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Chemical hazard communication comprehensibility in South Africa: Safety implications for the adoption of the globally harmonised system of classification and labelling of chemicals

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ABSTRACT

Chemical hazard communication is a key strategy to prevent illness and disability from exposures to potentially hazardous chemicals. The Globally Harmonised System of Classification and Labelling of Chemicals (GHS) was developed to strengthen national capacities for safe management of chemicals. In this paper we present the results of a descriptive study on comprehensibility of chemical hazard communication elements. The study of 402 respondents, including 315 workers in the manufacturing, transport and agricultural sectors and 87 consumers was conducted in 2003 to provide data on chemical hazard communication comprehensibility as part of a feasibility study into the possible adoption of the GHS in South Africa. Data were collected using an interviewer-administered instrument developed for the International Labour Office (ILO) to support GHS implementation.

Less than half of respondents reported any training in their current jobs in health and safety, and only 34% on labels. Agricultural workers were far less likely to have received any training. In general, comprehension of hazard communication labels and safety data sheets (SDSs) was low. Symbols such as the skull and crossbones (98%) and the flammable (93%) symbol were relatively well understood (either correct or partly correct responses), but the majority of hazard symbols were of moderate to poor comprehensibility (less than 75% correct or partly correct responses). Significant levels of critical confusions (5% or more) occurred with symbols for corrosive and compressed gas. Co-workers and supervisors were identified as important sources of information.

If the GHS is to provide a safety framework, there has to be investment in GHS training that emphasises comprehensibility. There should be a focus on those items causing critical confusion and peer trainers should be used. The GHS should be promoted through media to reach consumers. If the GHS fails to address problems of comprehensibility, it will only succeed in facilitating trade in chemicals without ensuing adequate safety.

1. Introduction

Chemical hazard communication, through the provision of labels and safety data sheets (SDSs), is a key strategy for the prevention of illness and disability due to unsafe use of, or from exposure to potentially hazardous chemicals (London and Rother, 2003). The intention is that hazard chemical communication tools will provide hazard information about the particular chemical for informed risk decision making, as well as promote scientifically determined cautionary behaviours required to prevent hazardous exposures (Rother and London, 2008; Weyman et al., 1998). Increasing international concern for chemical safety and the existence of too many varied chemical hazard communication systems has seen the development of a Globally Harmonised System of Classification and Labelling of Chemicals (GHS, 2005; Winder et al., 2005). This system not only endeavors to harmonise existing hazard classification and labelling of chemicals, it also attempts to strengthen and promote (especially in developing countries) national capacities for the management of chemicals in line with Chapter 19 of Agenda 21 (UNDES, 2004). This system is based on the intrinsic hazard of the chemical and not the risk (Silk, 2003). The GHS was approved by the United Nations Committee on Experts on the Transport of Dangerous Goods and the GHS (UNCETDG/GHS) in 2002 (GHS, 2005), and focuses on four main sectors – Transport, Industrial/Workplace, Consumer Products and Agriculture/Pesticides). The target implementation date was 2008 for this voluntary, non-legally binding treaty.

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No country is known to have fully implemented GSH until now (United States Department of Labour (ILO), 2012). Support initiatives have been introduced in a number of developing countries to implement the GSH (Ta et al., 2009). Ta et al. (2009) state that countries without existing legal requirements for the classification and labelling of chemicals can adopt the GSH criteria more rapidly than countries with existing related legislature. It should be noted that even with GSH adoption the classification of individual chemicals could differ in different countries (Miyagawa, 2010; Ta et al., 2009).

Critical to the success of the GHS is the question of comprehensibility of the GHS label and safety data sheet elements by the target populations in all four sectors, particularly in developing countries. Systems developed at international agency levels have to be tested at national and sub-national levels to ensure their meaningful effectiveness on the ground, and optimise their value for countries, consumers and working populations exposed to potentially hazardous chemicals. In light of this, the aim of the study was to assess how the elements of chemical labels in general and the proposed GHS specifically where understood by developing country workers in transport, manufacturing and agricultural sectors, and consumers. At the time of the study, the GSH had not yet been implemented in South Africa. Subsequently, in 2008 a GSH standard for use in local legislature (SA Bureau of Standards (SABS), 2008) was published and new legislation on classification and labelling of chemical substances incorporating GSH was drafted. This feasibility study contributed to the progress made in adopting GSH in South African legislature (London et al., 2003a,b). The draft legislature has not yet been promulgated into regulation under the South African Department of Labour because the US Occupational Health and Safety Act (OHSA) which is a reference for the South African legislation, is still under review and going through major changes. Also, the GHS text was found to be out of line with the SA constitution and so changes are being made in respect to this as well. South Africa established a National Committee on Chemical Safety in 2009 to oversee the monitoring and implementation of the GHS (2012 for substances and 2016 for mixtures). A rationale of the GHS is to harmonise and standardise safety data sheets (SDSs), which as the time of this study were of variable standards and quality in South Africa.

2. Methods

2.1. Subjects and study site

In 2003 a cross-sectional descriptive study of consumers and employees in industry, transport and agriculture, the four user sectors most affected by GHS implementation, was conducted in the Western Cape and Gauteng provinces of South Africa. It was not possible to select an equal number of subjects from the four sectors in the two provinces, because the different sectors are not equally represented in the two provinces. However, 200 subjects per province were targeted weighted according to the distribution of the workforce in each sector in each province. The final sample included 402 respondents, most (73%) from Cape Town and from the industrial sector (Table 1).

Table 1
Final sample realised in the study.

	Province 1	Province 2	Total
Chemical Industry	62	24	86
Industry other than chemical	63	27	90
Transport	44	28	72
Agriculture	55	12	67
Consumer	67	20	87
	291	111	402

Companies provided appropriate venues to interview workers, while consumers were interviewed in malls, or in venues provided by supermarkets and shops. Domestic workers were interviewed in private homes, as were employers of domestic workers.

Within the four sectors, subjects from different strata were selected. The industrial sector was stratified into a chemical stratum, which was over-sampled because it is an important user and generator of chemicals, and a non-chemical stratum which consisted of a combination of randomly selected Standard Industrial Classification (ILO, 1987) categories (mining, paper, textiles, electricity, gas and water, construction, and wholesale and retail trade) and then purposively selected categories thought to represent vulnerable populations with significant chemical exposure (health care, domestic works, and cleaning industries). The chemical and non-chemical strata were further categorised on company size (small = <20 employees, medium = 20–199 employees, large = >200 employees). Companies were selected from a sampling frame assembled from a multitude of sources including Chamber of Commerce lists, websites, telephone directories and membership of industry associations. If a company declined to participate, or did not respond, one substitution was allowed from the company next on the list. The transport sector was stratified by companies exclusively involved in transport versus companies in the manufacturing or other sectors who maintained substantial transport fleets (e.g. petroleum).

Co-operation was obtained in over 80% of employers. Where selected companies declined participation, or were not contactable, the next company on the sampling list was selected. Replacement was required in 5 of the chemical companies (42%), 9 of the non-chemical companies (45%) and 3 of the transport companies (23%). Appointments at participating companies were scheduled ahead of the field visit, at dates and times convenient to employees and employers. Companies were requested to facilitate interviews with appropriate categories of employees as outlined in a sampling frame.

The transport strata was also sub-divided based on company size and companies selected from a sampling frame generated in the same way as in the industrial sector. These included road, rail, air and sea workers (Table 1).

For agriculture, where the size of the operation is less important than the type of operation, the substrata included large commercial farming (including agribusiness), small commercial farming, emergent farmer and state-run farms. In addition, a stratum for pesticide retailers was used. Because of limitations in access, farms were selected by opportunistic sampling and subjects included managers and farm workers (Table 1).

Consumers were sampled by opportunistic sampling from supermarkets, laundromats, hairdressers and hardware shops, stratified by urban and rural consumers (Table 1).

2.2. Survey instrument

The Hazard Communication Comprehensibility Testing (CT) Tool survey instrument used in the study (Table 2) was an abbreviated version of the original instrument developed for the International Labour Ogranziation (ILO) by the Occupational and Environmental Health Research Unit of the University of Cape Town in 2000 (http://www.unitar.org/cwm/ghs_partnership/CT.htm). The adapted tool included 7 of the original 9 questionnaires appropriate for each of the 4 sectors. Each questionnaire represents a module which deals in detail with a specific hazard communication element found on the label or SDS – for example, symbols, signal words, colour, hazard statements and pictograms. A manual to accompany the modules was compiled as guide for

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Table 2
Tool outline: modules included.

Module number	Description
1	Demographic data, visual acuity, colour blindness
2	Labels: Familiarity, recall, sequence of reading, comprehension of symbols, signal words, hazard statements, hazard ranking; and ability to identify hazard information on a SDS
3	Labels: Colour ranking, symbol comprehension
4	Labels: Identification of hazard class from symbols
5	Comprehension of Pictograms. Additional GIFAP advisory pictograms for agricultural chemicals included for farm workers and consumers
6	Safety Data Sheets: Ability to identify safety information from a SDS, comprehensibility of information; what is read and in what order; identify information that is used, useful, appropriate and understandable; impact on intention to behave safely
7	Post-interview questionnaire: Work history, exposure to chemicals at work and home, safety training, chemical information needs

administration. The modules also test recall and sequence of reading of elements on the label (to determine overall the most commonly read label elements based on the ranking of elements from first to last by participants). Impact on behaviour is determined through reported intention to practice safety behaviours. Data on demographics, colour blindness and visual acuity necessary for reading hazard communication elements and a detailed work history were also collected. A sub-set of repeat questions were included to test the effectiveness of a limited training opportunity on comprehension (that is, a 5-min explanation was provided by the interviewer before retesting). Open-ended feedback comments were also included in each module.

Labels and SDSs were specifically designed by the research team to accompany the questionnaires. However, these were based on real chemical SDSs (e.g. acetone, cholorpyrifos, etc). The labels and SDSs carried hypothetical brand details (such as trade names, manufacturer, address, contact details). This was done to avoid situations where workers acquainted with a particular chemical perform better than others because of familiarity, rather than because of their comprehension.

SDSs chosen were those derived from US sources, because of the high variability and occasional poor quality of the majority of South African SDSs sourced in preparing for the study (Dalvie and Ehrlich, 1999). The particular SDSs selected for this study were sourced through a review for chemical information in CCINFO (UM, 2001).

The survey tool was implemented over 4 months, commencing March 2003 and ending June 2003 by a team of trained interviewers in each of the study provinces. Interviews were conducted in the language of interviewee.

2.3. Ethics

The study was approved by the University of Cape Town's Research and Ethics Committee. All participants were given information on what the study was about and asked for their consent before inclusion. Participants were assured of complete confidentiality and study data obtained were kept secure. No companies were given individualised data so as to protect individual participants' identity. Consumers who participated were reimbursed for their time (the equivalent of approximately $8).

2.4. Coding and analyses

Comprehension of label and SDS elements were coded as correct, partially correct (for example, a worker may grasp part of the concept behind a hazard symbol without fully understanding the exact intention of the icon), incorrect, critically confused (a misunderstanding that will lead to an action that increases risk, for example if a respondent interprets the symbol for environmental hazard to mean that you can apply the chemical to trees, the respondent's understanding leads to increased environmental contamination) or do not know. Where respondents gave wrong answers for particular symbols, qualitative analysis of the nature of the wrong answers was captured to give a sense of what stereotypes and misjudgements are typical in this area.

Variables for usage of information sources and recall of label elements were collected first as unprompted then prompted responses. Along with comprehension of label elements, these were analysed as dichotomous variables. Scores were constructed for recall of label elements and sequence of recalling label elements.

3. Results

3.1. Demographics of participants

Less than 2.5% of participants reported no formal schooling and over 40% had some form of post-school training, either a diploma (26%) or a degree/technicon qualification (18%; Table 3). The least formally educated respondents were those in agriculture, where 31% had less than a primary school education ($p < 0.001$) and 7% had no schooling at all. The sample was predominantly male (68%), reflecting the demographics in different industries and age distribution consistent with a predominantly working population. Twelve percent of respondents were identified as having one or more forms of colour blindness on screening. Thirty-six percent of participants reported usually wearing glasses and two-thirds (in all sectors) of these had their glasses on when tested, as a result of which, visual acuity tested on screening was impaired in only 9% of individuals.

The most commonly reported home languages were Afrikaans (35% of respondents) and English (for 33%), while indigenous African languages were less commonly reported. Notably, even though 31% of respondents indicated their home language was other than English, only 9% reported having no proficiency in English. Agricultural respondents were more likely ($p < 0.001$) to report no proficiency in English (25% versus less than 7%) that other sectors.

The occupational profile of respondents largely matched the sampling strategy. That is, fourteen percent production workers, 18% managers or supervisors, 17% skilled workers and 12% drivers.

Slightly over 80% of all respondents reported ever having used, or worked with, chemicals. Industry respondents reported the highest history of contact with chemicals (90%) compared to transport (68%), agriculture (75%) and consumers (77%; $p < 0.001$). This picture was similar, although not exactly the same, from work histories collected from respondents, which indicated that 26% of

Table 3
Demographic factors ($N = 402$).

		Percentage
Gender	Male	68
	Female	32
Age	<20 years	1.2
	20–29 years	21
	30–39 years	38
	40–49 years	24
	>49 years	17
Marital status	Married	68
Children	Have children	79
Educational level	No Schooling	2.5
	Less than primary school	11
	High schooling	39
	Further education beyond school	47

participants had never worked in a job with potential chemical exposure (Table 4). As might be anticipated, consumers were most likely (46%) to report a work history with no exposure to chemicals ($p < 0.001$). Over 80% of respondents (in all sectors) indicated that either they or someone else at home had used household chemicals either sometimes, or a great deal. The equivalent figure for occupational exposure in their current job was 73%, and 71%, respectively, for exposure to chemicals handled by someone else at work. The study sample was thus typical of a high-risk group who are the exact target group that the GHS seeks to protect.

3.2. Previous training

Approximately 43% of all respondents indicated they received some form of health and safety training in their current job. No substantial differences were noted in whether training was given at induction or in-service. When asked if training had been received ever (i.e. any job in the past) the percentage reporting training increased somewhat (Table 4). However, what is evident is that two thirds of respondents had never received training on SDS's and more than half had never been trained on labels.

Levels of training (whether for general health and safety training, training on labels or training on SDS's) differed widely between sectors. The highest levels of training were evident in the industry sector (particularly chemical sub-sector) and in the transport sector. Training on (a) general health and safety, (b) on labels and (c) on SDS's was reported by 62%, 56% and 34% of transport respondents, and 65%, 50% and 68% of chemical sector respondents. However, even at best, only about a half of respondents indicated receiving training on labels in their current jobs. Very low levels of training were reported for agricultural and consumer respondents. That is, training on (a) general health and safety, (b) on labels and (c) on SDS's was reported by 35%, 21% and 11% of agricultural respondents, and 16%, 12% and 7% of consumer respondents.

Data on "ever trained" (i.e. training received in any previous job) for agricultural and consumer respondents was very low. For example, training ever in a lifetime on general health and safety, on labels and on SDS's was reported by 59%, 34% and 19% of agricultural respondents, and 25%, 16% and 11% of consumer respondents.

Of those receiving training, most training (70%) was in-house training, and the quality of this training is difficult to determine. Only about 27% indicated receiving training that had some evidence of external accreditation.

3.3. Information sources

Respondents were asked how they would find out about the hazards of a particular chemical with which they were in contact. Unprompted, labels were cited as the most common information source of all the options listed in Table 5. Labels were particularly important (64%) for consumers compared to other sources of hazard information (all other sources 8% or less). Occupational health personnel (OHPs) and trade unions were uncommonly reported as unprompted sources of information.

After prompting, almost all categories of source increased substantially, and virtually everyone identified a label as a source of information. SDSs, however, were not universally identified as an information source and the increase after prompting for SDS's was much lower than for other categories.

The increase after prompting was highest for respondents who identified co-workers and supervisors as sources of information, indicating the importance of workplace peers and colleagues as sources of information. For example, with prompting, the percentage who agreed that co-workers were a source of information on chemical hazards rose from 8% to 77%. Trade unions, as a source of information, were relatively poorly reported. Even after prompting, only a third of respondents indicated trade unions as a source of information.

Familiarity with labels and SDS's was tested by asking respondents if they had seen a label or SDS before (Table 6). Transport respondents (86%) and chemical industry respondents (77%) were more likely ($p = 0.002$) to have seen a label than agricultural workers (63%) or consumers (64%). In general, labels were far more likely to have been seen, read and used than SDS's. Nonetheless, there appears to be a core of respondents who use SDSs regularly.

Table 4
Work histories ($n = 387$).

Years with potential occupational chemical exposure	None	26%
	1–9 years	33%
	10–19 years	23%
	>19 years	18%
Training in:	In current Job	In any job, past or present
General Health and Safety	44%	66%
Labels and chemical safety	34%	48%
SDSs and chemical safety	27%	34%

Table 5
Identified sources of information ($N = 402$).

Unprompted		With prompting	
Label	58%	Label	94%
SDS	15%	SDS	48%
Co-workers	8%	Co-workers	77%
Supervisors	5%	Supervisors	79%
Training	11%	Go for Training	68%
Occupational health personnel	5%	Occupational Health Personnel	62%
Other specialist personnel	4%	Other specialist Personnel	48%
Trade Union office	2%	Trade Union office	33%
Public information service (e.g. Poison Centre)	3%	Public information service (e.g. Poison Centre)	4%

Table 6
Familiarity with hazard communication tools (Labels and SDSs).

		Label ($n = 402$) (%)	SDS ($n = 315$) (%)
Ever seen		73	40
Able to name		45	21
Read	Never	18	46
	Less than 10 times	30	16
	Many times (>10)	52	18
Used	Never	27	45
	Less than 10 times	31	15
	Many times (>10)	42	18

Table 7
Total recall of label elements ($N = 402$).

	Without prompts (%)	After prompting (%)
Correct chemical name	29	61
Skull and crossbones symbol	80	95
Flammable symbol	65	91
Environmental hazard symbol	50	78
Signal word: Danger or Warning	40	44
Active ingredient acetone	22	44
At least one of the hazard statements	33	82
At least one first aid measure	30	49
Emergency contact phone number	22	74
Use of protective clothing	24	76

Respondents were asked whom they thought a SDS is intended for. The majority (80%) responded that it was intended for all persons working with, or in contact with chemicals. Less common understandings of whom the SDSs were intended for included supervisors or managers (11%), drivers (5%), health care professionals (3%) and laboratory staff (3%). Only 2% of respondents cited shop stewards or safety representatives as targets for SDSs. Transport respondents were more likely to cite specifically drivers (92%) than to indicate "all persons" (15%) as targets for the SDS ($p < 0.001$). SDS's appeared more likely than labels to be read with a view to use, since the percentage distribution of readers and users of SDSs were almost identical, whereas usage of labels was lower than reading of labels.

3.4. Recall of label elements

Respondents were given a study label to examine for a minute and then asked to return the label, after which their recall of label elements was asked, unprompted and then prompted (Table 7). The symbols/pictograms were by far the items on the label most commonly recalled. The symbols with the highest recall frequency was first for the skull and crossbones, next the flammable symbol, and thirdly the environmental hazard symbol consistently between all sectors.

After prompting, both the flammable and skull and crossbones symbols were almost universally recognised. The environment hazard icon was 'overtaken' by other hazard communication elements after prompting in all sectors.

Almost all items for which there was low unprompted recall (less than 35%) were commonly remembered after prompting. For example, only a third of respondents cited any hazard statement unprompted but over 80% could identify a hazard statement after prompting. Patterns were similar among sectors.

Respondents were asked to identify the sequence in which they read the elements on the label to determine overall the most commonly read elements (Table 8). The symbols, particularly the skull and crossbones and flammable symbols were reported most commonly as read either first, second or third. The two symbols were

Table 8
Sequence of reading of label elements ($N = 402$).

	Ranking[a]			
	First (%)	Second or third (%)	Any rank (%)	Mean score[b]
Correct chemical name	19	11	47	14.3
Skull and crossbones symbol	54	19	84	26.1
Flammable symbol	5	52	76	22.9
Environmental hazard symbol	4	38	68	13.8
Signal word: Danger or Warning	10	17	54	14.8
Active ingredient acetone	37	9	33	17.6
Emergency contact phone number	2	3	24	6.7
Use of protective clothing	1	2	10	2.6

[a] Ranking percentage as row percentage;
[b] Mean score calculated as (32–rank)/402.

Table 9
Comprehension of symbols ($N = 402$).

	Comprehension				
	Correct (%)	Partly correct (%)	Incorrect (%)	Critical confusion (%)	Does not know (%)
Corrosive to skin and metal 	22	31	26	6	16
Skull and crossbones 	81	17[a]	1	1	0.3
Flammable 	61	32	5	0.3	2
Environmental hazard 	39	17	15	4	26
Explosive 	54	4	22	2	19
Oxidising 	8	35	50	1	6
Acute health hazard 	1	27	39	3	30
Skin irritant	19	35	27	2	18
Reproductive health effects 	19	14	44	1	22
Carcinogenic 	16	12	41	1	31
Health hazard (Chronic)[b] 	19	3	65	0.3	13
Compressed gas 	7	7	28	7	51

[a] Includes 19 respondents who associated this symbol with death.
[b] Comprehension of the chronic symbol alone (without text indicating the specific effect) is estimated from 206 respondents without any explanatory 'training'.

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also most commonly read at any rank, consistent with the data from recall of label items above. The two symbols and the environmental symbol all scored higher than other label elements. This was particularly the case for the skull and crossbones, reflecting both frequent recall (column ‘‘any rank’’ in Table 8) and high ranking (columns ‘‘first’’ and ‘‘second or third’’ in Table 8) of recall.

3.5. Comprehension of label elements

The comprehension of symbols was determined by testing if participants understood the meaning of a symbol present on a label. Table 9 lists comprehension findings for 11 variations of the nine GHS symbols used in the GHS based on questions which asked respondent to identify the meaning of a particular symbol on a label.

The skull and crossbones faired best and was almost universally understood. Correct or partly correct responses were in excess of 96% for all sectors, and were 100% for transport respondents.

The flammable symbol also performed well (upward of 89% correct or partly correct across all sectors) and the explosive symbol (44% correct or partly correct in agricultural sector, 54% in transport sector, 58% in industrial sector and 71% in consumer sector), and the environmental symbol (40% correct or partly correct in industrial sector, 54% in transport and agricultural sectors and 58% in consumer sector) performed adequately but at a lower degree of comprehensibility. In contrast, many of the health-related symbols did not perform well, particularly those related to long-term health effects.

A small number of respondents described hazard symbols in terms of other common usages – for example as in traffic signs. Critical confusions varied from 0.3% to 7% with symbols for compressed gas and for corrosiveness demonstrating the highest percentage of these critical confusions (An example of a critical confusion is the response of one participant to the symbol indicating reproductive hazard, who thought the symbol indicated an effect beneficial to reproductive capacity).

4. Discussion

4.1. Previous training

The data demonstrate a significant gap in training. In the agricultural sector, training levels are so low as to approximate the levels found in the general non-working (consumer) population. Given the data on the importance of co-workers and supervisors above, there is a need for training and information availability that builds on peer networks. Even in the chemical sector, while higher, reported levels of training were not adequate, and certainly less than what is mandated by the South African Hazardous Chemical Substance Regulations (Department of Labour (DL), 1995). While some of the responses to the questions may not have been entirely accurate, it is unlikely that respondent bias in answering the questions would explain this entire shortfall. Training in the GHS should therefore clearly be a priority for action. Wherever possible, future comprehensibility testing should ideally be linked to training in hazard communication.

Training on SDSs was less common than on labels, except for respondents in the chemical industry. This reflects a culture which does not value SDSs as a source of information outside of the chemical industry. Although there are no published studies of levels of training on the GSH in the literature, the need for training has been highlighted amongst university students and industrial workers (Adane and Abeje, 2012; Banda and Sichilongo, 2006; Ta et al., 2010).

4.2. Information source

Labels were the most commonly identified unprompted information source, exceeding the next most common category of information source by two to threefold. The data therefore indicate that workers and consumers regard a label as their priority source of information on a chemical and that, despite multiple sources of information other than labels, these sources were infrequently identified by respondents.

Use of SDS in practice was very poor and occupational health practitioners and Poison Information Centres were uncommonly identified (less than 8% and 6%, respectively) as possible sources, despite their skills and expertise. The challenge is how to promote these information sources in all sectors. In contrast, Ta et al. (2010) found that both labels and SDSs are the most commonly used information sources amongst Malaysian industrial workers and that usage of these sources (82%) was significantly higher than in this study indicating better safety culture amongst Malaysian workers compared South African workers.

Perceptions that Trade Unions could serve as sources of safety information were low (less than 4%). This may reflect low unionisation in the study sample, or that the system put in place by current labour relations structures is not working adequately. The relatively low level of reporting of Trade Unions in SA as a source of information is an issue the labour sector should address, since organised labour serves as an important source of information on chemical hazards in other countries. Indeed, the ILO Chemicals Convention (ILO, 1990) specifically refers to the role of employer and employee organisations in giving effect to hazard communication priorities.

Co-workers and supervisors were the categories that increased by the greatest amount when respondents were prompted as to sources of hazard information, across all sectors. These increases varied from 4- to 14-fold. The data therefore demonstrate the importance of peers as a source of information, particularly co-workers and supervisors. A tiered approach to training utilising peer-educators could be promoted in an effort to enhance comprehension of chemical hazard communication tools.

The finding that SDS's appear to be more likely to be read with a view to use shows that some respondents saw the SDS as a repository for ‘‘all’’ information and may have seen the SDS as a kind of ‘‘bank’’ of information to be used as back-up. However, that also implies that although this bank of information is available, it may not be used at all by the same people who identify the SDS as being intended for everybody. It is as if a culture of non-use of SDSs exists but can be compatible with feeling secure that the SDS is ‘there’. Further research may be helpful to clarify this problem.

4.3. Recalling of label elements

Almost all label items were commonly remembered after prompting. Symbols were the most common hazard item recalled and read on labels especially the skull and crossbones and flammable symbols, which were almost universally recognised after prompting. In the study on Malaysian workers (Ta et al., 2010), the most frequently recalled label elements were also pictograms, followed by hazard information and then the precautionary statement.

4.4. Comprehension of label elements

The comprehensibility of symbols was found to be highly variable with the percentage of correct or partly correct responses less than 50% for 6 symbols and the skull and crossbones and flammable symbols scoring between 75% and 100% correct or partly cor-

Table 10
Performance of Symbols based on US ANSI Z535.3-1998.

	More than 85% correct	Less than 5% critical confusions
Corrosive to skin and metal	No	No
Skull and crossbones symbol	Yes	Yes
Flammable symbol	Yes	Yes
Environmental hazard symbol	No	Yes
Explosive	No	Yes
Oxidising	No	Yes
Acute health hazard	No	Yes
Skin irritant	No	Yes
Reproductive health effects	No	Yes
Carcinogenic	No	Yes
Chronic	No	Yes
Compressed gas	No	No

rect across all sectors while the other symbols scored less. Thus other than the skull and crossbones, comprehensibility was found to be weak or poor, particularly for symbols indicating chronic hazards, and for the compressed gas symbol. The performance of the symbols based on ANSI Standards (ANSI, 1998) (Table 10), suggest that none of the symbols other than the skull and crossbones or the flammable symbol would achieve acceptable comprehensibility (85% correct answers and less than 5% critical confusions). Training and other interventions should therefore address symbols that have lower comprehensibility and not rely only on the two "high performers".

The finding that a small number of respondents described hazard symbols in terms of other common usages may be an implication for safety if people presume a meaning based on an entirely different context, but it may also present opportunities for training in hazard symbols to draw on other common usages to improve intelligibility. It is therefore important to ensure that the negative message of a warning symbol is adequately conveyed by the symbol or through training.

The levels of comprehension in this study were significantly higher than those measured amongst Ethiopian university students (Adane and Abeje, 2012) and Zambian participants from the same sectors as in this study (Banda and Sichilongo, 2006) but lower than amongst Malaysian industrial workers (Ta et al., 2010). As in this study, the skull and cross-bones and flammable symbols were the best understood by Malaysian industry workers (Ta et al., 2010). Also consistent with this study was the low comprehension of the compressed and oxidising symbols in the Malaysian study with the poor comprehension of the latter symbol interestingly ascribed to confusion with the flammable symbol. It therefore appears that workers around the world have similar patterns of comprehension.

4.5. Study limitations

The representivity of the sample is limited to the sectors selected, and by the fact that, for practical reasons, the study was restricted to Gauteng and the Western Cape. However, given the consistency of many results across sectors and sub-sectors, there is no reason to anticipate that results for other provinces or sectors would be much different (South Africa has a total of nine provinces). If anything, it is likely that the small but evident percentage (23–45%) of initial non-response amongst industry and transport companies in this study (which may bias the results upward – i.e. to better comprehensibility) and the relatively high levels of economic development in these two provinces would tend to produce a slightly better picture than may be the case for the whole country, and therefore reflect a better-case scenario. However, as a starting point for considering the implementation of the GHS, this remains a useful snapshot to understand where priority efforts should be focused in future.

The fact that labels were predominantly in English and Afrikaans should have not been a limitation in the study as only 9% of respondents reported having no proficiency in English.

5. Conclusions and recommendations

The data demonstrate that no hazard communication system is intuitively obvious. While a few commonly recognised items show good understanding, considerable further work is required if chemical hazard communication tools are to play an effective role in safety of workers and consumers. If the GHS is to provide a safety framework, there has to be investment in GHS training that emphasises comprehensibility of hazard communication elements. There should be a focus on those items causing critical confusion and peer trainers should be used. The GHS should be promoted through media and school curriculums to reach consumers. If the GHS fails to address problems of comprehensibility, it will only succeed in facilitating trade in chemicals without ensuing adequate safety.

In order to improve on comprehension of hazard communication tools, several factors affecting comprehension need to be addressed.

5.1. Training and awareness raising

Training and awareness raising are clearly key recommendations to emerge from this study. Workers and consumers will need carefully directed information and training materials to assist the uptake of the GHS if it is to be effective as a risk reduction measure. In developing such materials, cognisance should be taken of the items that workers and consumers currently recall most easily from labels which are symbols. Training in comprehension of all symbols should be a priority. Training should also aim to ensure that users of chemicals learn to recognise items that they do not 'normally' remember or regard as important – i.e. it should not simply repeat knowledge already known to the trainees. Training on symbols should take account of the way in which symbols similar to the GHS symbols are used in other contexts (e.g. targets, road traffic signs) in the design of the training material. The latter must be an explicit component of training for farm workers and those handling pesticides. Peer education is a key strategy to employ since co-workers and, to a lesser extent, supervisory staff were identified as important sources of information. This approach would also be a means for addressing workers who are illiterate and unable to read labels or SDSs.

5.2. Content of hazard communication tools

Consideration should be given to some of the content issues for SDSs and labels. Inclusion of symbols on the SDS may attract workers' attention and prompt them to explore the information present on an SDS, which is presently not well utilised but could be added as part of the GHS building block approach. That is, as long as mandatory items are included in the SDS, additional information that is not contradictory can be added to enhance comprehension (Rother and London, 2008). Maybe having an abridged version that is more user friendly at the beginning or end of the SDS would help. Alternatively, training should ensure that all employees are SDS-literate.

5.3. Role of sources of information in comprehension

The roles of other sources that can provide very useful information for chemical hazards, for example, occupational health practitioners in certain professions and access to Poison Information Centres for certain types of personnel should be strengthened.

In general, the GHS covers the range of information identified by respondents as important – health risks, hazard identification, etc. Attention should be paid to ensure the font and layout of labels meets minimum requirements.

Further studies are needed to characterise the link between knowledge (understanding) of the GHSand the ''correct''/intended safety behaviour to reduce exposure.

5.4. Summary of conclusions and recommendations

This study found that the comprehension of hazard communication labels and SDSs amongst workers in the agricultural, industrial and transport sectors as well consumers were generally low. The skull and crossbones and the flammable symbols were relatively well understood, but the majority of hazard symbols were not. The corrosive and compressed gas symbols caused significant levels of critical confusions. The low comprehensibility is likely due to low levels (<50%) of training in health and safety amongst workers and consumers. Although labels were the most common information source for hazard information, co-workers and supervisors were also identified as important sources of information. Recommendations to improve hazard communication amongst workers therefore include training and awareness raising, improvement of the content as well as the font and layout of hazard communication tools and strengthening the role of information sources other than labels.

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