databases, corresponding bibliographies, hand searches and HSE website searches were undertaken using relevant key words and search strings. Two reviewers screened articles for their relevance. Where one reviewer took the lead in examining an article, the other double-checked their decision to include or exclude. Fifteen of 312 articles originally identified as potentially relevant were found to comply with inclusion criteria. The main reasons for rejection concerned omission of baseline assessment, control groups, and appropriate exposure measures. Data was then extracted from the fifteen included articles so that the two main research questions to be answered were: (1) how effective are the interventions in general, and (*effectiveness*) (b) how did they achieve behavioural change (*process*)? Data-extraction was also double checked by a second reviewer to reduce interpretation bias. To provide an average indicator of the intervention effectiveness, a meta-analysis was then run on articles sharing similar characteristics according to intervention type, hazard type, and outcome type.

Main findings:

Intervention Effectiveness: Training, publicity campaigns, behaviour reinforcement approaches and occupational health management interventions were represented in the included articles. They contained too much heterogeneity, according to intervention type, exposure outcomes, hazard type, and time until post intervention assessment, to enable reliable meta-analysis across the 15 included studies. However, a predominance of small effect sizes, particularly for articles with larger samples, implies that behavioural interventions, generally, have limited impact upon dermal and respiratory exposure. Heterogeneity testing did reveal a narrower selection to have sufficient characteristics in common to warrant a 'mini' meta-analysis. These studies concerned training interventions for dermal hazards using self-reported behavioural outcomes. Their corresponding mean demonstrated a small effect. This provides still more convincing evidence that training interventions, to date, have produced a marginal impact upon dermal exposure.

Conclusion 1: *Evidence implies that behavioural interventions on their own yield a small reduction in exposure to dermal and respiratory hazards. This conclusion is based on rigorous consideration of the literature.*

Process: Just four studies based their intervention upon a recognised behaviour change approach. None contained sufficient procedural information to enable replication. However, comparison of the most with least effective interventions revealed that the least effective interventions omitted strategies for sustaining change, such as repeating training, repeating knowledge testing, prompting or providing ongoing observation and constructive feedback. Strategies for sustaining change thus appear a vital component for occupational-health based behavioural interventions, and, indeed, are essential to ensure that exposures and health risks are effectively controlled.

Conclusion 2: *Evidence implies that behavioural interventions containing strategies that sustain awareness of the need to control dermal and respiratory hazards are the most effective. Repeating training, regularly testing knowledge of risks, providing 'poster prompts' that remind employees as to the correct course of action, feeding back health surveillance results, and providing ongoing observation accompanied by constructive feedback, are examples of strategies used in the most effective interventions. These serve to remind employees of the importance of controlling exposure.*

Recommendations: Many of the interventions reviewed suffered methodological shortcomings. These design faults will have undermined their ability to produce a detectable change in exposure. Foremost is the need for improvements in the design quality of behavioural research in occupational health contexts. The practical compromises often demanded by applied research should not entirely preclude the use of:

(1) Prospective power analysis to determine sample sizes. More confident generalisations about the applicability of a finding to other contexts can then be made.

(2) Objective outcomes to lend credibility to self-report based outcomes,

(3) Pre-post intervention comparisons with control group comparisons. Alternative explanations of exposure can then more readily be ruled out.

(4) Behavioural interventions that encompass raising awareness, attitude change, environmental modifications, detailed planning, goal setting and strategies for maintaining change over time.

Above all, one-off attempts to raise awareness of dermal and respiratory hazards should be avoided. These are unlikely to be effective in preventing disease.

1 INTRODUCTION

1.1 THE HIERARCHY OF CONTROLS APPROACH

By law, under regulation 7 of the Control of Substances Hazardous to Health (COSHH) Regulations, (COSHH Schedule 2A, Fifth Edition, 2005, page 28) employers are expected to "*ensure that the exposure to substances hazardous to health is either prevented, or where this is not reasonably practicable, adequately controlled*". Traditionally, in occupational hygiene, a "hierarchy of controls approach" has been used for prioritising choice of precautions (Gressel, 2005; Roelofs, Barbeau, Ellnebecker and Moure-Eraso, 2003; Turner, 1998; Wagner, 1999; Sargent & Gallo, 2003). Preventing exposure by eliminating hazards, or through substituting with safer alternatives, is preferred over engineering solutions that control exposure which is transmitted from source. These take precedence over controls that protect the employee rather than affect the source, such as administrative changes or personal protective equipment (PPE). Solutions lower in the hierarchy are more dependent upon behavioural compliance, and are thus more susceptible to human fallibility (Gressel, 2005; Roelofs et al 2003; Turner, 1998; Wagner, 1999). PPE, in particular, is highly dependent on the wearer's cooperation for its effectiveness as a control measure and is vulnerable to the effects of poor fitting and misuse. In practice, employers tend to use these less reliable solutions (Hopkins, 2006), because they are often perceived as the most feasible and least costly (Cowley, Else & Lamotagne, , 2004; Garcia, Boix & Canosa, 2004; Hopkins, 2006; Janicak, 1996).

The limitations of the hierarchical approach are recognized in the amended Regulation 7(7) of COSHH (COSHH (2004)) which stresses adoption of an integrated package of technical, organisational and behavioural controls through the application of eight principles of Good Control Practice. It is explicit in the new approach that software controls, including behavioural interventions such as training, are as important as hardware measures in achieving adequate control of exposures to hazardous substances.

Recent research exploring the aetiology of contemporary occupational health problems also highlights the role of behavioural, and psychosocial related contributors (Blair, 2005; Coggon, 2005; Curran & Fishwick, 2003; Lunt & White, 2005; Manos, 2004; Kogevanis, 2005; Santana, 2005). Inevitiably, even where properly applied, the hierarchy of controls approach cannot be expected to remove behavioural-related risk factors since many are integral to the hierarchy itself. For example, deciding on appropriate ventilation systems, understanding exposure routes, developing a PPE programme, or being aware of the full range of safer hazard substitutes each comprise a behavioural or psychosocial component. For these reasons, tackling behavioural risk factors with behavioural solutions is unavoidable.

1.2 INTERVENTION DESIGN

Wanless (2004) has already called for stronger evidence of behavioural change interventions to stem the rise in lifestyle related public health threats, such as smoking and obesity. Not only should such an evidence base inform which interventions actually change behaviour, and to what extent, it should also elucidate the causal mechanisms, by which behaviour change occurred. As Michie and Abraham (2004) emphasise, to enable dissemination of good practice, and replicability, behaviour interventions must answer three questions, 'does it work?', 'how well does it work?', and 'how does it work?'. Understanding how interventions work requires adequate documentation of the intervention ingredients precipitating change, and the underlying theoretical model through which that change can be explained (Abraham & Michie, 2005; Michie & Abraham, 2004). These same requirements apply to occupational health (Vẽzina,

Bourbonnais, Brisson & Trundel, 2004; Cowley, Else & LaMontagne, 2004). To bring about a reduction in common place occupational health problems arising from behavioural non-compliance with health and safety precautions, an evidence base is required that differentiates the effectiveness of different forms of behaviour interventions, and the process through which they affect change. This is not to say that what works in public health will also work in occupational health. Self-regulation based interventions, reliant on self-monitoring, for example, currently appear successful for lifestyle related conditions such as smoking and nutrition (Abraham & Michie, 2005; Michie & Abraham, 2004). However, since employers have a duty of care to protect their employees' health, and will be judged accordingly by their staff, successful interventions are also likely to require some environmental modification (Fleming & Lardner, 2002; Hopkins, 2006, DeJoy, Searcy, Murphy & Gershon, 2000; Dejoy & Southern, 1993). Consequently a separate evidence base is needed for behavioural interventions as applied to occupational health.

1.3 SYSTEMATIC CONSIDERATION

Systematic reviews provide a tool for developing a reliable evidence base by reducing subjectivity and bias from the literature review process. This is accomplished by:

- Being exhaustive and accommodating published and unpublished literature,
- Setting predetermined inclusion criteria for sifting relevant articles,
- Judging each article's ability to answer the research questions against predetermined quality criteria, and
- Incorporating inter-rater reliability checks.

Systematic reviews are typically assumed the province of mainstream medicine because of the greater predominance of well-designed randomised control trials (Baker, Brockhaus, Boucier, Chapman, Collins, Goldenhaur, Heaney, Landsbergis, Martonik, Most, Schneider, Scarf, Sinclair, 2000; Verbeek, Husman, van-Dijk, Jauhianen, Pasternack & Vainio, 2004; Vineis, 2004). Pragmatic considerations such as cost and time often preclude such well-designed interventions from occupational settings (Verbeek et al., 2004). However, to support decisions surrounding resource allocation, calls have been made for more widespread use of systematic reviews in the occupational domain (Baker et al 2000; Verbeek, et al., 2004). Their application to the field of occupational medicine will, however, necessitate a reduction in the threshold by which articles are considered eligible for review, and some methodological adjustments in order to accommodate deviations from a rigorous scientific approach (Beahler, & Sundhiem, 2000; Rosenstock & Thacker, 2000; Oliver, Harden, Rees, Shepherd, Brunton, Garcia & Oakley, 2005; Verbeek et al., 2004; Vineis, 2004). At least some impartiality can then be built into the evidence base underpinning occupational health decisions.

1.4 DISEASE REDUCTION PROGRAMME

Through its Disease Reduction Programme HSE is focusing on reducing the incidence of respiratory disease, skin disease and cancer. Since compliance with COSHH reflects actual behaviours on the part of employers, employees and others with statutory duties, behavioural interventions aiming to reduce the incidence of exposure (and complement other measures aimed at promoting compliance, eg., inspection), would, in principle, play a crucial role in HSE meeting its targets (see Figure 1 for a summary of reasons for conducting this review). The Disease Reduction Programme is predicated on changing behaviour in the workplace and focuses on behavioural change pathways that can be influenced through interventions such as

stakeholder engagement and inspection. Consequently, this literature review aims to contribute to the ongoing development of programme interventions by systematically:

1. Evaluating the effectiveness of preventative behavioural interventions intended to reduce exposure to occupational dermal and respiratory hazards. Corresponding interventions will target the immediate behavioural precursors of dermal or respiratory exposure. To keep the volume of literature manageable the review process will exclude pathogenic dermal or respiratory hazards. For the purpose of this review, behavioural intervention refers to any intervention intended to affect immediate behavioural predictors of non-compliance, such as knowledge, attitudes, violations or slips and mistakes. Since the review will inform the actual reduction in disease prevalence rates, preventative behavioural interventions will form the focus of this review.

2. Produce a set of best practice recommendations for ensuring optimal behavioural compliance with health and safety guidance for occupational health hazards associated with dermal or respiratory exposure.

In so doing, it will seek to answer the questions outlined in figure 1.

- How effective are behavioural interventions for reducing workers' exposure to occupational health hazards where exposure occurs through dermal and respiratory routes?

- What is the most effective behavioural intervention for reducing workers' exposure to occupational health hazards where exposure occurs through dermal and respiratory routes?

Figure 1 Research Questions

2 METHOD

The review's protocol is provided in Appendix 1.

2.1 SEARCH STRATEGY

Seventeen electronic psychology, health and safety or occupational health related electronic databases were searched from January to March 2006 (Allied and Contemporary Medicine, Assia, Chem Abs, Cinhal , Ebsco TOC Primer, EM Care, Glae Group Health, Global Health, healsafe, Ohsrom, Pascal, Psychlit Pubmed/Med line, Science Direct, Toxfile, Social Science Research and Science Citation Index) to identify relevant articles. Bibliographies of retrieved articles, and of relevant systematic reviews identified from electronic research registers (Cochrane and Dare) were also scanned for relevant publications. To access unpublished research, internal databases from the Health and Safety Executive, and Health and Safety Laboratory were also searched. Hand searches were also conducted of key peer reviewed journals that could be accessed by authors (International Archives of Occupational & Environmental Medicine, American Journal of Industrial Medicine, Occupational Medicine, Annals of Occupational Hygiene, and Applied Occupational Hygiene).

Due to an anticipated paucity of well-documented behavioural interventions an 'inclusive' search strategy was developed. Cochrane guidelines for constructing search terms were adapted to the aims of the project (http://www.cochrane.org/resources/handbook/). Key words were combined using the framework outlined in Table 1. Boolean operators were applied where appropriate. Search terms were kept broad by:

- Proceeding at the broadest level. This corresponds to level 1 within Table 1. (see Table 1, Level 1b for phrasing structure). Where these yielded more than 300 articles level two phrase structure was used for further focus. More specific search phrases were avoided to prevent overlooking relevant articles.

- Using a range of phrases for each set of search terms. Where appropriate, wild cards accommodated international spelling variations.

- Using general intervention labels rather than design types as intervention terms.

- Avoiding naming specific occupational health conditions. Using the term 'exposure' in level 1a, and substituting 'exposure' with the phrase 'respiratory' or 'dermal' in level 1b, should have captured relevant dermal or respiratory conditions.

Table 1 Summary of Search Strategy

Search Term Structure			
Level 1a	(Population terms separated the Boolean "OR") AND (Intervention terms separated by the Boolean "OR") AND "exposure"	Level 1b	(Population terms separated by the Boolean "OR") AND (Intervention terms separated by the Boolean "OR") AND (respiratory "OR" dermal).
Level 2a	(Population terms separated the Boolean "OR") AND (Intervention terms separated by the Boolean "OR") AND "exposure" AND (Behavioural related indicators separated by Boolean "OR")	Level 2b	Population terms separated by the Boolean "OR") AND (Intervention terms separated by the Boolean "OR") AND (respiratory "OR" dermal") AND (Behavioural related indicators separated by Boolean "OR").

Search Term Expressions	
Term	**Expressions**
Population	Occupation, occupational, work, worker, job, employer, employee
Intervention	Intervention, prevention, training, health promotion, behaviour* modification, behaviour* change, behavioural* modification, behavioural* change
Behavioural–related indicators	Behaviour*, behavioural*, attitude, compliance

* Wild cards applied for these terms to accommodate spelling variations e.g. behav*r captured corresponding English (behaviour) and American (behavior) spellings.

2.2 SELECTION CRITERIA

Selection criteria aimed to minimise excessive heterogeneity in the behavioural and psychosocial contributors to occupational health conditions. Focusing on behavioural interventions for controlling exposure to non-pathogenic dermal and respiratory hazards enabled some reduction. Physical hazards were included within this sampling approach but (space missing) pathogenic hazards were excluded to keep the review manageable. Interventions were regarded behavioural if they influenced behavioural or psychosocial contributors to errors or violations, such as knowledge, attitudes, risk perception, and decision-making. Examples include training, risk communication, education, information provision, education, goal setting, behaviour modification and health promotion interventions addressing occupational respiratory or dermal hazards. An anticipated shortfall in the number of well-controlled studies necessitated initial inclusion of evaluation studies without control groups. Specific inclusion and exclusion criteria are detailed in table 2 below. No date restrictions were applied, apart from ruling out studies published after study inception (January 2006).

Table 2 Selection criteria

Inclusion Criteria	Exclusion Criteria
• Evaluation studies of interventions that address behavioural precursors of dermal or respiratory exposure to chemical-based occupational health hazards. This may be the main focus of the study, or included amongst other aims. • Primary intervention studies that are intended to prevent or reduce exposure to respiratory or dermal occupational health hazards. Secondary intervention studies for employees with pre-existing dermal and respiratory conditions that control continued exposure. • Evaluation studies that use at least a 'before and after' comparison for gauging intervention effectiveness. • Health promotion studies that address occupational chemical hazard exposure. • Full article written in English.	• Non-occupational interventions. • Studies that focus exclusively on non-behavioural exposure control solutions (e.g. engineering or administrative) • Health promotion studies pitched at general lifestyle change rather than occupational health hazards. • Exclusively process evaluation studies • Condition management or rehabilitation interventions. • Infection or contagion based hazards (thereby excluding interventions that focus on preventing exposure via blood borne pathogens, sharp/needle stick injuries and interventions aimed at improving compliance with universal precautions).

Due to the large number of articles included following first application of the selection criteria (see figure 3), the inclusion criteria were refined further. Consequently, full data extraction was applied to those studies also possessing:

- Control group(s) corresponding to a no-intervention control group, or some intervention variation such as a multiple base line design.

- Exposure outcomes indicative of behaviour change. This encompassed primary exposure indicators, including airborne hazard levels, and secondary exposure indicators concerning health effects or work practice changes.

Data were extracted from each article to:

- Provide general descriptions of interventions,

- Discern effectiveness in achieving behavioural change, and

- Discern ability to demonstrate underlying behavioural change processes.

Each article was thereby evaluated according to its ability to answer the three main questions highlighted by Michie and Abraham (2004) necessary for disseminating good practice: *does it work?, how well does it work?, and how does it work?* The first two questions inform intervention effectiveness, the third reflects process.

Process data was also extracted from those articles which reached the first but not second sift to capture a wider range of potentially useful behaviour change strategies.

2.2.1 Intervention effectiveness:

Effectiveness characteristics also included requirements that methodological biases are ruled out. These biases correspond to those used in Cochrane's Systematic Reviews

(http://www.cochrane.org/resources/handbook/), and concern selection, attrition, participant and detection effects (see Table 3 for descriptions). Presence or absence of such biases reflected each study's overall quality. It also conveyed generalisability to the working population represented. Articles were provided with a score of one where an affirmative response could be provided for each of the below characteristics. A score of 0 was allocated where these criteria were not met.

Does it work? (score range=0-7)

- At least one of the exposure indicators is statistically significant for a between groups comparison at the post intervention stage. This accommodated variation in the number of outcomes assessed by studies.
- At least one of the exposure indicators is an objective outcome, and therefore non reliant of self-report measures, observations or expert opinion.
- The sample is based on a prospective power analysis to determine the sample size necessary for allowing reliable generalisation of findings.
- Selection, attrition, detection or performance bias can be ruled out (score of one for each bias absent).

How well does it work?(score range=0-4)

- A large effect size is apparent, or can be calculated, for the between-groups comparison at a post–intervention stage.
- There is some triangulation of evidence whereby conceptually related dependent measures are similarly affected by the intervention.
- A dose-response relationship is evident between intervention amount and outcome change.
- Behavioural change at a minimum of 6 months follow-up is evident, reflecting the intervention's sustained effectiveness.

2.2.2 Behavioural Change Process:

To gauge '*how does it work*' a score of one was also allocated where:

- An independently tested theoretical model of behaviour change was used for planning the intervention.
- Mediators or moderators of behavioural change (behavioural change 'drivers' such as knowledge acquisition, attitudinal shift, locus of control, self-efficacy or peer influence) were assessed.
- Mediators or moderators changed in a manner consistent with the behavioural outcomes and underlying theory.
- Behaviour change mechanisms are clearly identifiable, for example, through raising awareness, instilling cognitive dissonance (whereby workers realise factual evidence contradicts beliefs), modelling correct practices, planning, goal setting or reinforcement.

- Work environment modifications are made to support behavioural change efforts, through, for example, ensuring appropriate controls are available and accessible, or generating management commitment.

- Sufficient methodological detail is provided to enable study replication.

Summing scores for each fulfilled characteristic produced a 'process score', reflecting each article's ability to inform behavioural change approaches and allow dissemination of good practice.

Table 3 Methodological bias guide

Selection Bias	Does the sample systematically differ from the working population from which it was selected? *e.g.:* • In terms of demographics, experience, job tenure, occupational health status, exposure levels, job characteristics, seniority, gender mix.
Performance Bias	Are there any other factors operating besides the intervention that encourages participants to behave differently than in a normal working context? *e.g.* • Were participation incentives provided? • Was participation voluntary or obligatory? • Could social desirability effects or reporting biases be operating? • Were any subject/participant reporting biases operating (e.g. Hawthorne effect, social desirability). • Were any author reporting biases operating?
Detection Bias	Were known confounders that could provide alternative explanations for intervention outcome adequately controlled (e.g. measured as covariates, through inclusion, exclusion criteria)? *e.g:* • Were there other changes occurring within the organisation/industry that could account for any observed change (e.g. organisational change, change in engineering/administrative or PPE controls)? • Were appropriate outcome measures used? • Did measures have sufficient reliability and validity (described, demonstrated or referenced) ?
Attrition Bias:	Was there any participant drop out over the duration of the study that resulted in the sample potentially differing from that assessed at baseline? *e.g:* • Were any strategies used for controlling for attrition effects, e.g. (intention to treat analysis, drop out/retained comparison)? • Can a healthy worker effect be ruled out? • Does the post intervention group systematically differ from the pre-intervention group in characteristics (e.g. demographics, job characteristics, job status, resilience) other than those that may be effected by the intervention (OH status, exposure levels)?

2.3 PROCEDURE

Identifying relevant articles: Two reviewers independently assessed article titles produced by computerised and hand searches to gauge their potential relevance. At this stage, titles demonstrating potential to inform the research questions were judged relevant. These encompassed not just interventions, but also studies examining the role of psychological precursors to behavioural non-compliance, such as knowledge or attitudes, as well as review articles. The two reviewers met to ensure decision unanimity. Bibliographies of all 'relevant articles' were scanned to identify other relevant sources.

Applying the first phase of inclusion criteria: The two reviewers jointly screened titles of all articles originally judged relevant to isolate those potentially representing behavioural interventions. General reviews, and exploratory studies were eliminated. The remaining intervention studies were then subjected to the first phase of selection criteria specified in table 2. Two reviewers then applied these criteria, and a third reviewer (project leader) checked these decisions to ensure consistency in their application.

Application of refined criteria and data extraction: The large number of studies found to fulfill initial inclusion criteria warranted refinement of the inclusion criteria so that data was extracted from a manageable amount of articles. Two reviewers worked together in applying refined criteria. Data was extracted from included studies by one reviewer, and independently checked by a second. Figure 3 summarises the procedural stages.

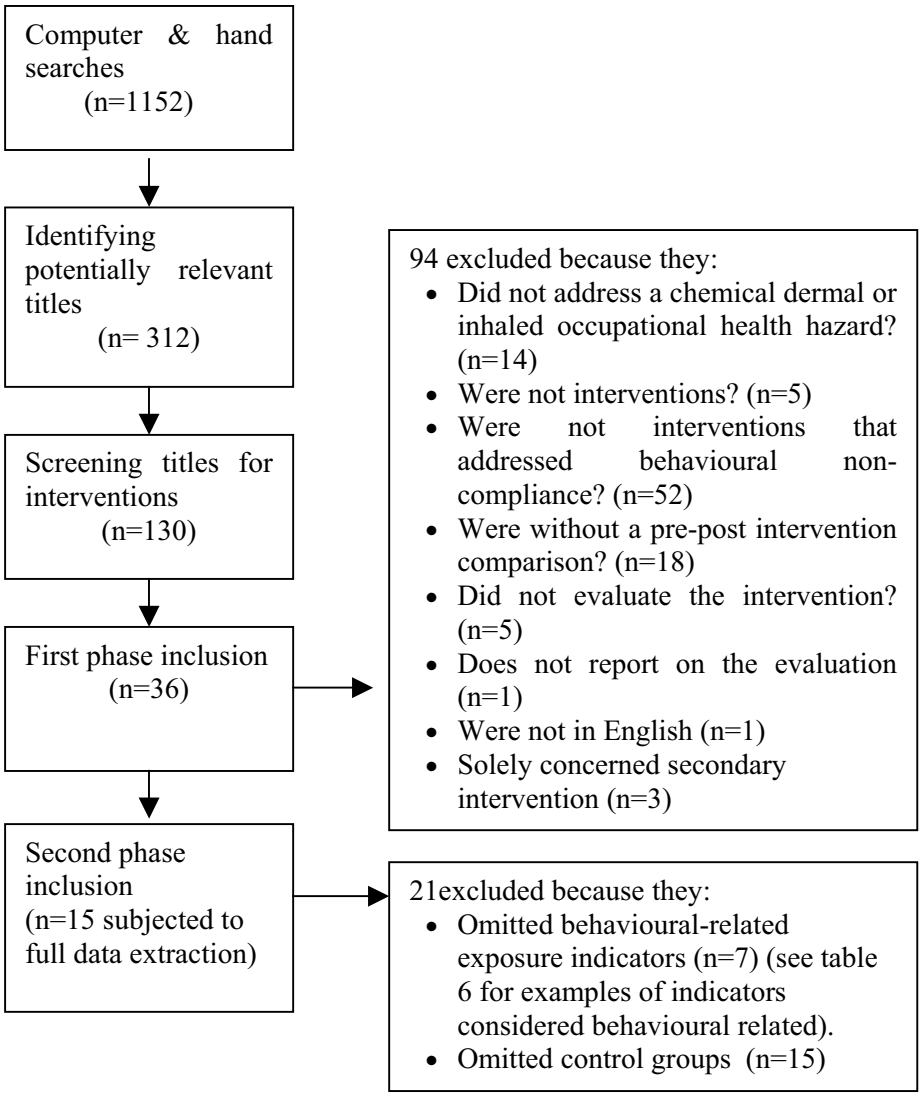

Figure 3 Flow chart demonstrating study selection process

Combining effect sizes: Where not already provided, effect sizes were calculated using 'article' data, or by authors on request. All effect sizes were converted to Pearson's Product Moment Correlation Coefficient (r) (see Clark-Carter, 1997, page 550 for equations). Effect sizes were categorised into 'small' 'medium' or 'large' effect using Cohen's (1988) guidelines Corresponding 95% confidence intervals were also calculated for each 'r', using Fisher's transformation (Clark-Carter, 1997), to establish the population parameters within which the true 'r' lay. Heterogeneity tests for effect size were then conducted to scope the viability of a meta-analysis. (see Clark-Carter, 1997, page 555 for equations).

Identification of potential behaviour change components: Prochaska and Diclemente's (1986) Stages of Change paradigm was used to help identify potential behaviour change ingredients.

According to this approach behaviour change arises from precontemplation, contemplation, preparation, action and maintenance stages. When in a *precontemplation* stage, change is not considered. During *contemplation*, preliminary considerations of the need to change are made at a remote, often non-committal level. The individual then engages in *preparation*, whereby they actively plan for the implementation that occurs in the *action* stage. The subsequent *maintenance* stage reflects efforts in sustaining change over time. Although originally

developed to explain individual change, Prochaska and Diclemente's (1986) stage model has also been applied to population and organisational change (Prochaska, 2007; Evers, Prochaska, Johnson, Mauriello, Padula, Prochaska; 2006).

'Raising awareness' and 'perceptual change' provided umbrella terms for motivation strategies potentially overcoming knowledge, attitudinal and risk perception barriers. This corresponds to a shift from Prochaska and Diclemente's (1986) precontemplation to contemplation stage. Corresponding strategies include:

- Education or information to promote awareness.
- Persuasive risk communication methods that encourage a sense of personal, workmate or family susceptibility.
- Recruiting 'peer' leaders to educate on risks.

Preparation and implementation categories encompass strategies that help translate change intentions into action by:

- Improving workers' skills base and confidence in their ability to avoid risks (self-efficacy, Bandura, 1986).
- Ensuring that a 'facilitating environment' by increasing management support, or making appropriate controls is readily available.
- Trainers demonstrating, or modelling safer behaviours.
- Observing workers whilst practising new tasks, and giving constructive feedback where improvement is necessary.
- Helping workers or managers plan how they will implement change, e.g. goal setting.

Maintenance comprised strategies that potentially sustain behaviour change, including:

- Reinforcing new behaviours through praise and recognition.
- Repeating some facet of training.

To capture a suitable breadth of material, all articles that passed the first sift were compared with this framework. Two assessors worked independently to discern how intervention components mapped onto the stages of change framework, but met periodically to discuss ambiguous intervention components.

3 RESULTS.

Of 312 articles that were judged as potentially relevant 15 were finally included. Reasons for excluding interventions are summarised in Figure 3, and listed by article in Appendix 3. Included interventions were classified as either training, marketing, occupational health management or behaviour modification. For the purpose of this review, training refers to face-to-face or computer based delivery of knowledge or skills based interactive learning. Marketing campaigns correspond to interventions utilizing multiple information dissemination methods in order to raise awareness amongst a large audience. Occupational health management interventions entail modification of occupational health management at an organisational level, while behaviour modification based approaches reinforce desirable work practices utilising operant conditioning (Hopkins et al., 2006). The content of included interventions is summarised in Table 4.

Accordingly, nine were classified as training interventions:

1. Azizi, Flint, Sadetzki, Solomon, Lerman, Harari, Pavlotsky, Kushelevsky, Glesinger, Shani & Rosenberg (2000).

2. Bauer, Kelterer, Bartsch, Pearson, Stadeler, Kleesz, Elsner & Williams (2002).

3. Flyvholm, Mygind, Sell, Jensen & Jepsen (2005).

4. Geller, Glanz,, Shigaki, Isnec, Sun & Maddock (2001).

5. Girgis, Sanson-Fisher, & Watson (1994).

6. Held, Mygind, Wolff, Gyntelberg & Agner (2002).

7. Lazovich, Parker, Brosseau, Milton, Dugan, Pan, & Hock (2002).

8. Parkinson, Bromet, Dew, Dunn, Barkman & Wright (1989).

9. Perry & Layde (2003).

Of these, three used a 'train the trainer' method for cascading learning (Azizi et al.,, 2000; Flyvholm et al.,, 2005; Held et al.,., 2002).

Two papers reported on different outcomes arising from the same occupational health system intervention that supplemented a standard health promotion programme:

1. LaMontagne, Barbeau, Youngstrom, Lewiton, Stoddard, McLellan, Wallace & Sorensen (2004)

2. LaMontagne, Stoddard, Youngstrom, Lewiton, & Sorensen (2005)

Two articles also reported upon the effectiveness of behavioural modification based interventions:

1. Hopkins, Conard, Dangel, Fitch, Smith & Anger (1986a)

2. Hopkins, Conard & Smith (1986b).

Table 4 Summaries of included interventions

Author	*Hazard /occupational health risk*	*Intervention classification*	*Intervention description*	*Design*	*Sample description*	*Outcome measures*
Azizi et al., (2000)	Solar radiation	Training	2 'pulse' intervention separated by 20 months. Comprised: (1) Safety officer training (S0): 1 day clinical training by study team to persuade colleagues in sun burn prevention strategies; (2) Health education (HE): 90 minutes presentation slide on UVR risks and prevention strategies by research physician plus skin & eye Complete intervention - HE & SO pulse 1&2 plus PPE at pulse 2. Partial intervention - HE & SO at pulse, 1, PPE at pulse 2. Minimal intervention: PPE pulse 2 only. assessment (3) Supply of sun protective equipment (PPE).	Randomised concurrent graded intervention controls	144 Male outdoor workers (doing construction work for water company): Israel.	(1) Change in frequency of sunscreen use (2) Daily % skin exposure to UVR (3) Change in rate of self-examination
Bauer et al., (2002)	Wet Work	Training	2 x 60 minutes training separated by 4 weeks. (15 mins video, 15 mins taught lecture, 30 mins hands on training. Conducted by project team). Knowledge - covered skin hazards, skin structure & function, occupational skin diseases, skin protection, cleaning & care. Skills: correct application and use of protective gloves, barrier creams and skin care was practised intensively.	Before-after study with non-randomised concurrent controls	83 First year Bakers' apprentices from an occupational school for food processing: Germany	Use of (1) barrier creams, (2) gloves (3) skin care
Borland et al.,	Solar radiation	Marketing	3 months campaign. Distribution of	Randomised	6 districts	Observations of sun

Author	*Hazard /occupational health risk*	*Intervention classification*	*Intervention description*	*Design*	*Sample description*	*Outcome measures*
(1991)		campaign	depot & and individual materials. Depot materials: 4 posters encouraging sun protection, video testimony about young man dying of cancer, & instructions for distribution of posters individual materials. Individual folders: introductory brochure, supportive letter from management, lapel buttons with protective behaviour prompts (I hide under a hat), (keep your shirt on), & skin protection instruction for using maximum sunscreen protection, recommended times to avoid the sun.	control trial	(3x control & 3x intervention). 522. Australia	protective behaviour by line staff
Buller et al., (2005)	Solar radiation	Marketing campaign & training	3.5 months campaign. Logos, slogans, brochures, posters. Perceived risk, self-efficacy and protection advice messages & behavioural prompts. 6 x unit training for staff including Prescriptive instructions. Encouraging peer influence, and messages to deliver via daily staff briefings. Risk message, behavioural and brand/ logo prompts. Website. Placement - sponsor lift operators to promote message. Utilises written, electronic, visual & interpersonal channels of communication. Direct target -staff; indirect target - resort users/	Randomised control trial	2094 Ski resort employees. USA	(1) Percentage of staff with sunburns (2) Campaign awareness (3) Sun protective behaviour
Flyvholm et al.,	Wet work	Training & role	Skin care training applied to project	Randomised	416 (18 work sites)	Self-reported

Author	*Hazard /occupational health risk*	*Intervention classification*	*Intervention description*	*Design*	*Sample description*	*Outcome measures*
(2005)		modelling	team including 2-5 'gut' workers from each department across 2 days separated by a month. Train the trainer cascade across the organisation via role modelling. Evidence base content. Training included: knowledge of eczema risks & precautions; principles of occupational health management system. Delivered via lectures, discussions, reflection, homework & feedback.	control trial	Swine slaughterhouse workers. Denmark	(1) Eczema incidence in previous 3 months (2) Use of protective gloves & cotton under-gloves.
Geller et al., (2001)	Solar radiation	Training	3 months: (1) Lifeguard training module; (2) Leader's guides, (3) 8 lesson sun safety curriculum; (4) interactive sun safety activities for children, (5) provision of sun screen dispensers, (6) Participation/teaching incentives (sunscreen & hats). 45-60 min training sessions for aquatic staff covered: skin cancer, sun protection (correct sunscreen application, clothing, seek shade, minimize exposure), teaching children sun protection, Pool Cool programme overview & life guards as role models	Randomised control trial	28 sites (15x intervention =sun protection 13x control = child injury protection sites) Outdoor aquatic staff. USA	Self-reported (1) Mean frequency of sun burn, (2) sun protection habits index, (3) social norms, knowledge, policy improvements
Girgis et al., (1994)	Solar radiation	Training	1 x30 min training session by 'cancer council' education officer. Education on skin cancer risk and precautions. Pamphlet A Pre/post intervention skin examination by dermatologists.	Randomised control trial	263 Outdoor workers of an electrical supply company. Australia	Photo-damage, pre-malignant or malignant damage, solar protection behaviour, knowledge & attitudes.
Held et al., (2002)	Wet work /	Training (train	2 x 4 hours training to team of	Randomised	313	Knowledge,

Author	*Hazard /occupational health risk*	*Intervention classification*	*Intervention description*	*Design*	*Sample description*	*Outcome measures*
	contact dermatitis	the trainer)	representatives from staff, managers & local safety board. Covered: Anatomy, physiology, risks, controls instructions (hand washing, moisturisers, protective gloves, cotton gloves), acute/chronic eczema, allergic/irritant eczema communication skills and policy production. Train the trainers' dissemination. Delivery methods: Video, diary, interactive dialogue, role-play, preparation or written instructions. Skin care policy with written instructions introduced to each work place.	control trial	(207: intervention, 106: control) Wet work employees at care homes for elderly. Demark.	self reported skin symptoms, self reported protective space missing behaviour, medical examination.
Hopkins et al., (1986b)	Styrene	Behaviour modification	231 days total duration. Identification of hazardous behaviour from observations & 'grab' samples, Observer training and inter-reliability checks, worker training video, behavioural observation against checklist, constructive feedback & testing.	Multiple baseline study	3 large plants. Multiple observations (N unspecified) workers producing fibreglass reinforced plastics. USA	(1) Mean ppm of styrene, (2) Behaviour observations of housekeeping &work practice compliance (3) Gel coat/resin usage as production indicator
Hopkins et al., (1986a)	Styrene	Behaviour modification	15 days duration. Identification of hazardous behaviour, observer training and inter-reliability checks, trainer advises workers on safer work practices, behavioural observation against checklist, constructive feedback & testing.	Multiple baseline study	4 workers, multiple observations. Plastic workers. USA	(1) Mean ppm of styrene (2) Behaviour observations of housekeeping & work practice compliance (3) Gel coat/resin usage as production indicator
LaMontagne et al.,,	Multiple	Modifying	1-2 days per site. (1) Management	Randomised	107 (17 work sites)	Change in exposure

Author	*Hazard /occupational health risk*	*Intervention classification*	*Intervention description*	*Design*	*Sample description*	*Outcome measures*
(2004)	carcinogens, asthmagens, irritants and reproductive hazards	Occupational Health management systems	consultation. One to one technical assistance, education, group educational sessions, consultation with OSH committees. Addressed management practices in integrating OSH as a core business function, OSH decision making; worker involvement (2) Worker OSH training - committees, hazard analysis, procedures, accident investigation; controls (3) Physical worker environment Industrial hygienist walk through assessments & recommendations.	control trial	Manufacturing workers. USA	prevention ratings (industrial hygiene observation) (better/best versus same/worse)
LaMontagne et al., (2005)	Multiple carcinogens, asthmagens, irritants and reproductive hazards	Modifying Occupational Health management systems	-2 days per site. (1) Management consultation. One to one technical assistance, education, group educational sessions, consultation with OSH committees. Addressed management practices in integrating OSH as a core business function, OSH decision making; worker involvement (2) Worker OSH training - committees, hazard analysis, procedures, accident investigation; controls (3) Physical worker environment Industrial hygienist walk through assessments & recommendations.	Randomised control trial	107 (17 work sites) Manufacturing workers. USA	Hazard prevention and control activities
Lazovich et al., (2002)	Wood dust	Training	1 year duration. Employees: 1 hour training on health effects & controls. Problem solving groups. Feedback on effectiveness of worksite controls at worksite. Employers: Industrial	Randomised control trial	48 work sites (24, 24) Small wood working businesses. USA	(1) Work Practices Questionnaire (2) Dust Measurements (3) Task Observation

Author	*Hazard /occupational health risk*	*Intervention classification*	*Intervention description*	*Design*	*Sample description*	*Outcome measures*
			hygienist walk through assessment & recommendations, financial incentives, tour of model worksite.			(% time controls used when available) (4) Ventilation Assessments
Parkinson et al., (1989)	Coke oven emissions	Training	4 deliveries over 2 years. 4th program comprised repeating participants. Module 1: United Steel Workers Association's history of improving steel plant working conditions; development of coke oven exposure standard by member of Coke Oven Advisory Committee. Module 2: Health effects by medical consultant. 4: Work practices training by union Health & Safety representative. 5: Current status by local union rep. Preceded by publicity campaign. Program based on collaboration between university & union.	Randomised control trial	307 (14 worksites) Coke oven workers regulated by OSHA (1976) standard. USA	Self reported (1) Knowledge (2) Work place practices
Perry et al., (2003)	Pesticides	Training	1-hour educational session (sample covered by 3 sessions). Covered cancer susceptibility, simulation of pesticide exposure, feedback self-reported exposure and PPE usage data. Endorsed by respected peer farmer. Modelling PPE usage and practice under observation.	Randomised control trial	400 dairy farmers certified to apply pesticides	Self reported: (1) PPE usage (2) Most recent gear usage (3) Dermal exposure (4) Pesticide safety knowledge (5) Pesticide safety Intentions (6) Risk perception

However, Hopkins et al (1986a) can be regarded as a pilot of the Hopkins et al (1986b) investigation.

Two further articles were classified as marketing campaigns:

1. Buller, Andersen, Walkosz, Scott, Cutter, Dignan, Zarlengo, Voeks, & Giese (2005).

2. Borland, Hocking, Godkin, & Hill (1991).

The respiratory and dermal hazards addressed comprised solar radiation, wet working, coke oven emissions, styrene, pesticides and various carcinogens (see table 4). Hopkins et al (1986a, 1986b) employed a multiple baseline intervention to evaluate intervention effectiveness. While not a mainstream occupational hygiene hazard, the solar radiation interventions featured amongst the included studies because they tended to be better designed, and because they provided useful suggestions on how to achieve behavioural change. Participating organisations undergoing intervention at a later point can be regarded as a control group for those already receiving the intervention. Two interventions were classified as non-randomised control designs with concurrent controls (Azizi et al., 2000; Bauer et al., 2002). The remainder were randomised controls trials.

3.1 EFFECTIVENESS

Table 5 indicates how each included intervention scored on demonstrated effectiveness criteria. In only 7 of the 15 interventions did the experimental group differ significantly from their respective control group at the post intervention stage. Of these, two were compared on the basis of the degree of change across the intervention (Buller et al., 2005; Parkinson et al 1989). The remaining five compared end points (Bauer et al., 2002; Borland et al., 1991; Geller et al., 2001; Held et al., 2002; Perry et al., 2003). None of the interventions achieved a large effect size and only two produced medium effect sizes (Held et al., 2002; Bauer et al., 2002), both in relation to increased glove usage. Azizi et al (2000) demonstrated an intervention dose-response effect through using a graded intervention design, whereas Parkinson et al (1989) demonstrated dose response through identifying larger effect sizes for repeating participants. Seven studies provided triangulation of evidence. Two did this through consistent changes across related self-reported work practices (Bauer et al 2002; Parkinson et al., 1989). Three of the fifteen studies showed potential behaviour change mediators, such as knowledge (Lazovich et al., 2002; Held et al., 2002; Parkinson et al., 1989) and management commitment (LaMontagne et al 2004) responding in the same direction as exposure outcomes. Three provided triangulation of evidence by significantly impacting upon both health effect and self-reported behavioural outcomes (Flyvolm et al., 2005; Lazovich et al., 2002; Perry et al., 2003). Six studies demonstrated evidence of behavioural change at 6 months, on the basis of either health effects (Azizi et al., 2000; Flyvolm et al., 2005) or self-reported behaviours (Bauer et al., 2002; Parkinson et al., 1989; Held et al., 2002, Perry et al., 2003).

Actual main effect outcomes for each of the included studies are provided in Table 6, broken down according to indicator type. Consequently, air-monitoring indicators were regarded as primary exposure outcomes whereas health effects and work practices were considered secondary indicators. Three articles produced main effect outcomes that spanned more than one category (Flyvolm et al., 2005; Perry et al., 2003; Held et al., 2002). Effect sizes and confidence intervals are also listed. These could be calculated for 18 outcomes on the basis of article content or information acquired from authors. The intervention effect sizes ('r' values) and corresponding confidence intervals yielded by included interventions are provided in Table 6. Of the 15 outcomes demonstrating small intervention effects, 10 produced confidence intervals that crossed 0, thereby casting doubt over the reliability of these outcomes. A funnel plot was

also drawn of effect size by sample size (Sterne & Harbord, 2004). As expected, 'r' coefficients varied widely for small samples size, but more consistently generated small effect sizes in the order of 0.05 (small effect) for studies containing larger samples (see figure 4). A predominance of small effect sizes, particularly for studies based on large sample sizes, implies the behavioural interventions for dermal and respiratory hazards exerted limited impact upon exposure.

3.1.1 Combining Effect Sizes: Meta-analysis:

Included articles were judged to contain too much heterogeneity to render meta-analysis of the 15 articles viable. Examples of heterogeneity include the intervention type, occupational hazards addressed, outcome type, adjustment for covariates, and time at which the second assessment was conducted. However, a heterogeneity test of effect sizes for five training interventions targeting dermal hazards, and using self-report behavioural outcomes was conducted (Bauer et al., 2002; Flyvholm et al., 2005; Girgis et al., 1994; Held et al., 2002; Perry et al., 2003). Absence of a statistically significant difference ($\chi^2_{(7)}$ 12.439, ns) means that the combined effect size (weighted mean r= 0.19, CI: 0.13-0.25, combined z=7.54, p<0.00001) for this narrower selection of studies demonstrates training interventions to yield a small but positive impact on self-reported dermal exposure according to Cohen's (1988) effect size criteria. Since the Fail-safe N (520) is larger than the critical number of studies (50) necessary for demonstrating a publication bias to positive outcomes (Clark Carter, 1997), this finding can be considered robust. Any unpublished research demonstrating negative or insignificant findings are therefore unlikely to be of sufficient number to jeopardise the reliability of the main findings.

Figure: 4 Scattogram comparing sample size with effect size

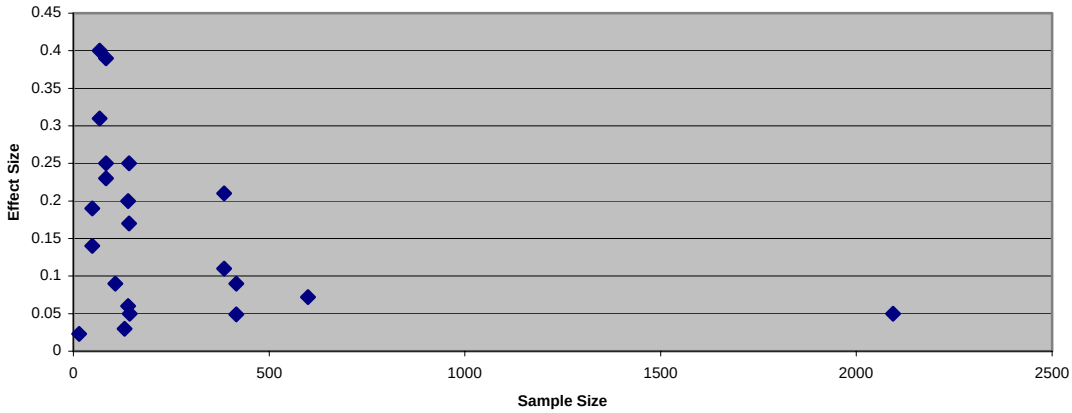

Table 5 Effectiveness Scoring*

Author	Post intervention between-groups significance?	Use of objective indicator?	Power analysis?	Large between-groups effect size on at least one indicator?	Triangulation of evidence?	Dose response?	Behavioural change at 6 months?	**Effectiveness Score (excluding quality)**	Selection Bias	Performance Bias	Detection bias	Attrition Bias	**Quality Score**	**Combined effectiveness scores**
Azizi et al (2000)	NI	0	0	NI	0	1	1	**2**	0	0	0	0	**0**	**2**
Bauer et al (2002).	1	0	0	0	1	0	1	**3**	0	0	0	1	**1**	**4**
Borland et al (1991)	1	0	0	0	0	0	0	**1**	0	0	0	1	**1**	**2**
Buller et al (2005)	1	0	0	0	0	0	0	**1**	0	0	0	1	**1**	**2**
Flyvholm et al (2005)	0	0	0	0	1	0	1	**2**	0	1	0	1	**2**	**4**
Geller et al (2001)	1	0	0	NI	0	0	0	**1**	0	0	0	0	**0**	**1**
Girgis et al (1994)	0	0	0	1	0	0	1	**2**	0	0	0	1	**1**	**3**
Held et al (2002)	1	0	1	0	1	0	0	**3**	1	0	0	1	**2**	**5**
Hopkins (1986b)	NI	0	0	NI	1	0	0	**1**	0	0	0	0	**0**	**1**
Hopkinset al (1986a)	NI	0	0	NI	1	1	0	**2**	0	0	1	1	**2**	**4**
LaMontagne et al (2005)	0	0	0	0	0	0	0	**0**	0	0	0	0	**0**	**0**
LaMontagne et al., (2004)	0	0	0	0	1	0	0	**1**	0	0	0	0	**1**	**2**
Lazovich et al (2002)	0	0	0	0	1	0	0	**0**	0	0	0	1	**1**	**1**
Parkinson et al., (1989)	1	0	0	0	1	1	1	**4**	0	1	0	0	**1**	**5**
Perry et al (2003)	1	0	1	NI	1	0	1	**4**	1	0	0	1	**2**	**6**

* NI denotes no information

Table 6: Intervention Effectiveness Summary for Between Groups Comparison

	Article Name	Exposure Related Outcome	r (effect size)[1]	CI	Samples Size (Pre-Post Test Comparison)	Effect size classification (Cohen's criteria)
Primary Exposure Indicators						
	Hopkins et al (1986)	Airborne styrene	NI	NI	19	NI
	Hopkins et al (1986)	Airborne styrene	NI	NI	19	NI
	Lazovich et al., (2002)	Airborne dust concentration	0.14	-0.104 –0.45	48 (sites)	Small
Secondary Exposure Indicators						
(a) Health Effects (Self Report)						
	Buller et al (2005)	Sun burn incidence	0.05*	0.007-0.09	2094	Small
	Flyvholm et al (2005)	Hand eczema frequency	0.049	-0.09-0.05	416	Small
	Geller et al (2001)	Sun burn incidence	NI†	NI	291	NI
	Perry et al (2003)	Dermal exposure incidence	NI†	NI	385	NI
(b) Health Effects (Clinical Examination)						
	Azizi et al (2000)	Daily exposure to ultra violet radiation	NI†	NI	144	NI
	Held et al (2002)	Severe skin symptoms	0.31**	0.045-0.53	67	Medium
Behavioural Exposure Indicators						
(a) Observation	Borland et al (1991)	Sun protective behaviour	0.072*	0.057-0.29	599	Small
	Hopkins et al (1986)	Work practices - good practice compliance	NI†	NI		
	LaMontagne et al (2005)	*Improved exposure prevention ratings (	0.09	-0.1-0.27	107	Small
		Housekeeping - good practice compliance	NI†	NI		
	Lazovich et al (2002)	% time dust controls used when available	0.19	-0.1-0.45	48 (sites)	Small
(b) Self-Reports	Bauer, et al . (2002).	Barrier cream usage	0.39**	0.19-0.56	83	NI
		Glove usage	0.23*	0.01-0.42	83	Medium
		Skin Care	0.25*	0.03-0.44	83	Small
	Geller et al (2001)	Sun protection habits index	NI*	NI	291	Small
	Flyvholm et al (2005)	Glove usage	0.09*	-0.01-0.19	416	Small
	Girgis et al., (1994)	Sun protective behaviour	0.17*	-1.76-0.59	142	Small
	Held et al (2002)	Cotton gloves usage	0.4***	0.18	67	Medium
	LaMontagne et al (2004)	*Hazard prevention/control activities (mean)	0.023*	-0.4-0.53	15 sites	Small
	Parkinson et al (1989)	Wash face before lunch	0.03*	-0.14-0.2	131	Small
		Do not eat or drink anything other than water on the battery	0.25**	0.08-0.39	142	Small
		Wear face shield, safety glasses, goggles	0.2*	0.03-0.35	140	Small
		Take home protective clothing	0.06	-0.1-0.23	140	Small
		Wear respirator	0.05	-0.11-0.21	144	Medium
	Perry et al (2003)	Glove usage	NI	NI	385	NI
			NI*	NI	385	NI

3.2 QUALITY ASSESSMENT

Included articles were also scored on the basis of quality to discern the extent to which their findings could be generalised to the wider population (see Table 5). None of the studies scored higher than 2 out of a possible 4. Methodological shortcomings were identified in the following areas.

Selection bias:

Just three of the fifteen included studies had conducted a prospective power analysis (Perry et al., 2003, Held et al., 2002, La Montagne et al., 2004; 2005). All 10 articles that were based on a randomised control design used work sites rather than individuals as the unit of randomisation (Borland, et al., 1991; Buller,et al., 2005; Flyvholm, et al., 2005; Geller et al., 2001; Girgis et al., 1994; Lazovich et al., 2002; LaMontagne et al., 2004, 2005; Parkinson et al., 1989, Perry et al., 2003), and cannot therefore be regarded as truly randomised. By using before and after studies with non-randomised concurrent control trials Bauer et al (2002); and Azizi, et al., (2000) were still more prone to selection biases. With the exception of Held et al (2002), none of the randomised control trials detailed their randomisation process. Lazovich et al's (2004) focus on small woodworking businesses prevents generalisation to larger woodworking establishments. Neither Parkinson et al (1989), LaMontagne et al (2004, 2005) or Hopkins (1986a,b) could rule out self-selection of more motivated participants. In their solar protection intervention, Azizi et al (2002) discovered non-responders to be more educated and have a higher sun burn rate than participants. Accordingly, only Held et al (2002) and Perry et al (2003) were judged to have taken sufficient precautions to prevent selection bias.

Performance Bias:

Five studies controlled for non-specific performance effects by ensuring control group participants were engaged in a neutral intervention of some description, such as receiving written information, attending a routine meeting, or a different type of intervention (Azizi, et al., 2000; Borland, et al., 1991; La Montagne et al., 2004, 2005; Lazovich et al., 2002; Perry et al., 2003). These interventions were therefore better able to control for placebo effects created by the intervention simply drawing target groups closer together ("work group cohesiveness") or enthusiasm on the part of the investigator (Volin, 1999). Nonetheless, demand effects or reactivity biases may still have been operating in all investigations utilising observational techniques (Borland, et al., 1991; Buller et al., 2005; Geller et al., 2001; Held et al., 2002; Hopkins, 1986a,b; Bauer et al 2002; La Montagne et al., 2005; Lazovich et al., 2002). These may also have led to an over-estimation of self-reported exposure (Held et al., 2002). Three studies cited potential contamination between intervention and controls (Buller,-et al., 2005; Bauer et al., 2002; Lazovich, 2002), and one between an external publicity campaign and the main sample (Borland et al., 1991). Provision of participant monetary incentives by Hopkins (1986a,b), and Geller et al. (2001); and of monetary incentives to employers for implementing recommendations (Lazovich et al., 2002), may have created performance biases, so too may the variations in management commitment encountered in Azizi et al's (2000) investigation. Parkinson et al. (1989) used former workers to conduct telephone-administered questionnaires. This perhaps gave workers greater confidence to provide honest accounts of their activities. Two studies were judged to be without performance bias (Flyvolm et al., 2005; Parkinson et al., 1989).

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[1] *NI=Insufficient information for effect size calculation, *p<0.05, **p<0.01, ***p<0.001, †Not enough information to calculated significance*

Detection Bias:

Exclusive reliance on self-report measures by nine studies (Buller,et al., 2005; Flyvholm, et al., 2005; Geller et al., 2001; Girgis et al., 1994; Held, et al., 2002; La Montagne et al., 2004, 2005; Parkinson et al., 1989; Perry et al., 2003) undermined the objectivity of their findings. Of these, three failed to report adequate reliability of validity, or reference it elsewhere (Azizi et al., 2000; Buller et al., 2005; Held, et al., 2002). Two of the six studies utilising observational techniques failed to utilise inter-rater reliability checks to control for observational biases (Bauer et al., 2002; Borland et al., 1991). Geller et al. (2001) used different samples at follow-up assessment from baseline. This seriously jeopardised the reliability of their within groups comparison. Two studies suffer from floor effects by having high-base line levels of worker compliance (Hopkins et al., 1986a,b; Lazovich et al., 2002), thereby reducing their ability to detect behavioural change arising from the intervention. High compliance rates at the beginning of the study will have made it all the more difficult to create obvious improvements. Attempts to control for detection biases included: measuring other influences of exposure as covariates (Borland, 1991; Hopkins, 1986a,b); using two air monitoring measures (Hopkins, 2004, 2005), and exclusion of participants with pre-existing dermal conditions. Consequently two studies were rated to be without excessive detection bias (Hopkins et al., 1986b; Girgis et al., 1994).

Attrition Biases:

Ten studies experienced participant drop-out between base line and post intervention assessment. Four conducted intention to treat, or drop out analysis revealing no systematic difference between drop-outs and continuers (Bauer et al., 2002; Buller et al., 2005; Girgis et al., 1994; Held., et al., 2002). By conducting such analysis these studies were assessing whether drop outs significantly differed in occupational health characteristics from those who remained in the study. Such differences could not be ruled out for Azizi et al. (2000), Geller et al. (2001), Hopkins et al. (1996a), LaMontagne et al. (2004, 2005) and Parkinson et al. (1989).

Since methodological shortcomings undermined the external validity of the included articles, quality scores were combined with effectiveness scores to provide an overall effectiveness score (see Table 5). Out of a possible score of 11, just three studies scored higher than 4 (Held et al., 2002, Parkinson et al., 1989, Perry et al., 2003).

3.3 PROCESS

Table 7 contains process scores. Just four included studies appeared to base their investigation upon a behavioural change theory. Hopkins (1986a,b) used behavioural modification principles (Hopkins et al., 2006) of goal setting, observation and feedback to reinforce desirable 'housekeeping' and work practices. Buller et al. (2005) designed their sun protection marketing campaign for increasing uptake of solar protection using Diffusion of Innovation principles (Rogers, 2003) to achieve a critical mass of awareness, and social cognition theory (Bandura, 1986) to model good practice. Finally, Lazovich et al. (2002) based their intervention evaluation upon elements of the PRECEDE (Green & Kreuter, 1991) model, ensuring that predisposers, enablers and reinforcers of compliance were covered. These represent a small selection of the various behavioural models available (see discussion). Eight studies assessed recognised mediators of behavioural change. These included risk awareness or knowledge (Geller et al., 2001; Girgis et al., 1994; Held et al., 2002; Lazovich et al., 2002; Parkinson et al., 1989, Perry et al., 2003), attitudes, defined as readiness to change (Lazovich et al., 2002, Perry et al., 2003) and social norms (Geller et al., 2001). Parkinson et al. (1989) demonstrated larger effect sizes for knowledge mediators rather than behavioural end points. This is perhaps as expected if raised awareness is a necessary precursor of behavioural change. Only Geller et al. (2001) and Lazovich et al. (2002) failed to produce a change in their underlying social norms and attitude mediators. None of the studies identified underlying change mechanisms. However, 11 did include some element of environmental modification. Six did so by providing appropriate PPE (Azizi et al., 2000; Baur et al., 2002; Buller et al., 2005; Geller et al., 2001; Held et al., 2002; Flyvolm et al., 2005) Three did so by including managers in the intervention (LaMontagne et al., 2004, 2005; Held et al., 2002). Held et al., (2002) also affected the environment by encouraging development of a skin care policy. Implementing recommendations from industrial hygienist assessments, as undertaken by Lazovich et al. (2002) and LaMontagne et al. (2004) corresponded to environmental modifications. None of the studies were judged to contain sufficient procedural detail to enable replication. Lazovich et al. (2002) achieved the highest score of 4 out of a possible 6.

Table 7 Process Scoring

Author	Underlying theory?	Mediators/moderators assessed?	Mediators/moderators behave change as expected?	Change mechanisms identified?	Environment Modification?	Replication?	Total Process Score (Maximum=6)
Azizi et al., (2000)	0	0	0	0	1	0	**2**
Bauer et al., (2002).	0	0	0	0	1	0	**1**
Borland et al., (1991)	0	0	0	0	1	0	**1**
Buller et al., (2005)	1	1	0	0	1	0	**3**
Flyvholm et al., (2005)	0	0	0	0	1	0	**1**
Geller et al., (2001)	0	1	1	0	1	0	**3**
Girgis et al., (1994)	1	1	0	0	0	0	**2**
Held et al., (2002)	0	1	1	0	1	0	**3**
Hopkins et al., (1986a)	1	0	0	0	0	0	**1**
Hopkins et al., (1986b)	1	0	0	0	0	1	**2**
LaMontagne et al., (2004)	0	1	1	0	1	0	**3**
LaMontagne et al., (2005)	0	0	0	0	1	0	**1**
Lazovich et al., (2002)	1	1	1	0	1	0	**4**
Parkinson et al., (1989)	0	1	1	0	0	0	**2**
Perry et al., (2003)	0	1	0	0	0	1	**2**

Although none of the interventions isolated any causal mechanisms for behaviour change, examination of their content using Prochaska and Diclemente's (1986) stages of change framework reveals (see table 8):

- Universal attempts to raise awareness of risks and controls across all interventions (*Raising awareness).*

- Fewer direct attempts to change attitudes. Strategies used include train the trainer approaches (Azizi et al., 2000; Flyvolm et al., 2005; Held et al., 2002), allowing participant discussions about risks and controls (Buller et al., 2005), or using peer endorsement (Perry et al., 2003); all could alter attitudes via peer influence (Bandura, 1986). Feeding back participants results of their health surveillance, or self-reported exposure, could also force perceptual change (Azizi et al., 2002; Geller et al., 2002, Perry et al., 2003). The feedback could create a state of 'cognitive dissonance' (Michie & Abraham, 2004) whereby workers realise that factual evidence, in the form of health effects, contradicts underlying beliefs about their susceptibility to harm. Workers may then change their attitudes so they are more consistent with objective evidence. Other potentially motivating strategies used included informing participants that they are to be 'role models' for others (Geller et al., 2001), and

highlighting the benefits that safer practices have (such as wearing sun hat) for 'image' conscious participants (Buller et al., 2005) (*Attitude/perceptual change)*.

- Environmental modifications made by 11 of the included studies, either in terms of improving management support or improving controls, helped to facilitate safer work practices. Lazovich et al. (2002) offered 'tours' of an exemplar worksite to managers from participating wood working businesses. Four studies included some 'modelling' of correct work practices by using a credible instructor, such as a recognised expert to demonstrate safer work practices (Azizi et al., 2000; Bauer et al., 2002; Flyvholm et al., 2005; Perry et al., 2003). Three studies also incorporated 'hands on practice', under observation, into their training (Bauer et al., 2002, Hopkins 2006 a,b, Perry et al., 2003). Those interventions that potentially force workers and managers to consider 'how' they will implement safer practices included provision of step by step written instructions (Buller et al., 2005), training on writing skin care policy (Held et al., 2002), and instructive poster prompts (e.g. "have you put on your sun block today"), typically put up in 'point of decision' locations (e.g. at the bottom of ski lifts) (Borland, 1991; Buller et al., 2005) (*Planning/Implementation)*.

- Hopkins et al. (1986, a,b) have provided styrene workers with ongoing observation and constructive feedback conducted on a regular basis. By periodically reinforcing good practice through praise, and objectively advising on improvements, this approach is more likely to enable and sustain behaviour change. Repeating training, or at least some aspect of training, as done by Azizi et al. (2000) and Parkinson et al. (1989), is more likely to sustain learning (Warr, 2002). Strategies for maintaining awareness included (*Maintenance)*:

    - Repeating medical assessments (Azizi et al., 2000; Bauer et al., 2002), or knowledge testing (Held et al., 2002).

    - Posters, logos, and branding providing their content and location is changed from time to time (Borland et al., 1991; Bauer et al., 2002)

Table 8 Summary of potential behavioural change mechanisms

	INTERVENTION	***Raises Awareness***	***Perceptual Change/Cognitive Dissonance***	***Planning/ Implementation***	***Maintenance***
Azizi et al., (2000)	Training	Risks and controls	Peer influence. Health Surveillance.	Modelling PPE Provision	Repetition of health education & health surveillance
Bauer et al., (2002)	Training	Risks, causal mechanisms, controls		Modelling Hands on practice PPE provision	Repeated training
Borland et al., (1991)	Publicity campaign	Risks, controls,		Posters as point of decision prompts	Prompts
Buller et al., (2005)	Publicity campaign	Risks, controls	Image conscious messaging Peer influence discussions.	Self-efficacy messages. Step by step instructions. Instruction prompts. PPE provision	Prompts. Daily participant briefings.
Flyvholm et al., (2005)	Training & role modelling	Risks, controls, OH management systems	Peer influence	Modelling PPE provision	Repeated training Repeated Assessment
Geller et al., (2001)	Training	Risks, controls	Role model for others as incentive	PPE provision	
Girgis et al., (1994)	Training	Risks, controls	Health Surveillance		
Held et al., (2002)	Training (train the trainer)	Risks, Controls, Causal Mechanisms	Peer influence via train the trainers	Skin policy production. PPE provision Management inclusion in training	Knowledge quiz at T2. Behavioural diary.
Hopkins et al., (1986 a&b)	Training, behaviour modification	Risky behaviours		Identifies risk behaviours. Modelling & practice under observation	Ongoing observation & constructive feedback
LaMontagne, et al., (2004, 2005)	Modifying occupational health management systems	OH management system, worker training		Industrial hygienist assessment/recommendations, management coaching, worker involvement	
Lazovich et al., (2002)	Training	Risks & controls	Health & control surveillance feedback	Worker problem solving group, Industrial hygienist assessment/recommendations, tour of examplar company,	
Parkinson, et al., (1989)	Training	History, risks, controls, status	Peer influence: Credible educators		Knowledge testing, repeat training
Perry et al., (2003)	Training	Risks, controls, susceptibility	Peer influence	Modelling & practice under observation	self-reported exposure/PPE usage feedback.

3.3.1 Comparing effectiveness with process

Comparison of process scoring (Table 7) with effectiveness scoring (Table 5) fails to demonstrate a clear relationship between effectiveness and the behavioural change components utilised by an intervention. Interventions such as that of Lazovich et al. (2002) used a range of features that would, in theory, yield greater impact. However, they failed to do so because of methodological design flaws such as high baseline compliance rates. Even so, the intervention content of studies yielding the highest effectiveness scores were compared with those producing the lowest to discern potential differences in approaches. Prochaska and Diclemente's (1986) stages of change approach was again used for making this comparison. Whilst high and low effectiveness studies share similar components, what this contrast emphasises is the absence of strategies that would sustain change from low effectiveness studies (see table 9). This implies that using some means of sustaining awareness and behavioural change, through reminder training, booster sessions, or periodical observation and feedback, is a vital characteristic of an effective behavioural change intervention.

Table 9 Comparison of the approaches used for higher and lower effectiveness studies*.

Stage of Change	Intervention Component	Effectiveness Score >3						Effectiveness score<3		
		Perry et al., (2003)	Held et al., (2002)	Parkinson et al., (1989)	Bauer et al., (2002),	Hopkins et al., (1986b)	Flyvolm et al., (2005)	Geller et al., (2001)	LaMontagne et al ., (2004, 2005)	Lazovich et al., (2004)
Pre-intervention	Expert steering group			Y						
	Publicity Campaign			Y						
	Pre-existing health Surveillance			Y						
Raising awareness	>1 training sessions		Y	Y	Y	Y	Y		Y	Y
	Training>1 hours		Y		Y	Y			Y	Y
	Specific Risks & Precautions	Y	Y	Y	Y		Y	Y		Y
Perceptual Change	Credible Educator	Y		Y						
	Train the trainer		Y				Y			
	Problem solving groups/group discussion						Y			Y
	Health surveillance/exposure feedback	Y		Y						Y
Preparation/ implementation	Modelling & practice	Y			Y	Y				
	PPE/control provision		Y		Y			Y		
	Policy development skills		Y							
	Manager participation		Y							
	OH management system						Y			
Maintenance	Repeated follow-up assessment				Y		Y			
	Repeated knowledge testing		Y							
	Constructive Feedback					Y				
	Repeated follow-up training			Y	Y		Y			

Y=Used in intervention

4 DISCUSSION

4.1 OVERVIEW

This review sets a precedent in two ways. It is amongst the first attempts to systematically evaluate the evidence base of behavioural interventions targeting exposure to occupational health hazards. Secondly, it judges articles according to their ability to demonstrate the mechanisms by which behaviour change occurs in an occupational health context. In so doing, it sought to (1) gauge the effectiveness of behavioural interventions for occupational dermal and respiratory hazards, and (2) identify an optimal approach to changing behaviour to reduce exposure to such hazards.

Intervention effectiveness: While it was not possible to conduct a full meta-analysis, a predominance of small effect sizes, particularly amongst larger scale interventions implies behavioural interventions have had minimal impact upon exposure. The selection criteria applied renders this conclusion specific to non-pathogenic dermal or respiratory hazards. Sub-analysis of training interventions for dermal hazards revealed sufficient homogeneity amongst self-reported behavioural outcomes to more reliably discern a small impact upon exposure. This review's basis in a rigorous, impartial consideration of the literature means that these conclusions can be stated with some confidence, particularly since only one article was excluded due to its not being written in English. Apparent intervention ineffectiveness can, in part, be attributed to (a) methodological design faults potentially obscuring beneficial effects and (b) absence of a conceptual behavioural model upon which to base methodology. It may also be attributable to difficulties in addressing what might be complex behaviours with one type of behavioural intervention.

Common design flaws included:

- Widespread omission of a baseline assessment. Eighteen articles were excluded at the first sift for this reason.
- A dearth of properly randomised control trials (RCTs). Whilst there were more of these than anticipated, randomisation was usually on the basis of work site rather than participants. Labelling them as RCTs is therefore a misnomer. Although it is recognised that the pragmatic constraints of occupational health research can render true RCTs impractical, they would perhaps be less misleading in their claims if they were to refer to themselves as 'quasi-experimental'.
- Near absence of prospective power analysis for determining a sample size that permits generalisation of findings. It is essential that this becomes more common practice in occupational health research if there is to be sensible evidence-based dissemination of good practice.
- Excessive reliance on self-report measures to evaluate main effects. More studies need to triangulate their evidence by examining accompanying changes in objective exposure indicators, such as personal air sampling, occupational hygienist audits of risk control indicators, or biomarkers so that their findings are less vulnerable to self-reporting biases.
- A widespread tendency not to report the validity and reliability of self-report behavioural measures for measuring the sample in question, or provide references for them.

- Some tendency not to assess 'drop outs' to discern whether their characteristics differ from those participants who remain in the intervention. In so doing, healthy worker effects cannot be ruled out.

- Some tendency to use no-intervention control groups. Non-specific effects, generated through merely participating as a control, such as social desirability reporting, may have created undue performance biases.

Aside from design faults, failure by many to use a recognised model of behaviour change to steer their methodology could largely account for their limited impact. Whilst many use strategies that can be retrospectively aligned to behaviour change approaches such as the stages of change (Prochaska & Diclemente, 1986), their rationale for choosing them is not explained in terms of behaviour change mechanisms. Many do, however, measure some mediator of change, typically knowledge of risk. Interventions yielding greater impact on the precursors of behavioural change than on behaviour change itself is as expected (Parkinson et al., 1989). If behaviour change is a process that unfolds over time as a result of shifts in underlying cognitive processes, then this finding concurs with cognitive-behavioural models of behaviour (Abraham & Michie, 2005; Conner & Norman, 2005). Most of the interventions included some element of environmental modification which tended to focus on provision of personal protective equipment. More widespread involvement of management could increase an intervention's potential to exert change. What is more telling from comparison of the most with the least effective studies is the omission of strategies for ensuring sustained change, such as repeated training, or ongoing observation and reinforcement. This is consistent with contemporary intervention research, which posits that interventions often fail because they do not sustain the momentum achieved early on. Participants are not 'reminded' of the intervention's significance or whether they're doing the right thing (Michie & Abraham, 1994; Prochaska & Diclemente; 1986). None of the included interventions make the mistake of assuming 'raised awareness' as sufficient for generating change. Nine of the 15 included studies included some strategies for altering perceptions and attitudes. Only two (Girgis et al., 2001; Parkinson et al., 1989) were apparently without strategies that assisted with implementation. Unfortunately, none of the studies possessed sufficient procedural information to enable straightforward replication. Collectively, the included interventions did not possess sufficient procedural detail to shed sufficient light on behavioural change mechanisms, and allow dissemination of good practice. They did, however, highlight the importance of not just raising awareness, but sustaining awareness of occupational health concerns.

4.2 CAVEATS

Certain limitations must be borne in mind when interpreting this review's findings:

- Firstly, the quality rating system is to a certain extent reliant upon what information is reported. It cannot be simply assumed that because an activity is not reported, it was not conducted. Editorial and word length restrictions may have prevented its inclusion in the article.

- Secondly, the inclusion criteria were kept relatively broad since it was anticipated that there would be an absence of good quality studies evaluating behavioural interventions. This, however, has given rise to a large amount of heterogeneity within the included articles. Whilst the conclusions are based on the best quality evidence, articles are being pulled together that still contain wide variation at the time at which post intervention data was assessed, the type of interventions assessed, inferential statistics employed, hazards targeted and outcomes evaluated. Research in this area clearly has not reached a position to merit a full-scale meta-analysis. Since the term 'behavioural' ultimately covered a range of interventions that were quite disparate in

their objectives and approach, future systematic reviews may need to restrict their inclusion criteria to specific intervention types, but broaden them to encompass a broader range of occupational health hazards. They may need to be still less stringent about the quality of the articles they consider. Although less rigorous selection criteria could undermine the reliability of interpretations.

- Solar protection interventions are perhaps over-represented in the included studies, because they are better designed. Nonetheless, their methodology can still help inform an optimal approach.

- The cut off point used for separating more from less effective interventions is somewhat arbitrary. It is based on the need to retain sufficient studies from which a trend can be observed, but not so much that the difference in effectiveness is negligible.

- None of the included interventions were evaluated in terms of cost-effectiveness. This is perhaps a pressing need, if dissemination of good practice is to be equated with value for money.

- The system adopted for rating the quality of the evidence may still have been pitched too high to accommodate the practical compromises occupational health research has to make.

4.3 RECOMMENDATIONS

4.3.1 For ensuring better quality designs

Solutions for improving the quality of behavioural-based occupational health research, based on shortcomings identified by this review, are provided in table 10 below.

Table 10 Design improvements for future research

Bias to avoid.	**Solutions**
Selection	▪ Conduct a prospective power analysis to determine a sample size that allows confident generalisations. ▪ Where 'sites' rather than individuals are randomly allocated to control groups, ensure worker characteristics, hazards, controls and operational procedures are kept constant across the sites. Such studies should be labelled quasi-experimental rather than RCTs.
Performance	▪ Control groups with which an intervention is compared should contain some form of 'neutral' intervention (e.g. attendance to a usual meeting, information provision) so that any biases created by simply participating in an intervention, such as 'group cohesiveness', or 'researcher enthusiasm' (Volinn, 1999) do not distort findings.
Detection	▪ Where self-report outcome measures are used to evaluate interventions, also use objective outcomes to lend greater confidence to the findings. If possible, use more than one measure of the same outcome, e.g. personal and static exposure, biological monitoring, or risk control audit by an occupational hygienist.

Bias to avoid.	Solutions
	▪ Using former workers to conduct interviewer-administered questionnaire may encourage more honest participation. ▪ Select a group of workers for which baseline compliance with controls is low so that any improvement can more readily be detected. ▪ Where observational studies are to be conducted, minimise biases created by awareness of being observed by cross-referencing observations with supervisor and operator's feedback on their usual practice. ▪ Carry out observer inter-rater reliability checks and ensure observers receive rigorous training to improve the reliability in their observations. ▪ Wherever possible, control for alternative explanations of exposure by excluding pre-existing occupational health conditions (e.g. dermatitis). ▪ Measure change mediators, such as knowledge, attitudes, locus of control and readiness to change as well as behaviour end points. ▪ Use behavioural change interventions as a supplement to other industrial hygiene interventions, not as a substitute. ▪ Include management within interventions.
Attrition	▪ Test whether drop-outs and participants differ according the key health parameters being addressed.

4.3.2 For producing behaviour change: An optimal approach

In generating behavioural-based solutions for reducing exposure to dermal and respiratory hazards, key findings from contemporary behavioural change research must be observed. These findings have been replicated in health and safety contexts (Beatty & Beatty, 2004; Johnson & Hall, 2005; Petrea, 2001; Sheeran & Silverman, 2003):

- Creating an intention to change does not guarantee actual change. A recent meta-analysis by Webb and Sheeran (2006) showed that a medium-to-large change in intention (d=0.66) led to a small-to-medium change in behaviour. In other words, motivation is not enough.
- According to this same meta-analysis, intentions are more likely to translate into actions if (a) they remain stable over time, and (b) they are planned by specifying the circumstances when it can be carried out, and the action that needs to be initiated, e.g. "When I get in work at 9.00am, I will make sure that I check that my air fed mask is in full working order (e.g. check visor, air hoses, filter etc)".
- A UK based expert-panel (the "Psychological Theory Group") has recently distilled those behavioural change components necessary for precipitating and informing

evidence-based policy (Michie, Johnston, Abraham, Lawton, Parker & Walker. 2005). The following domains, in combination, were judged by the panel as necessary for driving an effective behavioural change approach.

- Nature of the behaviour ("specify what needs to be changed")
- Knowledge and skills
- Goal intention ("what to aim for")
- Beliefs about consequences (i.e. that the consequences are beneficial or adverse)
- Beliefs about their own capabilities (i.e. that they are able to affect change)
- Goal plan ("how to achieve change").
- Environment – social
- Environment – physical
- Stress/emotion
- Memory/attention/decision making processes
- Beliefs about controls/guidelines (i.e. their effectiveness).

The above better describes the ingredients necessary for precipitating behavioural change, rather than the mechanisms by which they exert the effect. However, this review has highlighted strategies for sustaining change as discriminating the most from least effective interventions (see table 8 and 9). Transposing Prochaska and DiClemente's (1986) Stages of Change framework over these components could therefore be used to determine the sequence by which they can be introduced to bring about an enduring transformation (see figure 5) amongst populations as well as individuals. Table 11 lists their potential sequence, and strategies and tips identified by this review that correspond to each component. This table can be used as a planning guide for designing effective behavioural change interventions that are based on the best available evidence on how behaviour change is achieved. The underlying principles should apply to how (1) HSE persuades employers to tackle respiratory and dermal hazards, (2) employers can reduce their employee's exposure, and (3) employees reduce their own exposure. These recommendations should also be applicable to all types of occupational health hazards, not just respiratory and dermal. Moving to another stage is contingent on the previous stage having properly been addressed. A preliminary behavioural audit, or psychosocial risk assessment should be undertaken to identify at which stage the intervention should start. Assessing risks, and identifying suitable strategies should be undertaken in collaboration with staff of all levels using worker engagement principles (Rasmussen, Gassock, Hansen, Carstensen, Jepse, Nielsen, 2006). After all, where employees know the risks, but are found not to have the necessary skills to avoid them, then the intervention should start at improving skill training.

STAGE OF CHANGE

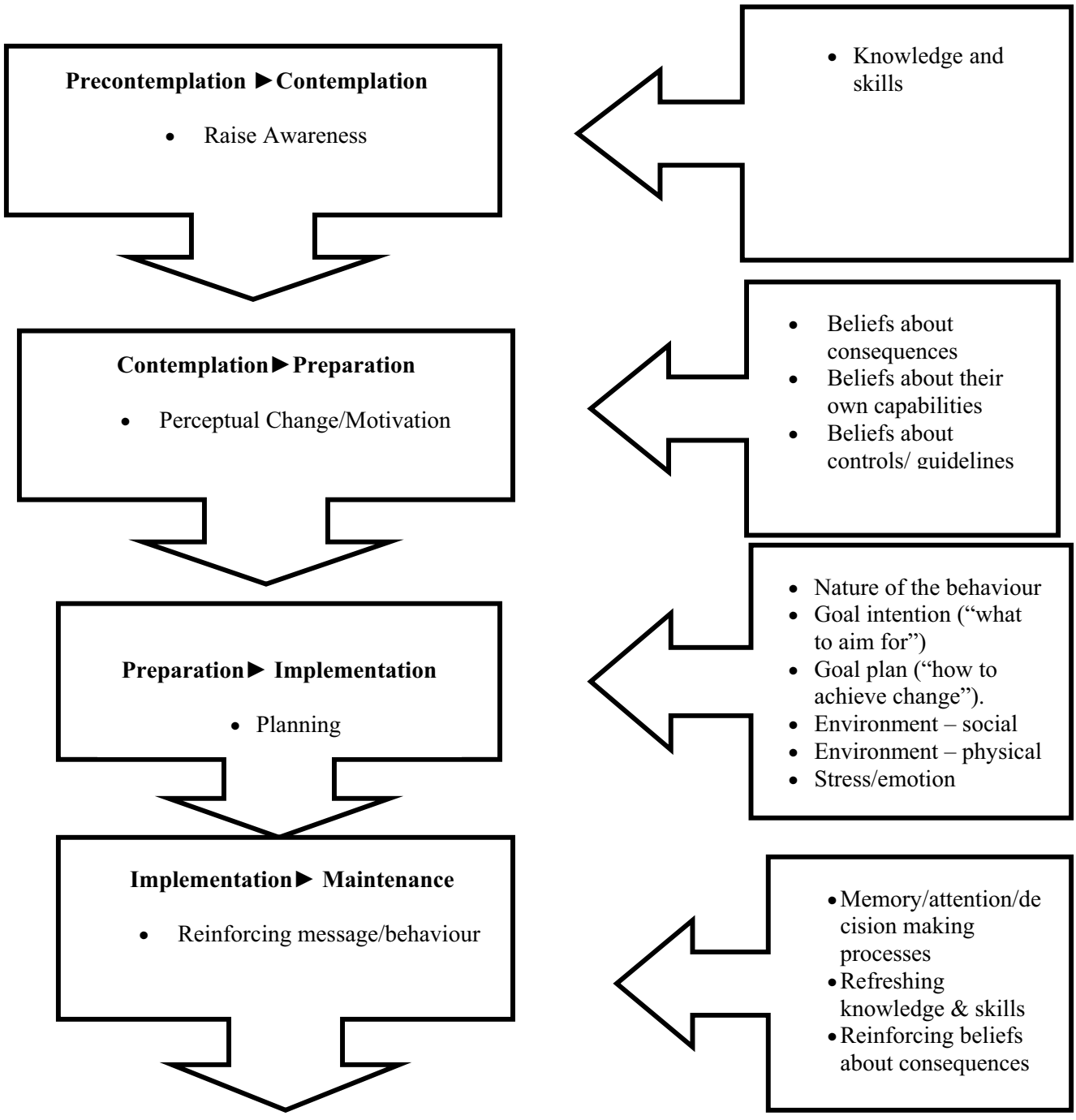

Figure 5 Transposing behaviour change components onto stages of change

4.3.3 For future research

This review has revealed that many of the behavioural interventions so far undertaken for dermal and respiratory hazards contain useful strategies for improving behavioural compliance. Overall their inclusion appears ad hoc, and not based on systematic consideration of all the ingredients needed for propelling change. More occupational health based behavioural interventions, in general, need to be designed using contemporary evidence based approaches that inform how to move workers and managers from a state of raised awareness, through to motivation, through to action and, most importantly, through to sustained action. This review has highlighted strategies that ensure sustained change as essential for guaranteeing their effectiveness. None the less this review has also emphasised the need for better quality behavioural change interventions, utilising the principles highlighted in Table 2, and more rigorous reporting of outcomes. Otherwise, any improvements gained by basing interventions on proven behavioural change techniques will continue to be masked by methodological error or poor reporting.

Table 11: Sequencing strategies according to behavioural change components

Stage	***Component***	***Implication for exposure to respiratory and dermal hazards***	***Techniques/tips****
Raise Awareness	Knowledge and skills	Engrain knowledge of risks.	Keep education material up to date with contemporary research. Educate on causal mechanisms as well as risk and controls to reinforce understanding. Integrate health promotion with occupational health messages where work and lifestyle risk factors have a similar impact on health (e.g. smoking and respiratory hazards) Capitalise on publicity campaigns to prime awareness
Perceptual change/ Motivation	Beliefs about consequences	Use techniques that emphasise personal susceptibility to risks by making health consequences personally meaningful for target audience (as per techniques used at Motor Vehicle Repair Safety and Health Awareness Days).	Personal testimony of people with specific occupational disorders. Feedback health surveillance results to participants Use exposure visualisation techniques to make 'hidden dangers' of dusts, surface contamination etc apparent. For example 1.Use florescent tracer tests to demonstrate dermal exposure, or 2. *Use dust lamps very effective at highlighting aerosols that can't usually been seen e.g. grain dust, crab meat protei, aerosol*. *Use video exposure monitoring to provide real time feedback of the link between behaviour and exposure.* Use biological effect monitoring where applicable, to make individuals aware of early signs of potential health damage. Multimedia delivery of risk communication, relying on visualisation techniques to highlight 'dangerous exposures and inadequate control approaches.
	Beliefs about their own capabilities	Provide skills training/messages so that it improves confidence in ability to avoid risk. Make the audience believe that the desired behaviours are achievable in their work context. Changes that are perceived as costly, impractical, unfamiliar or a potential threat to work quality are very difficult to implement.	Self-efficacy messages "its as easy as…."

	Beliefs about controls/guidelines	Provide workers with unequivocal evidence that controls work.	*Video visualisation of exposures useful for developing training materials – not easy to use routinely.* *Direct reading instruments for dusts and vapours can highlight high exposures and show that controls are performing effectively.* *Smoke tubes or generating machines can be used to highlight ineffective/effective controls and demonstrate ways in which employees need to work in order to maintain control effectiveness* *A respirator fit test can be used to give workers confidence that they can fit the respirator properly and achieve a certain level of protection. Colorimetric indicators are available which can be used to test workplace performance of gloves and again help to reinforce good practice.* *Biological monitoring is very useful for demonstrating whether or not an overall control strategy is working.* Health surveillance feedback following implementation of control measures.
Planning /Implementation	Nature of the behaviour	Identify specific behaviours that give risk to increased exposure. These can be used as indicators for evaluating intervention effectiveness.	Differentiate housekeeping from work practices to ensure that less obvious risky behaviours are included. Use hygienist audits followed by air sampling, if appropriate, to identify riskier behaviours
	Goal intention ("what to aim for")	Specify goals for decreasing exposure that are linked with compliance	*Set exposure reduction goals (or behavioural goals based on Good Control Practice) for individual, teams and organisations*

	Goal plan ("how to achieve change").	Specify what actions should be taken, and under what circumstances -"What, when, where and how".	Provide managers training in policy writing. Model correct work practices Practice in the training context accompanied by corrective feedback. *Plan in detail what, when, where and how improvements are to be introduced.*
	Environment – social	Recruit respected peers to help deliver interventions. Ensure managers consistently 'model' good practice. Develop a safety culture in which occupational health is prioritised, for example, by developing systems that respond quickly to health and safety concerns. Encourage worker involvement	Use an expert steering group for planning intervention. Use credible educators Use train the trainer, respected and credible educators and peer discussion groups to harness peer influence. Management inclusion in training Management commitment, worker involvement and effective supervision. Tour of sector specific exemplar sites. Identify management champions to drive intervention locally for each sector. .
	Environment – physical	Ensure appropriate controls are available, accessible, up to date, and easy to use.	Combine top down improvements on OH management system, and management involvement, with bottom up-behavioural change strategies. Follow principles of Good Control Practice ensure all exposure controls are practical, workable and sustainable. Implementing industrial hygienist recommendations Ensure control, availability, accessibility, usability and maintenance.
	Stress/emotion	Control work demands such as pressure.	*Implement 'Stress Management Standards' (www.hse.gov.uk)*

Maintenance	Memory/attention /decision making	Pace tasks. Clearly define responsibilities for exposure control	
	Refreshing knowledge	Sustain awareness of the importance of exposure reduction.	Change locations or prompts quarterly (Heron et al.,, 1997) Self assessments with feedback Gain critical mass of interested individuals who that act as a 'tipping point ' for wider dissemination of behavioural change. Repeated knowledge tests. Provide follow-up medical assessments. Behavioural diaries
	Reinforcing beliefs about consequences	Provide constructive feedback that praises good performance and advises on improvements. Provide incentives for reducing exposure.	Regular praise from management when receiving observing correct practice. *Incentivise good practice – team awards, recognition etc..* *Incorporate health and safety goals into performance appraisals.*

* Suggestions in italics are derived from related work rather than articles passing first sift (e.g. Lunt et al., 2005)

Abraham, C. & Michie, M. (2005). Contributing to public health policy and practice. *The Psychologist 18*, 676-679.

Azizi, E., Flint, P., Sadetzki, S., Solomon, A., Lerman, Y., Harari, G., Pavlotsky, F., Kushelevsky, A., Glesinger, R., Shani, E. & Rosenberg, L. (2000) A graded work site intervention program to improve sun protection and skin cancer awareness in outdoor workers in Israel. *Cancer Causes Control, 11,* 513-21.

Baker, R., Brockhaus, A., Boucier, D., Chapman, L., Collins, J., Goldenhar, L., Heaney, C., Katz, T., Landsbergis, P., Martonik, J., Most, I., Schneider, S., Sharf, T & Sinclair, T. (2000). May 2000 supplement on preventing occupational injuries (Letter). *American Journal of Preventative Medicine, 20*, 308-309.

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory.* Englewood Cliffs, NJ: Prentice Hall.

Bauer, A., Kelterer, D., Bartsch, R., Pearson, J., Stadeler, M., Kleesz, P., Elsner, P. & Williams, H. (2002). Skin protection in bakers' apprentices. *Contact Dermatitis, 46*, 81-85.

Beahler, C.C. & Sundheim, J.J. (2000). Information retrieval in systematic reviews: challenges in the public health arena. *American Journal of Preventative Medicine, 18,* 6-10.

Beatty, P.C. & Beatty, S.F. (2004). Anaesthetists' intentions to violate safety guidelines. *Anaesthesia, 59,* 528-540.

Blair, A. (2005). Occupational medicine at a turning point. *Occupational and Environmental Medicine, 62*, 285.

Borland, R.M., Hocking, B., Godkin, G.A., & Hill, D.J. (1991). The impact of skin cancer control education package for outdoor workers. *Medical Journal of Australia, 154,* 686-88.

Buller, D.B., Andersen, P.A., Walkosz, B.J., Scott, M.D., Cutter, G.R., Dignan, M.B., Zarlengo, E.M., Voeks, J.H. & Giese, A.J. (2005). Randomized Trial Testing a Worksite Sun Protection Program in an Outdoor Recreation Industry. *Health Education and Behaviour, 32*, 514-535.

Clark-Carter, D. (1997). *Doing Quantitative Psychological Research From Design to Report.* Hove: Psychology Press.

Cochrane's Systematic Reviews http://www.cochrane.org/resources/handbook/ visited December, 2005.

Coggon, D. (2005). Occupational medicine at a turning point. *Occupational and Environmental Medicine. 62,* 281-283.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioural Sciences* (2nd Edn.). London: Wiley.

Conner, M. & Norman, P. (2005). *Predicting Health Behaviour* (2nd ed). Milton Keynes: Open University Press.

Cowley, S., Else, D. & La Montagne, A. (2004). Increasing the adoption of OHS risk controls in small business: can social marketing help to achieve change? *Journal of Occupational Health and Safety,20,* 69-77.

Curran, A.D. & Fishwick, D. (2003). Occupational asthma: research, change and the 30% target. *Annals of Occupational Hygiene, 4,* 433-6.

DeJoy, D.M. & Southern, D.J. (1993). An integrative perspective on work-site health promotion. *Journal of Occupational Medicine, 35,* 1221-30.

DeJoy, D.M., Searcy, C.A., Murphy, L.R., & Gershon, R.R.M. (2000). Behavioral-diagnostic analysis of compliance with universal precautions among nurses. *Journal of Occupational Health Psychology, 5,* 127-141.

Evers, K.E., Prochaska, J.O., Johnson, J.L., Mauriello, L.M., Padula, J.A., Prochaska, J.M. (2006). A randomised clinical trial of a population and the transtheoretical model based stress-management intervention. *Health Psychology, 25,* 521-529.

Fleming, M. & Lardner, R. (2002). Strategies to promote safe behaviour as part of a health and safety management system. Prepared by the Keil Centre for the Health and Safety Executive. *HSE Contract research report 430/2002.*

Flyvholm, M.A., Mygind, K., Sell, L., Jensen, A. & Jepsen, K.F. (2005). A randonised controlled intervention study on prevention of work related skin problems among gut cleaners in swine slaughterhouses. *Occupational and Environmental Medicine, 62,*642-9.

Garcia, A.M., Boix, P. & Canosa, C. (2004). Why do workers behave unsafely at work? Determinants of safe work practices in industrial workers. *Occupational and Environmental Medicine, 61,* 239-246.

Geller, A.C., Glanz, K., Shigaki, D., Isnec, M.R., Sun, T. & Maddock, J. (2001). Impact of skin cancer prevention on outdoor aquatics staff: the Pool Cool program in Hawaii and Massachusetts. *Preventive Medicine, 33,* 155-61.

Girgis, A., Sanson-Fisher, R.W. & Watson, A. (1994). A workplace intervention for increasing outdoor workers' use of solar protection. *American Journal of Public Health, 84*, 77-81.

Green, L.W. & Kreuter, M.W. (1991). *Health promotion planning: an education and environmental approach* (2nd ed.). Mountain View, CA: Mayfield

Gressel, M. (2005). Hierarchy of controls and inherently safe design. http://www.aiha.org/aihce05/handouts/r219gressel_files/frame/htm visited April 2006.

Held, E., Mygind, K., Wolff, C., Gyntelberg, F. & Agner, T. (2002). Prevention of work-related skin problems: an intervention study in wet work employees. *Occupational and Environmental Medicine, 59,* 556-561.

Health and Safety Executive (DRP) http://www.hse.gov.uk/aboutus/plans/hscplans/0607/plan0607.pdf visited July, 2006.

Hopkins, A. (2006). What are we to make of safe behaviour programs? *Safety Science,44,* 583-597.

Hopkins, B.L., Conard, R.J., Dangel, R.F., Fitch, H.G., Smith, M.J. & Anger, W.K. (1986a) Behavioral technology for reducing occupational exposures to styrene. *Journal of Applied Behavioural Analysis,19,* 3-11.

Hopkins, B. L., Conard R.J. & Smith, M.J. (1986b). Effective and reliable behavioral control technology. *American Industrial Hygiene Association Journal, 48,* 785-91.

Janicak, C.A. (1996). Employers' knowledge of the Hazard Communication Standard requirements and the perceived barriers to compliance. *Journal of Safety Research, 27,* 223-39.

Johnson, S.E. & Hall, A. (2005). The prediction of safe lifting behaviour: an application of the theory of planned behaviour. *Journal of Safety Research, 36,* 63-73.

Kogevinas, M. (2005). Occupational medicine at a turning point. *Occupational and Environmental Medicine, 62*, 286.

LaMontagne, A.D., Barbeau, E., Youngstrom, R.A., Lewiton, M., Stoddard, A.M., McLellan, D., Wallace, L.M. & Sorensen, G. (2004) Assessing and intervening on OSH programmes: effectiveness evaluation of the Wellworks-2 intervention in 15 manufacturing worksites. *Occupational and Environmental Medicine, 61,* 651-660.

LaMontagne, A.D., Stoddard, A.M. Youngstrom, R.A., Lewiton, M., & Sorensen, G. (2005). Improving the prevention and control of hazardous substance exposures: a randomized controlled trial in manufacturing worksites. *American Journal of Industrial Medicine, 48,* 282-92.

Lazovich, D., Parker, D.L., Brosseau, L.M., Milton, F.T., Dugan, S.K., Pan, W. & Hock, L. (2002). Effectiveness of a worksite intervention to reduce an occupational exposure: the Minnesota wood dust study. *American Journal of Public Health, 92,*1498-505.

Lunt, J. & White, J. (2005). *Psychosocial and organisational factors affecting the development and control of occupational asthma: A critical review of the literature.* HSL report WPS/05/09 http://www.hse.gov.uk/research/hsl_pdf/2005/hsl0543.pdf*

Manos, J. (2004). Broadening the scope of vocational rehabilitation: the aim of the recently established Centre for Psychosocial and Disability Research at Cardiff University. *Occupational Health Review, 111*, 19-21.

Michie, S. (2004). Changing behaviour: Theoretical development needs protocol adherence. *Health Psychology, 24.*

Michie, S. & Abraham, C. (2004). Interventions to change health behaviours: Evidence based or evidence inspired? *Psychology and Health, 19*, 29-49.

Michie, S., Johnston, M., Abraham, C., Lawton, R., Parker, D. & Walker, A. (2005). Making psychological theory useful for implementing evidence based practice: a consensus approach. *Quality & Safety in Health Care, 14,* 26-33.

Oliver, S., Harden, A., Rees, R., Shepherd, J., Brunton, G., Garcia, J. & Oakley, A. (2005). An emerging framework for including different types of evidence in systematic reviews for public policy. *Evaluation, 11,* 428-446.

Parkinson, D.K., Bromet, E.J., Dew, M.A., Dunn, L.O., Barkman, M & Wright, M. (1989). Effectiveness of the United Steel workers of America 'Coke Oven Intervention Program. *Journal of Occupational Medicine, 31,* 464-472.

Perry, M.J. & Layde, P.M. (2003). Farm pesticides: outcomes of a randomised controlled intervention to reduce risks. *American Journal of Preventive Medicine, 24,* 310-5.

Petrea, R.E. (2001). The theory of planned behaviour: use and application in targeting agricultural safety and health interventions. *Journal of Agricultural Safety and Health,* 7, 7-19.

Prochaska, J.M. (2007). Commentary: The Transtheoretical Model Applied to the Community and the Workplace. *Journal of Health Psychology, 12,* 198-200.

Prochaska, J.O. & DiClemente, C.C. (1986). Toward a comprehensive model change. In W.R. Miller and N. Heather (Eds) *Treating Addictive Behaviours: Processes of Change*. New York: Plenum Press.

Rasmussen, K; Galssockl, D.J.; Hansen, O.N., Carsensen, O., Jepsen, J.F. & Nielsen, K.J. (2006). Worker participation in change processes in a Danish industrial setting. *American Journal of Industrial Medicin, 49,* 767-779

Roelofs, C.R., Barbeau, E.M., Ellenbecker, M.J. & Moure-Eraso, R. (2003). Prevention strategies in industrial hygiene: a critical literature review. *American Industrial Hygiene Association Journal,* 64, 62-7.

Rogers, E.M. (2003). *Diffusion of innovations* (5th ed.) New York: Free Press.

Rosenstock, L. & Thacker, S.B. (2000). Toward a safe workplace: the role of systematic reviews. *American Journal of Preventive Medicine 18*, 4-5.

Santana, V.S. (2005). Beyond the duality of disease and illness in occupational medicine. *Occupational and Environmental Medicine, 62*, 284.

Sargent, E.V. & Gallo, F. (2003). Use of personal protective equipment for respiratory protection. *Institute of Laboratory Animal Resources Journal, 44,* 52-6.

Sheeran, P. & Silverman, M. (2003). Evaluation of three interventions to promote workplace health and safety: evidence for the utility of implementation intentions. *Social Science and Medicine,* 56, 2153-2163.

Sterne, J.A.C. & Harbord, R.M. (2004). Funnel plots in meta-analysis. *Stata Journal., 4,* 127-141.

Turner, G (1998). The hierarchy of controls: Risk Management: Buzz, bull or good for business? *Australian Safety News,* 24-26, 28-30.

Verbeek, J., Husman, K., van-Dijk, F., Jauhiainen, M., Pasternack, I. & Vainio, H. (2004). Building on evidence base for occupational health interventions. *Scandinavian Journal of Work, Environment and Health, 30*, 164-168.

Vineis, P. (2000). Evidence based primary prevention? *Scandinavian Journal of Work, 26*, 443-448.

Volinn, E. (1999). Do workplace interventions prevent low-back disorders? If so, why?: a methodologic commentary. *Ergonomics,42,* 258-272

Wagner, G (1999). The hierarchy of controls: An alternative to behaviour-based safety. *Occupational Hazards, 61,* 95-97.

Wanless, D. (2004). *Securing good health for the whole population*. London: HMSO.

Warr, P (2002). Learning and Training. In P. Warr (Ed.) (5th edn) *Psychology at Work,* pp.153-177. London: Penguin.

Webb, T. & Sheeran, P. (2006). Does Changing Behavioral Intentions Engender Behavior Change? A Meta-Analysis of the Experimental Evidence. *Psychological-Bulletin, 132,* 249-268.

5 APPENDICES

5.1 APPENDIX 1: PROTOCOL

Proposal: Systematic Review Evaluating the Effectiveness of Behavioural Interventions for Respiratory or Dermal Occupational Health Hazards

Background:

Targets: During 2004 the Division of Work and Pensions (DWP) was set certain Public Service Agreement (PSA) targets that inherited indicators from the Government's 10 year "Securing Health Together" SH2 occupational health strategy that were set in 2000. Those PSA targets addressing occupational health included:

- A reduction in the incidence rate of work-related ill health: 6 per cent reduction by 2007-08;
- A reduction in the number of days lost due to injuries and ill health: 9 per cent reduction by 2007-08.

These are part of wider SH2 obligations to ensure by 2010:

- a 20% reduction in the incidence of work-related ill health
- a 20% reduction in ill health to members of the public caused by work activity
- a 30% reduction in the number of work days lost due to work-related ill health
- everyone currently in employment but off work due to ill health or disability is, where necessary and appropriate, made aware of opportunities for rehabilitation back into work as early as possible; and
- everyone currently not in employment due to ill health or disability is, where necessary and appropriate, made aware of and offered opportunities to prepare for and find work.

The Health and Safety Exectutive has set up two strategic delivery programmes to enable these PSA targets, of which one, "Fit for work, Fit for life, Fit for tommorrow" (Fit 3) includes a reduction in the incidence of diseases arising from exposure to hazourdous substances, namely occupational skin disease, cancer, and occupational asthma.

Behavioural Compliance: As way of minimising exposure to hazardous substance, traditional occupational hygiene measures recommend the implementation of the hierarchy of controls approach (e.g. Roelofs, Barbeau, Ellnebecker and Moure-Eraso, 2003), in which elimination or reduction of the hazard takes presidence over engineering, administrative and ultimately personal protective equipment (PPE) solutions. This is based on the premise that preventing a hazard at source is ultimately more effective in reducing the number of workers exposed than process measures or individual protection in turn. Nonetheless, even where all of these controls levels are accomodated by a work place, exposure reduction is still reliant on worker's ongoing behavioural compliance with health and safety guidelines. An apparent unchanging trend in the incidence of occupational disease since the inception of SH2 (James and Walters, 2004), would, to some extent, imply widespread behavioural non-compliance with health and safety regulations. Furthermore, general behaviour prediction research has repeatedly demonstrated awareness to be insufficient for ensuring actions that are

in accordance with that knowledge (e.g. Conner and Norman, 2001). In order to make an impact on PSA occupational health targets HSE therefore needs to know how to overcome barriers preventing translation of health and safety knowledge into action.

Systematic Consideration: Problems in identifying an effective behavioural intervention is compounded by reliance within occupation hygiene literature upon health surveillance as means of gauging exposure control effectiveness (Roelofs et al., 2003). Health surviellance per se does not allow different control techniques to be compared because, unlike evaluation studies, it precludes comparison groups including baseline comparison (Verbeek, Husman, van Dijik, Jauhiainene, Pasternack and Vainio, 2004).The evidence base for informing effective preventative interventions is consequently flawed (Verbeek et al., 2004). More rigorous examination and synthesis of occupational health literature is needed in order to elucidate intervention characteristics necessary for ensuring maximally effective interventions. This can be accomplished through a systematic review[2]. Such a review could provide a more objective evidence base for making rational decisions about how to reduce the health risks associated with chemical hazards.

In order to identify a best practice behavioural intervention for reducing health risks associated with chemical hazards, the proposed review will examine:

- the effectiveness of any behavioural interventions work designed to reduce health risks stemming from exposure to hazardous substances, including consideration of the extent to which behavioural change is sustained
- by what method,
- and, in keeping with the need to provide economic solutions (e.g. Nicholson, 2004), at what cost?

Topic:

Evaluation of the effectiveness of behavioural change interventions intended to reduce worker's exposure to hazardous substances agents in the workplace, and, by implication, exposure to associated health risks. The findings will be used to inform how behavioural change interventions can be used to complement the hierarchy of control principles underpinning current COSHH guidance. That is to say they will guide how to optimise behavioural compliance where appropriate risk elimination or containment through engineering controls, administrative solutions and provision of appropriate PPE have been implemented, but a risk of exposure attributable to behavioural factors, still remains. Relevant behavioural change interventions may include education, training, health promotion or behavioural modification approaches. As way of avoiding an excessive degree of variance, or heterogeneity in behavioural risk factors addressed by the interventions considered, this review will focus on interventions targeting occupational health hazards that exert their effects via dermal or

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[2] *Systematic reviews are regarded as yielding a high quality evidence base due to their removing subjective bias from the reviewing process. The review is as exhaustive as possible and includes published as well as unpublished work. Quality criteria are produced for judging each article's ability to inform the review's research question. Moreover, the same information is extracted from each source to ensure equality of treatment for all of the evidence considered.*

respiratory routes. Addition of other exposure routes, such as those related to noise, vibration or extreme temperature may lend excessive complexity to the behavioural influences being considered, and thereby make it more difficult to reliably answer research questions posed by the review. Nonetheless, a focus on dermal and respiratory related hazards will still allow for behavioural interventions addressing a diverse range of hazardous substances, occurring in airborne, liquid or solid forms to be considered.

Aims:

To evaluate the effectiveness of behavioural interventions intended to reduce exposure to occupational hazards that effect health through respiratory or dermal routes. Corresponding interventions will be designed to reduce unsafe work practices by focussing on the behavioural precursors directly linked with exposure.

To produce a set of best practice recommendations for ensuring optimal behavioural compliance with health and safety guidance for occupational health hazards associated with dermal or respiratory exposure.

Objectives:

- To conduct an initial scoping literature search in order to establish whether the available literature is suitable for a literature review.
- To produce a protocol specifying research questions, search strategy, selection criteria, quality assessment, data extraction strategies and evidence synthesis.
- To develop a data extraction sheet.
- Identify suitable literature through the predefined search strategy.
- Carry out data extraction (using two 'raters' to provide inter-rater reliability).
- Synthesise data using meta-analysis[3] for studies sharing the same methodologies and outcome variables (i.e. where there is homogeneity in the factors being considered).
- Produce recommendations
- Produce a report suitable for external publication in a peer-reviewed journal.,

Research questions:

1. How effective are behavioural interventions for reducing workers' exposure to occupational health hazards where exposure occurs through dermal and respiratory routes?

2. What is the most effective intervention for reducing workers' exposure to occupational health hazards where exposure occurs through dermal and respiratory routes?

[3] When applied to evaluation studies, a meta-analysis provides an aggregate statistic summarising the overall impact the included interventions have upon a common outcome (e.g. desired behaviour change. This is done by combining the effect sizes and probabilities across the studies reviewed. Combining the results from a range of studies enables the power (i.e. overall samples size) of the statistical test to be increased.

Population:

Adult workers at risk of exposure to hazardous substance through hazards that can cause occupational illnesses through inhalation or dermal absorption (e.g. asthma, COPD, silicosis, asbestosis, dermatitis, or cancer.

Interventions: Preventative interventions/solutions focussing on employees that are aimed at behavioural change (rather than policy, or engineering or occupational hygiene solutions).

Potential Intervention Outcomes for Inclusion (dependent variables):[4]
The table below lists possible indicators or dependent variables that provide either more direct evidence of behavioural change (i.e. objective exposure or behaviour measures) as primary outcomes or indirect indicators of behavioural change (e.g. self-reported behaviour change, self-reported attitude change, longer-term occupational health outcomes, compensation and sickness absenteeism indicators) as secondary outcomes.

Primary Outcomes (direct exposure indicators) *	**Secondary Outcomes (indirect Exposure Indicators).****
1. Personal exposure sampling *in situ* (e.g. monitor attached to lapel). 2. Static exposure monitoring (e.g. air monitoring) *in situ.* 3. Exposure biomarkers/bio-monitoring outcomes. 4. Demonstrable/observable behavioural change.	1. Self-reported behavioural change. 2. Self-report measures of attitude change. 3. Incidence reduction in relevant occupational disease. 4. Compensation claim reduction. 5. Time of work reduction.

***Indicators prioritised in descending order according ability to reliably and objectively gauge 'real time' exposure levels.*
***Indicators prioritised in descending order according to their relevance to behavioural change and proximity to the exposure event.*

Eligible study designs:

Evaluation studies. Given a paucity of control group comparison research within occupational health, prospective interventions evaluated using a before and after comparison will form the main evaluation criteria for inclusion within the review.

Search Strategy:

Search terms:
The search terms will be expressed using the format given below as a framework. This will be expanded or contracted according to the volume of material each search level produces.

(Population terms separated the Boolean "OR") AND (Intervention terms separated by the Boolean "OR") AND (exposure outcome) AND (behaviour, health or cost effectiveness outcome)

Possible expressions for each question facet are summarised in the table below.

[4] The range of outcomes for inclusion may be reduced in order to keep scope of review manageable.

Expressions for each question facet:	
Population	*Occupational, work, employee*
Interventions	*Prevention, intervention, training, education, health promotion, behaviour change, behaviour modification*
Outcome	**Exposure indicators:** *exposure, monitoring, monitoring, video, measurement* **Health effect Indicators:** *Biomarkers, biological monitoring, health effects, illness, time off work, sickness absence and compensation.* **Behavioural change indicators:** *Behaviour, attitude, compliance,*
Study design	*Excluded to optimise inclusivity*
Occupational illness	*E.g. Occupational asthma, occupational skin dermatitis, occupational cancer, chronic obstructive pulmonary disorders, asbestosis, silicosis, mesothelioma*
Occupational hazards	*e.g. isocyanates, flour dust, grain, enzymes, colophony, latex, glue, resin*

Wildcards*:	**Covering expressions**
Occupation*	Occupational, occupation,
Work*	Work, workers, working
Behavio*r	Behavior, behaviour
Employ*	Employee, employer, employment

The search term used will be implemented in descending order of detail using the following frameworks:

N.B these search terms are to be applied to anywhere in the article.

1. (Population terms separated the Boolean "OR") AND (Intervention terms separated by the Boolean "OR") AND "exposure".

   Occupation* AND Intervention AND Exposure
   Occupation* AND Prevention AND Exposure
   Occupation* AND Training AND Exposure
   Occupation* AND Health Promotion AND exposure
   Occupation* AND Behavio*r Modification AND exposure
   Occupation* AND Behavio*r Change AND exposure
   Work AND Intervention AND Exposure
   Work AND Prevention AND Exposure
   Work AND Training AND Exposure
   Work AND Health Promotion AND exposure
   Work AND Behavio*r Modification AND exposure
   Work AND Behavio*r Change AND exposure
   Employ* AND Intervention AND Exposure
   Employ* AND Prevention AND Exposure
   Employ* AND Training AND Exposure
   Employ* AND Health Promotion AND exposure
   Employ* AND Behavio*r Modification AND exposure
   Employ* AND Behavio*r Change AND exposure

AND
Occupation* AND Intervention AND (Dermal or Respiratory)
Occupation* AND Prevention AND (Dermal or Respiratory)
Occupation* AND Training AND (Dermal or Respiratory)
Occupation* AND Health Promotion AND (Dermal or Respiratory)
Occupation* AND Behavio*r Modification AND (Dermal or Respiratory)
Occupation* AND Behavio*r Change AND (Dermal or Respiratory)
Work AND Intervention AND (Dermal or Respiratory)
Work AND Prevention AND (Dermal or Respiratory)
Work AND Training AND (Dermal or Respiratory)
Work AND Health Promotion AND (Dermal or Respiratory)
Work AND Behavio*r Modification AND (Dermal or Respiratory)
Work AND Behavio*r Change AND (Dermal or Respiratory)
Employ* AND Intervention AND (Dermal or Respiratory)
Employ* AND Prevention AND (Dermal or Respiratory)
Employ* AND Training AND (Dermal or Respiratory)
Employ* AND Health Promotion AND (Dermal or Respiratory)
Employ* AND Behavio*r Modification AND (Dermal or Respiratory)
Employ* AND Behavio*r Change AND (Dermal or Respiratory)

2. Population terms separated the Boolean “OR”) AND (Intervention terms separated by the Boolean “OR”) AND “exposure” AND (behaviour outcome)

Occupation* AND Intervention AND Exposure AND Behavio*r
Occupation* AND Prevention AND Exposure AND Behavio*r
Occupation* AND Training AND Exposure AND Behavio*r
Occupation* AND Health Promotion AND exposure AND Behavio*r
Work AND Intervention AND Exposure AND Behavio*r
Work AND Prevention AND Exposure AND Behavio*r
Work AND Training AND Exposure AND Behavio*r
Work AND Health Promotion AND exposure AND Behavio*r
Employ* AND Intervention AND Exposure AND Behavio*r
Employ* AND Prevention AND Exposure AND Behavio*r
Employ* AND Training AND Exposure AND Behavio*r
Employ* AND Health Promotion AND exposure AND Behavio*r
Occupation* AND Intervention AND Exposure AND Attitude
Occupation* AND Prevention AND Exposure AND Attitude
Occupation* AND Training AND Exposure AND Attitude
Occupation* AND Health Promotion AND exposure AND Attitude
Work AND Intervention AND Exposure AND Attitude
Work AND Prevention AND Exposure AND Attitude
Work AND Training AND Exposure AND Attitude
Work AND Health Promotion AND exposure AND Attitude
Employ* AND Intervention AND Exposure AND Attitude
Employ* AND Prevention AND Exposure AND Attitude
Employ* AND Training AND Exposure AND Attitude
Employ* AND Health Promotion AND exposure AND Attitude
Occupation* AND Intervention AND Exposure AND Compliance
Occupation* AND Prevention AND Exposure AND Compliance
Occupation* AND Training AND Exposure AND Compliance
Occupation* AND Health Promotion AND exposure AND Compliance
Work AND Intervention AND Exposure AND Compliance
Work AND Prevention AND Exposure AND Compliance
Work AND Training AND Exposure AND Compliance
Work AND Health Promotion AND exposure AND Compliance
Employ* AND Intervention AND Exposure AND Compliance
Employ* AND Prevention AND Exposure AND Compliance
Employ* AND Training AND Exposure AND Compliance
Employ* AND Health Promotion AND exposure AND Compliance

Search Sources:

(a) General health and medical databases

- MEDLINE
- EMBASE
- CINAHL
- PSYCHINFO
- WEB OF SCIENCE
- COCHRANE REVIEWS
- DARE
- Occupational health databases (list them here)

(B) Reference Lists

(C) Journal hand searches

(list them here)

e.g. Occupational Health Psychology, Occupational medicine, Occupational and Environmental Medicine, Annals of Occupational Hygiene, Journal of Occupational and Environmental Hygiene/American Journal of Industrial Hygiene, Applied Occupational and Environmental Hygiene meeting.

(D) Researchers/experts:

(E) Research Registers (e.g. Cochrane)

Review Inclusion/Exclusion Criteria:

Corresponding criteria are based on the need to minimise excessive variance in the range of behavioural and psychosocial influences mediating non-compliance by adopting more restrictive parameters for exposure routes. However, by focussing on skin contact/absorption and inhalation the review will still be relatively inclusive in terms of the range of occupational health risks it encompasses. A variety of hazardous substances and associated conditions are linked with dermal and respiratory exposure. Accordingly, the search strategy should yield a satisfactory number of studies for allowing useful conclusions can be drawn.

Inclusion Criteria	***Exclusion Criteria***
• Evaluation studies of interventions that address behavioural precursors of dermal or respiratory exposure to chemical-based occupational health hazard or hazards. This may be the main focus on study, or included amongst other aims. • Intervention studies that are intended to reduce exposure to respiratory of dermal occupational health hazards. • Relevant hazardous substances may therefore be airborne (e.g as a vapour,	• Non-hazardous substances arising in the work place that may be inhaled or absorbed through the skin. • Non-occupational based interventions. • Evaluation studies that fail to compare intervention outcomes against an equivalent baseline measure. • Studies that focus exclusively on non-behavioural industrial hygiene solutions • Exclusively health promotion studies pitched at general lifestyle change

Inclusion Criteria	*Exclusion Criteria*
dust, particles, grain, flour or gas), liquid (e.g. chemical solvent or solution, paint, food stuff) or solid (e.g. lead). • Hazardous substances must be recognised as causes/contributors of occupational health conditions associated with dermal and respiratory exposure (e.g. occupational asthma, dermatitis and cancer). They may act as irritants, sensitisers or contaminants. • Evaluation studies that at least use a 'before and after' comparison for gauging intervention effectiveness. • Primary studies • Health promotions studies that address chemical hazard exposure where the relative contribution of the behavioural • change intervention addressing chemical hazard exposure can be isolated • Studies that include primary prevention even if secondary prevention is also described.	(rather than altering behaviours directly related to hazard exposure). • Exclusively process evaluation studies • MSD, stress and occupational diseases related to physical agent exposure. • Interventions that concern the management of or rehabilitation from occupational health conditions. • Infection or contagion based hazards (thereby excluding interventions that focus on preventing exposure via blood borne pathogens, sharp/needlestick injuries and interventions aimed an improving compliance with universal precautions) • Studies that detail secondary prevention alone (with no primary prevention at all)

Quality Assessment Criteria:

Each study's relative ability to inform the overall aim of this review will be judged according to the following criteria:

- The effect size and statistical significance yielded.
- Any triangulation of evidence.
- Evidence of the intervention being based on an independently verified theoretical model.
- Provision on adequate procedural detail to enable easy replicability.
- Minimisation of bias (either selection, performance, detection and attrition biases)
- Use of appropriate, reliable and valid outcome measures.
- Exclusion of confounding alternative explanations.
- Generalizability (representativeness of employees working with hazardous chemicals).
- Evidence of sustained behavioural change.

Study quality will therefore be scored as summarised in the following table. Please note that these criteria may be subject to review as the systematic review unfolds.

Does it work?		
Is the change statistically significant between before and after assessments?		**1**
Did the study have sufficient power?		**1**
Does the study provide triangulation of evidence (e.g. corroboration of self-report with objective indicators, of primary with secondary outcomes, or of different objective variables behaving in a way that is consistent with exposure reduction via behavioural change)?		**1**
Have alternative explanations been ruled out?	**Selection bias:** • Does the intervention group differ from population from which it was selected (i.e. all employees subjected to the occupational hazard) in terms of demographics, OH status, exposure levels and job characteristics?	**3** All or nearly all criteria met (Low risk of bias relative to other studies) **2** More than half of the criteria met (Medium risk of criteria relative to other studies) **1.** More that half of the criteria not met (High risk of bias relative to other studies)
	Performance bias: • Were there other changes occurring within the organisation/industry that could account for any observed change (e.g. organisational change, change in engineering/administrative or PPE controls)? • Were participation incentives provided? • Was participation voluntary or obligatory?	
	Detection Bias: • Were known confounders adequately controlled (e.g. measured as covariates, through inclusion, exclusion criteria)? • Were appropriate outcome measures used? • Were they of sufficient reliability (r>0.65) and validity (described, demonstrated or referenced) ? • Were any subject reporting biases operating (e.g. beta change, social desirability). • Were any author reporting biases e.g. not all outcomes reporting?	

	Attrition Bias: • Were any strategies used for controlling for attrition effects, e.g. (intention to treat analysis, drop out/retained comparison? • Can a healthy worker effect be ruled out? • Does the post intervention group systematically differ from the pre-intervention differ in characteristics (e.g. demographics, job characteristics, job status, resiliance) other than those that may be effected by the intervention (OH status, exposure levels) •	
Generalisability	Is the sample representative of the wider target population (in terms of hazard characteristics to which they are subjected)?	**1**
How well does it work?		
Effect size	Is there a large effect size for before/after comparison?	**1**
Follow up	Is there demonstrable evidence of behavioural change having been sustained at at least 6 months follow up?	**1**
How does it work?		
Theoretical basis	Is the intervention based on an independently tested theoretical model?	**1**
Mediators/Moderators	Were theoretically relevant mediators and moderators assessed? Do mediators and moderators behave as expected?	**2**
Replicability	Does the procedure have sufficient replicability?	**1**
How representative is this study of the target population?	Is the sample representative of the wider target population (in terms of hazard characteristics to which they are subjected)?	**1**

Evidence synthesis

In addition to utilising the study scoring criteria as means of gauging the overall relevance of each stage to the overall research questions, if feasible, and provided sufficient studies are deemed eligible, meta-analysis will be conducted on studies sharing equitable outcomes measures. Again, if viable, a second means of introducing further homogeneity into the studies included within a given meta-analysis will be to only include those using equitable dependent variables in order to assess exposure to the same occupational health hazard or occupational illness.

Meta-analysis Method (As per DCC guidelines)

Identify universally applicable effect size (e.g. mean difference for before and after comparisons)

Effect sizes:
Convert to common effect size for each study
Convert r to r' for each study

As per DCC guidelines
Weight individual studies according to size or quality
Combine effect sizes
Conduct homogeneity/heterogeneity analysis of Ra's (funnel plot, forest plots, stats tests) and sub-meta analysis where appropriate
Determine whether using fixed effects or random effects and justify, provides confidence interval (needs heterogeneity statistic)
Sensitivity analysis (according to quality, different designs, missing data (substituting missing data for most and least favourable)
Test for publication bias (file drawer method).

Risk Assessment:

Risk	Strategy
Literature search yields an unwieldy amount of literature.	• A preliminary scoping of the literature suggests more inclusive criteria as necessary for yielding a sufficient number of studies. • Narrow inclusion criteria to interventions intended to reduce susceptibility to exclusively occupational asthma, occupational skin dermatitis, and cancer cause by occupational factors as way of retaining relevance to current PSA targets. • Or, narrow the range of outcomes/indicator types included.
Literature search yields an insufficient number of articles for consideration.	• Inclusion criteria will be broadened out to include occupational health hazards stemming from physical/ work environment agents such as noise, vibration, light, humidity and extreme temperature.
Under-usage of occupational hygiene terminology.	• To consult with client if and when these situations arise. • To pitch reporting style to according to target journal specifications.
Review is not completed within the original timescale.	• Keep client informed and renegotiate deadline in the event of difficulties in attaining original endpoint.

Deliverables:

A report suitable for publication in a peer reviewed journal as a systematic review. This will contain recommendations of behavioural interventions characteristics necessary for guaranteeing exposure to occupational health hazards occurring that are either inhaled or absorbed through the skin.

Milestones:

Milestone	Date
Protocol Development	April 2005
Literature Search	June 2005
Data extraction	May – July 2005
Meta Analysis	August 2005
Report	End of September 2005

Cost[5]:

Milestone	Date
Protocol Development Literature Search Data extraction Meta Analysis Report	
	£35k (£17.5k per funding source)

References:

Conner, M and Norman, P (1996). *Predicting Health Behaviour.* Open University Press: Buckingham

James, P and Walters, D (2004). Is workplace health and safety really revitalised? *Occupational Health Review.* Issue 108

Roelofs CR, Barbeau EM, Ellenbecker MJ, Moure-Eraso R. (2003) Prevention strategies in industrial hygiene: a critical literature review. *AIHA.* 64(1):62-7. Review.

[5] *To be equally split between Len Morris and Colin Mackay as customers.*

5.2 APPENDIX 2: DATA EXTRACTION SHEET:

BEHAVIOURAL INTERVENTION EFFECTIVENESS: RESPIRATORY/DERMAL HAZARD EXPOSURE

REF NO:		**REVIEWER**		**DATE REVIEWED**	
JOURNAL REFERENCE (IN FULL) [6]					
Review		**Primary Data**		**Other study type**	
Dermal/Inhaled occupational health hazard?	**Yes/No**		**Exposure Reduction**	**Yes/No**	
Prevention?	**Yes/No**				
Intervention Evaluation study?	**Yes/No**		**Before/After Comparison as minimum**	**Yes/No**	
Does it intend to change/effect behavioural compliance with h&s measures?	**Yes/No**		**If health promotion, does it address behavioural compliance?**	**Yes/No**	

Included?		**Excluded?**	
Reason			

SAMPLE CHARACTERISTICS

Worker Group		**N**		**Age (mean/range)**		**Gender**	
Company type		**N**		**Industry sector**			
Exposure Agent		**Exposure Route**		**Dermal/Inhaled**	**Sensitiser/Irritant?**		

[6] *APA format Inc. date, vol, part, pages*

Occupational heath risk		**Latency**			**Chronicity**	
Workability Implications	**Job loss/redeployment/continuation/long term disability**					
Extant Controls	**Risk Assessment/Substitution/ Engineering controls/ PPE/ Health Surveillance**					
Power Analysis	**Yes/No**	**Retrospective /Prospective?**	**R/P**	**Sufficient Power?**	**Yes/No/Don't Know**	
Sample inclusion criteria						

INTERVENTION CHARACTERISTICS

Research Question:

Intervention description					
Type of Intervention	**Training/Information/Modelling/Practice in training env./ training in situ/health promotion/observation/ goal setting/ planning (inc. goal setting)/ biomarker feedback (health surveillance), video exposure monitoring/ reinforcement (verbal) feedback/incentive schemes)/ problem solving other/peer influence:**				
Target Behaviour	**PPE usage, maintenance, engineering control usage, maintenance, work practice:**				
Intervention content					
Underlying theory?					
Length		**No. Sessions**		**Follow-up (type**	
Theoretical change mechanism	**Environmental contingencies/ Self-Efficacy/ Cognitive Dissonance (belief mod/ /Action Planning**				
Change Method (If explained)					
New Behaviour	**Cognitive Rehearsal/ guided imagery/ skills development/modelling/ self-instruction, environmental contingencies/ action planning/raising awareness**				
Habit Breaking	**Self-monitoring/ Behavioural Contracts/ External Monitoring**				
Maintenance/generalisation	**Reinforcement/ experimenting with different conditions or contexts/self-attribution of successful change**				

Delivery Mechanism	**Elearning/ Internet/ Cascade Training/ Face to Face/ other**		
Deliverer			
Worker involvement?			
Training Setting			
Any Environmental Modification? Describe		**Score**	

DESIGN CHARACTERISTICS (Quality)

STUDY DESIGN	RCT, before-after study with non-randomised matched controls/ before after study with non-randomised concurrent controls, before after study with historic controls, before-after studies with no controls,			
Control group description				
Follow-up evaluation?	**Yes/No**	**When?**		
IVs			**Variable Role [7](mediator, moderator, endpoint)**	
DVs				
Intervention Addition?				
Selection Bias	Does the intervention group differ from population from which it was selected (i.e. all employees subjected to the occupational hazard) in terms of demographics, OH status, exposure levels and job characteristics, e.g. because of inclusion criteria? Does the study have sufficient statistical power?			
Performance Bias	Were there other changes occurring within the organisation/industry that could account for any observed change (e.g. organisational change, change in engineering/administrative or PPE controls)? Were participation incentives provided? Was participation voluntary or obligatory?			
Detection Bias	Were known confounders adequately controlled (e.g. measured as covariates, through inclusion, exclusion criteria)? Were appropriate outcome measures used? Were they of sufficient reliability (r>0.65) and validity (described, demonstrated or			

[7] *Antecendant (A), Mediator (Me), Moderator (Mo), Outcome (O)*

	referenced)? Were any subject reporting biases operating (e.g. beta change, social desirability). Were any author reporting operating?
Attrition Bias:	• Were any strategies used for controlling for attrition effects, e.g. (intention to treat analysis, drop out/retained comparison? • Can a healthy worker effect be ruled out? • Does the post intervention group systematically differ from the pre-intervention differ in characteristics (e.g. demographics, job characteristics, job status, resiliance) other than those that may be effected by the intervention (OH status, exposure levels) ?
Score: **4.** Four bias sources cannot be ruled out **3.** Three bias sources cannot be ruled out **2**. Two bias sources cannot be ruled out **1.** One bias sources cannot be ruled out. **0.** None of the main bias sources can be ruled out	

EVALUATION CHARACTERISTICS[8]

Level of Analysis

Measure	Outcome B, A, H, E, C or O (see table below)	Content Summary	Reliability	Validity	

Demographics collected							
Outcome type	**Behavioural**	**Attitudinal**	**Knowledge**	**Health Effect**	**Exposure Level**	**Cost-Effectiveness**	**Other**
Pre-Intervention	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**
Post-Intervention	**I :** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**
Control Group	**I :**	**I:**	**I:**	**I:**	**I:**	**I:**	**I:**

[8] *I = Inferential Statistic, P= Probability. ES=Effect Size*

	P: **ES:**	**P:** **ES:**	**P:** **ES:**	**P:** **ES:**	**P:** **ES:**	**P:** **ES:**	**P:** **ES:**
Follow-up	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**	**I:** **P:** **ES:**
Standard ES							

SCORING

EFFECTIVENESS			
Is the change in at least one of the exposure indicators (primary exposure indicator, health effects, behaviour/work practices statistically significant)	**Yes/No**	**Score:**	
Is one of these indicators objective (ie not reliant on self-report, observations or expert opinion)	**Yes/No**		
Is there a large effect size on at least one indicator for the between group comparison?	**Yes/No**	**Score:**	
Does the study have sufficient power	**Yes/No**	**Score:**	
Is there any triangulation of evidence (Are conceptually related dependent measures similarly effected by intervention (internal consistency)	**Yes/No**	**Score:**	
Was there a dose response relationship between intervention amount, and outcome change?	**Yes/No**	**Score:**	
Is there evidence of behaviour change at at least 6 months follow up?	**Yes/No**	**Score:**	
EFFECTIVENESS SCORE			
PROCESS			
Does the study use and underlying psychosocial theoretical model to plan the intervention?	**Yes/No**	**Score:**	
Does the study measure mediators or moderators of behavioural change?	**Yes/No**	**Score:**	
Do mediators and moderators behave as expected? E.g in right direction, dose response effects	**Yes/No**	**Score:**	
Does it isolate the mechanisms by which change occurred? I.e. conduct a components analysis to show relative contribution of intervention types & explain how that component exerted its effect?	**Yes/No**	**Score:**	
Does the intervention modify the environment?	**Yes/No**	**Score:**	
Does the method provide sufficient detail to enable replication?	**Yes/No**	**Score:**	
PROCESS SCORE			
QUALITY/GENERALIZABILITY			
BIASES (take score from page 4)		**Score:**	

GENERALIZABILITY

Does this study have internal validity? Yes/No

- **I.e. Have alternative explanations ruled out?**
- **Is there evidence of internal consistency (DV's behaving similarly, triangulation of evidence)**
- **Can the sample findings be generalised to the population from which it was selected?**

Does the study have external validity? Yes/no

- **i.e. Is the sample representative of the wider target population (in terms of hazard characteristics to which they are subjected)?**

Cost effectiveness?

Implications?

Other comments?

Total Score	

5.3 APPENDIX 3: EXCLUDED ARTICLES

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
Abrams, D.B., Boutwell, W.B., Grizzle, J., Heimendinger, J., Sorenson, G. & Varnes J. (1994) Cancer control at the workplace: The working well trial., *Preventative Medicine 23*, 1-13.		Yes	No behavioural indicator
Acosta, M.S.V., Chapman, P., Bigelow, P.L., Kennedy, C. & Buchan, R.M. (2005). Measuring success in a pesticide risk reduction program among migrant farmworkers in Colorado. *American Journal of Industrial Medicine 47,* 237-45.		Yes	No behavioural indicator
Agner, T. & Held, E. (2002). Skin protection programmes. *Contact Dermatitis, 47,* 253-256.	Yes		Not an intervention study
Allen, H.M.Jr., Borden, S.4th, Pikelny, D.B., Paralkar, S., Slavin, T., & Bunn, W.B.3rd. (2003). An intervention to promote appropriate management of allergies in a heavy manufacturing workforce: evaluating health and productivity outcomes. *Journal of Occupational and Environmental Medicine, 45,* 956-72.	Yes		Addresses seasonal allergies rather than occupational health hazards.
Allmers, H., Schmengier, J. & Skudlik, C. (2002). Primary prevention of natural rubber latex allergy in the German health care system through education and intervention. *Journal of Allergy and Clinical Immunology, 110,* 318-323.		Yes	No control group
Anderson, D.O. (1997). Limiting disocyanate exposure. *Occupational Health and Safety, 66,* 52-54.	Yes		Not an intervention
Arcury, T.A., Quandt, S.A., Austin, C.K., Preisser, J. & Cabrera, L.F. (1999). Implementation of EPA's Worker Protection Standard training for agricultural Laborer: an evaluation using North Carolina data. *Public Health Reports, 114,* 459-68.	Yes		Training needs analysis rather than behavioural intervention.
Augusto, L.G., Fontbonne, A., De Carvalho, E.M. & Novaes, T.C. (1999). Socio-medical intervention in occupational health: benzenism in Brazil. *International Journal of Occupational and Environmental Health, 5,* 20-5.	Yes		Not a behavioural intervention with a pre-post intervention comparison.
Austin, C., Arcury, T.A., Quandt, S.A., Preisser, J.S., Saavedra, R.M. & Cabrera, L.F. (2001). Training farmworkers about pesticide safety: issues of control. *Journal of .Health Care Poor Underserved 12,* 236-49.	Yes		Not a behavioural intervention with a pre-post intervention comparison.

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
Bauer, A., Bong, J., Coenraada, P.J., Elsner, P., English, J. & Williams, H.C. (2003). Interventions for preventing occupational irritant hand dermatitis. *The Cochrane Database of Systematic Reviews*, 3, Art. No.: CD004414. DOI: 10.1002/14651858.CD004414.	Yes		Not an intervention. This is a protocol for conducting a literature review.
Becker, P. & Morawetz, J. (2004). Impacts of Health and Safety Education: comparison of Worker Activities Before and After Training *American Journal of Industrial Medicine, 46*, 63-70.		Yes	No control group
Bellows, J & Rudolph, L (1993). The Initial Impact of a workplace lead poisoning prevention project. *American Journal of Public Health 83,* 406-410.	Yes		No before and after comparison. Plus this is more about monitoring and actual surveillance than actual preventive action such as PPE use.
Benjamin, K., Beswick, J., Smith, P., Sreenivasan, B. & Travis, K. (2002). Review of Training Provided to Asbestos Removal Workers. *HSL report* WPS/02/06.	Yes		Not an intervention study
Bewington, J.G. (1989). *Implementation of health promotion and disease prevention activities in industrial organizations*. The University of North Carolina at Chapel Hill, Ph.D. 195.			NOT AVAILABLE
Binkley, H.M., Schroyer, T. & Catalfano, J. (2003). Latex allergies: A review of recognition, evaluation, management, prevention, education, and alternative product use. *Journal of Athletic Training,38,* 133.	Yes		Not an intervention. A review of preventative strategies for latex allergies.
Bly, J.L., Jones, R.C. & Richardson, J.E. (1986). Impact of worksite health promotion on health care costs and utilization. Evaluation of Johnson and Johnson's Live for Life program. *Journal of American Medical Association, 256,* 3235-40.	Yes		A health promotion intervention that does not address behavioural compliance with health and safety precautions for dermal or respiratory hazards.
Bogon, D. A. & Daunton, B. (2003). The Effectiveness of control measures for isocyanates in motor vehicle repair. *HSL Internal Report.*	Yes		This is not an intervention, it is an information gathering exercise.

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
Bracker, A., Blumberg, J., Hodgson, M. & Storey, E. (1999). Industrial hygiene recommendations as interventions: a collaborative model within occupational medicine. *Applied Occupational and Environmental Hygiene*, 14, 85-96.	Yes		Not a behavioural intervention. Concerns a survey evaluating the usefulness of worksite visits by industrial hygienists.
Breathe easy: training programme (1999). *Occupational and Environmental Medicine, 56,* 789-90.	Yes		Not an intervention. Discusses training.
Britt, M., Chrislip, D., Bayer, S., Cole, H., Kid, P., Parshall, M., Isaacs, S., Struttman, T., Colligan, M. & Scharf, T. (1999). Farm work planning simulation in multi-media: a comparative evaluation. *American Journal of Industrial Medicine, Suppl. 1* 113-115.	Yes		Not a report of a study. It is a proposal of intended research
Brosseau, L.M. & Parker, D.L. (2002). Designing intervention effectiveness studies for occupational health and safety: The Minnesota wood dust study. *American Journal of Industrial Medicine, 41*, 54-61.	Yes		Results of intervention not discussed
Brown, T. & Rushton, L. (2003). The development of risk reduction strategies for the prevention of dermatitis in the UK printing industry. *HSE Research Report 158*	Yes		Not an intervention study
Brown, T. (2004). Strategies for prevention: occupational contact dermatitis. *Occupational Medicine, 54,* 450-457.		Yes	No control group
Bryant, C.J., Cole, H.P., Umberger, G.H., Kwak, E., Ruch, W.E. & Colligan, M.J. (1992). Evaluative research and methods development for the assessment of training effectiveness in occupational respiratory protection. *Scandinavian Journal of Work Environment and Health,* 18, 66-8.	Yes		Not about behavioural compliance. Only measures if knowledge increased, not if behaviour changed. No behavioural measures.
Buranatrevedh, S. & Sweatsriskul, P. (2005). Model development for health promotion and control of agricultural occupational health hazards and accidents in Pathumthani, Thailand. *Industrial Health, 43,* 669-76.		Yes	No Behavioural indicator
Buzzetti, A.J., Greene, F. & Needham, D. (2005). Impact of Lead-Safe Training Program on Workers Conducting Renovation, Painting, and Maintenance Activities. *Public Health Reports, 120,* 25-30.		Yes	No control group

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
Carrozzi, F.M., Katelaris, C.H., Burke, T.V & Widmer, R.P. (2002). Minimizing the risks of latex allergy: the effectiveness of written information. *Australian Dental Journal, 47,* 237-40.	Yes		No before/after comparison. Addresses latex allergy management rather than prevention/
Chambers, H., Sandys, V. & Piney, M. (2005). Effectiveness of control measures during use of isocyanate containing paints in motor vehicle repair at Hartwells. *HSL Report OH/2005/02.* RESTRICTED.	Yes		No before and after comparison. Not a behavioural intervention.
Chen et al (1998). Evaluation of a safety educational programme for the prevention of pesticide poisonong. *Medicina del Lavoro 89,* 591-598.		Yes	No control group
Cole, B.L. & Brown, M.P. (1996). Action on worksite health and safety problems: a follow-up survey of workers participating in a hazardous waste worker training program. *American Journal of Industrial Medicine, 30,*730-43.	Yes		No base line/ pre-intervention data collected
Collins, A. (2003). Health and safety in the rubber industry: A guide to training. *HSL Report* RAS/03/13.	Yes		A training guide. No evaluation
Colton, C.E. (1993). Respiratory program develops training, fit-testing routines. Respiratory equipment minimizes exposure to potentially hazardous airborne contaminants. Occupational Health and Safety, 62, (5):54-7.	Yes		Not an intervention study
Creely, K.S., Leith, S., Graham, M.K., Cowie, H.A., Hughes, J., George, P. & Cherrie, J.W. (2003). *Effective communication of chemical hazard and risk information using a multimedia safety data sheet.* HSE RR072. HSE Books: Sudbury.		Yes	No Control Group
Donham, K.J., Merchant, J.A., Lassise, D., Popendorf, W.J. & Burmeister, L.F. (1990). Preventing respiratory disease in swine confinement workers: intervention through applied epidemiology, education, and consultation. *American Journal of Industrial Medicine,18,* 241-61.		Yes	No control group
Earnest, G.S., Ewers, L.M., Ruder, A.M., Petersen, M.R. & Kovein, R.J. (2002). An evaluation of retrofit engineering control interventions to reduce perchloroethylene exposures in dry-cleaning shops. *Applied Occupational and Environmental Hygiene, 17,*104-11.	Yes		Not a behavioural intervention

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
Eckerman, D.A., Lundeen, C.A., Steele, A., Fercho, H.L., Ammerman, T.A. & Anger, W.K. (2002). Interactive training versus reading to teach respiratory protection. *Journal of Occupational Health Psychology, 7,* 313-23.		Yes	No behavioural measures
Elms, J., Robinson, E., Rahman, S. & Garrod, A. (2004). Exposure to Flour Dust in UK Bakeries and Current use of Control Measures. *Annals of Occupational Hygiene,49,* 85-91.	Yes		Not an Intervention. Assesses current exposure and practice.
Enander, R.T., Gute, D.M. & Missaghian, R. (1998). Survey of Risk Reduction and Pollution Prevention Practices in the Rhode Island Automotive refinishing Industry. *American Industrial Hygiene Association Journal 59,* 478-489.	Yes		A survey of pollution prevention, environmental control practices and occupational health in a Rhode Island automotive refinishing industry sector. Not an intervention.
Ewers, L.M., Ruder, A.M., Petersen, M.R., Earnest, G.S., & Goldenhar, L.M. (2002). Effects of retrofit emission controls and work practices on perchloroethylene exposures in small dry-cleaning shops. *Applied Occupational and Environmental Hygiene, 17,* 112-20.	Yes		Not a behavioural intervention.
Ferguson, K.J. & Scharf, T. (1996). Intervention research in agriculture: examples from the swine confinement and respiratory health project. *American Journal of Industrial Medicine, 29*, 382-3.	Yes		Not an intervention. Discusses the effectiveness of Health and Safety education interventions for agricultural audiences.
Flocks, J., Clarke, L., Albrecht, S., Bryant, C., Monaghan, P. & Baker, H. (2001). Implementing a community-based social marketing project to improve agricultural worker health. *Environmental Health Perspectives, 109,* 461-8.	Yes		Not an intervention. Provides advice on implementing a community social-marketing intervention.
Gannon, P.F.G., Berg, A.S., Gayosso, R., Henderson, B., Sax, S.E. & Willems, H.M.J. (2005). Occupational asthma prevention and management in industry - an example of a global programme. *Occupational Medicine, 55,* 600-605.	Yes		Not an Intervention. No before and after comparison.
Ghosh, S.K., Gokani, V.N., Parikh, J.R., Doctor, P.B., Kashyap, S.K. & Chatterjee, B.B. (1987). Protection against 'green symptoms' from tobacco in Indian harvesters: A preliminary	Yes		Not about behavioural compliance. Compares two types

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
intervention study. *Archives of Environmental Health, 42,* 121-23.			of PPE
Glasgow, R.E., Terborg, J.R., Hollis, J.F., Severson, H.H. & Boles, S.M. (1995). Take Heart: Results from the initial phase of a worksite wellness program. *American Journal of Public Health, 85,* 209-216.	Yes		Not a worksite hazard = general health hazard associated with smoking, lack of exercise and poor diet.
Gomes, J., Lloyd, O.L. & Revitt, D.M. (1999). The influence of personal protection, environmental hygiene and exposures to pesticides on the health of immigrant farm workers in a desert country. *International Archives of Occupational and Environmental Health, 72,* 40-5.	Yes		Not an intervention study. Assesses PPE usage.
Held, E., Wolff, C., Gyntelberg, F. & Agrer, T. (2001). Prevention of work related skin problems in student auxiliary nurses: An intervention study. *Contact Dermatitis, 44,* 297-303.			NOT OBTAINED
Heumann, M. (2003). *Model occupational dermatitis surveillance/interventions.* Final Grant Report, National Institute for Occupational Safety and Health.			NOT OBTAINED
Hewitt, A.M. (1993). *The impact of continuing medical education on occupational physicians' and nurses' preventive pulmonary knowledge, attitude, practices and worksite environments.* Temple University PhD, p327.			NOT AVAILABLE
Heron, R.J. (1997). Worker education in the primary prevention of occupational dermatoses. *Occupational Medicine, 47,* 407-10.		Yes	No Control group
Hibbs, B.F. (1994). Chemical exposure evaluation and intervention for occupational health nurses. *American Association of Occupational Health Nurses Journal, 42,* 284-9, 296-9.	Yes		Not a before and after comparison, it is a discussion paper on the role of the occupational health nurse in chemical exposure cases. Not an intervention study.,
Hillert, L., Savlin, P., Levy Berg, A., Heidenberg, A. & Kolmodin-Hedman, B. (2002). Environmental illness--effectiveness of a salutogenic group-intervention programme. *Scandinavian Journal of Public Health, 30,* 166-75.	Yes		Environmental illness not occupational.,
Hunt, J. & Murphy, C. (2004). Measurement of	Yes		Blood borne

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
nursing staff occupational exposures in the operating suite following introduction of a prevention program. *Australian Infection Control, 9,* 57-60, 62-3.			pathogens/body substance splashes
Hunt, M.K., Lederman, R., Stoddard, A.M., LaMontagne, A.D., McLellan, D., Combe, C., Barbeau, E. & Sorensen, G. (2005). Process evaluation of an integrated health promotion/occupational health model in WellWorks-2. *Health Education & Behavior, 32*, 10-26.	Yes		Cross sectional study - comparison of health promotion. Health promotion plus occupational health and safety intervention. No pre intervention assessment.
Hynes, H.P., Maxfield, R., Carroll, P. & Hillger, R. (2001). Dorchester Lead-safe yard project: a pilot program to demonstrate low-cost, on-site techniques to reduce exposure to lead-contaminated soil. *Journal of Urban Health, 78*, 199-211.	Yes		Not occupational based
Illesley, S. & Borthwick, A.M. (2002). Respiratory protective mask effectiveness: a study of attitudes, beliefs and behaviour. *British Journal of Podiatry, 5,* 15-8.	Yes		Not a before and after comparison. Monitors PPE use and gains views via questionnaire
Janer, G., Sala, M. & Kogevinas, M. (2002). Health promotion trials at worksites and risk factors for cancer. *Scandinavian Journal of Work, Environment and Health, 28,* 141-157.	Yes		Does not address dermal/respiratory occupational health hazards.
Jansson, B. & Haglund B. (1991). Intervention strategies directed at exposure to organic solvents at worksites: a case study. *Journal of Primary Intervention, 11,* 295-317.	Yes		Not an intervention.
Jones, M.S., Bussey, D. & Morgan, C. (2000). Educational innovations: community-based nursing education at the campsite - Farm Safety Day Camps. *Journal of Nursing Education, 39,* 283-4.	Yes		A report on a regular event aimed at educating children who live on farms, on farm safety. No before and after evaluation detailed.
Kalimo, K., Kautiainen, H. Niskanen, T. & Niemi, L. (1999). 'Eczema school' to improve compliance in an occupational dermatology clinic. *Contact Dermatitis, 41,* 315-9.	Yes		Secondary prevention for participants with occupational skin disease.
Keifer, M.C. (2000). Effectiveness of interventions in reducing pesticide overexposure and poisonings. *American Journal of Preventive Medicine, 18,* 80-89.	Yes		Not an intervention. A literature review of working methods of exposure control methods (excluding

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
			behavioural).
LaMontagne, A.D., Kelsey, K.T., Ryan, C.M. & Christiani, D.C. (1992). A participatory workplace health and safety training program for ethylene oxide. *American Journal of Industrial Medicine, 22,* 651-64.	Yes		Does not evaluate an intervention.
LaMontagne, A.D., Oakes, J.M. & Lopez Turley, R.N. (2004) Long-term ethylene oxide exposure trends in U.S. hospitals: relationship with OSHA regulatory and enforcement actions. *American Journal of Public Health, 94*, 1614-9.	Yes		Study looks at how well exposures are controlled and assesses areas that need intervention - not an intervention
LaMontagne, A.D., Youngstrom, R.A., Lewiton, M., Stoddard, A.M., Perry, M. J., Klar, J.M., Christiani, D.C. & Sorensen, G. (2003). An exposure prevention rating method for intervention needs assessment and effectiveness evaluation. *Applied Occupational and Environmental Hygiene, 18*, 523-34.	Yes		Not a behavioural intervention. Examines changes in exposure following introduction of a standard.
Langard, S. (1994). Identification and prevention of work - and environment - related individual a priori disease risks. *Advances in Modern Environmental Toxicology, 23,* 21-32.	Yes		Not a behavioural intervention
Latza, U., Haamann, F. & Baur, X. (2005). Effectiveness of a nationwide interdisciplinary preventive programme for latex allergy. *International Archives of Occupational and Environmental Health, 78,* 394-402.		Yes	No control group
Lipkus, I.M., Skinner, C.S., Dement, J., Pompeii, L., Moser, B., Samsa, G.P. & Ransohoff, D. (2005). Increasing colorectal cancer screening among individuals in the carpentry trade: test of risk communication interventions. *Preventive Medicine, 40,* 489-501.	Yes		Aimed at increasing co rectal screening rather than compliance with health and safety practices
Lipscomb, H.J. (2000). Effectiveness of interventions to prevent work-related eye injuries. *American Journal of Preventive Medicine, 18*, 27-32.	Yes		Accident generated eye injuries, rather than exposure to an occupational health hazard.
Liss, G.M. & Tarlo, S.M. (2001). Natural rubber latex-related occupational asthma: Association with interventions and glove changes over time. *American Journal of Industrial Medicine, 40,* 347-353.	Yes		No before and after comparison
Lormphongs, S., Morioka, I., Miyai, N., Yamamoto, H., Chaikittiporn, C., Thiramanus, T. & Miyashita, K. (2004). Occupational Health Education and Collaboration for Reducing the Risk of Lead poisoning of Workers in a Battery		Yes	No control group

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
Manufacturing Plant in Thailand. *Industrial Health, 42,* 440-445.			
Lusk, S.L., Kerr, M.J., Ronis, D.L. & Eakin, B.L. (1999). Applying the health promotion model to development of a worksite intervention. *American Journal of Health Promotion, 13,* 219-27.	Yes		Concerns hearing problems. Does not address respiratory or dermal hazards.
Maes, S., Verhoeven, C., Kittel, F. & Scholten, H. (1998). Dutch work-site wellness health program: The Brabrantia Project. *American Journal of Public Health, 88,* 1037-41.	Yes		Not a dermal/respiratory hazard
Mancini, G., Baldasseroni, A., Laffi, G., Curti, S., Mattioli, S. & Violante, F.S. (2005). Prevention of work related eye injuries: long term assessment of the effectiveness of a multi-component intervention among metal workers. *Occupational and Environmental Medicine, 62,* 830-835.	Yes		Focuses on injuries from accidents as opposed to dermal or respiratory health hazards per se.
Maples, T.W., Jacoby, J.A., Johnson, D.E., Ter Haar, G.L. & Buckingham, F.M. (1982). Effectiveness of employee training and motivation programs in reducing exposure to inorganic lead and lead alkyls. *American Industrial Hygiene Association Journal, 43,* 692-94.			
Marcus, A.C., Baker, D.B., Froines, J.R., Brown, E.R., McQuiston, T. & Herman, N.A. (1986). ICWU cancer control education and evaluation program: Research design and needs assessment. *Journal of Occupational Medicine 28,* 226-36.	Yes		Reports baseline data only
Mastrangelo, G., Grange, J.M., Fadda, E., Fedeli, U., Fedeli, U., Buja, A. & Lange, J.H. (2005). Lung cancer risk: effect of dairy farming and the consequence of removing that occupational exposure. *American Journal of Epidemiology, 161,* 1037-46.	Yes		Not a behavioural related intervention.
Mata, A. (1999). Pesticide safety training - Implementation of EPA's Worker Protection Standard safety training for agricultural laborers: an evaluation using North Carolina data. *Public Health Reports, 114,* 459-68.			NOT OBTAINED
Materna, B.L., Harrington, D., Scholz, P., Pagne, S.F., Stubbs, H.A., Hipkins, K., Merideth, E., Kirsch, L., Lomax, G., Coyle, P. & Uratsu, C. (2002). Results of an intervention to improve lead safety among painting contractors and their employees. *American Journal of Industrial Medicine, 41,* 119-30.		Yes	No Control Group

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
McCullum, D.M., Conaway, M.B., Drury, S., Braune, J. & Reynolds, S.J. (2005). Safety-related knowledge and behavior changes in participants of farm safety day camps. *Journal of Agricultural Safety and Health, 11,* 35-50.		Yes	No control group
McDiarmid, M. & Curbon, B. (1992). Risk communication and surveillance approaches for workplace reproductive hazards. *Journal of Occupational Medicine and Toxicology, 1,* 63-74.	Yes		Not an intervention.
Meeker, B.J., Carruth, A. & Holland, C.B. (2002). Health hazards and preventive measures of farmwomen. *American Association of Occupational Health Nurses Journal, 50,* 307-315.	Yes		Not an intervention.
Merchant, J.A., Lumsden, J.C., Kilburn, K.H., O'Fallon, W.M., Copeland, K., Germino, V.H., McKenzie, W.N., Baucom, D., Currin, P. & Stilman, J. (1974). Intervention studies of cotton steaming to reduce biological effects of cotton dust. *British Journal of Industrial Medicine, 31,* 261-74.	Yes		Not a behavioural intervention.
Merler, E., Buiatti, E. & Vainio, H. (1997). Surveillance and intervention studies on respiratory cancers in asbestos-exposed workers. *Scandinavian Journal of Work Environment and Health, 23*, 83-92.	Yes		Not a behavioural intervention.
Michaels, D., Zoloth, S., Berstein, N., Kass, D. & Schrier, K. (1992). Workshops are not enough: making Right-to-Know training lead to workplace change. *American Journal of Industrial Medicine, 22,* 637-49.		Yes	Not a behavioural Indicator
Moonen, I.P.P., Van-der-Rijt, G.A.J., Van-Koppen, K.F.C.J. & Van-der-Gulden, J.W.J. (1995). Evaluation of an information campaign about working safely with carcinogenic substances. *Safety Science, 21,* 131-44.		Yes	No control group
Moongtui, W., Gauthier, D.K. & Turner, J.G. (2000). Using peer feedback to improve hand washing and glove usage among Thai health care workers. *American Journal of Infection Control 28,* 365-9.	Yes		Concerns blood borne pathogen exposure
Mpofu, D., Lockinger, L., Bidwell, J. & McDuffie, H.H. (2002). Evaluation of a respiratory health program for farmers and their families. *Journal of Occupational and Environmental Medicine, 44,* 1064-74.	Yes		Not a behavioural intervention
Mullan, P.B., Gardiner, J.C., Rosenman, K., Zhu, Z. & Swanson, G.M. (1996). Skin cancer	.		NOT OBTAINED

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
prevention and detection practices in a Michigan farm population following an educational intervention. *Journal of Rural Health, 12,* 311.			
National Institute for Occupational Safety and Health (1978). *Health and safety guide for masonry, stonework, tile setting, insulation and plastering contractors.* Cincinnati, DHEW (NIOSH) Publication No. 78-208.	Yes		Health and safety manual not an intervention
Neuberger, M. Ambrosch, P. & Kundi, M. (1985). Prevention of occupational cancer in the asbestos cement industry (preliminary report) *Zentralblatt fur Bakteriologie, Mikrobiologie, und Hygiene [B], 181,* 81-6.	Yes		Article not in English
Nicholson, P.J., Cullinan, P., Taylor, A.J.N., Burge, P.S. & Boyle, C. (2005). Evidence based guidelines for the prevention, identification and management of occupational asthma. *Occupational and Environmental Medicine, 62,* 290-9.	Yes		A systematic review. Does not encompass behavioural interventions.
Niewohner, J., Cox, P., Gerrard, S. & Pidgeon, N. (2004). Evaluating the efficacy of a mental models approach for improving occupational chemical risk protection. *Risk Analysis, 24,* 349-61.	Yes		Does not measure Health and Safety behavioural compliance related outcomes.
Nurminen, M. & Hernberg, S. (1985). Effects of intervention on the cardiovascular mortality of workers exposed to carbon disulphide: a 15-year follow-up. *British Journal of Industrial Medicine, 42,* 32-5.	Yes		Not a behavioural intervention. Concerns transfer of symptomatic workers to exposure-free work areas.
O'Hara, R. (2005). Evaluation of four pilot Safety and Health Awareness Days (SHADs) for motor vehicle paint sprayers - DRAFT COPY. *HSL Report RAS/05/DRAFT.*	Yes		Study aims to investigate the best way of conveying risk information in a specific context. It is not an intervention.
O'Hara, R., Davies, T. & Sandys, V. (2006). Evaluating the impact of the Pilot Bristol Safety and Health Awareness Day (SHAD) on motor vehicle repair bodyshops' control of health risks. *HSL Report SOFS/06/2.*	Yes		No baseline measure.
O'Hara, R., Williamson, J., Walsh, P. & Clark, R. (2004, November). *Risk visualisation: A tool for communicating information about workplace hazards.* Paper presented at the European Association of Occupational Health Psychology Conference, Lisbon.		Yes	No Control Group
Porru, S., Donato, F. Apostoli, P., Coniglio, L.		Yes	No Control Group

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
Duca, P. & Alessio, L. (1993). The utility of health education among lead workers - the experience of one program. *American Journal of Industrial Medicine, 23,* 473-81.			
Quandt, S.A., Arcury, T.A., Austin, C.K. & Cabrera, L.F. (2001). Latino immigrants: preventing occupational exposure to pesticides using participatory research with Latino farm workers to develop an intervention. *Journal of Immigrant Health, 3*, 85-96.	Yes		Not a behavioural intervention. A training needs assessment. No before-after comparison
Quinlan, R., Kowalczyk, G., Gardiner, K. & Calvert, I. (1995). Exposure to polycyclic aromatic hydrocarbons in coal liquefaction workers: impact of a work wear policy on excretion of urinary 1-hydroxypyrene. *Occupational and Environmental Medicine, 52,* 600-5.	Yes		Not about behavioural compliance. Compares two types of work wear.
Rao, P.L. (2004). Training effects on health and safety-related self-efficacy beliefs among hazardous waste site workers and emergency responders. *Dissertation Abstracts International: Section B: The Sciences and Engineering, 65*, 2353.	Yes		Does not evaluate an intervention
Rautianen, R. & DeRoo, L.A. (2001). Effectiveness of farm safety interventions. Using Past and Present to Map Future Actions. *Proceedings of Agricultural Safety and Health, Baltimore, MD, 200.*			
Rosen, G., Andersson, I.M., Walsh, P.T., Clark, R.D.R., Saamanen, A., Heinonen, K., Riipinen, H., & Paakkonen, R. (2005). A review of video exposure monitoring as an occupational hygiene tool. *Annals of Occupational Hygiene, 49*, 201-217.	Yes		No pre-post intervention comparison
Sadhra, S., Holloway, S., Jackson. C. & Foulds, I. (2005). Development of a field method for the assessment of the effectiveness of barrier creams in preventing skin irritation reactions. *HSE Research Report 300*	Yes		Not a behavioural intervention.
Schurer, N. Y., Klippel, U. & Schwanitz, H.J. (2005). Secondary individual prevention of hand dermatitis in geriatric nurses. Int Arch Occup Environ Health 78: 149-157	Yes		A secondary Intervention for pre existing occupational dermatitis.
Schwanitz, H.J., Riehl, U., Schlesinger, T., Bock, M., Skudlik, C. & Wulfhorst, B. (2003). Skin care management: educational aspects. *International Archives of Occupational and Environmental Health, 76*, 374-81.		Yes	No behavioural Indicator

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
Sell, L., Flyvholm, M.A., Lindhard, G. & Mygind, K. (2005). Implementation of an occupational skin disease prevention programme in Danish cheese dairies. *Contact Dermatitis, 53*, 155-61.		Yes	No control group
Shipp, E.M., Cooper, S.P., Burau, K.D. & Bolin, J.N. (2005). Pesticide safety training and access to field sanitation among migrant farmworker mothers from Starr County, Texas. *Journal of Agricultural Safety and Health, 11,* 51-60.	Yes		Not an intervention study
Silverstein, M., Dodey, P. & Long, M. (1987). *Evaluation of workplace cancer control education.* Detroit United Automotive Workers International Union.			NOT OBTAINED
Skov, T. & Kristensen, T.S. (1996). Etiologic and prevention effectiveness intervention studies in occupational health. *American Journal of Industrial Medicine, 29,* 378-81.	Yes		Discussion document of distinction between etiologic and prevention effectiveness studies. Not an intervention.
Skulberg, K.R., Skyberg, K., Kruse, K., Eduard, W., Djupesland, P., Levy, F. & Kjuus, H. (2004). The effect of cleaning on dust and the health of office workers: an intervention study. *Epidemiology, 15*, 71-8.	Yes		Not a behavioural intervention. Evaluates different cleaning regimes.
Vela Acosta, M., Chapman, P., Bigelo, P.L., Kennedy, C. & Buchan, R.M. (2005). Measuring Success in a Pesticide Risk Reduction Program Among Migrant Farmworkers in Colorado. *American Journal of Industrial Medicine, 47,* 237-245.		Yes	No behavioural indicator
Sorensen, G., Himmelstein, J.S., Hunt, M.K., Youngstrom, R., Hebert, J.R., Hammond, S.K., Palombo, R., Stoddard, A. & Ockene, J.K. (1995). A model for worksite cancer prevention: integration of health protection and health promotion in the WellWorks Project. *American Journal of Health Promotion, 10,* 55-62.	Yes		Article written before final data collection, unable to comment on effectiveness of strategy
Sorensen, G., Stoddard, A., Ockene, J.K., Hunt, M.K. & Youngstrom, R. (1996). Worker participation in an integrated health promotion/health protection program: results from the WellWorks project. *Health Education Quarterly, 23,* 191-203.	Yes		No pre-post intervention comparison.
Sorenson, G., Stoddard, A., Hunt, M.K., Herbert, J.R., Ockene, J.K., Spitz Avrunin, J., Himmelstein, J. & Hammond, S.K. (1998). The	Yes		Does not measure Health and safety behavioural

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effects of health promotion-health protection intervention on behavior change: the WellWorks study. *American Journal of Public Health, 88,* 1685-90.			compliance related outcomes.
Sorenson, G., Stoddard, A.M., LaMontagne, A.D., Emmons, K., Hunt, M.K., Youngstrom, R., McLellan, D. & Christiani, D.C. (2003). A comprehensive worksite cancer prevention intervention: behavior change results from a randomized control trial (United States). *Journal of Public Health Policy, 24,* 5-25.		Yes	No behavioural indication
Sorenson, G., Thompson, B., Glanz, K., Feng, Z., Kinne, S., DiClemente, C., Emmons, K., Heimendinger, J., Probart, C. & Lichtenstein, E. (1996). Work site-based cancer prevention: Primary results from the working well trial., *American Journal of Public Health, 86,* 939-47.	Yes		Does not focus on occupational dermal or respiratory hazards
Tarlo, S.M., Easty, A., Eubanks, K., Parsons, C.R., Min, F., Juvet, S. & Liss, G.M. (2001). Outcomes of a natural rubber latex control program in an Ontario teaching hospital., *Journal of Allergy and Clinical Immunology, 108,* 628-33.	Yes		Not a behavioural intervention. Concerns replacement of powdered gloves.
Thayer, P.A. (2003). Practice tip. Remember the rainbow - an educational tool for respiratory mask fit testing. *American Association of Occupational Health Nurses, 51,* 336.	Yes		Not an evaluation study
Tillett, S., Ringen, K., Schulte, P., McDougall, V., Miller, K. & Samuels, S. (1986). Interventions in high-risk occupational cohorts: a cross-sectional demonstration project. *Journal of Occupational Medicine, 28,* 719-27.	Yes		Not a behavioural intervention. Discusses occupational health screening methods.
Tompa, A., Jakab, M.G. & Major, J. (2005). Risk management among benzene-exposed oil refinery workers. *International Journal of Hygiene and Environmental Health, 208,* 509-16.	Yes		Evaluates exposure to assess the need for intervention
Vainio, H. & Hemminki, K. (1991). Use of exposure information and animal cancer data in the prevention of environmental and occupational cancer. *Cancer Detection and Prevention, 15,* 7-16.	Yes		Not a behavioural intervention. Represents info on carcinogenic risk of different agents based on animal data.
Vainio, H. & Staymer, L. Can health promotion at the workplace help prevent cancer? (2002). *Scandinavian Journal of Work, Environment and Health, 28,* 137-139.	Yes		Secondary data. Health Promotion focuses on lifestyle.
Verma, D.K., Purdham, J.T. & Roels, H.A.	Yes		Not an intervention.

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
(2002). Translating Evidence about Occupational Conditions into Strategies for Prevention. *Occupational and Environmental Medicine, 59,* 205-214.			Includes case examples to illustrate previous experiences in introducing preventative control strategies. A discussion paper rather than before and after comparison of a specific intervention.
Walz, J.A. & Wehse, K.L. (2002). Wellness for welders: prevention strategies. *American Association of Occupational Health Nurses Journal, 50,* 303-6.	Yes		Not an intervention.
Weinger, M. & Lyons, M. (1992). Problem solving in the fields: an action-orientated approach to farmworker education about Pesticides. *American Journal of Industrial Medicine, 22,* 677-90.	Yes		No before-after comparison.
Wells, D. & Greenall, A. (2005). Evaluating the effectiveness of legislation, technology and working methods for reducing occupational exposure in the foundry industry. *HSE Research Report 374.*	Yes		Not an intervention
Weyman, A. & Goddard, H. (1996). Evaluation of the asbestos awareness campaign. *HSL Report EWP/96/25* –Restricted.	Yes		Not a before and after intervention.
White, C.M. & Berger, M.C. (1992). Using force field analysis to promote use of personal protective equipment. *Infection Control and Hospital Epidemiology, 13,* 752-5.	Yes		Concerns universal precautions.
White Queen Safety Strategies (2005). Enhancing chemical risk control for reducing exposure in the workplace through advanced risk messaging techniques. *HSE Research Report 354.*	Yes		No before or after measurement
Wigger-Alberti, W., Maraffio, B., Wernli, M. & Elsner, P. (1997). Training workers at risk for occupational contact dermatitis in the application of protective creams: Efficacy of a fluorescence technique. *Dermatology, 195,* 129-133.		Yes	No control group
Williams, M.G. Jr., & Crossman, R.N. Jr. (2003). Asbestos release during removal of resilient floor covering materials by recommended work practices of the Resilient Floor Covering Institute. *Applied Occupational*	Yes		Not a behavioural intervention

Paper title	Excluded at 1st sift?	Excluded at 2nd sift?	Reason for exclusion
and Environmental Hygiene, 18, 466-78.			
Zohar, D. (1980). Promoting the Use of Personal Protective Equipment by Behavior Modification Techniques. *Journal of Safety Research, 12,* 78-85.	Yes		Not a respiratory/dermal hazard