ORIGINAL ARTICLE

Workers' understanding of chemical risks: electroplating case study

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Occup Environ Med 2002;**59**:689–695

Background: There is limited research concerning how small companies in particular, respond to health and safety messages.

Aims: To understand individuals' knowledge and beliefs about chemical risks and to compare these with those of experts.

Methods: The use of chromic acid in particular, and also other chemicals associated with chrome plating were studied. All chromium plating firms were based in the West Midlands. The methodology involved initial face to face interviews (n = 21) with chromium platers, structured questionnaires (n = 84) to test the prevalence of beliefs identified in the interviews, an expert questionnaire, and a workshop to discuss findings. The responses of platers were compared with those of occupational health and safety experts.

Results: Although chromium platers appeared to understand the short term adverse effects of the chemicals to which they are exposed, their understanding of long term, or chronic effects appeared to be incomplete. They had good knowledge of acute effects based primarily on experience. Platers were aware of the hazardous nature of the chemicals with which they work, but did not draw distinction between the terms "hazards" and "risks". They had difficulties articulating the effects of the chemicals and how exposure might occur; although it is inappropriate to equate this with lack of knowledge. A significant minority of platers displayed deficiencies in understanding key technical terms used in Safety Data Sheets.

Conclusions: This study provides a method which can be used to gain some understanding of workers' knowledge and beliefs about risks that they are exposed to in the workplace. The study also identifies gaps between the platers' knowledge and beliefs and those of experts. New risk information needs to be designed which addresses the information needs of platers using language that they understand.

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Accepted 12 March 2002

Communication, as a vehicle for attitude change, is known to be a key organisational process—organisations with good safety records generally have effective communication systems. However, communication in this context covers a range of activities—formal and informal, defined activities, and communication that is an inherent part of the management structure and culture.¹ Written communication is one element of these activities. Indeed, definitions of risk communication now stress a two way process of listening and engaging people rather than simply a one way process of information provision from "expert" to any other party.² The goal of risk communication is more than just imparting scientific facts. It is also about ensuring that people understand fully the hazards and risks and that they are able to make informed decisions under conditions of uncertainty.³ It is argued that risk communication has no value unless it actually informs or changes behaviour in order to ensure safety; therefore, it is about "winning hearts and minds".⁴

The following are important: (1) the credibility, skill, and knowledge of the communicator⁵; (2) the relevance of the message to the needs and circumstances of the receiver, and the perceived importance of the message; (3) the form in which the message is delivered (the power of face to face communication in the workplace being unchallenged⁶); (4) the characteristics of the receiver (including age, intelligence, personality); (5) the receiver's values, needs, and interests; (6) the extent and impact of safety subcultures⁷; and (7) safety attitudes, including familiarity with hazardous activities/tasks⁸ and organisational factors.^{9, 10}

Even when given the same information on workplace hazards, people's responses are known to vary. Differing

behavioural effects may result from differences in perception by different groups of employees, such as managerial and non-managerial groups, or groups that differ in experience, attitude, personality and skill, context, and hazard knowledge.^{4, 11–13} However, there has been relatively little work investigating the variables that underlie these broad factors.

To date the majority of research on risk communication in the UK has focused on larger companies. However, given that companies with less than 250 employees represent 99% of total businesses—38% in the size range of 10–249 employees, with micro firms (those with up to nine employees) representing about 60% of all businesses and employing 56% of all employees—it is right that focus should be on their information needs to ensure health and safety.

The conclusions of a workshop organised for the UK Health and Safety Executive in 1999¹⁴ were that formal risk messages might need to be tailored to meet the needs and understanding of the target audience. Small firms were considered to be a potential target in this respect, being perceived to be (1) isolated from guidance, and (2) reluctant to ask questions of regulators for fear of enforcement action relating to incorrect behaviour. Research relating to small and medium sized enterprises (SMEs) and the environment, which also partly addressed health and safety compliance attitudes,¹⁵ suggests

Abbreviations: COSHH, Control of Substances Hazardous to Health; HSE, Health and Safety Executive; MEL, maximum exposure limit; PPE, personal protective equipment; SEA, Surface Engineering Association; SMEs, small and medium sized enterprises

that small companies are unlikely to have specialist staff with dedicated health and safety functions, specialist chemical risk knowledge, and access to information.

There are numerous vehicles for formally communicating risks in the workplace; however, they have rarely been evaluated in terms of their impact on a specific audience's understanding, hazard warning labels being a notable exception.^{16, 17} There is a tendency to focus on distribution and awareness success as opposed to impact on attitudes and performance.

A key objective of this study was to understand how workers in small companies perceive chemical risks to which they are exposed, including their knowledge, attitudes, and understanding of health and safety information. The study concentrated on chemical related risk messages and control measures used to minimise risks, and particularly compared knowledge with information contained in chemical Safety Data Sheets. The aim was to identify any deficiencies in knowledge, which may affect behaviour. The study was funded by the UK Health and Safety Executive (HSE) and assisted by the trade body, the Surface Engineering Association (SEA).

METHODS

Selection of industrial sector and chemicals

Electroplating was chosen as the industrial sector for the study as most plating shops employ less than 20 people, and the health risks of the chemicals used are well established and documented. Chromium plating involves the use of chromic acid—that is, chromium in its hexavalent form as the electrolyte, which forms a mist during the plating process. Workers may also be exposed to chromic acid during weighing and mixing of acid powders, and during transfer of liquids and articles in to and from plating baths. Most chromium plating processes may precede acid/solvent cleaning and nickel plating; thus chrome platers may also be exposed to nickel compounds (nickel sulphate and nickel chloride, both as powders and mists) as well as organic solvents and mineral acids. Both chromic acid and nickel compounds are classified as category 1 carcinogens—that is, they have the potential to cause cancer in humans by inhalation.¹⁸ Studies have reported that chromium platers are at increased risk from lung cancer.^{19–21} Chromic acid also has the potential to cause respiratory irritation and sensitisation, severe burns and chrome ulcers by skin contact, serious eye damage from splashes, damage to the nasal septum, contact dermatitis, and kidney damage. Chromic acid has been assigned a maximum exposure limit (MEL) of 0.05 mg/m³ over an eight hour reference period. As well as toxicological effects, chromic acid is a strong oxidising agent. The HSE and the SEA have produced various health and safety guidance notes covering assessment of exposure, health surveillance, and the selection and effectiveness of control measures to minimise exposure to chromic acid.

Approximately 30% of the UK's surface engineering activities are based in the Midlands, the region selected as the focus of this study. The SEA provided a list of its West Midlands members who were involved in electroplating to assist in the identification of firms. Companies were contacted to establish whether they currently carry out chromium plating and the number of workers engaged in this activity. To facilitate interviews, companies with a minimum of four chromium platers were identified. Companies were selected randomly from this list.

Initial interviews

Initial face-to-face interviews were conducted in a small number of companies. The interviews were semistructured with a set of prompt questions to encourage the participants to (1) think about the nature of their job and their work environment, (2) talk about their view of themselves in relation to

their work risks, (3) describe the hazards that they thought they were exposed to, and (4) consider whether the risks identified are significant and ways in which they may be controlled or minimised. The interviews were tape recorded and transcribed so that individuals' own words and statements could be used to develop the subsequent questionnaire. In total, 21 interviews were conducted with platers and managers in eight companies. The interviews were stopped at 21 because no significant new comments or views were being heard.

Structured questionnaires for platers

The views expressed in the initial face-to-face interviews were used to develop and construct a structured questionnaire. The questionnaire was designed to determine the prevalence of the beliefs identified in the initial interviews among a larger sample of chromium platers. The questionnaire included questions relating to degree of agreement with a number of attitude statements that included those elicited in the initial interviews, using similar words as far as possible. These statements related to sources and consequences of exposure, perceived seriousness of harm, use of control measures, health and safety culture, and the credibility of information sources. A section included questions to test knowledge about hazards and risks as presented in various information sources such as Safety Data Sheets, trade association leaflets, and HSE chemical risks information. A further section comprised questions on the use of various sources of information and their relative usefulness.

The questionnaire was piloted with six platers interviewed in the initial phase plus health and safety advisers within the SEA and their consultants. Of the 54 firms contacted, 19 (35%) agreed to participate in this phase; in total, 170 questionnaires were delivered to the firms. Questionnaires were returned from 84 (49%) platers from 15 companies (two with less than 20 employees, 10 with between 20 and 50 employees, and three with over 50 employees).

The expert questionnaire

An expert questionnaire was designed to collect expert understanding of the risks of electroplating and also their perceptions of platers' understanding and plating shop safety practices. "Expert" was defined to include occupational health, hygiene, and safety expertise among individuals who either advise or inspect electroplating work premises. The expert group comprised registered consultant occupational hygienists and HSE inspectors. A total of 15 experts participated.

The questionnaire was designed as a two step process, the aim being to identify consensus views and also reasons for any disagreements, relating to topics covered in the questionnaire for the plating companies. The questionnaire focused on the chemical risks and the factors influencing their occurrence in small electroplating firms, safe work practices, use and effectiveness of control measures, and use and relevance of different safety information.

Workshop

The final step in the methodology was to bring together academics with an interest in chromium and risk communication methodologies and representatives of participating plating companies, trade associations, and the relevant HSE policy division and inspectorates. The discussion focused on the usefulness of chemical risk messages, the reasons for apparent differences between expert and plater knowledge and beliefs, and the need to design and test new risk messages to bridge the gaps in knowledge.

RESULTS

This section presents the findings of the initial platers' interviews and questionnaires and the expert questionnaires.

Table 1 Knowledge of chemical hazards for platers

Statement	% agree (no. responses)
1 Solvents may make your skin tingle but cause no harm	21 (82)
2 Chromic acid used in plating is not harmful because it is in dilute form	4 (80)
3 Chromic acid is more dangerous than nickel salts	86 (81)
4 Inhaling chrome mists can give you lung cancer	89 (79)
5 Chromic acid burns the skin	93 (82)
6 Nickel produces skin rashes	92 (80)
7 Chromic acid mist causes ulcers in the nose	96 (80)
8 Chrome stains on the skin are not harmful	17 (78)
9 Nickel causes cancer	57 (68)
10 There is no known safe limit for chromic acid mist in the atmosphere	56 (77)

The discussion focuses on the characteristics of the respondents, their knowledge and perception of the chemical risks, how platers acquire this knowledge, the relative importance of different sources of information, and attitudes towards the use of controls to minimise exposure to chemicals.

Characteristics of platers

From both the interviews and the questionnaires the workforce was identified to be predominantly male and very stable. Apart from one female managing director, all those interviewed were men. Of the valid questionnaire responses, 63% ($n = 79$) had worked in plating for 10 years or more, with 39% ($n = 79$) aged between 35 and 49 years, and 27% aged 50 and over. A total of 49% ($n = 83$) had worked in their present company for more than 10 years. Thirteen (16%) of the respondents ($n = 82$) were not native speakers of English; of these the majority identified Punjabi as their first language.

Of the 84 questionnaire respondents, 16 were managers (19%). There were 16 supervisors (19%), 35 platers (42%), 15 jiggers (18%), and two laboratory workers (2%). In small companies these job titles tend to be fluid, with most managers describing themselves as "hands on managers". A supervisor may also work as a plater, and a plater's function may include some metal preparation work, as well as loading and removing articles for plating (jigging). Given the relative small number of questionnaire respondents and the difficulties presented in grouping individuals by job titles, the main results are presented for all respondents (excluding the two technicians)—that is, $n = 82$, referred to as the platers. In a few cases a distinction is made between platers and managers. In this context managers include supervisors, and platers are grouped with jiggers, giving a total of 32 managers and 50 platers. The variations in the number of respondents are a result of missing responses to some questions from the platers.

Knowledge of chemical hazards

In the interviews most platers perceived chemical hazards as being most important, although a few mentioned mechanical hazards such as fork lift trucks. Hazards and risks were not differentiated. Most platers were aware of these terms, but could not explain the difference. Nor did they regard the distinction as useful. The platers often talked in generic terms about chemicals, using terms such as "degreasing solvents" and "acids"; specific chemical names were rarely mentioned. Acids were often described as "hazardous" or dangerous". They talked less readily about health effects and their possible causes, and often had to be prompted. The acute effects, particularly burns to skin and eyes, splashes, and skin contact were often the first to be mentioned and most frequently discussed. Long term effects were rarely mentioned without prompting, and even then people were often unsure about what the effects of long term exposure may be. In the

interviews protective clothing was sometimes the only control measure to be mentioned.

Table 1 shows responses to a number of statements made by one or more platers in the initial interviews. In the questionnaire the platers were asked to indicate whether they agreed or disagreed with these statements (in order to obtain an understanding of the prevalence of such beliefs among a larger population). Table 1 suggests commonality of beliefs in relation to statements 3–7, each of which, although loosely worded, can be interpreted as suggesting a reasonable understanding of the hazards and relative potency of chromic acid and nickel. However, there is less agreement about the risks relating to solvents and chrome stains on skin. There is also evident confusion in relation to the cancer causing properties of nickel. Forty four per cent of the platers did not agree with the statement "there is no safe limit for airborne exposure to chromic acid".

The experts were asked to rank a list of health outcomes from chromic acid exposure, taking account of both the "likelihood of their occurrence" and "seriousness of outcome". This ranking by the 13 respondents identified nasal septum perforation as number one, with allergic contact dermatitis and occupational asthma ranked second and third. Blindness caused by burns to the eyes was ranked fourth, lung cancer fifth, and severe burns sixth. The experts were not asked to justify their rankings, for example, in terms of seriousness of outcome or likelihood of harm. However, there is a clear difference in the ranking with the experience of platers who considered burns to skins as the most frequent risk from plating with chromic acid. No platers mentioned the potential for occupational asthma in the interviews.

Perceptions of the risks

Table 2 compares the responses of experts and platers to a number of statements relating to risk perceptions. The statements were derived directly from comments made by platers during interviews. It is important to note that experts were considering these in terms of how they thought platers might respond—that is, their perception of whether platers understand the risks of the work that they do and whether plating companies take the risks of working with chemicals seriously. Table 2 (particularly statements 2 and 7) shows that the experts have less confidence in the understanding of platers and the platers' perceptions of the companies' attitudes towards health and safety. However, table 2 shows that the experts correctly interpret platers' concerns that there may be special safety problems for workers who do not understand English, and that it is easy for platers to become complacent about the hazards they are exposed to. Statements 8 and 9 appear to have been considered by experts in terms of their own (rather than platers') understanding. It is, however, important that a significant minority of platers (27%) believed that skin rashes are more likely to be caused by wearing gloves than by nickel, although table 1 shows that 92% of platers

Table 2 Responses of experts and platers to statements relating to risk perceptions (%)

Statement	% agree	
	Experts* (no. responses)	Platers (no. responses)
1 There's no special safety problem for workers who don't understand English	0 (13)	14 (78)
2 I have a good understanding of the risks from the work I do	23 (11)	98 (81)
3 It is easy to become complacent about the risks in my work	100 (13)	85 (82)
4 People don't take safety seriously until they have an accident	85 (13)	85 (82)
5 Working in plating causes no long term health problems	15 (13)	31 (78)
6 All chemicals are safe as long as they are handled correctly	N/A	84 (80)
7 My company takes the risks of working with chemicals very seriously	23 (12)	74 (77)
8 Skin rashes are more likely to be caused when wearing protective gloves than by nickel	0 (13)	27 (74)
9 As long as you swill your eyes with water, a chrome splash will not harm you	0 (13)	13 (79)

*Note experts' response in terms of their perception of what platers would say.

understand that nickel can produce skin rashes. Nickel is a common skin sensitiser; however, some platers may have experienced contact allergy with gloves used, which is likely to affect their perception of relative risks.

The 31% of respondents who did not believe that working in plating causes long term health problems (statement 5, table 2) consisted of 13 managers (40%) and 11 (22%) platers. This can be compared with table 1 where 89% of the platers knew that inhaling chrome acid mist can cause lung cancer. The statements themselves are not "correct" in that health problems may or may not be caused. What the responses to the statements as generated by platers suggest is that not all platers associate lung cancer with long term exposure, or they do not fully understand the term "long term".

Knowledge of technical terms

The questionnaire tested knowledge of hazard and risk phrases in two sections. The first section listed phrases taken from the chromic acid Safety Data Sheet and asked respondents to say whether they were true or false. All statements applied to chromic acid correctly and so the correct answer was true for each of the nine statements. The responses were recorded as "true", "false", or "don't know" (table 3). The most significant finding was the number of respondents (35%) who did not know that chromic acid was a category 1 carcinogen, despite the majority apparently knowing that

inhaling chrome acid mist caused lung cancer (table 1). Other significant findings were that 29% did not know that chromic acid is an oxidising agent and that it is assigned a MEL (26%).

In the second section of the questionnaire, five hazard phrases were given, with four possible definitions for each. Box 1 presents the options given. These were generated by the project team (which included occupational health specialists), the intention being to include some definitions that had been offered by platers but were patently "wrong", and one definition (marked by * in box 1), which could be considered to be closest in meaning to the hazard phrase. Table 4 shows the percentages of "correct" responses, "wrong" responses, and "no" responses. Toxic proved problematic. An expert interpretation of toxic (can cause serious health effects) was taken as correct. However, 63% of respondents ticked "poisonous" which arguably may not be considered "wrong". When offered four possible explanations of the term "category 1 carcinogen" (likely to cause cancer, highly corrosive, poisonous, contains tar), only 56% chose the "right" answer, 25% getting the answer wrong (14% poisonous, 11% highly corrosive). Only 42% chose the "correct" definition for the phrase sensitisation by skin contact, 44% choosing the wrong answer (29% choosing causes skin burns and 15% choosing blistering of the skin). Only 51% were able to choose the correct definition for an oxidising agent.

Table 3 Percentage wrong responses and don't know to hazard phrases (n=84)

	% false	% don't know
Chromic acid		
Is toxic if swallowed	0	2
Can cause severe burns	7	4
Is a respiratory carcinogen	2	24
Is a category 1 carcinogen	4	35
May cause sensitisation by skin contact	8	10
Is assigned a maximum exposure limit (MEL)	6	26
Is a respiratory irritant	1	13
Is an oxidising agent	0	29
Prolonged exposure can cause serious damage to health	0	8

Table 4 Responses to definitions of hazard phrases for plating workers (n=84)

Hazard phrase	% correct	% wrong	% no response
1. Respiratory irritant	77	20	2
2. Category 1 carcinogen	56	25	19
3. Oxidising agent	51	27	21
4. Toxic	18	72	11
5. Sensitisation by skin contact	42	44	14

Box 1 Definition options of hazard phrases 1–5 (see table 5)

- (1) Irritate the skin; Causes cancer; *Makes the nose and lungs uncomfortable; Causes asthma
- (2) *Likely to cause cancer; Highly corrosive; Poisonous; Contains tar
- (3) *Contact with combustible materials can cause fire; May catch fire spontaneously; May explode; Crumbles easily
- (4) Can cause cancer; Can cause intoxication; Poisonous; *Can cause serious health effects
- (5) Sensitisation by skin contact; Causes blistering of skin; *Causes an allergic reaction; Causes skin burns; Causes the skin to peel

Sources of knowledge and importance of different information sources

Table 5 shows the responses of platers and experts to statements relating to sources of information. Platers' own words were used for the platers' questionnaire; for the experts' questionnaire, the platers' statements were slightly modified, replacing the word "I" and "my" with "platers"—that is, asking experts for their own views on the importance and usefulness of information sources for platers. There was disagreement between expert and platers in relation to some statements. Experts appeared to be sceptical of company practices and knowledge, only 23% believing that companies make sure that people read safety information (statement 2), compared to 77% of platers saying that their companies do this. A minority of platers (22%) believed that Safety Data Sheets could not add to their own knowledge. Whereas 92% of experts believed that platers learn from those they work with, a smaller majority of platers (74%) believed this. Platers and experts seemed to agree that some form of written information is essential. Twelve of the 13 experts agreed that platers would find Safety Data Sheets to be too complex. However, platers were more positive, 68% believing that they are not too complex.

Platers were also asked to indicate how frequently they consult key health and safety information which included labels, Safety Data Sheets, HSE leaflets, HSE inspectors' reports, assessments produced under the Control of Substances Hazardous to Health (COSHH) Regulations 1996,

trade association literature, company health and safety literature, and reference books. Experts were also asked to estimate how often they think managers and platers use these information sources. Only 15% of the experts considered that platers often used labels and none considered that managers used them. However, 84% of managers and 76% of platers said that they used labels often. HSE leaflets and inspectors' reports, COSHH assessments, and Safety Data Sheets were all considered by experts to be used by managers to a lesser extent than managers claimed. Nineteen per cent of platers had never used a Safety Data Sheet, although 40% say they use them often. Trade magazines are the least important sources of health and safety information to managers and of no importance to platers (83% never using them). Platers referred to the value of videos, verbal briefings, and pictograms. Experts did not favour chemical suppliers providing verbal information, nor did they value presenting leaflets in other languages.

Use of control exposure to minimise exposure and advice to new platers

Platers and experts were asked to tick up to two of the pieces of advice listed in table 6 as the most important to give to someone new to plating (here experts were giving their own views). Table 6 shows the percentage of platers and experts who ticked each item. Experts supported reading of Safety Data Sheets to a greater extent than platers. The priority for the platers was practical measures, with a focus on prevention before reading about the risks. The confidence in the use of personal protective equipment was further supported when 32% of the platers (n = 81) agreed with the statement "As long as you wear protective clothing you cannot be harmed", whereas none of the experts agreed with this statement. However, only 5% of platers thought that there was no danger if the extractor on the plating tank was not working.

DISCUSSION**Method**

Before discussing the results further, comment on the method is appropriate, not least because it was designed to be tested for its potential as a general approach to identifying risk information needs in terms of chemical risks in the workplace. Firstly, engaging with very small companies is difficult,

Table 5 Response of experts and platers to statements relating to sources of information

Statement	% agree	
	Experts* (n = 13)	Platers (n = 81)
1 Written information about the chemicals is essential to my job	92	94
2 My company makes sure everyone reads written safety information	23	77
3 I have learned most of what I know about risks of plating from the people I have worked with	92	74
4 I don't need to know what a chemical could do to me; I just need to know how to handle it safely	0	12
5 Safety Data Sheets are too complex for most platers to understand	92	32
6 A Safety Data Sheet on a substance I use is not going to tell me anything I don't know already	8	22

*The above statements were reworded in the experts' questionnaire, replacing the words "I" and "my" with "platers", that is, asking experts to express their own views on the information needs of platers.

Table 6 Most important pieces of advice to a new plater

	% experts (n = 13)	% platers (n = 81)
Always wear protective clothing	23	68
If you're not sure, ask a person in charge	39	42
Wash off chemical splashes immediately	31	40
Listen to experienced people	31	34
Read the Safety Data Sheets	46	30

requiring not only access to information about their existence, but also the ability to convince busy managers that such a study is worthwhile. Only 35% of those contacted agreed to take part.

Secondly, the use of questionnaires can be difficult where workers may not have experience of such methods and may face reading/literacy difficulties. While the interviews suggested a willingness to engage with the topic, when platers were asked to respond to questions about chromic acid, the response rate was only 49%. Informal discussions with the companies suggested a combination of work and time pressures on individuals as well as difficulties with a questionnaire, despite considerable efforts to present it in "lay" language. However, the approach being used was not to derive "representative" beliefs among all platers. The method merely aimed to ascertain whether expressed views among a small number of platers were prevalent among a larger number. In this case the response rate is considered reasonable.

Results

It could be expected that platers' experience of the risks of chromic acid in everyday working would fundamentally affect their knowledge and perceptions. Platers experience both first hand and through observation of their colleagues, splashes, acid burns, skin rashes, and ulcers. They experience and observe the frequency and seriousness of effect. Platers in the interviews used accidents as a means of describing these effects, whereas they were less able to articulate the effects in terms of a "textbook" explanation. There was also strong evidence that platers had rationalised the potential for harm and had faith in their own experience, common sense, and adoption of correct handling procedures. The experts on the other hand did not see this as rationalisation but as avoidance of the issue.

Lung cancer from inhaling chromic acid is a theoretical risk to most platers, that is well understood by experts as a potential outcome with the classification of a category 1 carcinogen. The potential for cancer was known by 89% of platers (table 1), when prompted in the questionnaire; however, despite appearing to know that chrome mists can cause cancer, a third of platers did not believe that working in plating causes long term health effects (table 2). Since more than half (63%) of the platers who had completed the questionnaires had worked in plating for more than 10 years without evidence of long term effects, then the seriousness of potential health effects remains theoretical.

It is important to recognise that the concept of a "long term" health effect lacks clarity. A lay interpretation of the phrase might include the potential for harm where the effects might last for a long time, or the potential for exposure to a chemical but no evidence of the effects until some point in the future, or the potential for irreversible effects. For experts, long term versus short term, or acute versus chronic is a key distinction. Platers are aware that they can have an accident with immediate effects or that they may develop a skin problem or nasal septum perforation after some time in the job. However, they do not draw distinctions between brief exposure to a high concentration of a substance, and exposure over time to a low concentration. This is not surprising when it is the effects or harm which are known to be of most importance to people. This is further supported by the fact that platers find the distinction between the terms hazard and risk an unnecessary complication, while the use and understanding of these terms is of fundamental importance to experts.

While experts ranked nasal septum perforation as the most serious risk outcome from plating, this was not the effect that most platers mentioned first, although it was recognised as being a potential outcome. Platers, drawing from experience,

tended to talk automatically and most easily about burns, whereas experts ranked these sixth in terms of risk, presumably drawing distinctions based on seriousness of effects and possibly reversibility of effects rather than probability. It was noticeable that occupational asthma was not mentioned in the interviews by a single plater, whereas the experts ranked this as the third most serious risk, with the occupational health specialists particularly noting this as a significant risk.

The greatest difference between plater and expert was evident in the knowledge of technical terms, such as "respiratory carcinogen", "sensitisation by skin contact", and "category 1 carcinogen" (table 4). The questionnaire responses suggested some considerable confusion in that some platers could identify that chromic acid was carcinogenic or might cause sensitisation by skin contact, but then were not able to define these terms. Other platers could choose the right answer out of four definitional options, but did not know that the phrase related to chromic acid. Platers were able to recognise technical terms associated with chromic acid, but they did not really know what they meant and thus they were of limited relevance to many platers. Equally it would be wrong to automatically equate difficulties of articulation with lack of understanding; this is why the method of talking to people and identifying their knowledge and beliefs is important.

Safety Data Sheets adopting scientific terminology cannot be expected to influence beliefs if the primary language is unintelligible or remote to the reader. It is important to note that 49% of platers had no formal educational qualifications. Another study for the HSE²² has identified a low reading age (63% below 12 years 5 months reading age) among workers in firms in a number of sectors, including electroplating. There was evidence in this study that platers had primary reading/literacy problems, and not just understanding deficiencies. For example, some questionnaires were incomplete and some managers pointed to difficulties that platers experienced in completing the questionnaires (particularly those for whom English is not their first language). Safety Data Sheets are designed as a starting point for a risk assessment, not as a day to day usable information resource for workers. Furthermore, they are substance specific rather than activity/process specific. Platers may not understand all of the terminology in Safety Data Sheets, but they do believe that they are likely to tell them something they may not know. Eighty eight per cent believed that they needed to know not only how to handle a chemical safely, but also its health effects (table 5).

Platers' claims to read labels on chemical containers were often greeted with considerable scepticism by the experts. Indeed, it could be questioned why people with such a length of experience in a job would need to read labels routinely and frequently. However, a more appropriate interpretation of the responses may be simply that warning labels on equipment and chemical containers are "part and parcel" of everyday experience in the plating shop: legally required, impossible to miss, familiar, with people being continually aware of them. The importance of over familiarity with warning signs in industries such as plating is something to be built on in the design of new risk messages.

Experts think in terms of a hierarchy of risk reduction, starting from the possibility of changing processes to less hazardous ones, particularly chemical substitution, and finishing with personal protective equipment (PPE) as the last line of defence for people who have to work with hazardous substances. By contrast, platers, especially if they are employees rather than managers, think of PPE as the first control to which they have access, and possibly the only one over which they have any influence. Asked about the relative importance of different controls, they simply say that all are important.

Platers learn from one another rather than from written information. Plating shops are small in terms of the numbers of people involved in the process, and in many very small firms most people worked in the plating process, including the

manager. A tight knit workforce focused on one activity inevitably draws on individuals as a source of knowledge and experience. The oral tradition within the plating shops focuses on the translation of messages relating to the need to be careful of certain chemicals (not necessarily why) and what to do to protect yourself from exposure, which combines with "learning from experience" of getting it wrong. This was reflected in the platers' identification of the most important advice for a new plater being to always wear the protective equipment. The oral tradition is practical and pragmatic. Experts who have the skills and opportunity to engage platers face-to-face to describe the hazards, risks, and effective use of control measures (as opposed to merely providing written information) are important, if not essential.

New workers in plating learn from more senior platers "on the job". Indeed, managers stressed the importance of this process of personal, as opposed to classroom training. Working and learning about risks and risk avoidance on the shop floor was also important. In some plating firms we were told that this became part of the selection criteria for new platers—that is, the ability to learn from mistakes and to follow instructions and systems of work. The expert questionnaire, however, indicated that experts believed that the failure of formal training results in poor work practices, and poor working conditions.

The project specifically included Asian platers, although a comparative study of English and Asian workers was not possible because of the small sample size. Only a relatively small number of Asian workers (18%) were respondents. Asian platers tended to have higher educational qualifications, and were younger and had spent fewer years in plating. It is evident that where platers do not have English as a first language, this can present problems of understanding, as well as ability to participate in research. In one company the questionnaire was completed as part of an English class; this is indicative of the difficulties of involvement. Returned questionnaires often included a number of "don't know" responses, particularly to the questions relating to the characteristics of chromic acids and the definitions of key technical terms. The general responses from platers and experts identified concern that Asian workers may have particular safety problems because of the language difficulties; 15 of the 16 Asian workers agreed with this. This element of the work must be viewed as a pilot study; there is still an urgent need to understand cultural influences on risk knowledge and beliefs.

Designing "new" risk messages

The overall aim of the project as specified by the HSE was to test a method which would assist in the designing of new risk information. The findings reported here relate to the first phase of the work—that is, ascertaining the key differences between experts' and platers' beliefs, and understanding how platers perceive the hazards and risks involved in chrome plating and their information needs. The project has gone on to design "new" information on hazards and risks, specifically seeking to increase understanding of the potential for long term health effects. At the time of writing, the new information has been provided to all of the companies who took part in the first phase, and a process of evaluation of the effectiveness of the information has commenced.²³

Conclusion

This study provides a potential method, which can be used to gain some understanding of workers' knowledge and beliefs about the hazards and risks that they are exposed to in the workplace.

The study identifies gaps between platers' knowledge and beliefs and that of experts. While platers display considerable practicable knowledge and are aware of key risks, there are

gaps in understanding, particularly in terms of the awareness of the potential long term health effects and understanding of how these might be caused, and understanding of what to do to minimise the risks.

Where deficiencies in knowledge and beliefs are identified, new information needs to be designed, enabling the workforce to make fully informed decisions about the hazards and risks to which they are exposed. The rationale for the design should be the use of language which platers understand rather than "expert" language. Although the focus of the study has been individuals' beliefs and knowledge, the findings point to the importance of the complex mix of information processes, institutional structures, social group behaviour, and individual responses which shape the experience of and response to risks.

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