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FACTORS AFFECTING COMPREHENSIBILITY OF THE GLOBALLY HARMONIZED SYSTEM OF CHEMICALS IN THE UNITED STATES

by

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B.S., Murray State University, 1992
M.S., Murray State University, 1995

A Dissertation
Submitted in Partial Fulfillment of the Requirements for the
Doctor of Philosophy Degree

Department of Public Health and Recreation Professions
in the Graduate School
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DISSERTATION APPROVAL

FACTORS AFFECTING COMPREHENSIBILITY OF THE GLOBALLY HARMONIZED SYSTEM OF CHEMICALS IN THE UNITED STATES

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Mary Susan Miller

A Dissertation Submitted in Partial

Fulfillment of the Requirements

for the Degree of

Doctor of Philosophy

in the field of Health Education

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AN ABSTRACT OF THE DISSERTATION OF

Mary Susan Miller, for the Doctor of Philosophy degree in Health Education, presented on June 19, 2020, at Southern Illinois University Carbondale.

TITLE: FACTORS AFFECTING COMPREHENSIBILITY OF THE GLOBALLY HARMONIZED SYSTEM OF CHEMICALS IN THE UNITED STATES

MAJOR PROFESSOR: Dr. Robert J. McDermott

In this study, the researcher explored to what extent factors affect workers' comprehension of chemical hazards in the workplace when utilizing the new Global Harmonization System (GHS) of chemical labels and Safety Data Sheets (SDSs), required by the Occupational Safety and Health Administration's (OSHA) Hazard Communication Standard (HCS). The sample consisted of 422 participants that worked with chemicals as part of their previous or current work-related duties in the United States (U.S) and received chemical safety training. These participants were part of a convenience sample and were recruited utilizing Survey Monkey to collect responses. The participants were asked qualifying questions to verify they have worked with chemicals in the U.S. as a routine part of their previous or current job duties and chemical safety training. Sampling from this particular group made the data generalizable to many other workplaces in the U.S.

Using a quantitative study design, the researcher adapted an existing instrument developed and implemented by the United Nations Institute for Training and Research (UNITAR) in 2010. The research question was to what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees'

- comprehension about GHS chemical labels and SDSs?
- ability to recognize and use labels and SDSs?

- perception of danger?
- ability to locate essential chemical safety information correctly?
- comprehension of pictograms and other hazard classification elements? and
- chemical hazard ranking and interpretation?

The researcher first conducted a pilot study before collecting the full-scale sample data and analyzed the data using linear multiple regression to answer the multi-faceted research question. Descriptive analyses were also conducted on the demographics of the participants, such as age, sex, education level, work experience, safety training level, and chemical exposure level. The findings identified areas where capacity building interventions are necessary to improve GHS understanding therefore improving employee health and safety and reducing negative health effects of working with chemicals.

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CHAPTER 1

OVERVIEW

Background of the Problem

Manufacturing greatly increased in 1939 at the beginning of World War II and the years following the war. This increase in use of hazardous chemicals in the industrial marketplace led to the development of the first Material Safety Data Sheets (MSDS) in the 1950s (Karstadt, 2012). Those original MSDS were not for regular employees to use; instead, they were designed to be utilized and implemented by safety professionals in industry. Now, however, employers and employees are the primary users of chemical MSDS (Fagotto & Fung, 2002). With the massive expansion and growth of industry in the United States (U.S.) came greater hazards to employees. The negative health effects of chemical exposures were eventually made public in the 1960s when asbestos-related deaths began to dominate the news. Many employees had no idea what chemicals they were being exposed to, much less the hazards of the chemicals and precautions they could have taken to avoid injury or disease (Karstadt, 2012). In response to the extensive use of hazardous chemicals used in the manufacturing industry in the U. S. and growing public concerns about employees' health, the Occupational Safety and Health Administration (OSHA) initially developed the Hazard Communication Standard (HCS) in 1983 (OSHA, 1983). The original HCS was performance based and tasked employers with the job of determining what chemicals used in their facilities were hazardous (OSHA, 1983). Then, the employers were responsible for providing training and informing employees about the dangerous chemicals and their associated hazards. Some safety professionals were critical of the original HCS because it allowed companies to determine which chemicals were dangerous and their determination was not required to be reviewed or approved by OSHA (Janicak, 1996; Karstadt, 2012). This may have allowed employers enough leeway to hide or distort the seriousness of some chemicals used in the workplace.

Robins and Klitzman (1988) stated that systemic learning and understanding will be achieved when the ecological model of disease prevention is applied successfully to an employer's hazard communication program. Competencies and predispositions of the overall hazard communication system to identify, assess, and reduce issues related to safety and health should be enhanced. Health educators who base disease prevention on the ecological model will be more successful in designing interventions. To promote acceptance and implementation of a successful intervention program, as well as have an impact on the knowledge, attitude, and individual worker behaviors, current intra-organizational alliances must be assessed and included in the overall program (Robins & Klitzman, 1988).

OSHA broadened the scope of the HCS to include all work-related facilities where hazardous chemicals might be found in 1989 (Table 1). A decade later in 1999, the United Nations (UN) developed a committee to begin working on a chemical labeling system called the Globally Harmonized System GHS) that could be adopted worldwide to ease the burden on multinational corporations. GHS is reputed as a reasonable and thorough approach to standardizing and harmonizing the classification and labeling of chemicals worldwide (United Nations, 2009). Globally, there are more than 100 different hazard communication regulations in existence for chemical products (OSHA, 2013). Most countries were encouraged by the UN to fully adopt the GHS by 2008. OSHA added the adoption of GHS to their regulatory agenda in 2005, but it wasn't fully incorporated into a safety regulation until March 2012. The revised HCS established a compliance timeline for employers and manufacturers to transition to the new system. As outlined in the new HCS (2012) "employers must have trained all employees on how to read the GHS-formatted labels and Safety Data Sheets (SDS) by December 1, 2013."

Table 1

Timeline Showing Development of OSHA's HCS and Eventual Integration of GHS

Year	Hazard Communication Standard Development
1930s and 1940s	Increased use of hazardous chemicals in U. S. manufacturing
1960s	Increased public awareness of adverse health effects due to chemical exposures
1983	HCS is issued by OSHA covering the manufacturing industry
1989	HCS is expanded to include all industries where employees work with hazardous chemicals
1999	UN develops a committee to develop a globally-acceptable hazard system
2002	Countries are encouraged to adopt GHS by 2008
2005	OSHA adds GHS to its regulatory agenda
2012	On March 26, OSHA formally adopts and publishes the revised HCS which adopted GHS labels and SDS
2013	Employers must train all their employees by December 1 to understand GHS
2015	Chemical manufacturers must reclassify chemicals and distribute GHS formatted chemical labels and SDS by June 1
2016	All employers are required to be in full compliance with all aspects of the revised HCS

Manufacturers and distributors must have achieved full compliance with the new system no later than June 1, 2015. By the final compliance date of June 1, 2016, all employers must have achieved full compliance and made all updates to any workplace hazard communication programs (OSHA, 2012). In the U.S., chemicals are considered pervasive in the workplace environment. In fact, OSHA estimates that there are over 850,000 hazardous chemical products in use by more than 30 million U.S. workers in upward of 3 million workplaces (OSHA, 2013). There are virtually no workplaces in the U.S. that are not impacted by OSHA's HCS.

One of the fundamental changes to chemical labels was the mandated addition of signal words on labels and SDS. The signal words serve as an indication of the degree of severity of the hazardous chemical. The signal words are now standardized according to the GHS guidelines proclaiming "Danger" indicates a chemical with the most severe hazards and "Warning" indicates a chemical with less severe hazards (OSHA, 2013). In fact, in their study on the hazard perceptions of specific safety-related words and colors in Indian workers, Borade, Bansod, and Gandhewar (2008) found that industry workers made a clear and distinct connection with the word "Danger" representing the highest hazard possible, and the word "Warning" being the next hazardous class in order of importance.

OSHA claims that the changes to the chemical classification and labeling greatly increased the quality and consistency of labels which allowed workers to mitigate injuries and illnesses related to hazardous chemical exposures in the workplace (OSHA, 2013). One of the most noticeable changes with the adoption of GHS was the addition of nine hazard pictograms (Figure 1). Davies, Haines, Norris, and Wilson (1998) described a pictogram as an illustrative representation, instead of words, used to communicate chemical hazards which can be descriptive, proscriptive, or prescriptive in nature. Pictograms are widely used on consumer products to convey safety information to customers. Pictograms grab the individual's attention because they are more noticeable than a tedious caution statement (Davies et al, 1998). When pertinent and clear information is presented on the chemical label that answers the worker's questions, it greatly increases chemical hazard information retrieval speed and accuracy (Lehto, 1998).

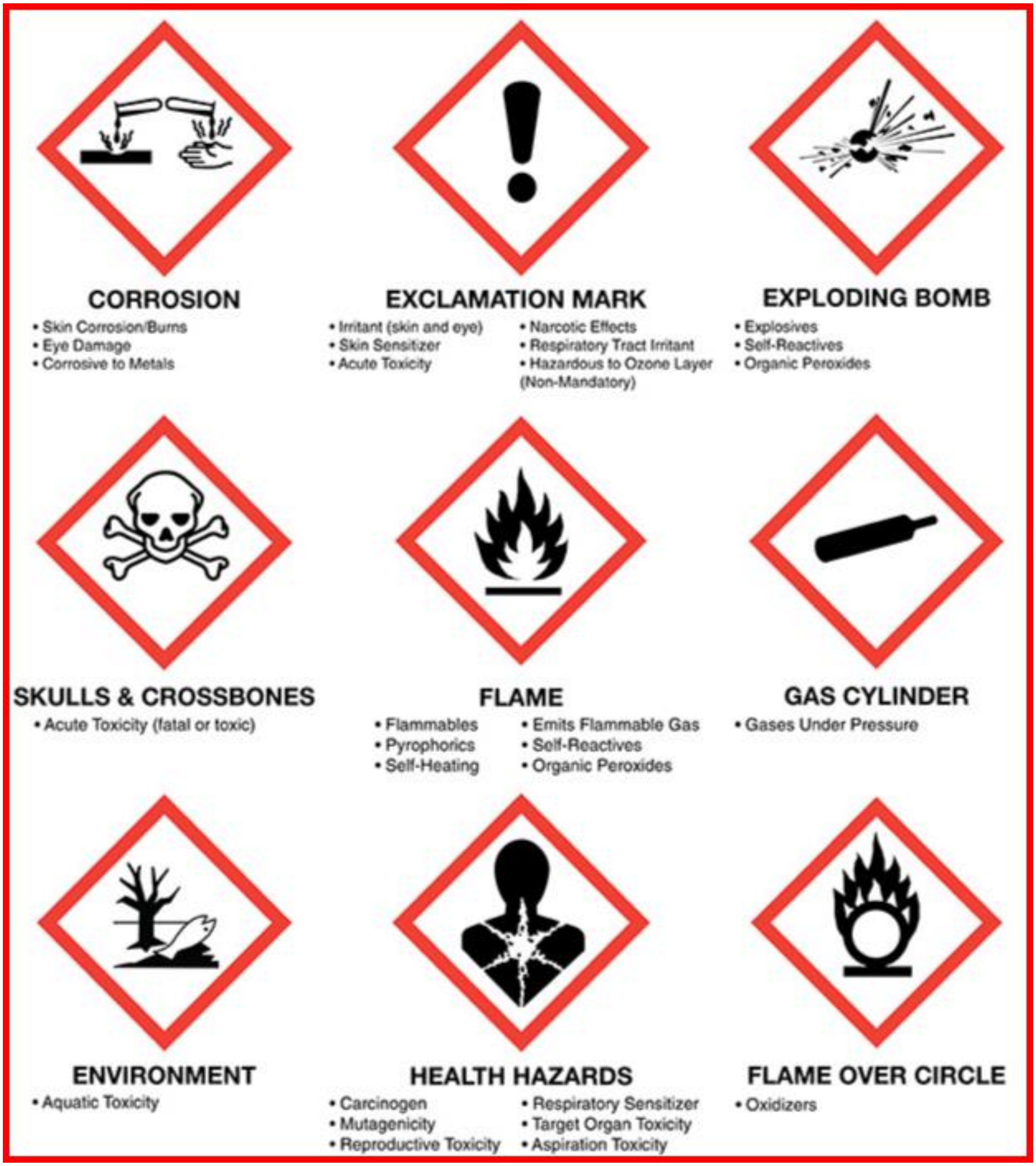

Figure 1. GHS Hazard Pictograms.

In 2012, OSHA revised the HCS to require GHS hazard pictograms be added to chemical labels and SDS. In addition, there are four personal characteristics that are thought to impact a person's ability to interpret the correct meaning of a pictogram. First, a person's previous experience and understanding with a pictogram greatly improves his/her comprehension in the future. Second, men were much more likely to recognize and comprehend pictograms than their female counterparts. Third, age plays an important role. Participants 55 years old and older typically have a more difficult time understanding the intended meaning of safety symbols and pictograms. Last, family structure also influences successful comprehension. That is, participants living in a household with small children had a higher probability of comprehending pictograms than those without young children (Easterby & Hakeil, 1981). Although Easterby and Hakeil (1981) specifically focused on consumer product safety pictograms, their findings can be easily applied to the occupational workplace as well. Therefore, older women in the workplace who have had little or no prior experience with pictograms would be expected to have greater difficulty in comprehending the GHS-formatted chemical labels and SDS and would be more likely to have a chemical-related injury or illness.

Furthermore, the GHS does not require a base panel of hazardous chemical ingredients to be identified on the SDS as HCS has done in the past. This could allow the manufacturers to obscure the chemical ingredients with generic names or completely delete the ingredients due to trade secret claims (Karstadt, 2012). Regrettably, even though the GHS SDS requires 16 sections to be presented in a specific order, the toxicology and health information related to the users' personal health are presented only in the last third of the SDS material. Perhaps the most important negative contrast between the original and GHS HCS is the potential for chemical manufacturers and employers to avoid including what was previously determined to be a hazardous chemical under the original HCS. The new GHS allows them to reclassify that chemical previously considered hazardous as non-hazardous which then allows them to exclude information about that chemical ingredient in the SDS. The end result ultimately is that less information on chemicals' hazards being provided to employees because they were reclassified as no longer dangerous by the new GHS classification guidelines. Furthermore, MSDS have historically been quite lengthy and loaded with technical jargon which was better suited for a chemical engineer than an average blue-collar, industrial worker. These characteristics, coupled with typically low literacy rates for industrial workers, compound the low comprehensibility of vital safety and health information intended to protect workers (Fagotto & Funk, 2002; Phillips et al., 1999; Ta, Mokhtar, Mohd Mokhtar, Ismail, & Abu Yazid, 2010).

On the other hand, some researchers have concluded that GHS pictograms enhance workers' comprehension and understanding of chemical labels and MSDS. In their study testing recognition of GHS labels among Japanese workers, Hara et al. (2007) found that, overall, pictograms did make it easier for users to comprehend hazards associated with chemicals. However, they noted that some individuals did have difficulty recognizing the unfamiliar pictograms for health hazard, corrosion hazard, gas under pressure cylinder, and environmental hazard. Further, some users could not differentiate the meaning between the flame (flammability) and flame over circle (oxidizer) pictograms (Hara et al., 2007). Clearly, the new GHS pictograms are confusing to some users. Training and education of employees, which are mandated by OSHA's HCS, are integral to the overall success of GHS implementation in the U.S. workplace and are instrumental in improving employee comprehension of the new GHS-required pictograms.

Boelhouwer, Davis, Franco-Watkins, Dorris, and Lungu (2013) surveyed 90 naive users (college students) and 45 experts (safety engineers and industrial hygienists) to determine if including GHS hazard pictograms had any positive effect on the comprehensibility of the label or

SDS. These researchers noted a positive effect on the participants' understanding of chemical hazards when pictograms were included on chemical labels and SDS. The authors state the findings were especially significant in the SDS survey with evidence of greatly increased understanding of chemical hazards presented in SDS-related pictograms (Boelhouwer et al., 2013). However, the participants in their study were not actual industrial workers, which is the intent of the HCS. Also, the study involved the use of precautionary pictograms, which are not included in the GHS, on the labels and SDS presented to participants. As a result, these two limitations diminish the overall impact of the findings related specifically to GHS and HCS (Boelhouwer et al, 2013).

Statement of the Problem

Numerous studies have been conducted, in the past, on the effectiveness of chemical labels and MSDS in communicating hazards of chemicals that employees are required to work with as part of their job assignments to employees (Boelhouwer, Piper, & Davis, 2009; Karstadt, 2012; Robins & Klitzman, 1988; UNITAR 2010). However, OSHA revised the HCS in March 2012 to be aligned with the GHS developed by the UN. This change has prompted occupational safety professionals and employers to question the effectiveness of GHS implementation on U.S. employees' comprehension of chemical hazards (Karstadt, 2012). Occupational injuries and diseases are potentially preventable when manmade conditions, which caused the hazard in the first place, are changed (Robins & Klitzman, 1988). This applies specifically to GHS comprehension being employed as a global tool to reduce or eliminate chemical-related injuries and illnesses.

Purpose of the Study

Comprehensibility refers to a person's ability to understand information given on a chemical label or SDS and take appropriate safety precautions. For that reason, comprehensibility testing is an integral part of determining the overall success of chemical hazard communication pictograms and SDS in communicating hazard information efficaciously (UNITAR, 2010). In this study, the researcher examined whether the GHS-revised chemical labels and SDS mandated by OSHA, increase U.S. workers' comprehension of hazards associated with chemicals used in the workplace. Therefore, the purpose of this study was to explore the factors that affect U.S. workers' comprehension of the new GHS-formatted chemical labels and SDS, mandated by OSHA's HCS.

Need for the Study

Chemicals present a capacious scope of health hazards (such as irritant, sensitizer, and carcinogen) and physical hazards (such as flammable, corrosive, and water reactive). OSHA's HCS was developed and implemented to mandate that information about chemical hazards and associated protective measures is distributed in the workplace. To accomplish this, chemical manufacturers and importers are required to evaluate the hazards of the chemicals they manufacture and sell, and to provide labels on shipped containers and more detailed chemical information listed on MSDS (OSHA, 1994). All employers with hazardous chemicals in the workplace must develop and establish a written hazard communication program and guarantee that all containers are labeled, employees are provided access to labels and SDS, and all potentially exposed employees are part of an effective training program. Fagotto and Fung (2002) also concurred that after the implementation of GHS, it is imperative to analyze the impact on U. S. employees' comprehension after referring to a GHS label and SDS.

Chemical hazard communication has been a perplexing problem, as different models of information are required for many types of individuals, such as users, workers, emergency responders, regular household consumers, and transporters (Winder, Azzi, & Wagner, 2005). GHS has the potential to break down much of the convolution in chemical classification and is expected to have positive effects on labeling and SDSs, which communicate the chemical hazards to workers. In addition, workplace risk assessments, chemical safety training, and workplace hazards control and risks may be improved by GHS implementation (Winder et al., 2005).

Boelhouwer et al., (2009) evaluated how well information presented in a SDS when GHS hazard symbols were present was comprehended. They found considerable issues with comprehension and recommended future research to examine the comprehension of GHS labels and SDS. The HCS is an important tool to promote chemical safety in the workplace. Since 1983, the amount of information available to workers on chemical hazards due to the HCS has greatly increased. However, certain concerns about definiteness and comprehensibility demand to be studied and addressed (OSHA, 2012). There is a great need to better understand the factors that impact worker's understanding of hazard communication and how workers interpret the chemical labels, pictograms, and SDS in context of making decisions about how to protect themselves from potentially hazardous or deadly scenarios.

The findings from this study will be essential in identifying factors impacting workers' comprehensibility of GHS to allow safety and health professionals to customize training to compensate for these factors to guarantee all employees have a profound understanding of GHS. A primary driver for OSHA's adoption of GHS was the desire to improve employee comprehension of critical chemical safety information (OSHA, 2012). With GHS, OSHA is saying it's not enough for workers to just know about the hazards in their work environment; instead, they also have the "right-to-understand" those hazards and to know what related safety precautions to take. Considering the overall changes brought by GHS alignment, this subtle word adjustment is easily overlooked, but it's a critical clue into OSHA's expectations for employee training moving forward. Training material must be presented in a manner that all employees can comprehend and retain. When applied to HCS training, this means that employees who interact with hazardous chemicals must receive training on those dangers in a way to ensure each employee understands the content. This ensures that employees who come in contact with toxic and potentially deadly chemicals fully understand the potential hazards.

Importance of the Study

In excess of 3 million workplaces in the U.S. use more than 850,000 hazardous chemical products (OSHA, 2013). Over 30 million U.S. employees are exposed to those hazardous chemicals when they are at work (OSHA, 2013). OSHA's HCS is intended to provide information to those in the workplace, employers, and employees that enables them to take specific actions to ensure health and protection in the workplace. The purpose of the study was to explore the effects of the new GHS-formatted chemical labels and SDS, required by OSHA's HCS, on U.S. workers' comprehension of chemical hazards in the workplace. It is imperative to explore the comprehensibility of the GHS hazard communication elements, specifically, the GHS pictograms and SDS. The possible factors influencing GHS comprehension need to be identified and analyzed (Ta et al., 2010).

The results of this study could have nationwide implications in the U.S. workplace. Considering that OSHA's revised HCS applies to all employers, employees, and chemical manufacturers in the country, employees working with chemicals in any industry are impacted by this change. The desired outcome of changing to the GHS format by OSHA is to provide chemical information in a more efficient and effective manner so U.S. workers can avoid injuries and illnesses relative to chemical use and exposures on the job. Through this study, the researcher determined to what extent factors affect workers' comprehension of chemical hazards in the workplace utilizing the GHS chemical labels and SDSs, required by OSHA's HCS.

Research Question

The research question was multifaceted; to what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees'

- comprehension about GHS chemical labels and SDSs?
- ability to recognize and use labels and SDSs?
- perception of danger?
- ability to locate essential chemical safety information correctly?
- comprehension of pictograms and other hazard classification elements? and
- chemical hazard ranking and interpretation?

Study Design

The design planned for this study was a quantitative, non-experimental, comparative approach. Using a comparative approach allowed the researcher to examine the presumed effect of attribute independent variables that the researcher cannot control (Gliner, Morgan, & Leech, 2017). These attributes were demographic variables such as age, sex, education level, work experience, safety training level, and chemical exposure level for this study. Determining which of these variables are related to comprehension and danger perception will allow safety and health professionals to customize training to compensate for these effects. Possibly on a more global scale, the GHS will need to be updated in the future to overcome these obstacles to employees' full comprehension of the system.

The researcher adapted a directly-administered questionnaire, GHS Comprehensibility Testing, that was developed and implemented by the United Nations Institute for Training and Research (UNITAR) in 2010 (Appendix A). For this study, the questionnaire was administered via a Web-based survey. This instrument had six modules. Module 1 was a general interview used to acquire demographic information and consent to proceed with the study questionnaire.

Module 2 asked the participants questions pertaining to recollection, reading, and comprehensibility of chemical labels and SDSs. Module 3 tested participant's ability to correctly rank chemicals based on severity of hazards from symbols and signal words. Module 4 tested participant's comprehension of pictograms representing the different chemical hazard classes. Module 5 tested participant's ability to recognize safety information from an SDS and analyze whether SDS information intended safety behaviors. Finally, module 6 was a post interview used to determine participant's levels of exposure to chemicals and training (UNITAR, 2010).

Sample

The sample consisted of 422 convenience sample participants that worked with chemicals as part of their previous or current work-related duties and received chemical safety training. The researcher estimated that a minimum sample size of 385 participants (confidence level = 95%, population size = 30 million U.S. employees exposed to hazardous chemicals at work, margin of error = 5%) was needed for this study (Field, 2009). The researcher decided to err on the side of caution and set the desired sample size at 400, slightly above the minimum required. The participants were part of the SurveyMonkey audience respondents and recruited utilizing Survey Monkey to collect responses. The participants were asked qualifying questions to verify they have worked with chemicals in the U.S. as a routine part of their previous or current job duties and had received chemical safety training. Sampling from this group of participants made the data generalizable to many other workplaces in the U.S.

Theoretical Framework

One of the earliest behavior change models in health education to explain a person's decision-making process and subsequent health behavior is the health belief model (Rosenstock, 1974). The model was developed in the 1950's by a group of psychologists (Rosenstock, 1974). Several decades after its inception, the theory persists and is widely used in health promotion today (Cottrell, Girvan, & McKenzie, 2012). The health belief model is based on six constructs: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy. The model asserts that individuals' belief about the probability of encountering a risk or being injured (perceived susceptibility), belief about the degree of seriousness of a condition and its consequences (perceived severity), belief in effectiveness of the precautions given to reduce the risk or seriousness of impact (perceived benefits), belief about the quantifiable and mental costs of the advised action (perceived barriers), strategies to activate readiness (cues to action), and confidence in his/her ability to take action (self-efficacy), operate in unison to determine if an individual will use suggested health behaviors.

The purpose of the GHS is to promote awareness of chemical hazards and recommend specific protective measures to take for individuals to avoid injury or illness when working with chemicals in the workplace. Researchers have found that simple reminders, cues to action, (i.e., chemical label, pictogram,) may be all that is needed for individuals to work safely with chemicals when there are high levels of perceived susceptibility, severity, self-efficacy and benefits and low levels of perceived barriers (Glanz et al., 2008). The researcher was concerned with how the health belief model constructs apply to and impact GHS comprehension in the U.S. workplace.

Limitations

A limitation of this study involved employee's unfamiliarity with some of the unique and newly-developed pictograms. Out of the nine pictograms selected and implemented in GHS, only three are familiar and recognizable to most workers (ANSI, 2010). The other six pictograms were created and developed as part of the GHS. Given some time to adjust and become familiar with the six new pictograms, workers' comprehension may improve greatly with routine and regular sightings of the pictograms through the course of their employment.

Follow-up studies ten or 20 years after full implementation of OSHA's GHS HSC in 2016 would be beneficial to see if several years of familiarity with all the pictograms would have any effect on employees' comprehension levels.

Another limitation of this study was setting. Because the researcher utilized a Web-based survey, the researcher can't control the setting in which participants take the survey. Likewise, not everyone was connected or had ready access to the Internet, so this survey method will not work with all populations (Dillman, Smyth, and Christian, 2014). Even if connected, not all potential participants were equally computer literate (Dillman et al, 2014). Information submitted by participants will not be able to be verified.

Delimitations

When interpreting the results of this study, the following delimitations should be considered:

1. The study sample included participants that have worked with chemicals.
2. The study sample included participants that live in the U. S.
3. The participants had real-world experience and knowledge of working with chemicals and reading and interpreting chemical labels and SDS.
4. Participants were limited to those who were recruited by the online survey collection service, Survey Monkey.

Assumptions

When interpreting the results of this study, the following assumptions should be considered:

1. Participants responded honestly to survey questions.
2. Participants understood instrument questions and interpreted them as intended by the researcher.

3. Participants responded accurately to instrument questions based on actual perceptions and knowledge.
4. Participants qualified for this study were similar to other employees found in general industry.
5. Instrument used in this study was valid and reliable, and was an accurate measurement of intended constructs.

Definitions

The following terms are defined to provide further explanation and will be utilized within this study:

1. *Comprehensibility* – "capable of being comprehended or understood; intelligible" (UNITAR, 2010).
2. *Globally Harmonized System (GHS)* – "a system for standardizing and harmonizing the classification and labelling of chemicals. It is a logical and comprehensive approach to:
   - Defining health, physical and environmental hazards of chemicals;
   - Creating classification processes that use available data on chemicals for comparison with the defined hazard criteria; and
   - Communicating hazard information, as well as protective measures, on labels and Safety Data Sheets (SDS)" (OSHA, 2012).
3. *Hazard Communication Standard (HCS)* – "OSHA standard intended to ensure that the hazards of all chemicals produced or imported are classified, and that information concerning classified hazards are transmitted to employers and employees. The requirements of this standard are intended to be consistent with the provisions of the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS), Revision 3. The transmittal of information is to be accomplished by

means of comprehensive hazard communication programs, which are to include container labeling and other forms of warning, safety data sheets and employee training" (OSHA, 2012).

4. *Hazard Statement* – "a statement assigned to a hazard class and category that describes the nature of the hazards of a chemical, including the degree of the hazard" (OSHA, 2012).
5. *Health Hazard* – "a chemical that is classified as posing one of the following hazardous effects: acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenicity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); or aspiration hazard" (OSHA, 2012).
6. *Label* – "brief, immediate source of chemical hazard information. It is on the chemical containers in an employee's work area and accessible at all times" (OSHA, 2012).
7. *OSHA* – *"*Occupational Safety and Health Administration" was created by Congress to ensure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance. (OSHA, 2012).
8. *Physical Hazard* – "a chemical that is classified as posing one of the following hazardous effects: explosive; flammable (gases, aerosols, liquids, or solids); oxidizer (liquid, solid or gas); self-reactive; pyrophoric (liquid or solid); self-heating; organic peroxide; corrosive to metal; gas under pressure; or in contact with water emits flammable gas" (OSHA, 2012).
9. *Pictogram* – "a pictorial symbol to represent a word or a phrase" (OSHA, 2012).

10. *Precautionary Statement* – "a phrase that describes the recommended measures to be taken to minimize or prevent adverse effects resulting from exposure to a hazardous chemical" (OSHA, 2012).
11. *Safety Data Sheet (SDS)* – "designed to provide both workers and emergency personnel with the proper procedures for handling or working with a particular substance. SDS include information such as physical data (melting point, boiling point, flash point etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, spill/leak procedures, and more" (OSHA, 2012).
12. *Signal word* – "a single word used to indicate the level of severity of the hazard and alert the reader to the potential danger. "Danger" is used for more severe hazards, while "warning" is used for less severe hazardous incidences" (OSHA, 2012).
13. *UNITAR* – "United Nations Institute for Training and Research" provides innovative learning solutions to individuals, organizations and institutions to enhance global decision-making and support country-level action for shaping a better future (UNITAR, 2010).

Summary

In a nation dominated by prominent use of hazardous chemicals in the workplace, there are virtually no workplaces in the U.S. that are not impacted by OSHA's changes to the HCS (OSHA, 2013). OSHA claims that the changes to the chemical classification, SDS, and labeling greatly increased the quality and consistency of labels which allow workers to mitigate injuries and illnesses related to hazardous chemical exposures of some 30 million workers in U.S. workplaces (OSHA, 2013). Numerous studies were conducted in the past on the effectiveness of chemicals labels and MSDS in communicating chemical hazards prior to the change to the GHS (Boelhouwer, Piper, & Davis, 2009; Karstadt, 2012; Robins & Klitzman, 1988). No recent studies have been conducted to measure the effectiveness of the GHS-complaint labels and SDS in the U.S. (UNITAR, 2010).

There is a significant need to understand the changes in employee comprehension of GHS chemical labels and SDS. The purpose of this study was to explore the effects of the new GHS-formatted chemical labels and SDS, required by OSHA's HCS, on U.S. workers' comprehension of chemical hazards in the workplace. Through this quantitative study, the researcher determined to what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' comprehension about GHS chemical labels and SDSs; ability to recognize and use labels and SDSs; perception of danger; ability to locate essential chemical safety information correctly; comprehension of pictograms and other hazard classification elements; and chemical hazard ranking and interpretation. The findings from this study may be critical in identifying factors impacting workers' comprehensibility of GHS to allow safety and health professionals to customize training to compensate for these factors to guarantee all employees have a profound understanding of GHS. The results of this study may have nationwide implications in the U.S. workplace.

CHAPTER 2

REVIEW OF LITERATURE

History of Standard

On December 29, 1970, the OSHA Act was signed into law by President Richard Nixon. The act established OSHA as the governmental agency responsible for establishing, implementing, and enforcing workplace safety laws. In the years leading up to the bill, the workers and medical professionals in the U.S. pointed to the dangers of chemical exposures and unsafe work environments as the cause of millions of injuries and illnesses annually. The bill was bi-partisan backed and supported by them both. Reportedly, workplace hazards were responsible for more than 14,000 U.S. deaths a year, 2.5 million work-related disabilities, and 300,000 work-related illnesses each year by the time the act was signed into law (OSHA, 1994).

OSHA standards mandate employers to provide a safe and healthy workplace for their employees, and established those safe and healthful working conditions as a basic right of all U.S. employees. OSHA created many of the safety standards employees consider customary today, including established exposure limits to toxic materials such as asbestos, lead, known carcinogens, and requiring personal protective equipment be provided by employers to their employees (Haight, 2012). When a safe workplace was not provided, it also granted employees an official route to submit a formal complaint, a process that ensured their safety concerns were thoroughly investigated by a third party. If an employer violated an OSHA standard, they were monetarily fined and in major cases, taken to court or ordered to shut down operations (OSHA, 1997).

In 1983, workplace safety laws were extended when OSHA published the HCS. The standard "required manufacturers and importers of chemicals to evaluate the hazards associated with the chemicals they produced and distributed" (OSHA, 1983). The information was mandated to be visible on all chemical container labels, and outlined in the complementary MSDS. Furthermore, the HCS required employers to train all employees who would be exposed to chemicals, as well as provide ready access to chemical labels and MSDS in the workplace. These new united regulations became known as the “Right to Know” laws (OSHA, 1997). The HCS mandates that chemical manufacturers communicate the hazards of their products to users through SDS, information sheets that provide information about health hazards, personal protective equipment, first aid guidance, and fire and spill mitigation protocol.

Overview of Standard

The purpose of the HCS is to transmit valuable data and precautions about the hazards associated with chemicals used in the workplace. In broad terms, this is accomplished by a unified three-branched structure. First, chemical manufacturers must test and evaluate the chemicals they produce for physical hazards (flammable, explosive, and corrosive, etc.) and health hazards (irritant, carcinogenic, lethal, etc.) (OSHA, 2012). Next, the manufacturer or importer must develop comprehensive SDS and labels for containers to inform any users of the known or possible hazards. Lastly, a written hazard communication program was required to be developed by the employer that must address how the hazardous chemicals will be handled in the workplace and how training will be provided to ensure employees understand the information presented on the labels and SDS (OSHA, 1994). The three fundamental branches in the hazard communication system – labels, SDS, and employee training – are all critical to the effective performance of the program. The labels provide a brief overview of the most important information employees need to know to work with chemicals safely (Haight, 2012). The SDS provide detailed technical data, and serve as a document of reference to health professionals providing services when employees are exposed to chemicals. Training guarantees employees understand the information provided on the labels and SDS, know how to access and interpret this information when needed, and know procedures to take to protect themselves (OSHA, 1994). Each branch significantly impacts the others.

The goal of greatly reducing the frequency of chemical-related illnesses and injuries in the workplace can be accomplished by individuals following the information on health effects and protective measures provided under the HCS. A successful hazard communication program will accomplish this goal through modifying and changing the behavior of employees and employers (Haight, 2012). Employers, many of whom may not have been aware of the potential chemical hazards associated with products they purchased for use in their facilities, will be able to use the technical data provided under the HCS to design and implement better safety procedures and programs. As a result, an employer may decide to purchase a less hazardous product, in this way preventing exposures to chemicals with more severe hazards and providing a safer workplace to their workforce (OSHA, 1994). Based on the information on chemical hazards, engineering controls can be better designed and installed, more appropriate personal protective clothing can be purchased and utilized, and effective respiratory protection can be provided to employees that will be prone to hazardous chemicals on the job. Improved comprehension of chemical hazards also allows supervisors and employees to work safer with chemicals on a daily basis so that injury and illness rates are decreased (Haight, 2012).

OSHA (2004) states when provided the necessary and relevant hazard information, employees are expected to participate at a higher level in and support the protective measures and safety programs established in their workplaces to protect them. The labels and SDS inform the worker of the chemicals' hazards as well as guidance to protect themselves. The employee training teaches them how to use the chemical-related information to change their behaviors and protect themselves from the associated hazards (OSHA, 2004). Employees that are properly trained in hazard communication know how to read and understand information on the labels and on the MSDS. They can then make safer, informed decisions when working with chemicals and know what actions to take in different emergency situations related to chemicals in the workplace. Information on chronic health effects assists employees in identifying and recognizing possible symptoms and side effects and allow them to seek treatment earlier for chemical-related diseases (OSHA, 1994).

Safety and health professionals will be able to ensure a safe and healthful workplace to exposed employees, such as medical surveillance, environmental workplace monitoring, and other services can be improved by the ready accessibility of health and safety data. According to OSHA (2004), "For any safety and health program, success depends on commitment at every level of the organization, this is particularly true for hazard communication, where success requires a change in behavior. This will only occur if employers understand the program, and are committed to its success, and if employees are motivated by the people presenting the information to them" (Appendix E of the 1910.1200 HCS).

Chemical classification and labelling systems that are different across national borders can lead to a higher occurrence of adverse events when employees use chemicals in the workplace. As a solution to this problem, GHS was adopted by the United Nations Economic and Social Council's Subcommittee of Experts on the GHS in 2002 and endorsed by the United Nations Economic and Social Council in 2003 (Ta, Jonai, Mokhtar, & Peterson, 2009). GHS provides the foundation for a global approach to chemical management and safety (Peterson, Mokhtar, Chang & Krueger, 2010). The mission of GHS is to "a) enhance the protection of human health by providing an internationally comprehensive system for communicating chemical hazards; b) provide an uniform framework for countries with no system currently; c) reduce the need for testing and evaluating chemical hazards; and d) facilitate international trade" (OSHA, 2012).

In the U.S. on March 26, 2012, OSHA officially ratified the adoption of the GHS. This adoption is a revision of the original HCS to systematically align with the GHS. OSHA dubbed this revision, HazCom 2012 (OSHA, 2012). The system provides the framework for a globalized, consistent, and coherent method to classifying chemical hazards and communicating that information to users. This new system, which was created by the collaborative efforts of the World Health Organization, the International Labor Organization, the Organization for Economic Cooperation and Development, and the United Nations has been met with broad support from the chemical industry because of its commitment to harmonize the method of chemical classification, labelling, and a uniform system for SDS (Winder et al., 2005).

Comprehensibility

Comprehensibility refers to “the ability of the person reading a chemical label, warning, or SDS to understand the information sufficiently to take the desired action” (UNITAR, 2010). Comprehensibility is a measure of how well the receiver of the information understood the material, which differs from readability because it is simply a measure of grade reading level of the written material. For example, a warning about chemical incompatibilities may be written a for a specific audience at the correct reading level, but the concept of incompatibility may be poorly explained and therefore the warning isn’t fully understood by most of the intended audience (Haight, 2012). Furthermore, the same warning may be easily comprehended by employees, but not properly understood by emergency responders with the same level of education, but variant work experiences. In the end, achieving high levels of comprehensibility does not guarantee that employees will take the actions recommended on the label or MSDS. This final, behavioral step is influenced by a complex blend of demographics, attitudes, knowledge, motivations, and potential ramifications that are specific to each employee in a particular situation (OSHA, 1997).

In their experiment concerning warning labels on household chemicals, Godfrey, Rothstein, and Laughrey (1993) indicated that individuals are able to differentiate between chemicals based on overall hazards. Based on the results of the study, these authors determined that when chemical users perceived a chemical as hazardous, there was a higher probability they would look for a warning on the container. In addition, males were less likely than females to look for a warning statement. Therefore, the researchers concluded perceived hazard, sex and product familiarity influence user's decision to look for a warning statement on the chemical labels of potentially hazardous chemicals.

Silver and Wogalter (1991) conducted a study in which hazards associated with 26 pest-control products were judged by a variety of college students, older adults, and pest control experts. The sample represented a wide variety in rates of exposures. Fumigators and foggers were identified as the highest hazard chemical products closely followed by sprays, systems, and traps. Despite the fact some fallacies of hazards for certain products were evident, the students and older adults' judgments were uniform with those of the pest control professionals. Also, perceived hazard was found to have a positive correlation with several nonpartisan characteristics of the chemical labels, including number of chemical elements, number of words and sentences, readability, and the latency and placement of certain warning statements on the label. These findings imply that users can judge correctly the level of hazardousness of different classes of chemicals, and the presence of different cues on the label may significantly aid their decision making (Silver & Wogalter, 1991).

Similar results were also noted by Desaulniers (1987) when he examined the influence of chemical warning layout and organization of semantics on the comprehensibility and recollection of warning information. In his study, he ascertained that warnings were easier to understand and comprehend, and had greater visual appeal when utilizing an outline layout type of hazard organization. In contrast, warnings using a paragraph layout were noted as not being as easy to read and comprehend for the chemical user.

Lastly, Black and Wood-Black (2013) studied the challenges of comprehension associated with the GHS. They concluded that participants found the GHS label was more precise and understandable. This suggests that the change to the GHS may be less puzzling to employees than expected, thereby increasing comprehensibility. The researchers pointed out that change in and of itself can create hazards, and that change must be handled effectively to decrease potential negative consequences (Black & Wood-Black, 2013).

Use of Symbols and Pictograms

The purpose of symbols and pictograms is to convey important information related to a hazard to chemical users in a quick and effective manner. Previously, chemical labels using written language in paragraph form have been found to be cumbersome and difficult for the user to quickly decipher important safety information (OSHA, 1997). Furthermore, the number of workers in the U.S. that speak English as a second language is increasing each year. This factor makes the use of symbols and pictograms to convey chemical hazards crucial towards efforts of global harmonization. Symbols and pictograms are a valuable tool to quickly communicate chemical hazards to individuals who cannot read chemical warning statements and information because of vision problems, inadequate reading skills, or a language barrier (Wogalter, Sojourner, & Brelsford, 1997).

The increasingly broad use of symbols and pictograms is based on the assumed benefits of depicting safety messages in pictorial form. Collins and Lerner (1982) assessed U.S. participants' comprehension of twenty-five prospective fire-related symbols. Some potentially deadly confusions in meanings were revealed, such as the poor performance of some critical symbols for an emergency exit were noted. As a result of their findings, the researchers cautioned the symbol development and uniformity process to include testing procedures as intrinsic elements before global implementation (Collins & Lerner, 1982).

Lehto and Clark (1991) reviewed the FMC Corporation Product Safety Sign and Label System Manual and concluded that replacing written words with pictorial or symbolic language greatly increased communication effectiveness among a greater representation of the population, both nationally and globally. The pictorials were combined with words and colors in formats with a unique design intended to convey thorough chemical hazard information in a precise and coherent manner. An example given by Lehto and Clark (1991) was the case of an extremely flammable floor-covering adhesive; users seemingly did not understand vapors coming off the liquid, rather the adhesive liquid itself, pose a fire hazard. The researchers determined the combination of words and symbols on a chemical label was most effective in communicating hazards (Lehto & Clark, 1991). In like manner, in a study by Wilkinson, Cary, Barr, and Reynolds (1997), chemical labels with pictograms and text were overwhelmingly perceived by the participants as significantly easier to comprehend and obtain information from than a chemical label with text only. When pictograms were added to the chemical label, they noticed a considerable increase in the number of participants choosing correct safety precautions for using and storing the chemicals.

However, some research results on the function of pictograms in assisting comprehension of warnings have been inconclusive at best (Wilkinson et al., 1997). Jaynes and Boles (1990) studied compliance rates associated with different warning designs, specifically those including pictograms. A written warning, a pictogram warning with a red circle wrapping each illustration, a pictogram warning with a triangle wrapping each illustration, a warning with both words and pictograms, and a control with no warnings were all tested and compared. For this study, participants carried out a lab-related task involving chemicals using a set of instructions containing one of the five listed conditions. These warnings instructed participants to wear safety glasses, respiratory protection, and hand protection. All four warnings had an increased rate of compliance than the condition with no-warning for the user. The researchers noted that the inclusion of pictograms to a written warning greatly increased participants' compliance rates. However, the enclosure shape (circle or triangle) had no effect on compliance rates, regardless of research that indicated unstable shapes are preferred.

Correspondingly, Koshy, Presutti, and Rosen (2015) studied lessons learned from GHS implementation. Participants had difficulty differentiating oxidizing and flammable materials pictograms, as they both are represented by an icon with a flame. Much of the new HCS nomenclature and pictograms contains precise differences and meanings that could easily be incomprehensible to regular workers (Koshy et al., 2015). Trainers disclosed problems teaching and communicating technical terms such as "carcinogen and mutagenicity" associated with the health hazard pictogram to a group of workers with different comprehension levels, as well as explaining how the health hazard pictogram (chronic health hazard) is specifically different from the skull and crossbones pictogram (acute toxicity which is fatal or toxic) (Koshy et al., 2015).

Similarly, Wogalter et al. (1997) concluded that one main reason pictograms and symbols may be not be comprehended well is that they are unsuccessful in communicating their intended message. The pictograms that are more easily understood tend to be of more tangible and familiar concepts (i.e., skull and crossbones), in comparison to the less understood conceptual pictograms that tend to involve abstract ideas (i.e., exclamation mark) (Wolff & Wogalter, 1993). The researchers also concluded the simple pairing of pictograms and signal words is an effective method to increase comprehensibility whenever possible (Wogalter et al., 1997).

Using graphical pictograms as an essential part of a hazard communication system to a diverse global audience requires research to evaluate comprehension. Yet, Hesse, Steele, Kalsher, and Mont'alvao (2010) found that GHS pictograms had a low comprehension level by the majority of participants in their study. Therefore, these researchers believed they had an urgent duty to address comprehension deficiencies with the GHS pictograms. Only four of the nine GHS pictograms (corrosive, flammable, acute toxicity, and skull and crossbones) met the ANSI Z525.3 comprehension criteria and only one pictogram (corrosive hazard) met the comprehension criteria of 85% in the study (Heese et al, 2010). Heese et al. (2010) found that pictograms depicting relatively abstract hazards (compressed gas, oxidizer, and health hazard) were among the least well-understood pictograms in the study. The researchers ascertained additional systemic research is needed to effectively determine the reasons pictograms aren't universally successful in conveying safety hazards to their audience (Heese et al., 2010). This study will explore factors that may influence comprehension of GHS pictograms.

Legibility

Both the typographical components and the sign, label, or paper upon which a hazard statement or message is printed is the basis of legibility (Hale, 1991). A good example of this was demonstrated in 1965 when Congress enacted the Federal Cigarette Labeling and Advertising Act requiring that the warning "Caution: Cigarette Smoking May Be Hazardous to Your Health" in small print be placed on at least one side panel of all cigarette wrappers (Givel, 2007). Font size and variances between the ink and the paper chosen, made the resulting health warning barely readable in most instances. In 1981, the Federal Trade Commission (FTC) furnished a report to Congress outlining health warning labels had an insignificant impact on public knowledge and attitudes regarding smoking (Givel, 2007). As a result of the FTC's report, Givel (2007) states Congress ratified the Comprehensive Smoking Education Act of 1984, which required all cigarette packages and advertisements contain one of the following four explicit health warnings:

- “SURGEON GENERAL’S WARNING: Smoking Causes Lung Cancer, Heart Disease, Emphysema, and May Complicate Pregnancy”
- “SURGEON GENERAL’S WARNING: Quitting Smoking Now Greatly Reduces Serious Risks to Your Health”
- “SURGEON GENERAL’S WARNING: Smoking by Pregnant Women May Result in Fetal Injury, Premature Birth, and Low Birth Weight”
- “SURGEON GENERAL’S WARNING: Cigarette Smoke Contains Carbon Monoxide”

Congress later authorized a similar requirement for beer and wine, in 1988 specific labeling stipulations were mandated, requiring that the warning must start with “GOVERNMENT WARNING,” printed in bold, all capital letters (Hale, 1991).

Mazis, Morris, and Swasy (1991), in a study to evaluate the effectiveness of the prescribed warnings, found that a contrast ratio, difference between color of print and color of the backdrop, is a valid and reliable measure of legibility. In addition, examples with high contrast ratio values were more difficult to read, despite containing the exact same wording and utilizing the same font size and type. Hale (1991) later determined, “if regulators and others who wish to formulate rules for legibility are to enjoy even modest success, it is clear that they will need the assistance of well-defined standards covering all the attributes described.” Howett (1983) derived a formula prescribing the necessary width of a letter stroke needed for legibility of words on a sign that can be easily observed from any distance if the individual has average clarity of vision. ANSI based safety label and sign regulations from Howett’s work. The ANSI standard that relates to the design and content of safety signs is Z535-2011. The ANSI Z535-2011 standard brings greater clarity to the identification of hazards and improved, standardized legibility. This standard created guidelines for the colors, symbols, information, and other aspects used on safety labels (ANSI, 2011).

Sex

Laughery and Brelsford (1993) noted that women are much more likely than men to search out and read warnings. Women also reported being more likely to obey and heed warning statements and safety communications. However, it was unclear whether sex is the factor contributing to the reported variances in the Laughery and Brelsford study (1993) with hazard perceptions or whether the variances were associated with other basic factors, such as knowledge of hazards, familiarity with chemicals, frequency of use, etc. Banda and Sichilongo's (2006) study found that education level, sex and age did not exert any influence on the comprehension levels of GHS constituent parts. Inconsistent results in prior studies have been reported on the effect of sex on GHS comprehension among individuals and there is scarce data among workers (Boelhouwer & Davis, 2010; Sathar, Dalvie, & Rother, 2016). Further systemic research that accounts for confounding factors, such as sex, is needed (Laughery & Brelsford, 1993). This study explored if sex influences GHS comprehension in the workplace.

Age

The age of the individual shows signs of affecting perceived level of hazard projected by typical signal words (Kotwal & Lerner, 1995). Kotwal and Lerner (1995) summarized their findings as follows:

> "Older subjects generally used signal words that implied greater hazards to represent the amount of risk involved in a given situation. Since older users have indicated that a given signal word implies a lower level of hazard than the same word implies for younger users, it may be necessary to apply relatively strong signal words for older users in order to connote a given level of hazard."

Desaulniers' (1987) ascertained that users 40 years old and older are undeniably more likely to obey precautions in acknowledgement of safety warnings and communications as reflected in their safety behaviors. On the other hand, Collins and Lerner (1982), found that users of advanced age displayed lower comprehension levels for safety signs utilizing pictograms. Finally, Laughery and Brelsford (1993) argue that older users are more likely to obey safety warnings, but increased focus on comprehension levels is warranted.

Wilkinson et al. (1997) found differences in perceptions of danger were accounted for by the age of the participant. In their study, farmers younger than 25 years of age tended to rate chemical labels on herbicides as being more dangerous chemicals than did farmers over the age of 25. This study examined if age influences GHS comprehension.

Education Level

Researchers have found that education level of employees in the workplace can influence their comprehension of chemical labels and SDS. Ta et al., (2010), not surprisingly, revealed that GHS study participants with a college degree obtained higher comprehension scores compared to participants that only completed high school or never earned a high school diploma. The researchers noted a profound difference in higher education levels greatly improving participants' aptitude in hazard identification associated with chemicals through the GHS pictograms (Ta, et al., 2010). Likewise, Hara et al., (2007) determined individuals with lower levels of education had a more difficult time understanding chemical labels than their higher educated coworkers. These findings emphasize the importance of proactive efforts taken by employers to educate and train their employees with lower education levels.

However, Banda and Sichilongo (2006) ascertained that education levels did not change the comprehension of GHS label segments and perceived hazard among workers in their study. A limitation of their study was the fact that demographic characteristics, such as education level, were not clearly presented in their findings. Also, Conklin (2003) found that level of education did not have a significant impact on the comprehension level of MSDS in his study. These conflicting findings in multiple studies highlights the need to study what influence individuals' education levels have on GHS comprehension. This study explored how education level influences GHS comprehension.

Work Experience

Laughery and Brelsford (1993) conducted a study on receiver characteristics in safety communications. They found that individuals with a moderate level of work experience (5-10 years) mostly relied on external information (chemical label) when analyzing a chemical-related safety decision. Individuals with high levels of work experience (more than 10 years) with chemicals did not need the information as frequently as the moderates. Additionally, the researchers noted that individuals with a low level of chemical-related work experience (less than 5 years) did not have the full capacity to use the chemical label and SDS information appropriately (Laughery & Brelsford, 1993). Likewise, Boelhouwer et al. (2013) confirmed that naïve users with 10 years or less of work experience correctly responded to only 67% of GHS survey questions, as opposed to an 86% correct response rate for experts with more than 10 years of work experience. The more experienced participants significantly inflated correct response rate suggests that work experience indeed plays a major role in GHS chemical label and SDS comprehension (Boelhouwer et al., 2013). This study investigated the influence work experience had on GHS comprehension.

Safety Training

More than one hundred OSHA standards addressing safety and health contain mandates for required training aimed at reducing risk factors for injury or disease in the workplace (OSHA, 2004). Training is one of the essential portions of a successful hazard communication program that can stimulate an employee's brain so they are receptive to the important messages about chemical hazards. The performance-based HCS legally requires employer inform their workers about chemical hazards on the job. Hazard communication in the workplace is accomplished through a process that includes methods for transmitting information, chemical labels and SDS, and influencing individual behavior. For example, reductions in employee injury rates were found after the workplace first-aid training programs were introduced, implying that this type of instruction boosts awareness of work-related safety and changes safety behaviors (OSHA, 2004; Laughery & Brelsford, 1993). Additionally, there appears to be a direct connection between safety training and the creation of a healthful and safe working environment. Boelhouwer and Davis (2010) noted "near unanimous" advantages that training can attain, such as increased levels of hazard awareness and overall safer behavioral changes. Wogalter, Sojourner, and Brelsford's (1997), in their study on safety pictograms and comprehension, support the notion that presenting pictograms in conjunction with associated written information is an effective method for training employees on the meanings of pictograms. This supports Boelhouwer and Davis's (2010) hypothesis taken from the dual code theory – combining written and pictorial information greatly assists with memorization and recall.

OSHA's HCS (2012) mandates "all employers provide information to their employees about the hazardous chemicals to which they are exposed, by means of a hazard communication program, labels and other forms of warning, safety data sheets, and information and training" as follows:

> "Employees are to be trained at the time they are assigned to work with a hazardous chemical. The intent of this provision (1910.1200(h)) is to have information prior to exposure to prevent the occurrence of adverse health effects. This purpose cannot be met if training is delayed until a later date. The training provisions of the HCS are not satisfied solely by giving employee the data sheets to read. An employer's training program is to be a forum for explaining to employees not only the hazards of the chemicals in their work area, but also how to use the information generated in the hazard communication program. This can be accomplished in many ways (audiovisuals, classroom instruction, interactive video), and should include an opportunity for employees to ask questions to ensure that they understand the information presented to them. Training need not be conducted on each specific chemical found in the workplace, but may be conducted by categories of hazard (e.g., carcinogens, sensitizers, acutely toxic agents) that are or may be encountered by an employee during the course of his duties. Furthermore, the training must be comprehensible."

> "Additional training is to be done whenever a new physical or health hazard is introduced into the work area, not a new chemical. For example, if a new solvent is brought into the

> workplace, and it has hazards similar to existing chemicals for which training has already been conducted, then no new training is required. As with initial training, and in keeping with the intent of the standard, the employer must make employees specifically aware which hazard category (i.e., corrosive, irritant, etc.) the solvent falls within. The substance-specific data sheet must still be available, and the product must be properly labeled. If the newly introduced solvent is a suspect carcinogen, and there has never been a carcinogenic hazard in the workplace before, then new training for carcinogenic hazards must be conducted for employees in those work areas where employees will be exposed. It is not necessary that the employer retrain each new hire if that employee has received prior training by a past employer, an employee union, or any other entity. General information, such as the rudiments of the HCS could be expected to remain with an employee from one position to another. The employer, however, maintains the responsibility to ensure that their employees are adequately trained and are equipped with the knowledge and information necessary to conduct their jobs safely. It is likely that additional training will be needed since employees must know the specifics of their new employers' programs such as where the MSDSs are located, details of the employer's in-plant labeling system, and the hazards of new chemicals to which they will be exposed. For example, 1910.1200(h)(3)(iii) requires that employees be trained on the measures they can take to protect themselves from hazards, including specific procedures the employer has implemented such as work practices, emergency procedures, and personal protective equipment to be used. An employer, therefore, has a responsibility to evaluate an employee's level of knowledge with regard to the hazards in the workplace, their familiarity with the requirements of the standard, and the employer's hazard communication program."

Inadequate safety training on the GHS is a probable influence for low comprehension levels of hazard communication in the workplace. Sathar et al. (2016) studied chemical hazard information comprehension levels among workers and discovered low comprehensibility rates among workers on most hazard pictograms due to lack of training or inadequate training. This impacts the overall safety and health of workers while using chemicals on the job. For employees, appropriate training on how to correctly interpret and understand GHS hazard and precautionary warning statements on the chemical label and SDS is an essential part of increasing comprehension, and also applying the information appropriately (Sathar et al., 2016). The evidence and data on the effect of training on GHS comprehension is limited due to the relative newness of the change to the OSHA HCS in 2012. This study investigated how safety training influenced GHS comprehension in the U.S.

Chemical Exposure Level (Familiarity)

Researchers have found a definite subjective effect from chemical product familiarity based on frequency of chemical exposures (DeJoy, 1989; Godrey et al, 1993; Otsubo, 1988). DeJoy (1989) conducted a thorough literature review and found several studies where higher frequencies of chemical exposures decreased the likelihood of noticing, reading, or obeying chemical label warnings. In addition, DeJoy also noted that the user's product-related expectations were the best indicator of how a user would behave. In like manner, Godfrey et al. (1993) and Otsubo (1988) have found that individuals are less likely to observe, read, and follow warnings on household chemicals with which they are familiar than they are with unfamiliar chemicals. The more time individuals work a chemical without experiencing a safety issue or consequence, they perceive the product to be less hazardous over time (Janicak, 1996). Likewise, Banda and Sichilongo (2006) studied comprehension levels of chemical labels of four groups in Zambia; agricultural, industrial, transport, and consumer. The researchers revealed a negative correlation ($p=.05$) between the comprehension levels and demographic factors such as sex, age, literacy level, education level, and type of employment in all four groups. Comprehension of GHS labels was shown to be more directly correlated with duration of chemical exposure (Banda & Sichilongo, 2006). Similarly, Purswell, Krenek and Dorris (1987) ascertained if an individual is regularly exposed to a chemical hazard warning while also not experiencing negative health effects, the chemical warning is much more likely to be filtered and ignored by the individual and thereby rendering it ineffective. Chemical exposure levels and familiarity have been well illustrated in previous studies where the consensus was the more an individual uses a chemical without experiencing an injury or illness, the less hazardous the individual perceives the chemical to be and will most likely ignore the chemical warning in future use (Banda & Sichilongo, 2006; Godrey et al., 1993; Otsubu, 1988). This study continued that work by examining if chemical exposure levels, or familiarity, influenced GHS comprehension.

Hazard and Risk Perception

The notion that a person's perception of the degree of a hazard associated with a chemical can actuate the overall effectiveness of a safety warning or label has been a homogenous conclusion in warning research (Laughery & Brelsford, 1993). Kotwal and Lerner (1995) found that many researchers have confirmed that the layout and design of a warning label may be secondary to the individual's expectations brought to the situation. Several researchers have connoted that anticipated severity of consequences is a strong predictor of behavioral intentions. In fact, the higher the perceived danger or hazard, the more likely individuals will look for and read a warning. They are also much more like to comply with and follow stated precautions (Donner & Brelsford, 1988; Friedman, 1988; Otsubu, 1988). Furthermore, the more straightforward the warning is about the potential severity of the injury, the greater the recollection of warning information and also the greater the perceived hazardous (Kotwal & Lerner, 1995).

Viscusi and Zeckhauser (1996) studied risk perception and found that if a warning is received and processed properly, it will alter the individual's risk assessments. Conveying hazard information that will lead to appropriate risk perceptions is not a trivial task; it is too easy to instigate undue complacency or create needless alarm. Individuals have a remarkably difficult time making sound decision in uncertain circumstances. Efficacy of warnings is limited by this struggle in promoting proper risk perceptions and encouraging rational, safe decisions (Viscusi & Zeckhauser, 1996). People's *a priori* perceptions of hazards associated with a product or environment are important determiners of whether or not they will look for and read warnings

(Laughery & Brelsford, 1993). If the warning is correctly received and processed, it should modify the individual's risk perception and consequent behavior.

Purswell et al., (1993) found that given the relevance of hazard and risk perception in safe behavior, there have been few trials to develop a good evaluation of risk-taking behavior. In their study, participants were presented with four chemical products to use in a controlled setting where the real focus of the study was obscured. The researchers determined individuals were more willing to read labels and warnings that contained more highly scored readability statements, a result that was determined to be due to their typical association with perceived hazard (Purswell, et al., 1993). In addition, Purswell et al. (1993) found that the proportion of risk information presented did not significantly influence the subjective rating of hazard perceived by the individual chemical user. Bogett and Rodriguez (1987) also investigated the impact of a perception of danger particularly related to chemical label warnings and safety warning programs. The results of their study coupled with supporting literature from Collins and Lerner (1982), inferred that a perception of danger, an impermissible level of risk or injury, must exist in order to heighten an individual's safety behavior. Thus, a need for more research to develop information regarding the way people process and apply perceived risk information was shown. In a manner, it is the proverbial "chicken and egg" type problem. Unless a warning is read, a hazard is not perceived, and a hazard cannot be perceived without the chemical hazard communication information.

Other researchers suggested that a worker's perception of risk is based on an aggregate of severity and probability information (Boelhouwer & Davis, 2010). Likewise, Wogalter, Young, Brelsford, and Barlow (1999) determined that a chemical user's rating of risk is impacted by the degree of injury severity listed on a chemical warning label. In their study, participants were able to recognize the potential hazard risk using the hazard and signal word designated by the hazard classifications. This finding fortifies one of the goals for GHS comprehensibility; the signal word used to show the hazard severity should be consistent across divergent hazard types (UN, 2009). However, Boelhouwer and Davis (2010) concluded the inclusion of a pictogram on the chemical label had no significant effect on the user's perceived risk of the chemical. Again, researchers have been unable to determine precisely which factors affect hazard and risk perception when individuals use chemicals in the workplace.

Communicating risk effectively is a challenge since situations involving risks and hazards are often coupled with weaknesses in the way safety information is presented, which can make it difficult for individuals to make sound decisions under these conditions of uncertainty (Wogalter et al., 1999). This complication minimizes the effectiveness of warnings to advance accurate risk perceptions and advance rational, safe decisions. However, information has the potential to greatly promote more informed choices and decisions (Kotwal & Lerner, 1995). In fact, risk information programs increase an individual's perceived risk associated with chemical hazards (Viscusi & Zeckhauser, 1996). This study examined the gaps in understanding hazard and risk perception as it related to the GHS for hazard communication of chemicals.

Stress

Stress is another influential factor which can impact an individuals' comprehension and behavioral compliance of information presented on a chemical label or SDS. Employing a chemistry task format, Magurno and Wogalter (1994) evaluated dichotomous stress: time constraints and social judgment by peers. They evaluated conditions involving low stress and high stress situations. Magurno and Wogalter (1994) determined that higher stress conditions produced seriously lower compliance rates. Obeyance with the instruction of wearing of personal protective equipment was greatly increased among individuals subjected to lower stress. The findings of the Magurno and Wogalter (1994) study add understanding about the influence of external warning factors by demonstrating that stressors in their experiment affects the extent of warning compliance rates. High levels of stress have been shown to negatively impact the higher level of decision-making in safety leading to an increased likelihood of a workplace injury or illness (Magurno and Wogalter, 1994).

Cost of Compliance

Cost of compliance refers to "the amount of effort an individual must exert in order to comply with a safety warning" (Kotwal & Lerner, 1995). By including personal protective equipment (gloves, hearing protection, respirator, etc.) when selling the hazardous chemical, the cost of compliance to the user can be greatly reduced (Kotwal & Lerner, 1995). Naturally, the less effort needed by a person to comply with the warning, the higher the increase in rates of compliance. Connecting the cost of compliance to other safety warnings, Kotwal and Learner (1995) found that a lower cost of compliance resulted in a better outcome on compliance rates than warning meaning and the counter influence of multiple warnings. Hathaway and Dingus (1992) also found that the advantages of a low cost of compliance could be improved by the addition of specific negative consequence information on the warning. They concluded that supplying the individual with information related to injury frequency and severity related to the hazard, as well as providing the necessary resources (personal protective equipment) required to model safe behavior, could significantly improve overall warning effectiveness.

Measurement and Protocols

The American National Standards Institute (ANSI) is "a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States" (ANSI, 2010). They also integrate U.S. standards with international standards so that products manufactured in the U.S. can be utilized worldwide. ANSI Z535 (2011) is a technical communicator guide of standards to be utilized in the development of effective hazard and safety warnings. The ANSI standard Z535.3-2011 entitled "Criteria for Safety Symbols," contains an evaluation process for gauging pictogram efficacy and "a criterion for success of 85% correct responses with no more than 5% critical confusion." Critical confusion refers to when the safety warning conveyed is the opposite of the safety warning intended, which could potentially be deadly. A score below the ANSI 85% correct response level for criterion success does not mean the pictogram shouldn't be utilized, but that it cannot be used solely and must be used in conjunction with a written warning or more instructions (ANSI, 2011).

Similarly, the International Organization for Standardization (ISO) is "an international standard-setting body composed of representatives from various national standards organizations" (Brugger, 1999). Founded in 1947, ISO promotes global ownership with technical and commercial standards (Brugger, 1999). ISO 9186, Procedures for the Development and Testing of Public Information Symbols, was issued by the ISO. This standard advocates testing methods to evaluate symbols planned to be used globally, as well as sets a lower level of acceptance in contrast to the 85% of the ANSI standard. ISO 9186 set a criterion level of 66% for safety symbols (ANSI, 2011).

Signal Words

The specific language of signal words and warnings often plays an important role in workplace chemical safety. Signal words such as "danger" and "caution," have well-defined meanings within the framework of the hazard warnings vocabulary; they imply a certain risk level (Viscusi & Zeckhauser, 1996). The objective of a warning should not be to provoke the most cautious response possible, but to enable the individual to make safe decisions of the risk level and take appropriate actions (Viscusi & Zeckhauser, 1996).

"Product Safety Signs and Labels" is ANSI standard Z535.4-2011 which dictates "when the following signal words should be used on chemical labels:

> *Danger* indicates the most severe hazard is present. This signal word is limited to the most extreme situations.
>
> *Warning* indicates a less severe degree of hazard is present."

The importance and meanings that ANSI and OSHA attach to signal words is not widely known or understood by the general public (Brugger, 1999). Leonard, Hill and Karnes (1998) studied signal word warnings and the general public's perception of the degree of danger being represented. The researchers concluded that participants are much more likely to use a signal word with a high seriousness rating to convey high risks to others. They did not detect differences among age groups with elder participants using signal words with more serious significance most often. Furthermore, Wogalter, Jarrad, and Simpson (1992) explored the influence of signal words on warnings and pictograms on perceptions of hazard for consumer products. The researchers determined that the appearance of a signal word greatly improved the perceived hazard compared to its nonappearance. However, the presence of a pictogram had no significant impact on the degree of hazard perception in participants. Individuals' understanding of the level hazard implied by a signal word on chemical labels can greatly enhance GHS comprehensibility.

Wogalter, Desaulniers, and Godfrey (1985) evaluated the standard practice of determining when four components are needed for safety warnings. Four-statement warning labels contained: 1) signal word, 2) hazard statement, 3) consequence statement, and 4) instruction statement. Four other supplementary three-statement warning labels, each with a different element absent, were used. Removing content statements did reduce perceived hazard level. The most important were the hazard and instruction statement, with a correlation between the greatest decrease in effectiveness and deletion of content. The researchers determined four-statement warning labels for the most hazardous situation were perceived by participants as the most effective warnings (Wogalter et al., 1985). This demonstrates additionally the importance of signal word understanding and risk perception in the overall strategy of effective comprehension of the GHS.

Safety Data Sheets

While the MSDS were originally outlined and mandated in the original 1983 HCS, OSHA and the Environmental Protection Agency (EPA) pushed to afford more knowledge to employees and the general public related to chemical hazards in workplaces and communities in the early 1980s. The HCS was enacted so that employers and employees would have a better understanding of the risks and hazards of chemicals in the workplace, and exercises safety precautions to guard themselves from injuries and illnesses on the job. It was imperative to know whether MSDS were accurate and comprehended by employees, particularly regarding the information most relevant to their health and safety (Kolp, Sattler, Blayney, & Sherwood, 1993). Kolp et al. (1993) discovered that a sizeable portion of key information on MSDS was not comprehended by workers. They concluded that the format and structure of MSDS may have factored into low levels of MSDS comprehension and much work was needed on MSDS, especially in the areas of policy and practice. In addition, Kolp et al. (1993) suggested serious consideration be given to determining the best format and then standardization of the format of MSDS and determining the role labeling can play in comprehending MSDS, with selective focus on the best integration of MSDS utilization into health and safety training to effectively communicate the hazards related to specific chemicals.

OSHA needed to earnestly assess the manner in which MSDS were written, audited and standardized, and to seriously examine the evidence base in the new global GHS enterprise

(Nicol, Hurrell, Wahyuni, McDowall, & Chu, 2008). The main objective of MSDS would not be achieved until workers had and fully understood the information they needed to protect themselves from hazardous chemicals in the workplace (Nicol et al., 2008). In the original HCS, manufacturers were required to provide physical and chemical properties, known health hazards, but the information didn't have to be presented in any specific order or format. In the 1994 GHS revision of HCS, information in the MSDS was standardized (Black & Wood-Black, 2013). While OSHA suggested this revision would improve worker health and comprehension, there were two key areas OSHA overlooked: the expanse of material presented and characteristics of human behavior (Black & Wood-Black, 2013).

It is paramount that MSDS be comprehensive without sacrificing comprehension. Cohen, Schmitt, and Colligan (1989) suggested that MSDS alone are an inadequate way of informing employees of chemical's hazards based on the following points: 1) there is little meaning to the average worker in the technical data provided and may even cause frustration in the worker's ability to read other sections that have pertinent safety information and practices; 2) information portraying hazardous conditions, side effects, and procedures for safe handling are written so vaguely that employees may struggle deciding the relevance between their own use and the written information; and 3) unfamiliar, too brief or vague terms may not generate concern that the employee should have regarding safe chemical usage.

MSDS were renamed by OSHA to SDS in the 2012 GHS HCS revision (OSHA, 2012). OSHA's HCS (2012) requires that "the chemical manufacturer, distributor, or importer provide SDS for each hazardous chemical to downstream users to communicate information on these hazards." SDS are one of the essential tools for information transmittal about chemical hazards in conjunction with the chemical label in the implementation of hazard communication programs. The information found on an SDS is mostly the same as the MSDS, except OSHA now requires the SDS be presented in a homogenous, user-friendly format with 16 sections, as mandated in the HCS (OSHA, 2012).

Sections 1 through 8 of the SDS consist of chemical general information, identification, hazards, ingredient, practices for safe handling, and measures to be taken in the event of an emergency (e.g., first-aid and fire-fighting procedures). The basic information is invaluable to those who need to get the information promptly. Sections 9 through 11 and 16 consists of other technical data, such as physical and chemical properties, stability and reactivity data, toxicological level data, information on how to control employee exposure, and other information including the preparation or last revision date. In addition, the SDS must consists of Sections 12 through 15, to be in line with the GHS, covering information on possible ecological impact, disposal methods, information on transporting chemicals, and regulatory information (OSHA, 2012). Prior to OSHA adopting the GHS, MSDS were required to have the sixteen sections, but they were not required to be presented in any specific order. This OSHA mandate of consistent sequencing of chemical-related safety information in specific sections and a specific order according to the GHS, will undoubtedly increase employee's ability to quickly access significant safety information and increase GHS comprehension (ANSI, 2010).

Theoretical Framework

Although health education and occupational safety and health may appear to have differences in emphasis and orientation, they share several general facets. First, both are clearly concerned with the health of employees. Second, the two exist within the context of the workplace. Third, both aim to decrease the incidence of disease and prevent unnecessary injuries and illnesses. Finally, the two regularly use policies and procedures established in education and behavior change (Robins & Klitzman, 1988). This study was grounded theoretically within the health belief model. The purpose of this section is to provide an overview of the health belief model constructs apply to the current research study. The theoretical model will be explained in the context of health promotion and occupational safety and health.

The health belief model evolved out of a set of public health research problems in the 1950s to help explain why individuals chose to seek health services or not (Rosenstock, 1974). Hochbaum, Kegeles, Leventhal, and Rosenstock were trained social psychologists tasked by the Public Health Service to collaborate and develop a model explaining why people failed to adopt strategies to prevent diseases or detection of disease by using early screening test methods (Rosenstock, 1974). The health belief model was the result of their combined efforts and research. The health belief model suggests that an individual's belief in a personal threat of an illness or injury together with an individual's belief in the effectiveness of the health behavior or action recommended will predict the probability the individual will adopt the behavior and is now widely used as predictor of preventive health behavior (Rimer & Glanz, 1995).

Glanz, Marcus-Lewis, and Rimer (1997) explain the understanding that an individual will take a health-related action is established on the health belief model (i.e., read chemical label and SDS) if that person:

1. "feels that a negative health condition (i.e., chemical-related injury or illness) can be avoided,
2. has a positive expectation that by taking a recommended action, he/she will avoid a negative health condition (i.e., following safety warnings on labels and SDSs will lower the chance of an injury or illness), and
3. believes that he/she can successfully take a recommended health action (i.e., he/she can use chemicals safely and follow protective measures with confidence)."

The health belief model includes six constructs; perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Glanz et al., 2008). The first four concepts were developed as the original canons of the health belief model; cues to action and self-efficacy were added as knowledge and understanding of the model unfolded (Cottrell, Girvan, & McKenzie, 2012). Table 2 summarizes the six health belief model constructs, definitions, applications, HCS applicability, and how they apply to the GHS comprehension testing elements of this study.

Table 2

Summary of Health Belief Model Constructs, Definitions, Application, HCS Applicability, and GHS Comprehension Testing Elements

Construct	**Definition**	**Application**	**HCS Applicability**	**GHS Comprehension Testing Elements**
Perceived susceptibility	Belief about the chances of experiencing a risk or getting injured	Make perceived susceptibility more consistent with individual's actual risk	Individual's belief that chemicals present a hazard in the workplace	Chemical exposure level
Perceived severity	Belief about how serious a condition and its consequences are	Specify consequences of risks and conditions	Hazard statement information on chemical label	Perception of danger, hazard ranking and interpretation
Perceived benefits	Belief in efficacy of the advised action to reduce risk or seriousness of impact	Define action to take: how, when, why	Safe handling practices on SDS	SDS comprehension
Perceived barriers	Belief about the tangible and psychological costs of the advised action	Identify and reduce perceived barriers through reassurance, correction of misinformation, assistance	SDS contains sections on advised actions for firefighting, first aid, and spill response	Locating information on SDS correctly
Cues to action	Strategies to activate "readiness"	Provide how-to information, promote awareness, use reminder system	Chemical labels, pictograms	Chemical label and pictogram comprehension
Self-efficacy	Confidence in one's ability to take action	Provide training and guidance in performing recommended action	OSHAs HCS mandates employers train all employees on how to read and understand GHS information	Hazard statement meaning, safety training level

Only providing chemical hazard information has been established in the fields of health education and health communication to be a fundamental, but insufficient, means for thwarting or modifying injurious or deadly healthy effects (Nicol et al, 2008). A growing body of health educators are not content with the effectiveness of SDS as a tool for safety and health communication in the workplace (DeJoy, 1996). Most of the discontent centers on the lack of a distinct association between merely supplying information and anticipating that the information will then have an effect on the health behaviors of the intended audience (Nicol et al, 2008). DeJoy (1996) stated very little effort has been made to apply health behavior models in the realm of occupational safety and health. In addition, Phillips et al. (1999) recommend using learning pedagogy, such as the health belief model, in interpreting efficacy and comprehension of different MSDS formats. One avenue of addressing these gaps in information is to research the GHS changes to hazard communication in the U.S. and share the findings with other safety and health professionals and lawmakers (Bouchard, 2007). The researcher intended to achieve better knowledge of factors affecting GHS comprehension and workplace self-protective behavior through this study.

Web-based Surveys

New technologies and the increase of Internet use now provide researchers contemporary ways of collecting information from broad segments of a population (Ekman, Klint, Dickman, Adami, & Litton, 2007). Web-based surveys offer several advantages when compared to traditional methods of data collection, such as face-to-face interviews and paper and pencil questionnaires (Varela et al., 2016). The first advantage is data entry and coding are free from process errors while at the same time providing automatic result compilation (Van Gelder, Bretveld, & Roeleveld, 2010; Schleyer & Forrest, 2000). Researchers can save and export data in multiple formats when using SurveyMonkey, a Web-based survey site (Varela et al., 2016).

This feature facilitates statistical analysis with a decreased chance of human error (McPeake, Bateson, & O'Neill, 2014). Van Gelder et al. (2010) touted an advantage of Web-based surveys is the ability to hide non-relevant follow-up questions and organize questions randomly if desired. In addition, data quality is improved by the capability of including checks or prompts when a participant enters an incomplete answer (Van Gelder, et al., 2010). When a participant skips a question or leaves essential answers blank, the program generates an automatic message to alert the participant. Aerny-Perreten et al. (2015) and Van Gelder et al. (2010) maintain that Web-based surveys are returned quicker than mailed questionnaires, with more participants daily. This also allows simultaneous execution so several participants can be engaged at the same time. Clear instructions on how to respond to each prompt can be provided on Web-based surveys (Schleyer & Forrest, 2000). SurveyMonkey offers a wide variety of default format questions for researchers to employ for simple and understandable survey designs (Varela et al., 2016). A main benefit of Web-based surveys is that it allows participants to remain anonymous (Cooper, Scherer, & Mathy, 2001). Many researchers have also noted a considerable cost reduction when employing Web-based surveys, including time and human resource-related expenses (Aerny-Perreten et al., 2015; Ekman et al., 2007; McPeake et al., 2014; Rosenbaum & Lidz, 2007; Van Gelder et al., 2010). Likewise, Web-based surveys are more ecologically friendly than traditional survey methods by utilizing less paper products for printing (Varela, et al., 2016).

Web-based surveys are easier to access and distribute via email links and social media platforms (McPeake et al., 2014). SurveyMonkey creates a personal Web link to directly access the survey (Varela et al., 2016). A way to decrease the likelihood of multiple submissions or having a study disrupted by disingenuous participants is to collect IP addresses (Cooper, Scherer, & Mathy, 2001). SurveyMonkey has this capability. Once a response has been received from a particular IP address, that address can be blocked or the researcher will be notified about duplicate response coming from the same computer (Heen, Lieberman, & Miethe, 2014).

Heen, Lieberman, and Miethe (2014) compared different online sampling approaches for generating national samples. SurveyMonkey's sampling platform produced one of the most representative samples of the U.S. population's elemental demographic population including sex and age range (Heen, Lieberman, & Miethe, 2014). The provided samples from SurveyMonkey were found to be within a 10% range of corresponding values of the U.S. population based on data from the 2010 census (Heen, Lieberman & Miethe, 2014). Heen, Lieberman, and Miethe (2014) found in their comparisons that online platform surveys provide an extremely productive and affordable method for collecting national survey data. Likewise, Cooper, Scherer, and Mathy (2001) found that an internet convenience sample and a random sample did not produce significantly different results. These finding suggest that Web-based surveys are indeed a valuable and useful tool in research.

Among the disadvantages of using a Web-based survey, lower response rates are experienced than traditional mail surveys (Kwak & Radler, 2002). Lower response with Web-based surveys can be attributed to characteristics of the population being surveyed, possible lack of familiarity with the Internet, inconsistent reliability of Internet access, and survey saturation when participants are routinely asked to complete Web-based surveys (Aerny-Perreten et al., 2015; McPeake et al., 2014). A Web-based survey limitation is nonresponse bias due to lack of delivering the Web-based survey to the intended participants, simple refusal to respond, lack of interest in research topic, and time constraints (Varela et al., 2016). Reliability and validity of data collected via Web-based surveys may be impacted due to suspected higher levels of measurement error than traditional methods of data collection (Varela et al., 2016). Self-reported data, bad questionnaire design, and participants' scrolling to find all questions and answering options or reading hastily can contribute to the measurement errors (Van Gelder et al., 2010). Another limitation is a lengthy Web-based survey may trigger participants to dropout and not complete all the questions (Varela et al., 2016). Adding a progress bar and stating at the beginning the estimated time required for completion can help offset participant dropout (Varela et al., 2016). Varela et al. (2016) contend Web-based surveys are a good way to make contact with and collect data from a broad population. Further, Heen, Lieberman, and Miethe (2014) concluded that the advantages of online surveys (i.e., data collection efficiency, lower costs, and acceptable approximations to national populations) far surpass their disadvantages in terms of external validity.

Summary

The OSH Act establishing OSHA as the governmental agency responsible for workplace safety nationwide was signed into law in 1970 (OSHA, 1994). In 1973, workplace safety laws were extended when OSHA promulgated the HCS requiring manufacturers of chemicals to evaluate the hazards associated with the chemicals they produced or distributed (OSHA, 1983). The HCS also mandated that chemical manufacturer communicate the hazards of their products to users through chemical labels and MSDS, information sheets that provide information about health hazards, needed personal protective equipment, first aid guidance, and fire and spill mitigation protocol (OSHA, 1997). In 2012, OSHA officially ratified the adoption of the GHS. GHS provides the framework for a globalized, consistent, and coherent system of classifying chemical hazards and communicating that information to the users.

Because the GHS requirements of chemical labeling, pictograms and SDS were implemented in all workplaces in the U.S. as mandated by OSHA in 2012, it is imperative to study the comprehensibility of these GHS tools. It is essential to verify from employees in the workplace the comprehensibility of GHS compliant labels, pictograms and SDS. To what extent factors, such as age, sex, education level, work experience, safety training history, or chemical exposure level, influence the comprehension of chemical labels, pictograms, and SDS were identified and analyzed in this study.

CHAPTER 3

METHOD

Introduction

This chapter provides a detailed description of how the study was conducted. The purpose of the study, the research question, and the research design are discussed. In addition, data collection procedures, the selection of participants, and the research instrument questionnaire are outlined.

Purpose of the Study

Comprehensibility refers to a person's ability to understand information given on a chemical label or SDS and take appropriate safety precautions. For that reason, comprehensibility testing is a crucial means for determining efficacy of chemical hazard communication pictograms and SDSs in communicating hazard information efficaciously (UNITAR, 2010). The purpose of this study was to explore the factors that affect U.S. workers' comprehension of the new GHS-formatted chemical labels and SDS, mandated by OSHA's HCS.

Quantitative Design

Quantitative research design was implemented to quantify a problem by way of collecting numerical data or data that can be converted into functional statistics (Creswell & Creswell, 2017). Attitudes, opinions, behaviors, and other defined variables are quantified using measurable data to systematically specify details and discover patterns in a study (Gliner et al., 2017). Data collection methods in a quantitative design include numerous types of surveys, such as online or paper surveys, face to face interviews, and directly administered questionnaires (Gliner et al., 2017). A quantitative method of research was the best option for this study utilizing a Web-based survey to determine to what extent factors influence GHS chemical label and SDS comprehension, ability to recognize and use labels and SDS, perception of danger, ability to locate essential safety information correctly, comprehension of pictograms and other hazard classification elements, and chemical hazard ranking and interpretation.

Research Question

The research question was to what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees'

- comprehension about GHS chemical labels and SDSs?
- ability to recognize and use labels and SDSs?
- perception of danger?
- ability to locate essential chemical safety information correctly?
- comprehension of pictograms and other hazard classification elements? and
- chemical hazard ranking and interpretation?

Variables

The study had six independent variables; sex, age, education level, work experience, safety training level, and chemical exposure level. There were six dependent variables; GHS chemical label and SDS comprehension, ability to recognize and use labels and SDS, employee's perception of danger, ability to locate essential chemical safety information correctly, comprehension of pictograms and other hazard classification elements, and employee's chemical hazard ranking and interpretation. The six independent variables were attribute variables and may be viewed in Table 3. The study had no active independent variables. This study analyzed how the six independent variables influenced the six dependent variables related to GHS comprehension.

Table 3

Variables, Levels of Measure, and Instrument

Variable	**Type**	**Levels of Measure**	**Instrument Questions**	**Data Analysis**
Sex	Independent	Nominal	3	Multiple Regression
Age	Independent	Ordinal	4	Multiple Regression
Educational level	Independent	Ordinal	5	Multiple Regression
Work experience	Independent	Ordinal	6	Multiple Regression
Safety training level	Independent	Ordinal	50	Multiple Regression
Chemical exposure level	Independent	Ordinal	48-49	Multiple Regression
GHS label & SDS recognition and use	Dependent	Ratio	7-11, 19-23	Multiple Regression
Perception of danger	Dependent	Ratio	14, 36	Multiple Regression
GHS label & SDS comprehension	Dependent	Ratio	12, 15-18, 25-28	Multiple Regression
GHS pictogram comprehension	Dependent	Ratio	34-35, 37-44	Multiple Regression
Hazard ranking and interpretation	Dependent	Ratio	45-47	Multiple Regression
Locating safety information	Dependent	Ratio	29-33	Multiple Regression

Research Method

The quantitative method of a Web-administered questionnaire was utilized to collect the data for the study. Quantitative data is objective and can be easily classified or quantified, either by the participant or the researcher (Gliner et al., 2017). Creswell and Creswell (2017) describe quantitative data and data collection procedures as usually gathered with some sort of instrument that can be scored numerically and reliably. The main advantage of this technique was allowing for responses to be gathered from large numbers of people in a short time frame (Dillman et al., 2014). Survey results were available for review and analysis immediately upon completion. The researcher adapted UNITAR's (2010) GHS Comprehensibility Testing to evaluate to what extent certain factors affect GHS-revised chemical labels and SDS, mandated by OSHA starting in 2012, have on U.S. workers' comprehension of hazards associated with chemicals purchased and used in the workplace.

The research design of this study was a quantitative, nonexperimental, comparative approach. The nonexperimental approach has attribute independent variables, meaning the researcher does not control or manipulate the independent variable (Gliner et al., 2017). Gliner et al. (2017) explain that in the comparative research approach, there are two to four levels of the independent variables that are not active. The authors continue to explain attribute independent variables are observed or measure characteristics of the participants or environment that either was not or cannot be wielded by the researcher.

Sample

The sample consisted of 422 convenience sample participants that have worked with chemicals as part of their previous or current work-related duties and received chemical safety training. The researcher estimated that a minimum sample size of 385 participants (confidence level = 95%, population size = 30 million U.S. employees exposed to hazardous chemicals at work, margin of error = 5%) was needed in this study (Field, 2009). The researcher decided to err on the side of caution and set the desired sample size at 400, well above the minimum required. These participants were randomly selected and recruited by utilizing Survey Monkey to collect responses. To take a survey, audience panel participants log into their Survey Monkey account and click "take a survey" from the dashboard. Survey Monkey also sends participants an email or text inviting them to take surveys. The participants were asked a qualifying question to verify they have worked with chemicals in the U.S. as a routine part of their previous or current job duties. SurveyMonkey.com (2020) states the following- “Our panels are representative of a diverse online population that voluntarily joined a program to take surveys. When you choose the United States as your country, you're buying responses from our Contribute or Rewards panel. SurveyMonkey Contribute panelists take surveys for charity and a chance to win a sweepstakes prize. Rewards panelists earn credits for completing surveys which they can redeem for gift cards or donate to charity. All panelists share demographic information about themselves like gender, age, and region, and other targeting attributes you might be interested in, like cell phone usage or job type. We balance Contribute and Rewards panels according to census data of age and gender.” Sampling from this convenience sampling group of participants made the data generalizable to many other workplaces in the U.S.

Data Collection

Data were collected for this study by adapting a directly-administered questionnaire, UNITAR’s GHS Comprehensibility Testing (Appendix A), to a Web-based survey (Appendix B). An online survey was developed employing Survey Monkey which was provided for student use by SIU Carbondale. The online survey replicated the questions from the original UNITAR test instrument. The use of online questionnaires is very popular and is the least expensive way to reach the greatest number of people (Dillman et al., 2014). Dillman, Smyth, and Christian (2014) reported that the majority of U.S. citizens now use the Internet on a daily basis. 85% of adults in the U.S. use the Internet and 70% have broadband Internet access in their homes (Dillman et al., 2014). In addition, the proliferative use of mobile devices, such as smartphones and tablets, has reinforced the growth of online use (Dillman et al., 2014). People are now much more receptive to completing surveys online.

The Web-based survey was designed so that each module of the original, written questionnaire was represented by an individual page of questions to be completed which more closely approximates a paper survey (Dillman et al., 2014). The online survey consisted of 9 pages with a total of 50 questions. Estimated time to complete the survey was 10 minutes. Approval for the study was granted from the Human Subjects Committee at Southern Illinois University, Carbondale (Appendix C).

Access was requested to an audience that met specific demographic criteria for this survey to get targeted responses from a specific group. The specific demographic criteria were respondents living in the U.S. and at least 18 years old. Survey Monkey sent requests by e-mail to individuals from whom a response was desired and provided a link to the Web survey on the Survey Monkey website. Respondents clicked on the link to go directly to the Web survey starting with an introductory screen that explained the purpose of the survey, asked them to give consent, and asked respondents if they worked with chemicals in previous or current work-related duties and received chemical safety training as qualifiers. Once at least 400 responses were collected, survey results were exported to SPSS for analysis. Results were presented to the dissertation committee for final review and approval. Table 4 shows a complete timeline of the research plan.

Table 4

Timeline of Research

Research Task	Description	Timeline
Research instrument selection and permission	• Select valid research instrument related to this study • Request and receive permission from UNITAR to use existing questionnaire	January 2019
Design-Web-based survey	• Create Web-based survey using SIU Carbondale's access to Survey Monkey	January 2020
Human Subjects Committee	• Apply and receive approval from Human Subjects Committee for study	February 2020
Pilot test survey	• Request 31 family, friends, or colleagues take the survey as a pilot test before the survey is sent out for mass data collection • Make adjustments or corrections to survey based on issues identified in pilot test	March 2020
Administer Web-based survey	• Administer survey to target audience of 400 U.S. citizens above the age of 18 that have or do use chemicals as part of work-related duties	April 2020
Review of findings	• Conduct quantitative analysis by exporting data to SPSS for multiple regression • Develop conclusions based on findings	April-May 2020
Present findings	• Write Chapters 4 and 5 of dissertation based on findings • Present findings to dissertation committee for final approval	May-June 2020

Participants' names were not collected. No confidential documents or information were collected. All records and information related to the research will be kept in a locked file for a minimum for one year after data collection is complete.

Research Instrument

The comprehensibility testing instrument offered a method for assessing the comprehensibility of labels and SDS for chemical hazards. Originally directed in the framework of the UNITAR/International Labor Office (ILO) Global GHS Capacity Building Program in 2010, this survey was built and based on prior studies conducted for the ILO Working Group on Hazard Communication as a component of the global effort to promote and evaluate GHS (UNITAR, 2010). The researcher received permission to use this existing instrument to test comprehensibility, with modifications, that was developed and implemented by the United Nations Institute for Training and Research (UNITAR) in 2010 (Appendix D). Table 5 provides an overview of instrument module sections, contents, objectives, and outcomes.

Table 5

Contents, Objectives, and Expected Outcomes by Module

Module	**Contents**	**Objectives**	**Outcomes**
Module 1	General Interview	• To collect general demographic data as basis for analysis of comprehensibility. • To determine linguistic, educational, and work experience as possible factors influencing comprehension.	• Relevant demographic and other data for linking to study results and analysis.
Module 2	General Comprehensibility of Labels	• To evaluate subjects' familiarity with a label, in visual identification, name and use. • To examine the order in which subjects recall label elements. • Assess the ease of understanding the label. • To test the comprehensibility of hazard statements. • To evaluate subjects' ability to identify precautionary statements on a label.	• Evaluate experience and familiarity with labels. • The most recalled elements of a label defined. • The label elements that are easy and difficult to comprehend identified. • Gain a general sense of comprehension of hazard statements. • Subjects' understanding of hazard statements tested. • The ability of users to identify precautionary information evaluated.
Module 3	General Comprehensibility of Safety Data Sheets	• To evaluate subjects' familiarity with SDS, in visual identification, name and use. • To assess the ease of understanding and identifying information on the SDS.	• Evaluate experience and familiarity with SDS. • Areas where comprehension of SDS elements are identified. • Subjects' ability to identify and understand various sections of the SDS tested.
Module 4	Safety Data Sheets and Labels	• To observe subjects' use of the label and SDS in finding necessary and relevant information about the chemical.	• Subjects' use of hazard communication tools understood.
Module 5	Comprehension of Pictograms and Hazard Communication Elements	• To test subjects' ability to identify possible hazards associated with particular pictograms. • To assess subjects' understanding of what pictograms should be used with which hazards. • To evaluate subjects' ability to discern more and less hazardous chemicals from particular hazard communication elements.	• Understanding of the relationship between certain hazards and their corresponding pictograms assessed. • Subjects' awareness of more or less hazardous chemicals based on communication elements evaluated.
Module 6	Post Interview	• To determine exposure to chemicals and training. • To identify chemical information needs from subjects.	• Results will indicate need for training.

GHS chemical label and SDS comprehension was scored based on correct responses to nine questions (12, 15-18, and 25-28 of modules two and three of the comprehensibility test). Ability to recognize and use GHS labels and SDSs was scored based on correct responses to ten questions (7-11 and 19-23 of modules two and three of the comprehensibility test). Perception of danger was scored based on correct responses to two questions (14 and 36 of module two of the comprehensibility test). Locating safety information correctly was scored based on correct responses to five questions (29-33 of module 4 of the comprehensibility test). Associating pictograms with the correct hazard classification was scored based on correct responses to ten questions (34-35 and 37-44 of module 5 of the comprehensibility test). Finally, chemical hazard ranking and interpretation was scored based on correct responses to three questions (45-47 of module 5 of the comprehensibility test).

Pilot Testing

A pilot study was performed following approval from the dissertation committee and the Human Subjects Committee at Southern Illinois University Carbondale. Conducting a pilot survey prior to the actual, large-scale survey presented many benefits and advantages. One of these was the exploration of particular issues that may potentially have an undesirable impact on survey results (Dillman et al, 2014). These issues include the appropriateness of questions to the target population. A pilot survey also tested the correctness of the instructions to be measured by whether all the respondents in the pilot sample were able to follow the directions as indicated (Dillman et al, 2014). It also provided better information on whether the type of survey is effective in fulfilling the purpose of the study (Dillman et al., 2014).

McDermott (1999) recommended a pilot test contain 20 to 50 participants. Participants should be asked their opinions about the pilot test and their performance monitored accordingly (McDermott, 1999). Email invitations were sent to 31 family members, friends, and colleagues to complete the online survey. A convenience sample of 31 participants was utilized to get feedback from a variety of trusted associates in the safety and health field as well as people who were known to have worked closely with chemicals in their job histories. The purpose of the pilot study was to collect valuable feedback on the utilization of the Web-based survey as well as validity and reliability data of the instrument to be used.

Reliability

Cronbach's alpha was used to determine instrument reliability for this study. Alpha was developed by Lee Cronbach (1951) to provide a measure of internal consistency of a test and is expressed as number between 0 and 1. Internal consistency describes the extent to which all items in a test measure the same construct and is therefore connected to the inter-relatedness of the items within the test (Cronbach, 1951). Alpha should be calculated for each concept or construct of an instrument as a larger number of questions will inflate the value of alpha on a large questionnaire (Nunnally & Bernstein, 1994; Swerdlik & Cohen, 2005). Statisticians have debated what constitutes an acceptable value for Cronbach's alpha (Nunnally & Bernstein, 1994; DeVillis, 2003). By convention, an alpha of .65-.80 is often considered acceptable for a scale used in human dimensions' research (Green, Lissitz & Mulaik, 1977; Spector, 1992; Vaske, 2008). A Cronbach's alpha value of 0.8 or greater is considered to have a high degree of reliability (Gliner et al., 2017). After the pilot test concluded, the researcher analyzed the reliability of the research questions' six constructs individually- comprehension about GHS chemical labels and SDSs; ability to recognize and use labels and SDSs; perception of danger; ability to locate essential chemical safety information correctly; comprehension of pictograms and other hazard classification elements; and chemical hazard ranking and interpretation. The modified UNITAR instrument thus can be considered a stable instrument for this study, given its Cronbach's alpha values of .71, .75, .64, .61, .81, and .96 correspondingly as shown in Table 6.

Table 6

Cronbach's Alpha for Each Research Question Construct, Pilot Study

Construct	**Cronbach's Alpha**
Comprehension about GHS chemical labels and SDSs	.71
Ability to recognize and use labels and SDSs	.75
Perception of danger	.64
Ability to locate essential chemical safety information correctly	.61
Comprehension of pictograms and other hazard classification elements	.81
Chemical hazard ranking and interpretation	.96

Validity

The researcher consulted with an expert instrument advisory panel comprised of eighteen occupational safety and health professionals to review the instrument for content validity. At the time of the study, all reviewers held at least a Bachelor's of Science in occupational safety and health and a full-time career in the field. Four of the reviewers were instructors or assistant professors of occupational safety and health at a post-secondary institution. The researcher conversed with the instrument advisory panel and reviewed the proposed online Web-based survey instrument. The committee determined the modified instrument was appropriately written for the purpose of assessing GHS comprehensibility in the six main construct areas. Some redundant and counterproductive questions identified by the advisory panel were removed from the Web survey. After obtaining and analyzing the results of the pilot testing, logistical, technical, and other issues or problems were addressed. The survey questions, instructions, and formatting were revised based on identified issues during the pilot test. After the revision of the survey, the full-scale survey was executed. Please see Appendix B for the revised Web-based survey that was used for this study.

Readability

It's essential for a researcher to evaluate the readability level required to complete an instrument being used in a study. The SMOG index is a regularly used method for assessing readability (McDermott, 1999). The SMOG procedure estimates readability in terms of a grade-level by counting the number of polysyllabic words in 30 sentences and comparing the resultant number to the SMOG conversion table (McDermott, 1999). The researcher selected 10 consecutive sentences from the beginning, middle, and end of the Web-based survey for a total of 30 sentences evaluated. Twenty-eight polysyllabic words were counted from the 30 sentences selected. This relates to an eighth-grade reading level when compared to the SMOG conversion table and is ideal for material meant for general consumption (McDermott, 1999).

Data Analysis

Linear multiple regression was used in this study to analyze the extent to which age, sex, education level, work experience, safety training level, and chemical exposure level influence GHS chemical label and SDS comprehension, ability to recognize and use GHS labels and SDS, perception of danger, ability to find location of essential chemical safety information correctly, comprehension of pictograms and hazard classification, and hazard ranking and interpretation. Multiple regression analysis is used for forming and examining multiple variables. Multiple regression analysis enhances regression analysis by outlining the connection between a dependent variable and multiple independent variables (Gauch, 2000). Multiple regression can be used both when the independent variables are normally distributed and when they are dichotomous (Gliner et al., 2017). Inserting demographic (independent) variables into one model and examining how they simultaneously influence each outcome (dependent) variable is a major advantage of multiple regression (Gliner et al., 2017).

Laerd (2015) states there are eight assumptions that need to be considered in order to run a multiple regression analysis. These assumptions are:

1. "One dependent variable is measured at the continuous level (i.e., the interval or ratio level).
2. Two or more independent variables are measured either at the continuous or nominal level.
3. The data should have independence of observations.
4. There needs to be a linear relationship between the dependent variable and each of the independent variables, as well as the dependent variable and independent variables collectively.
5. The data needs to show homoscedasticity of residuals (equal error variances).
6. The data must not show multicollinearity (two or more independent variables are highly correlated).
7. There should be no significant outliers, high leverage points, or highly influential points.
8. The errors in prediction, residuals, need to be normally distributed."

The researcher tested the data for these assumptions of multiple regression.

Research question, bullet one: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' GHS chemical label and SDS comprehension? To determine which general demographic factors predict the dependent variable, specifically GHS chemical label and SDS comprehension, multiple regression analysis was performed by regressing the dependent variable on the demographic factors of interest.

Research question, bullet two: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' ability to recognize and use labels and SDSs? To determine which general demographic factors predict the dependent variable, specifically employees' ability to recognize and use labels and SDSs, multiple regression analysis was performed by regressing the dependent variable on the demographic factors of interest.

Research question, bullet three: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' perception of danger? To determine which general demographic factors predict the dependent variable, specifically employees' perception of danger, multiple regression analysis was performed by regressing the dependent variable on the demographic factors of interest.

Research question, bullet four: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' ability to locate essential chemical safety information correctly? To determine which general demographic factors predict the dependent variable, specifically employees' ability to locate essential chemical safety information correctly, multiple regression analysis was performed by regressing the dependent variable on the demographic factors of interest.

Research question, bullet five: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' comprehension of pictograms and other hazard classification elements? To determine which general demographic factors predict the dependent variable, specifically employees' comprehension of pictograms and other hazard classification elements, multiple regression analysis was performed by regressing the dependent variable on the demographic factors of interest.

Research question, bullet six: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' employee's chemical hazard ranking and interpretation? To determine which general demographic factors predict the dependent variable, specifically employees' chemical hazard ranking and interpretation, multiple regression analysis was performed by regressing the dependent variable on the demographic factors of interest.

Plans for Dissemination of Results

The primary purpose of a research project is to gather information about an issue or problem and construct a report or release to disseminate the findings (Dillman et al., 2014). There are numerous key audiences for this study; academia, occupational safety and health professionals, safety trainers, employers, chemical companies, and governmental-regulating bodies. Findings will be submitted to several technical and academic journals for publication and presented at professional conferences and meetings. In like manner, the findings will be shared with safety and health listserv participants and colleagues that have been appointed to various safety and health boards and committees. Finally, UNITAR has requested the researcher share the findings with their agency because the study was not previously conducted in the U.S.

Summary

The purpose of this study was to explore the factors that affect U.S. workers' comprehension of the new GHS- formatted chemical labels and SDSs, mandated by OSHA's HCS. This study employed quantitative research design using a convenience sample of 422 participants completing a Web-based questionnaire via SurveyMonkey. The Web-based questionnaire was adapted from a test instrument (GHS Comprehensibility Testing) developed by the UNITAR/ILO Global GHS Capacity Building Program. A pilot test of the Web-based survey was conducted prior to the full-scale survey. The research question for this study was to what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' comprehension about GHS chemical labels and SDSs; ability to recognize and use labels and SDSs; perception of danger; ability to locate essential chemical safety information correctly; comprehension of pictograms and other hazard classification elements; and chemical hazard ranking and interpretation. Multiple regression analysis was used in this study to analyze the extent to which the independent variables affect the dependent variables.

CHAPTER 4

RESULTS

Introduction

The research question was: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees'

- comprehension about GHS chemical labels and SDSs?
- ability to recognize and use labels and SDSs?
- perception of danger?
- ability to locate essential chemical safety information correctly?
- comprehension of pictograms and other hazard classification elements? and
- chemical hazard ranking and interpretation?

A total of 818 responses were collected in five days using SurveyMonkey's audience panel. However, only 422 participants completed the entire survey, which was above the *a priori* participant level of 400. All participants (n=422) were at least 18 years old, indicated their consent, had a previous or current history working with chemicals as part of their work-related duties, and received chemical safety training. The average comprehensibility score for all participants was 71% correct responses. The average time spent to complete the survey by all participants that fully completed the survey was 12 minutes and 47 seconds.

Instrument Validity

A principal components analysis (PCA) was run on the 50-question questionnaire that measured comprehension of GHS labels and SDSs on 422 participants. The suitability of PCA was assessed prior to analysis. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The overall Kaiser-Meyer-Olkin (KMO) measure was 0.825 (Table 7) with individual KMO measures all greater than 0.7, classifications of 'middling' to 'meritorious' according to Kaiser (1974). Bartlett's test of sphericity was statistically significant ($p < .0005$), indicating that the data were likely factorizable. The PCA with Varimax rotation produced six extractions with 11 iterations. A set number of six components were used, as there were six constructs outlined as the basis for this study.

The interpretation of the data was consistent with the comprehension attributes the questionnaire was designed to measure with strong loadings of employees' comprehension of GHS labels and SDS items on Component 1, employees' ability to recognize and use GHS labels and SDS items on Component 2, employees' perception of danger items on Component 3, employee's ability to locate safety information correctly items on Component 4, employees' comprehension of GHS pictogram items on Component 5, and employee's hazard ranking and interpretation items on Component 6. Component loadings of the rotated solution are presented in Table 8.

Table 7

KMO and Bartlett's Test – SPSS Output

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.825
Bartlett's Test of Sphericity	Approx. Chi-Square	15094.009
	df	4851
	Sig.	.001

Table 8

Factor Loadings for Principal Components Analysis with Varimax Rotation of Modified UNITAR Instrument

	Component					
Item	1	2	3	4	5	6
7		.801				
8		.745				
9		.461				
10		.644				
11		.789				
12	.612					
13						
14			.746			
15	.632					
16	.707					
17	.824					
18	.685					
19		.689				
20		.714				
21		.829				
22		.445				
23		.711				
24	-	-	-	-	-	-
25	.697					
26	.745					
27	.526					
28	.741					
29				.824		
30				.767		
31				.722		
32				.707		
33				.604		
34					.719	
35					.865	
36			.699			
37					.774	
38					.812	
39					.844	
40					.493	
41					.764	
42					.609	
43					.745	
44					.466	
45						.651
46						.454
47						.428

Instrument Reliability

Cronbach's alpha was used to determine instrument reliability for this study. Alpha was developed by Lee Cronbach (1951) to provide a measure of internal consistency of a test and is expressed as number between 0 and 1. Internal consistency describes the extent to which all items in a test measure the same construct and is therefore connected to the inter-relatedness of the items within the test (Cronbach, 1951). Alpha should be calculated for each concept or construct of an instrument as a larger number of questions will inflate the value of alpha on a large questionnaire (Nunnally & Bernstein, 1994; Swerdlik & Cohen, 2005). Statisticians have debated what constitutes an acceptable value for Cronbach's alpha (Nunnally & Bernstein, 1994; DeVillis, 2003). By convention, an alpha of .65-.80 is often considered acceptable for a scale used in human dimensions' research (Green, Lissitz & Mulaik, 1977; Spector, 1992; Vaske, 2008). A Cronbach's alpha value of 0.8 or greater is considered to have a high degree of reliability (Gliner et al., 2017). After the full-scale survey concluded, the researcher analyzed the reliability of the research questions' six constructs individually- comprehension about GHS chemical labels and SDSs; ability to recognize and use labels and SDSs; perception of danger; ability to locate essential chemical safety information correctly; comprehension of pictograms and other hazard classification elements; and chemical hazard ranking and interpretation. The Web-based survey instrument thus can be considered a stable and reliable instrument for this study, given its Cronbach's alpha values of .85, .87, .71, .74, .86, and .89 correspondingly as shown in Table 9.

Table 9

Cronbach's Alpha for Each Research Question Construct, *Full-Scale Study*

Construct	**Cronbach's Alpha**
Comprehension about GHS chemical labels and SDSs	.85
Ability to recognize and use labels and SDSs	.87
Perception of danger	.71
Ability to locate essential chemical safety information correctly	.74
Comprehension of pictograms and other hazard classification elements	.86
Chemical hazard ranking and interpretation	.89

Demographic Information

Demographic data including gender, age, education level, work experience, safety training, and chemical exposure level were collected on one portion of the demographic survey. Of the 422 participants, 48.58% were female (n=205), 51.42% were male (n=217). Participants between the age ranges of 20-29 (n=95), 30-39 (n=97), and 40-49 (n=104) represented the age groups with the highest participation rates (Table 10). Most (n=350) participants attended college and/or completed a degree (Table 11); 5.21% of participants indicated being in the workforce less than one year (n=22). Whereas 20.14% (n=85) had worked 1-5 years, 15.88% (n=67) had worked 5-10 years, 20.38% (n=86) had worked 10-20 years, 22.27% (n=94) had worked 20-30 years, and 16.11% (n=68) had worked more than 30 years. 100% of participants (n=422) indicated they used chemicals in their previous or current work-related duties. Similarly, 83.41% of participants (n=352) indicated they were sometimes or often exposed to chemicals that someone else was using in the workplace (Table 12).

Table 10

Age Ranges of Participants

ANSWER CHOICES	RESPONSES	
18-19 years	4.27%	18
20-29 years	22.51%	95
30-39 years	22.99%	97
40-49 years	24.64%	104
50-59 years	17.77%	75
60-69 years	6.40%	27
70-79 years	1.18%	5
80 years and above	0.24%	1
TOTAL		422

Table 11

Education Level of Participants

ANSWER CHOICES	RESPONSES	
Did not complete high school	1.90%	8
High school or G.E.D.	15.17%	64
Associate's degree	13.03%	55
Some college	24.41%	103
Bachelor's degree	28.67%	121
Master's degree	14.69%	62
Terminal degree	2.13%	9
TOTAL		422

Table 12

Other Chemical Exposures of Participants

ANSWER CHOICES	RESPONSES	
Not at all/never	16.59%	70
Sometimes (less than 10 times a year)	58.53%	247
Often (10 or more times a year)	24.88%	105
TOTAL		422

Research Question and Findings

Comprehension of GHS Chemical Labels and SDSs

The research question was: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' comprehension about GHS chemical labels and SDSs. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.123. Values for Durbin-Watson can range between 0-4, with a value close to 2 indicative of independence of errors (residuals) (Laerd, 2015). A scatterplot displayed a linear relationship between employees' comprehension about GHS chemical labels and SDSs and independent variables collectively. Partial regression plots showed linear relationships between employees' comprehension about GHS chemical labels and SDSs and each of the independent variables. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. All the tolerance values were greater than 0.1 (the lowest was 0.439); therefore, the researcher is fairly confident there is no problem with collinearity in the data (Hair et al., 2014). No outliers greater than ± 3 standard deviations were detected by SPSS case-wise diagnostics. There were no leverage values above the safe value of 0.2 (Huber, 1981). The researcher inspected the ordered values for Cook's Distance as a measure of influence and determined there were no values above

1 (Cook & Weisberg, 1982) that required investigation. The assumption of normality was met, residuals were normally distributed as observed by the points aligning along a diagonal line on a P-P plot and a bell curve on a histogram of the standardized residuals of the dependent variable (Laerd, 2015).

The multiple regression model statistically significantly predicted employees' comprehension of GHS chemical labels and SDSs, $F(20, 401) = 4.879$, $p < .0005$, adjusted $R^2 = .156$. The independent variables of age, work experience, and chemical exposure level added statistically significantly to the prediction, $p < .05$. Regression coefficients and standard errors can be found in Table 13.

Table 13

Multiple Regression Results for Comprehension of GHS Chemical Labels and SDSs

		95% CI for B					
	B	LB	UB	SE B	β	R^2	Adj. R^2
Model						.196	.156***
Constant	.849	.794	.903	.028			
Sex	-.024	-.051	.002	.013	-.083		
Age							
18-19	.047	-.034	.127	.041	.065		
20-29	.087***	.038	.135	.025	.25***		
30-39	.051*	.009	.093	.021	.147*		
40-49							
50-59	.006	-.038	.051	.023	.017		
60-69	.036	-.030	.102	.034	.06		
70-79	-.44	-.168	.079	-.063	-.033		
80+	-.146	-.413	.120	.136	-.049		
Education Level							
Incomp. HS	-.137	-.247	-.027	.056	-.129		
HS/GED	.024	-.018	.066	.021	.060		
Associates	-.008	-.051	.036	.022	-.018		
Some college	.034	-.002	.071	.019	.102		
Bachelors	.027	-.033	.041	.020	-.024		
Masters	-.007	-.048	.034	.021	-.017		
Terminal	.053	-.039	.145	.047	.053		
Work Experience							
< 1 year	-.114**	-.194	-.033	.041	-.174**		
1-5 years	-.133***	-.186	-.080	.027	-.368***		
5-10 years	-.147***	-.196	-.097	.025	-.369***		
10-20 years	-.085***	-.130	-.040	.023	-.236***		
20-30 years	-.058**	-.055	-.029	.021	-.171**		
30+ years	-.031	-.049	.049	.025	.000		
Safety Training							
H&S chemicals	.032	-.013	-.021	.041	.004		
Read/use labels	-.056	-.002	-.009	.023	.011		
Read/use SDS	-.014	-.009	-.102	.014	.024		
Self-taught	-.033	-.046	-.078	.062	.021		
Chem Exposure							
Some <10/yr	.047***	.013	.078	.017	.167***		
Often 10+/yr	.052***	.025	.080	.014	.172***		

Note.
Model = “Enter” method in SPSS; *B* = unstandardized regression coefficient; CI = confidence interval; LB = lower bound; UB = upper bound; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; Adj. R^2 = adjusted R^2.
*p < .05, **p < .01, ***p < .001.

Recognizing and Using Labels and SDSs

The research question was: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' ability to recognize and use labels and SDSs. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.016. Values for Durbin-Watson can range between 0-4, with a value close to 2 indicative of independence of errors (residuals) (Laerd, 2015). A scatterplot displayed a linear relationship between perception of danger and independent variables collectively. Partial regression plots showed linear relationships between employees' ability to recognize and use GHS labels and SDSs and each of the independent variables. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. All the tolerance values were greater than 0.1 (the lowest was 0.365); therefore, the researcher is fairly confident there is no problem with collinearity in the data (Hair et al., 2014). No outliers greater than ± 3 standard deviations were detected by SPSS case-wise diagnostics. There were no leverage values above the safe value of 0.2 (Huber, 1981). The researcher inspected the ordered values for Cook's Distance as a measure of influence and determined there were no values above 1 (Cook & Weisberg, 1982) that required investigation. The assumption of normality was met, residuals were normally distributed as observed by the points aligning along a diagonal line on a P-P plot and a bell curve on a histogram of the standardized residuals of the dependent variable (Laerd, 2015).

The multiple regression model statistically significantly predicted employees' ability to recognize and use GHS chemical labels and SDSs, $F(20, 401) = 1.771$, $p < .05$, adjusted $R^2 = .035$. The independent variables of safety training and chemical exposure level added statistically significantly to the prediction, $p < .05$. Regression coefficients and standard errors can be found in Table 14.

Table 14

Multiple Regression Results for Recognizing and Using Labels and SDSs

		95% CI for B					
	B	LB	UB	SE B	β	R^2	Adj. R^2
Model						.285	.035***
Constant	.638	.571	.705	.034			
Sex	.002	-.030	.035	.017	.007		
Age							
18-19	-.054	-.153	.044	.050	-.066		
20-29	.034	-.025	.094	.030	.086		
30-39	.010	-.042	.062	.026	.025		
40-49	.007	-.064	.082	.022	.031		
50-59	-.055	-.110	-.001	.028	-.127		
60-69	-.103	-.184	-.022	.041	-.151		
70-79	-.078	-.152	.152	.167	-.024		
80+	-.084	-.412	.244	.167	-.024		
Education Level							
Incomp. HS	-.131	-.266	.005	.069	-.107		
HS/GED	.044	-.008	.095	.026	.094		
Associates	.012	-.042	.065	.027	.024		
Some college	.024	-.021	.069	.023	.062		
Bachelors	.029	-.019	.087	.021	.065		
Masters	.035	-.016	.086	.026	.074		
Terminal	.074	-.040	.188	.058	.064		
Work Experience							
< 1 year	-.005	-.104	.093	.050	-.007		
1-5 years	-.016	-.081	.049	.033	-.039		
5-10 years	-.029	-.091	.032	.031	-.064		
10-20 years	-.010	-.065	.046	.028	-.023		
20-30 years	.012	-.042	.087	.029	.043		
30+ years	.041	-.019	.101	.031	.090		
Safety Training							
H&S chemicals	.008	.013	.082	.091	.089		
Read/use labels	.045***	-.004	.065	.044	.195***		
Read/use SDS	.032***	-.012	.041	.007	.161***		
Self-taught	.002	-.041	.036	.012	.004		
Chem Exposure							
Some <10/yr	.033**	.007	.054	.021	.156**		
Often 10+/yr	.047**	.013	.081	.017	.133**		

Note.
Model = “Enter” method in SPSS; *B* = unstandardized regression coefficient; CI = confidence interval; LB = lower bound; UB = upper bound; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; Adj. R^2 = adjusted R^2.
*p < .05, **p < .01, ***p < .001.

Perception of Danger

The research question was: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' perception of danger. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.063. Values for Durbin-Watson can range between 0-4, with a value close to 2 indicative of independence of errors (residuals) (Laerd, 2015). A scatterplot displayed a linear relationship between perception of danger and independent variables collectively. Partial regression plots showed linear relationships between perception of danger and each of the independent variables. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. All the tolerance values were greater than 0.1 (the lowest was 0.397); therefore, the researcher is fairly confident there is no problem with collinearity in the data (Hair et al., 2014). No outliers greater than ± 3 standard deviations were detected by SPSS case-wise diagnostics. There were no leverage values above the safe value of 0.2 (Huber, 1981). The researcher inspected the ordered values for Cook's Distance as a measure of influence and determined there were no values above 1 (Cook & Weisberg, 1982) that required investigation. The assumption of normality was met, residuals were normally distributed as observed by the points aligning along a diagonal line on a P-P plot and a bell curve on a histogram of the standardized residuals of the dependent variable (Laerd, 2015).

The multiple regression model statistically significantly predicted employees' perception of danger, $F(20, 401) = 2.788$, $p < .0005$, adjusted $R^2 = .078$. The independent variables of age and work experience added statistically significantly to the prediction, $p < .05$. Regression coefficients and standard errors can be found in Table 15.

Table 15

Multiple Regression Results for Perception of Danger

	B	95% CI for B LB	UB	SE B	β	R^2	Adj. R^2
Model						.349	.078
Constant	.701***	.645	.757	.029			
Sex	-.006	-.033	.021	.014	-.021		
Age							
18-19	.087	.004	.170	.042	.123		
20-29	.082	.032	.132	.025	.240		
30-39	.044	.001	.088	.022	.130		
40-49	.021*	-.004	.065	.022	.052*		
50-59	.007*	-.039	.053	.023	.019*		
60-69	.007	-.061	.075	.035	.012		
70-79	-.024	-.151	.104	.065	-.018		
80+	-.070	-.345	.205	.140	-.024		
Education Level							
Incomp. HS	-.146	-.259	-.032	.058	-.139		
HS/GED	.018	-.025	.061	.022	.044		
Associates	.031	-.013	.076	.023	.074		
Some college	.017	-.021	.055	.019	.051		
Bachelors	.019	-.020	.057	.020	.050		
Masters	.021	-.022	.064	.022	.053		
Terminal	.040	-.056	.135	.048	.040		
Work Experience							
< 1 year	-.068	-.150	.015	.042	-.105		
1-5 years	-.084	-.138	-.029	.028	-.234		
5-10 years	-.084	-.135	-.032	.026	-.213		
10-20 years	-.061***	-.107	-.014	.024	-.171***		
20-30 years	.012***	-.019	.007	.025	.049***		
30+ years	.030***	-.021	.080	.026	.076***		
Safety Training							
H&S chemicals	.004	-.031	.024	.009	-.021		
Read/use labels	.087	-.002	.036	.004	-.019		
Read/use SDS	.085	.007	.035	.012	-.016		
Self-taught	.001	-.078	.012	.017	-.022		
Chem Exposure							
Some <10/yr	.049	.016	.079	.031	.215		
Often 10+/yr	.053	.024	.081	.015	.174		

Note.
Model = "Enter" method in SPSS; *B* = unstandardized regression coefficient; CI = confidence interval; LB = lower bound; UB = upper bound; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; Adj. R^2 = adjusted R^2.
*p < .05, **p < .01, ***p < .001.

Locating Essential Chemical Safety Information Correctly

The research question was: To what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' ability to locate essential chemical safety information correctly. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.039. Values for Durbin-Watson can range between 0-4, with a value close to 2 indicative of independence of errors (residuals) (Laerd, 2015). A scatterplot displayed a linear relationship between employees' ability to locate essential safety information correctly and independent variables collectively. Partial regression plots showed linear relationships between locating essential safety information correctly and each of the independent variables. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. All the tolerance values were greater than 0.1 (the lowest was 0.477); therefore, the researcher is fairly confident there is no problem with collinearity in the data (Hair et al., 2014). Only two outliers greater than ± 3 standard deviations were detected by SPSS case-wise diagnostics. There were no leverage values above the safe value of 0.2 (Huber, 1981). The researcher inspected the ordered values for Cook's Distance as a measure of influence and determined there were no values above 1 (Cook & Weisberg, 1982) that required investigation. The assumption of normality was met, residuals were normally distributed as observed by the points aligning along a diagonal line on a P-P plot and a bell curve on a histogram of the standardized residuals of the dependent variable (Laerd, 2015).

The multiple regression model statistically significantly predicted employees' ability to locate essential safety information correctly, $F(20, 401) = 2.783$, $p = .005$, adjusted $R^2 = .078$. The independent variables of work experience, chemical safety training, and chemical exposure level added statistically significantly to the prediction, $p < .05$. Regression coefficients and standard errors can be found in Table 16.

Table 16

Multiple Regression Results for Locating Essential Chemical Safety Information Correctly

		95% CI for B					
	B	LB	UB	SE B	β	R^2	Adj. R^2
Model						.122	.078**
Constant	.617***	.576	.658	.021			
Sex	-.009	-.029	.011	.010	-.044		
Age							
18-19	.089	.029	.150	.031	.173		
20-29	.050	.014	.087	.019	.201		
30-39	.025	-.007	.057	.016	.102		
40-49	.022			.015	.074		
50-59	.010	-.024	.043	.017	.035		
60-69	.015	-.034	.065	.025	.036		
70-79	.086	-.007	.179	.047	.089		
80+	.090	-.110	.291	.102	.042		
Education Level							
Incomp. HS	-.127	-.210	-.044	.042	-.166		
HS/GED	-.017	-.048	.015	.016	-.057		
Associates	-.046	-.078	-.013	.017	-.147		
Some college	-.017	-.044	.011	.014	-.069		
Bachelors	-.033	-.057	.003	.016	-.111		
Masters	.031	-.064	-.002	.021	.049		
Terminal	.055	-.014	.125	.035	.076		
Work Experience							
< 1 year	-.056	-.116	.004	.031	-.120		
1-5 years	-.055	-.095	-.015	.020	-.212		
5-10 years	-.060*	-.098	-.022	.019	-.210*		
10-20 years	-.044*	-.077	-.010	.017	-.168*		
20-30 years	-.032*	-.055	.013	.016	-.089*		
30+ years	-.009	-.046	.028	.019	-.032		
Safety Training							
H&S chemicals	-.046	-.129	.001	.015	-.106		
Read/use labels	-.033*	-.113	.009	.024	-.110*		
Read/use SDS	-.055*	-.124	.021	.031	-.104*		
Self-taught	-.032	-.118	.017	.022	-.120		
Chem Exposure							
Some <10/yr	.046	.007	.047	.016	.022		
Often 10+/yr	.035*	.014	.056	.011	.015*		

Note.
Model = "Enter" method in SPSS; *B* = unstandardized regression coefficient; CI = confidence interval; LB = lower bound; UB = upper bound; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; Adj. R^2 = adjusted R^2.
*p < .05, **p < .01, ***p < .001.

Comprehension of Pictograms and Other Hazard Classification Elements

The research question was to what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' comprehension of pictograms and other hazard classification elements. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.992. Values for Durbin-Watson can range between 0-4; with a value close to 2 indicative of independence of errors (residuals) (Laerd, 2015). A scatterplot displayed a linear relationship between perception of danger and independent variables collectively. Partial regression plots showed linear relationships between employees' comprehension of GHS pictograms and other hazard classification elements and each of the independent variables. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. All the tolerance values are greater than 0.1 (the lowest was 0.397); therefore, the researcher is fairly confident there is no problem with collinearity in the data (Hair et al., 2014). No outliers greater than ± 3 standard deviations were detected by SPSS case-wise diagnostics. There were no leverage values above the safe value of 0.2 (Huber, 1981). The researcher inspected the ordered values for Cook's Distance as a measure of influence and determined there were no values above 1 (Cook & Weisberg, 1982) that required investigation. The assumption of normality was met, residuals were normally distributed as observed by the points aligning along a diagonal line on a P-P plot and a bell curve on a histogram of the standardized residuals of the dependent variable (Laerd, 2015).

The multiple regression model statistically significantly predicted employees' comprehension of GHS pictograms other hazard classification elements, $F(20, 401) = 4.604$, $p < .0005$, adjusted $R^2 = .146$. The independent variables of age, work experience, and chemical exposure level added statistically significantly to the prediction, $p < .005$. Regression coefficients and standard errors can be found in Table 17.

Table 17

Multiple Regression Results for Comprehension of GHS Pictograms

	B	95% CI for B LB	UB	SE B	β	R^2	Adj. R^2
Model						.187	.146**
Constant	.572	.480	.664	.047			
Sex	.018	-.027	.063	.023	.037		
Age							
18-19	.075	-.060	.211	.069	.062		
20-29	.170	.088	.252	.042	.291		
30-39	.108***	.036	.179	.036	.186***		
40-49	.054***	-.025	.121	.033	.143***		
50-59	.010***	-.065	.085	.038	.015***		
60-69	-.017	-.129	.094	.057	-.017		
70-79	-.107	.031	.102	.106	-.047		
80+	-.096	-.546	.354	.229	-.019		
Education Level							
Incomp. HS	-.218	-.403	-.032	.095	-.122		
HS/GED	.006	-.064	.076	.036	.009		
Associates	-.015	-.088	.058	.037	-.021		
Some college	.038	-.024	.100	.032	.067		
Bachelors	.044	-.023	.111	.033	.073		
Masters	.057	-.013	.127	.036	.082		
Terminal	.155	-.001	.311	.079	.092		
Work Experience							
< 1 year	-.108	-.244	.027	.069	-.099		
1-5 years	-.149	-.238	-060	.045	-.245		
5-10 years	-.242***	-.326	-.158	.043	-.363***		
10-20 years	-.138***	.214	-.062	.039	-.228***		
20-30 years	-.054***	.047	-.004	.040	-.114***		
30+ years	.002	-.080	.085	.042	.004		
Safety Training							
H&S chemicals	.071	-.004	.214	.004	.074		
Read/use labels	.065	-.060	.202	.013	.079		
Read/use SDS	.024	-.032	.231	.022	.066		
Self-taught	.033	-.012	.227	.030	.051		
Chem Exposure							
Some <10/yr	.004	.061	.143	.012	.231		
Often 10+/yr	.126***	.079	.173	.024	.246***		

Note.
Model = "Enter" method in SPSS; *B* = unstandardized regression coefficient; CI = confidence interval; LB = lower bound; UB = upper bound; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; Adj. R^2 = adjusted R^2.
*p < .05, **p < .01, ***p < .001.

Chemical Hazard Ranking and Interpretation

The research question was to what extent does age, sex, education level, work experience, safety training history, or chemical exposure level influence employees' chemical hazard ranking and interpretation. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.056. Values for Durbin-Watson can range between 0-4, with a value close to 2 indicative of independence of errors (residuals) (Laerd, 2015). A scatterplot displayed a linear relationship between employees' chemical hazard ranking and interpretation and independent variables collectively. Partial regression plots showed linear relationships between chemical hazard ranking and interpretation and each of the independent variables. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. All the tolerance values were greater than 0.1 (the lowest was .456); therefore, the researcher was fairly confident there was no problem with collinearity in the data (Hair et al., 2014). Eight outliers greater than ± 3 standard deviations were detected by SPSS case-wise diagnostics. All eight outliers had a composite score of 0 based on the three questions related to chemical hazard ranking and interpretation on the survey. There were no leverage values above the safe value of 0.2 (Huber, 1981). The researcher inspected the ordered values for Cook's Distance as a measure of influence and determined there were no values above 1 (Cook & Weisberg, 1982) that required investigation. The assumption of normality was met, residuals were somewhat normally distributed as observed by the points forming a peak line on a P-P plot and a bell curve on a histogram of the standardized residuals of the dependent variable (Laerd, 2015).

The multiple regression model statistically significantly predicted employees' chemical hazard ranking and interpretation, $F(20,401) = 1.203$, $p = .247$, adjusted $R^2 = .010$. Predictions were made to determine the mean of hazard ranking and interpretation for females, 25 years old with a high school diploma, 5 years in the workforce, medium level of safety training, and often being exposed to chemicals. Mean hazard ranking and interpretation was predicted as .797 (scale 0-1) (95% CI, .686-.887). Regression coefficients and standard errors can be found in Table 18.

Table 18

Multiple Regression Results for Chemical Hazard Ranking and Interpretation

		95% CI for B					
	B	LB	UB	SE B	β	R^2	Adj. R^2
Model						.057	.010***
Constant	.791	.687	.896	.053			
Sex	.010	-.041	.061	.026	.019		
Age							
18-19	-.021	-.175	.133	.078	-.017		
20-29	.092	-.001	.185	.047	.149		
30-39	.024	-.057	.105	.041	.039		
40-49	.017	-.068	.102	.043	.026		
50-59	.065	-.062	.191	.064	.062		
60-69	.021	-.216	.258	.121	.009		
70-79	.191	-.320	.702	.260	.036		
80+	.195	-.298	.615	.202	.041		
Education Level							
Incomp. HS	-.149	-.360	.062	.107	-.079		
HS/GED	.007	-.073	.087	.041	.010		
Associates	-.069	-.152	.015	.042	-.090		
Some college	.016	-.054	.086	.036	.027		
Bachelors	.055	-.014	.072	.035	.024		
Masters	-.050	-.129	.030	.040	-.068		
Terminal	-.086	-.263	.091	.090	-.048		
Work Experience							
< 1 year	-.075	-.228	.079	.078	-.065		
1-5 years	-.077	-.178	.024	.051	-.120		
5-10 years	-.071	-.167	.024	.049	-.102		
10-20 years	-.016	-.103	.070	.044	-.025		
20-30 years	.012	-.045	.079	.041	.022		
30+ years	.024	-.070	.117	.048	.034		
Safety Training							
H&S chemicals	.024	-.201	.047	.041	.044		
Read/use labels	.017	-.107	.033	.064	.032		
Read/use SDS	.011	-.101	.023	.043	.056		
Self-taught	.023	-.099	.021	.022	.051		
Chem Exposure							
Some <10/yr	.029	-.012	.077	.013	.021		
Often 10+/yr	.033	-.020	.086	.027	.067		

Note.
Model = “Enter” method in SPSS; *B* = unstandardized regression coefficient; CI = confidence interval; LB = lower bound; UB = upper bound; SE B = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; Adj. R^2 = adjusted R^2.
*p < .05, **p < .01, ***p < .001.

Summary

The results of the research question were presented in this chapter. Altogether 422 completed surveys were collected using a SurveyMonkey audience panel. A PCA was run to verify the instrument's validity. Cronbach's alpha was used to determine the instrument was reliable.

Participants' gender was a near 50-50 mix between males and females. Most respondents were between the ages of 20 and 49 (70.14%). The majority (82.94%) of participants attended college/or and completed a degree. Only 5.21% of participants indicated they had been in the workforce less than one year. Among participants, 100% noted they used chemicals currently or previously at work. Correspondingly, 83.41% noted they were sometimes or often exposed to chemicals that someone was using while at work.

For the research question section related to comprehension of GHS chemical labels and SDSs, the researcher found there was a statistically significant difference in scores by age, work experience, and chemical exposure level. For the research question section related to employees' ability to recognize and use labels and SDSs, the researcher found there was a statistically significant difference in scores by safety training and chemical exposure level. For the research question section related to employees' perception of danger, the researcher found there was a statistically significant difference in scores by age and work experience.

For the research question section related to employees' ability to locate essential chemical safety information correctly, the researcher found there was a statistically significant difference in scores by work experience, chemical safety training, and chemical exposure level. For the research question section related to employees' comprehension of GHS pictograms and other hazard classification elements, the researcher found there was a statistically significant difference in scores by age, work experience, and chemical exposure level. Finally, for the research question section related to employees’ chemical hazard ranking and interpretation, the researcher found there was no statistically significant difference in scores by any of the independent variables.

CHAPTER 5

SUMMARY, CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

Introduction

Whereas, the purpose of this chapter is to provide an overview of the study and its findings, more specifically, it is to interpret these findings and assess them for their relevance to recommendations for the workplace. It also includes a discussion of how the findings might impact the safety and health profession, as well as potential contributions safety and health professionals can bring to employees' comprehension of GHS labels and SDSs. The following sections are included in this chapter: 1) discussion and interpretation of findings, 2) recommendations for future research, 3) implications for safety and health, 4) assumptions, 5) limitations, and 6) conclusion. The purpose of this study was to examine the factors that affect U.S. workers' comprehension of the new GHS-formatted chemical labels and SDS, mandated by OSHA's HCS.

Discussion and Interpretation of Findings

Among the six factors evaluated, work experience and chemical exposure levels were equally the two most important factors in determining the overall highest level of GHS label and SDS comprehension. Participants who had more years of work experience and a higher chemical exposure level were likely to have scores 19% higher than the mean score of 71% of all participants. The findings of this study are consistent with previous studies. Laughery and Brelsford (1993) found that individuals with a moderate level of work experience (5-10 years) mostly relied on external information (chemical label) when analyzing a chemical-related safety decision. Individuals with high levels of work experience (more than 10 years) with chemicals did not need the information as frequently as the moderates. Additionally, the researchers noted that individuals with a low level of chemical-related work experience (less than 5 years) had less capacity to use the chemical label and SDS information appropriately (Laughery & Brelsford, 1993). Likewise, Boelhouwer et al. (2013) confirmed that naïve users with 10 years or less of work experience correctly responded to only 67% of GHS survey questions, as opposed to an 86% correct response rate for experts with more than 10 years of work experience. The more experienced participants' significantly inflated correct response rate suggested that work experience indeed plays a major role in GHS chemical label and SDS comprehension.

In this study, participants who worked directly with or were exposed to others' chemical in the workplace were most likely to have high scores in comprehension of GHS labels and SDSs, recognition and use of chemical labels and SDSs, correctly locate essential chemical safety information, and comprehension of GHS pictograms. This finding was remarkable given that previously researchers have found a definite subjective effect from chemical product familiarity based on frequency of chemical exposures (DeJoy, 1989; Godrey et al, 1993; Otsubo, 1988). DeJoy (1989) conducted a thorough literature review and found several studies where higher frequencies of chemical exposures decreased the likelihood of noticing, reading, or obeying chemical label warnings. In like manner, Godfrey et al. (1993) and Otsubo (1988) found that individuals were less likely to observe, read, and follow warnings on household chemicals with which they are familiar than they are with unfamiliar chemicals. The more time individuals worked a chemical without experiencing a safety issue or consequence, they perceived the product to be less hazardous over time (Janicak, 1996). Likewise, Banda and Sichilongo (2006) studied comprehension levels of chemical labels of four groups in Zambia; agricultural, industrial, transport, and consumer. The researchers revealed a negative correlation (p = .05) between the comprehension levels and demographic factors such as sex, age, literacy level, education level, and type of employment in all four groups. Comprehension of GHS labels were shown to be more directly correlated with duration of chemical exposure (Banda &

Sichilongo, 2006). Similarly, Purswell, Krenek and Dorris (1987) ascertained if an individual is regularly exposed to a chemical hazard warning while also not experiencing negative health effects, the chemical warning is much more likely to be filtered and ignored by the individual and thereby rendering it ineffective. Chemical exposure levels and familiarity have been well illustrated in previous studies where the consensus was the more an individual uses a chemical without experiencing an injury or illness, the less hazardous the individual perceives the chemical to be and will most likely ignore the chemical warning in future use (Banda & Sichilongo, 2006; Godrey et al., 1993; Otsubu, 1988). This study examined if chemical exposure levels, or familiarity, influenced GHS comprehension and found conflicting results. One possible reason may be attributed to the transition to the GHS which is less familiar to employees that have been in the workforce for many years. The new format may cause longtime employees to be more cautious and pay more attention to the newly formatted and unfamiliar GHS labels and SDSs.

Age was a close third factor that directly relates to a greater number of years of work experience. In this study, age was statistically significant to employees' comprehension of GHS label and SDSs, perception of danger and comprehension of GHS pictograms. Older participants had higher overall scores compared to younger participants. Several studies found similar significant differences in comprehension related to the age of employees. Desaulniers' (1987) ascertained that users 40 years old and older are undeniably more likely to obey precautions in acknowledgement of safety warnings and communications as reflected in their safety behaviors. The age of the individual showed signs of affecting perceived level of hazard projected by typical signal words (Kotwal & Lerner, 1995). Finally, Laughery and Brelsford (1993) argue that older users are more likely to obey safety warnings, but increased focus on comprehension levels was strongly suggested.

Chemical safety training was among the factors not significantly related to GHS chemical label and SDS comprehensibility. This finding was unexpected given in the occupational safety and health field there is believed to be a direct connection between safety training and the creation of a healthful and safe working environment (OSHA, 2004). Boelhouwer and Davis (2010) noted “near unanimous” advantages that training can attain, such as increased levels of hazard awareness and overall safer behavioral changes. Wogalter, Sojourner, and Brelsford (1997), in their study on safety pictograms and comprehension, supported the notion that presenting pictograms in conjunction with associated written information is an effective method for training employees on the meanings of pictograms. This supports Boelhouwer and Davis’s (2010) hypothesis taken from the dual code theory – combining written and pictorial information greatly assists with memorization and recall.

Inadequate safety training on the newly-mandated GHS is a probable influence for low comprehension levels of hazard communication elements in this study. Sathar et al. (2016) studied chemical hazard information comprehension levels among workers and discovered low comprehensibility rates among workers on most hazard pictograms due to lack of training or inadequate training. This impacts the overall safety and health of workers while using chemicals on the job. For employees, appropriate training on how to correctly interpret and understand GHS hazard and precautionary warning statements on the chemical label and SDS is an essential part of increasing comprehension, and also applying the information appropriately (Sathar et al., 2016). The evidence and data on the effect of training on GHS comprehension is limited due to the relative newness of the change to the OSHA HCS in 2012. The researcher of this study recommends future research be conducted on the quality of GHS safety training and its effectiveness.

In this study, sex and education level had no statistically significant impact on GHS comprehensibility. The findings related to sex are consistent with most previous findings by other researchers. Laughery and Brelsford (1993) noted that women were much more likely than men to search out and read warnings. However, it was unclear whether sex was the factor contributing to the reported variances in the Laughery and Brelsford study (1993) with hazard perceptions or whether the variances were associated with other basic factors, such as knowledge of hazards, familiarity with chemicals, frequency of use, etc. In their study, Banda and Sichilongo (2006) found that education level, sex and age did not exert any influence on the comprehension levels of GHS constituent parts. Inconsistent results in prior studies have been reported on the effect of sex on GHS comprehension among individuals and there is scarce data among workers (Boelhouwer & Davis, 2010; Sathar, Dalvie, & Rother, 2016).

Finally, the findings in this study showed that education level had little to no impact on GHS comprehension. Previous research findings related to educational level and GHS comprehension were split down the middle. Some researchers found that education level of employees in the workplace can influence their comprehension of chemical labels and SDSs. Ta et al., (2010), not surprisingly, revealed that GHS study participants with a college degree obtained higher comprehension scores compared to participants that only completed high school or never earned a high school diploma. The researchers noted a profound difference in higher education levels greatly improving participants' aptitude in hazard identification associated with chemicals through the GHS pictograms (Ta, et al., 2010). Likewise, Hara et al., (2007) determined individuals with lower levels of education had a more difficult time understanding chemical labels than their higher-educated coworkers. These findings emphasize the importance of proactive efforts taken by employers to educate and train their employees with lower education levels.

However, Banda and Sichilongo (2006) ascertained that education levels did not change the comprehension of GHS label elements and perceived hazard among workers in their study. A limitation of their study was the fact that demographic characteristics, such as education level, were not clearly presented in their findings. Also, Conklin (2003) found that level of education did not have a significant impact on the comprehension level of MSDS in his study. These conflicting findings in multiple studies highlights the need to study what influence individuals' education levels have on GHS comprehension. The findings in this study may be attributed to the high education level of most participants; the overwhelming majority (83%) of participants in this study attended college and/or completed a degree (Table 11).

Recommendations for Future Research

After analyzing the data and reflecting on the study as a whole, a few recommendations are made for future research pertaining to examining the factors that affect U.S. workers' comprehension of the new GHS-formatted chemical labels and SDSs. The first recommendation is to conduct a qualitative study to research this topic. There are many facets of the original instrument that utilized open-ended questions in the questionnaire. A qualitative study would allow the researcher to extrapolate common themes among participants and perform a deeper dive into each participants' background and knowledge base related to GHS materials.

Another recommendation stemming from the feedback from the researchers' dissertation committee is to examine the readability of SDSs in general. Currently, there is no governmental or global agency directive on the level of readability, the level of detail, or the technical language that should be utilized in SDSs. Researchers have found average readability levels of a selection of SDSs was at a college level, slightly higher than a twelfth-grade reading level (Kolp et al., 1993; Taylor, 2010). It is recommended that health messages delivered to the general population be written for an audience reading at an eighth-grade reading level (US, DHHS, 1989). The new

SDSs associated with the GHS are an improvement in some areas, but as legally mandated documents required to serve many purposes for several audiences, SDS writers cannot adopt evidence-based communication practices intended for a single audience with a single message (Sinyai, MacArthur, & Roccotagliata, 2018).

A final recommendation for future research would be to study the effectiveness of GHS-related safety training material and techniques. Inadequate safety training on the GHS is a probable influence for low comprehension levels of hazard communication in this study. The level, type and effectiveness of safety training was not addressed in this study.

Implications for Safety and Health

This was the first national study in the U.S. to examine the factors that affect U.S. workers' comprehension of the new GHS-formatted chemical labels and SDSs, mandated by OSHA's HCS, using the UNITAR comprehensibility test instrument. A critical aspect of GHS adoption was its ability to improve employee comprehension of critical chemical safety information. When OSHA published the HCS in 1983, the concept of an employee's right to know of the hazards they work with helped shape the safety culture that is currently enforced today. The changes to HCS under GHS took that concept one step further by introducing the idea that workers not only had the right to know about hazards in their work environment, but also the right to understand them. Considering the overall changes brought about by the GHS alignment, this subtle word adjustment is easily overlooked. However, it's a critical clue that signals how OSHA expects employees to be trained (OSHA, 2004).

The findings from this study can serve as a foundation for future research as well as provide preliminary evidence to suggest expanding the training needs for GHS-formatted labels and SDSs. If the GHS is to provide a safety framework, there has to be investment in GHS training by safety and health professionals that effectively highlights comprehensibility. There should be a focus in training on items causing critical confusion and peer trainers should be used. Considering this study found that years of work experience and chemical exposure levels of employees were statistically significant factors in higher GHS comprehensibility scores, safety and health professionals need to concentrate extra effort on training newer, less experienced employees to be able to read and fully comprehend GHS chemical labels and SDSs. This group of employees is at the highest risk of not recognizing and/or understanding the material being conveyed about the hazards and precautions of chemicals in the workplace. Safety and health professionals must take training a step further by focusing more on the individual hazards employees face. Depending on the hazardous chemicals present in the facility, this training may either concentrate on a specific chemical and its hazards or a category of similar hazards for different chemicals; the key here is that it provides employees with a deeper understanding of the dangers and emergency situations they may face. Just as social distancing is the new normal now when dealing with infectious diseases such as COVID-19, GHS is the new normal for chemical safety in the safety and health profession.

Assumptions

There were five assumptions that pertained to this study. The first assumption was the participants in this study answered the survey questions honestly. The second assumption was the participants understood the survey questions and interpreted them as intended. Third assumption was participants responded accurately to survey questions based on actual personal perceptions and knowledge. The fourth assumption was the participants were similar to other employees found in general industry. Lastly, the fifth assumption was the instrument was valid and reliable and was an accurate measurement of the intended constructs.

Limitations

As with most survey research, the findings from this study should be interpreted in light of some limitations. In the present study, two limitations were most salient. The first limitation is that the attitudes of individuals who voluntarily participated in this study may be different than those who were not part of the sample or who chose not to participate in the study. Given that the research design employed convenience sampling, this limitation is nonetheless not likely to have influenced the results significantly. Information provided by the participants was not verifiable. Another limitation is the instrument advisory professional committee itself. The researcher of this study should have incorporated the assistance and feedback from regular workers that routinely work with chemicals in the workplace in the development of the modified UNITAR instrument. Having the feedback and input of regular chemical workers might have provided even stronger content validity, given that the instrument was used to assess employees' comprehension of GHS related materials.

Conclusion

Today's GHS chemical labels and SDSs are vital resources for employees, safety and health professionals, and safety program decision making. But they are not the best tools to share critical safety information with a worker audience. Workers need targeted materials designed to communicate to them the hazards of the chemicals in the workplace and precautions to take to protect themselves. For effective hazard communication, employers should supplement the SDSs with worker-oriented training materials for best results in comprehensibility. While SDSs are considered an anchor of worker health and safety, this research suggests that senior workers with more exposures to chemicals in the workplace are most likely to comprehend the newly-formatted GHS chemical labels and SDSs. Safety and health professionals need to ensure that employees not only have access to GHS material but, that the employees comprehend the GHS chemical labels and SDSs to be able to take appropriate precautions when working with chemicals to stay safe and healthy on the job.

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APPENDIX A

UNITAR GHS COMPREHENSIBILITY TESTING QUESTIONNAIRE

GHS Comprehensibility Testing

CT Questionnaire

Developed in the context of the
UNITAR/ILO Global GHS Capacity Building Programme
based on previous versions developed by the
University of Cape Town, South Africa and the ILO

September 2010

unitar
United Nations Institute for Training and Research

Introduction for Interviewers

Read prior to interviewing

The purpose of this questionnaire is for a country to assess how well target populations in the four sectors (i.e., agriculture, transport, industrial workplaces and consumers) comprehend GHS hazard communication elements such as symbols and information on labels. The data from this questionnaire will inform the GHS implementation committee as to where capacity building will be needed, especially in terms of training and awareness raising.

Before administering the questionnaire, become familiar with it. There are grey instruction boxes; read these carefully. Be sure to practice many times before you administer the questionnaire. Also, it is recommended that interviewers read the "Interviewers' Guidelines for GHS Comprehensibility Testing" to review appropriate etiquette for conducting the interviews.

Do not explain the questions, labels and SDS's to the point where you are influencing the Participant's answers. That is, DO NOT HELP THE PARTICIPANT ANSWER QUESTIONS. Do not coach or give any form of assistance in answering questions.

If the Participant does not know something you have asked them and asks you to explain, in order to not bias the data, please state: "I will explain this to you when we have finished the interview."

If you assist the Participant with answering the questions, the data will be biased and not reflect the true situation in your country. Remember, you are the pen of the Participant only writing down what he/she thinks!

At the end of this questionnaire there will be a debriefing section when you can explain what the symbols mean and respond to any other questions the Participant may have. Please remind the Participant that you will answer all their questions and explain things at the end of the interview.

BE SURE TO HAVE THE FOLLOWING BEFORE STARTING:

- Label 1
- SDS 1
- Label and SDS 2
- Pictogram table 1

MODULE 1: GENERAL INTERVIEW

Participant Number: ________________

Interviewer's Name: ______________________________________

Sector Represented by Participant:

Plumbing	= 1
Electric	= 2
Carpentry	= 3
HVAC	= 4
Grounds	= 5
Building Srv	= 6
Other	= 7 - Specify_________________

☐

Date: (Day/Month/Year):______/______/_______

Place of Interview: (City/Town)**:**_____________________________

Location of Interview:______________________________________
(Name of Department/Shop/etc.):

1.1 CONSENT PROCEDURE

Consent: Consent for participating is sought individually with each participant before asking questions.

- *Good morning/afternoon.*
- *My name is Susan Miller. I am conducting research as a PhD student of Southern Illinois University at Carbondale.*
- *Thank you for agreeing to speak to me. I would like you to help with a safety research project. I will be asking you some questions, as well as showing you some papers. Your answers will be very helpful to advise how workplaces can be made safer. You were randomly selected to participate as an employee in Facilities Management at Murray State University.*
- *Even though we will be asking you a lot of questions, this is not a test of your ability or knowledge. You will not be judged by how well or poorly you answer any questions. I am testing the information I will be showing you and not your ability. All I ask is that you try to answer the questions truthfully and as best as you can.*
- *There is no need to rush and you must not feel you have to impress me with your answer. Please remember that any information collected will be kept anonymous and confidential. Nobody, other than the researchers (myself and my colleagues) will know how you answered any of the questions.*

Read to participants:

- *Your participation will not affect your job and your supervisor/manager has agreed to your participation in this study. He/she knows that your answers will remain anonymous.*

- *It will take 60-90 minutes to conduct this interview.*

- *Do you have any questions? I would be happy to answer them.*

- *Thank you, we will now go ahead. Remember, even though you have said you are happy to participate, you do have the right to stop at any time if you so wish.*

- *Do you agree to take part in this study?*

Put X in box if Participant consents to participating in this study.

☐

1.2 PARTICIPANTS' BIOGRAPHICAL INFORMATION

1.2.1 Sex: for Male = 1, for Female = 2 Put number in box ☐

1.2.2 Age Range of Participant:

0-19 = 1
20-29 = 2
30-39 = 3
40-49 = 4
50-59 = 5
60-69 = 6
70-79 = 7
80+ = 8

Put number in box ☐

1.3 LANGUAGE

INTERVIEWER FILLS IN:

1.3.1 Language interview is conducted in: ______________________________

1.3.2 ***What language/s do you speak at home*? : ________________________**

1.3.3 Language Proficiency

Instructions:
Use the following codes to fill in table 1.3.3.

Proficient = 1	**Partially Proficient = 2**	**Unable to speak/read/write = 3**

Table 1.3.3

Please tell me if you can read, write, speak …	***Read***	***Write***	***Speak***
(fill in the language of this interview)			
(fill in the language commonly used on chemical labels)			

1.4 EDUCATIONAL STATUS

1.4.1 ***How much schooling have you completed?***
(Put appropriate number in box)

- no formal schooling = 1
- some formal schooling but never completed primary school = 2
- completed primary school = 3
- completed secondary/high school = 4
- completed post high school training/some university = 5
- completed bachelor's degree or higher = 6

1.5 WORK EXPERIENCE

1.5.1 How many years have you been in the workforce?

0-1 = 1
1-5 = 2
5-10 = 3
10-20 = 4
20-30 = 5
30+ = 6

Put number in box

– *Thank you very much for your effort.*
– *We will now proceed with the next set of questions.*

End of Module 1

MODULE 2: GENERAL COMPREHENSIBILITY OF LABELS

For this module, you will need label 1.

Read to participant:

– *I am going to ask you some more questions.*

– *Please do not be shy to ask me to explain the question to you.*

– *If you do not understand some of the words I use, please let me know and I will explain them to you.*

Instructions: Show the participant label 1.

2.1 LABEL RECOGNITION AND USE

2.1.1 ***Have you ever seen a document like this before?*** (Point to label 1)

Yes =1	No =2	Don’t know =3

Put number in box

2.1.2 **If 1 (yes), ask:** ***What do you call this document?*** (Point to label 1)

Label =1	Other name =2	Don’t know =3

Put number in box

Instructions:

– If the participant answers 2 or 3 to question 2.1.1, or does not say “label” to question 2.1.2, explain that ***“This is called a chemical label or just a label”.***

– If the Participant answers 2 or 3 to question 2.1.1, skip to 2.1.6.

2.1.3 ***How many times have you read any chemical labels in the last year?***

Tick code

Never	1	
A few times (<10)	2	
Many times/ regularly (>10)	3	

2.1.4 How many times in the last year have you used any information on a label?

	Tick code	
Never	1	
A few times (<10)	2	
Many times/ regularly (>10)	3	

2.1.5 **If 2 or 3 for 2.1.4 ask:** ***What did you use the label for?***

____

____

2.1.6 When would you most likely use a label? Explain. (do not give suggestions)

____

____

2.2 READING AND UNDERSTANDING A LABEL

Instructions: Give label 1 to the participant. Let the participant look at the label for up to 20 seconds.

2.2.1 Please list or point to what you remember looking at when I gave you this label in the order that you remember looking at them.

1. ______________________________________
2. ______________________________________
3. ______________________________________
4. ______________________________________
5. ______________________________________
6. ______________________________________
7. ______________________________________
8. ______________________________________
9. ______________________________________
10. ______________________________________

Instructions: After the Participant has studied the label, tell or write on a piece of paper the following rating scale for the Participant to use:
1 = not easy to understand
2 = understandable
3 = very easy to understand
4 = do not know

2.2.2 What is the name of the chemical on this label?

2.2.3 How easy do you think it would be for you to use this label to learn about the hazards of this chemical?

Tick the appropriate number

1	2	3	4

2.2.4 Are there any words on this label that you do not understand?

Yes = 1	No = 2	Illiterate = 3

Put number in box

2.2.5 If 1 (yes), ask: ***please list all the words you do not understand.***

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

2.3 PERCEPTION OF DANGER

2.3.1 Based on what you see on this label; would you consider this chemical dangerous?

Yes = 1	No = 2

Put number in box

2.3.2 Assuming it is dangerous, list the things on this label that you think indicate the chemical is dangerous.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

2.4 HAZARD STATEMENTS

2.4.1 What are the hazards of this chemical?

Participant identifies all hazards correctly from the list of hazard statements	1	
Participant comes up with partial list based on hazard statements	2	
Participant comes up with a response without using the label	3	
Participant does not know	4	

2.4.2 Meaning of Hazard Statements

Instructions: Point to section that says "Hazard Statements".

Read to Participant:

- *Please look at the section of the label that says "Hazard Statements."*
- *I will read to you, or point out some phrases listed under "Hazard Statements."*
- *Please tell me what you think these phrases mean.*

Instructions:

- Read out to the Participant the hazard statements from label 1, as indicated on Table 2.4.2 below.
- Fill in on Table 2.4.2 the meaning of the hazard statement as the Participant describes it.

Table 2.4.2

Hazard Statement	***What does this phrase mean?***
2.4.2.1 Extremely flammable gas	
2.4.2.2 Contains gas under pressure; may explode if heated	
2.4.2.3 Causes skin irritation	
2.4.2.4 May damage fertility or the unborn child	
2.4.2.5 Harmful to aquatic life	

2.5 OTHER LABEL ELEMENTS

Instructions: Skip this section if the Participant is illiterate.

2.5.1 **PREVENTION:** ***What kinds of preventative measures should be taken when working with this chemical?***

		Tick box
Participant reads possible responses correctly from the label	1	
Participant comes up with a response without using the label	2	
Participant does not know	3	

2.5.2 **If 1, which preventative measures are correctly listed?**

1.____
2.____

3.____
4.____
5.____

If 2 or 3, read the preventive statements to the Participant.

2.5.3 **RESPONSE:** ***What should be done if this chemical is inhaled?***

Tick box

Participant reads correctly from the label	1	
Participant comes up with a response without using the label	2	
Participant does not know	3	

If 2 or 3, read the response statements to the Participant.

2.5.4 **STORAGE:** ***Can you please tell me how this chemical should be stored?***

Tick box

Participant reads correctly from the label	1	
Participant comes up with a response without using the label	2	
Participant does not know	3	

If 2 or 3, read the storage statements to the Participant.

– *Thank you very much for your effort.*
– *Please pass the label back to me.*
– *We will now proceed with the next set of questions.*

End of Module 2

MODULE 3: GENERAL COMPREHENSIBILITY OF SAFETY DATA SHEETS

Note: Module 3 is not for Participants from the consumer sector. If Participant is a consumer, go to Module 5.

For this module, you will need SDS 1.

3.1 SDS RECOGNITION AND USE

3.1.1 FOR ILLITERATE PARTICIPANTS:
Go to Module 4 if Participant is illiterate and unable to read an SDS. Mark box if skipped ☐

Instructions: Show the Participant Safety Data Sheet 1

3.1.2 Have you ever seen this type of document before? *(Point to the SDS)*

Yes =1	No =2	Don't know =3

Put number in box ☐

3.1.3 What is this document called? *(Point to the SDS)*

Safety Data Sheet =1	Gave another name =2	Don't know =3

Put number in box ☐

Instructions:
– If the Participant answers 2 or 3 to question 3.1.2, or does not say Safety Data Sheet (SDS) to question 3.1.3, explain that ***"This is called a safety data sheet".***
– If the Participant answers 2 or 3 to question 3.1.2, do not ask question 3.1.4.

3.1.4 How many times have you read a Safety Data Sheet in the last year?

	Tick	code
Never	1	
A few times (<10)	2	
Many times/regularly (>10)	3	

Instructions: If the answer to 3.1.4 is **NEVER,** go to question 3.1.7.

3.1.5 How many times in the last year have you used any information on a Safety Data

Sheet?

		Tick code
Never	1	
A few times (<10)	2	
Many times/ regularly (>10)	3	

3.1.6 What would you use the SDS for?

____

____

3.1.7 When do you use or need a SDS? (do not give suggestions)

____

____

Instructions:
- Give the Participant Safety Data Sheet 1
- The Participant has up to 5 minutes to look at the SDS before questions are asked.

Read to Participant:

- *I am going to ask you some general questions about this safety data sheet.*
- *If you do not understand some of the words I use, I will explain them to you. Please do not be shy to ask me to explain the question to you.*
- *Please have a look at this safety data sheet. You have 5 minutes.*

3.2 UNDERSTANDING THE SAFETY DATA SHEET

Instructions: After the Participant has studied the SDS, tell or write on a piece of paper the following rating scale for the Participant to use:
1 = not easy to understand
2 = understandable
3 = very easy to understand

3.2.1 How easy is it for you to understand the information on this Safety Data Sheet?

Tick the appropriate number

1	2	3

3.2.2 How easy is it for you to find information on this Safety Data Sheet?

Tick the appropriate number

1	2	3

3.2.3 Are there any words on this SDS that you do not understand?

Yes = 1	**No = 2**

Put number in box ☐

3.2.4 If 1 (yes), ask: ***please list all the words you do not understand.***

1. ____
2. ____
3. ____
4. ____
5. ____

3.3 LOCATING INFORMATION IN THE SDS

3.3.1 What is the name of the chemical that this Safety Data Sheet is for?

		Tick box
Sharp's Do-It-All	1	
Gave another name	2	
Unable to Identify	3	

If 2 or 3, show the Participant the name on the front of the SDS.

3.3.2 Where can you find First Aid information in the Safety Data Sheet?

		Tick box
Participant turns to correct section (4 First Aid Measures)	1	
Participant points to an incorrect section	2	
Participant does not know	3	

If 2 or 3, turn to the correct section and show the Participant section "4 First Aid Measures".

3.3.2 a What should you do if this chemical comes in contact with someone's eye?

		Tick box
Participant reads correctly from the SDS (under section 4)	1	
Participant comes up with a response without using the SDS	2	
Participant does not know	3	

If 2 or 3, show the Participant the “after eye contact” heading in the “4 First Aid” section.

What kind of protective equipment do you need for fighting fires related to this chemical?

Tick box

Participant reads correctly from the SDS (under section 5)	1	
Participant comes up with a response without using the SDS	2	
Participant does not know	3	

If 2 or 3, show the Participant the “protective equipment” heading in the “5 Fire-fighting Measures” section.

3.3.3 How would you protect your respiratory system, hands, eyes and body when working with this chemical? Please list.

Tick box

Participant identifies all necessary protective measures with SDS	1	
Participant partially identifies protective measures with SDS	2	
Participant comes up with a response without using the SDS	3	
Participant does not know	4	

If 2, 3 or 4, show the Participant the relevant subheadings under the” Individual Protection Measures” heading in the “8 Exposure controls/personal protection section.”

- *Thank you very much for your effort.*
- *Please pass the SDS back to me.*
- *We will now proceed with the next set of questions.*

End of Module 3

MODULE 4: SAFETY DATA SHEETS AND LABELS

For this module, you will need label 2 and SDS 2.

Instructions:

- Give the Participant label 2 and SDS 2
- The Participant has up to 5 minutes to look at the materials before questions are asked.

Read to Participant:

- *I will now give you a SDS and a label for the same chemical.*
- *Please take a look at both. You can use either to answer the questions I am now going to ask.*
- *If you do not understand some of the words I use, I will explain them to you. Please do not be shy to ask me to explain the question to you.*
- *You have 5 minutes to look at the materials before I ask you the questions.*

4.1 LOCATING INFORMATION

4.1.1 What is the name of the chemical?

		Tick box
Emulso GM3	1	
Gave another name	2	
Unable to identify	3	

4.1.1a- If 1, what did the Participant use to answer the question?

Label	**1**	
SDS	**2**	
Both	**3**	
Neither	**4**	

4.1.2 What is the active chemical ingredient in Emulso GM3?
(do not help Participant answer)

		Tick box
Tetrapropylene benzene sulphonate-ca-salt, Isobutanol	1	
Gave another name	2	
Unable to identify	3	

4.1.2a- If 1, what did the Participant use to answer the question?

Label	**1**	
SDS	**2**	
Both	**3**	
Neither	**4**	

4.1.3 What hazards are associated with Emulso GM3?

Tick box

Participant identifies all hazards	1	
Participant partially identifies the hazards	2	
Participant responds without using the SDS or label	3	
Participant does not know	4	

4.1.3a- If 1 or 2, what did the Participant use to answer the question?

Label	**1**	
SDS	**2**	
Both	**3**	
Neither	**4**	

4.1.4 What should you do if the chemical is accidentally released?

Tick box

Participant correctly reads from section "6 accidental release measures"	1	
Participant partially identifies the release measures	2	
Participant responds without using the SDS or label	3	
Participant does not know	4	

This information is only available in the SDS. If the Participant cannot find the information, turn to section 6 of the SDS to show the Participant where to find the answer.

– *Please pass the SDS and label back to me.*
– *Thank you very much for your effort.*
– *We will now proceed with the next set of questions.*

End of Module 4

MODULE 5: COMPREHENSION OF PICTOGRAMS AND HAZARD COMMUNICATION ELEMENTS

For this module, you will need label 1, label 2 and table 1.

5.1 PICTOGRAMS

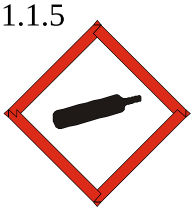
Instructions: Give label 1 and 2 to the Participant. Put Participant's answers to each symbol in Table 5.1.1

Read to Participant: *I am going to point out different elements on these labels.*

5.1.1 Please tell me what these symbols/words mean.

Table 5.1.1

Point to Element on Label	***What does this symbol/word mean?***
5.1.1.1 	
5.1.1.2 	
5.1.1.3 	
5.1.1.4 The word: **DANGER**	

5.1.1.5 	
5.1.1.6 	

5.1.2 There are some pictograms that were not found on these labels, and I would like to ask you about them as well.

Instructions: Give the Participant the GHS pictogram table 1

Read to the Participant:

– *Here is a complete table of GHS pictograms. I am going to point to a few pictograms, and I would like you to please tell me what you think this pictogram means to you.*

Point to pictogram	***What does this symbol mean?***
5.1.2.1 	
5.1.2.2 	
5.1.2.3 	

5.1.2.4 	

5.2 ASSOCIATING PICTOGRAMS WITH HAZARD CLASSES

<u>Read to the Participant:</u>

– *For this exercise we are going to continue using the complete table of GHS pictograms*

– *I am going to ask you to identify which pictogram may be used to indicate a certain hazard.*

– *If you do not understand some of the words I use, I will explain them to you. Please do not be shy to ask me to explain the question to you.*

Instructions:
***for this section, use the GHS pictogram table 1 only.**
1. Tick the blocks corresponding with the answer given by the Participant.
2. If more than one symbol is chosen per answer, note all the symbols chosen in the "another symbol" column.
3. If subject doesn't know how to answer, irrespective of whether they asked for an explanation or not, tick the column marked "don't know".
4. If you need to explain the definition of the hazard, tick the box to the right of the explanation.

Table 5.2

Questions	Definitions of terms		Label Identified		
	Tick in the box to the right if you have to explain meaning to Participants		**Tick Box corresponding with Participant's answer choice:**		
5.2.1 Which symbol or symbols do you think identifies a chemical that is oxidizing?	An oxidizing chemical can react, even in the absence of air, with other chemicals and cause fire.		Flame over circle	Another symbol	Don't know
5.2.2 Which symbol or symbols do you think identifies a chemical that is flammable?	A flammable chemical is one that can easily catch fire and burn.		Flame	Another symbol	Don't know
5.2.3 Which symbol or symbols do you			Corrosive	Another symbol	Don't know

think identifies a chemical that is corrosive to metal?	A corrosive chemical is one that can cause severe damage to eyes, skin, metal and other materials.				
5.2.4 Which symbol or symbols do you think identifies a chemical that is an environmental hazard?	A chemical that is an environmental hazard can damage or kill fish, or other aquatic organisms.		Environment hazard	Another symbol	Don't know
5.2.5 Which symbol or symbols do you think identifies a chemical that is explosive?	An explosive chemical is one that can blow up and cause an explosion.		Exploding bomb	Another symbol	Don't know
5.2.6 Which symbol or symbols do you think identifies a chemical that is severely acutely toxic?	A chemical that is severely acutely toxic can be fatal.		Skull and crossbones	Another symbol	Don't know
5.2.7 Which symbol or symbols do you think identifies a chemical that is skin irritant?	A chemical that is a skin irritant can cause skin rashes and irritation.		Exclamation mark	Another symbol	Don't know
5.2.8 Which symbol or symbols do you think identifies a chemical with a reproductive effect?	A chemical that is a reproductive hazard can cause problems for a person's ability to have children or cause birth defects in offspring.		Health hazard	Another symbol	Don't know
5.2.9 Which symbol or symbols do you think identifies a compressed gas?	A chemical that is packaged under pressure and may explode if the cylinder is heated or ruptured; and contents may cause burns.		Gas cylinder	Another symbol	Don't know

5.3 HAZARD RANKING AND INTERPRETATION

5.3.1 If you saw a label with the signal word "warning" and one with the signal word "danger" which would you consider the more dangerous chemical?

Tick the box considered more dangerous:

Warning	**1**	
Danger	**2**	

5.3.2 **If unable to rank which is more dangerous or less dangerous, tick box:**

☐

Instructions: Point to the exclamation mark and to the corrosion pictograms.

5.3.3 ***If you saw a label with this pictogram, and another one with this pictogram, which one would you consider the more dangerous chemical?***

Tick the box considered more dangerous:

Exclamation mark	**1**	
Corrosion	**2**	

5.3.4 **If unable to rank which is more dangerous or less dangerous, tick box:**

☐

Instructions : Point to the exclamation mark and to the skull and crossbones.

5.3.5 ***If you saw a label with this pictogram, and another one with this pictogram, which one would you consider the more dangerous chemical?***

Tick the box considered more dangerous:

Exclamation mark	**1**	
Skull and crossbones	**2**	

5.3.6 **If unable to rank which is more dangerous or less dangerous, tick box:**

☐

- *Thank you for your effort.*
- *Please pass the table back to me.*
- *We will now move onto the final module.*

End of Module 5

Module 6: Post Interview

6.1 EXPOSURE TO CHEMICALS

INSTRUCTIONS:
The rating scale used in the next questions is: 1 = not at all/never
2 = sometimes (<10x/month)
3 = a great deal/always/often (>10x/month)

Put number in box

6.1.1 In your current job, how often do you use chemicals?

Put number in box [ ]

6.1.1 Sometimes you might be exposed to a chemical that someone else is using. In your current job/daily life, how often are you exposed to chemicals that someone else is using?

Put number in box [ ]

6.2 TRAINING

6.2.1 Workers: In your current job, have you received any training?

Type of training	**Yes = 1** **No = 2**
6.2.1.1 On *safe use of chemicals at work?*	
6.2.1.2 About reading and using labels?	
6.2.1.3 About reading and using SDS?	
6.2.1.4 About meanings of pictograms?	

6.3 HEALTH AND SAFETY EXPERIENCE

6.3.1 Have you ever been a health and safety representative, factory manager or a shop steward at your work?

Yes =1	No =2	Don't know =3

Put number in box [ ]

Read to Participant: *Now I would like to ask you to give some feedback on this interview process so that I can improve comprehensibility testing.*

6.4 EXERCISE EVALUATION

6.4.1 Do you think this was a valuable interview?

Yes =1	No =2	Don't know =3

Put number in box

6.4.2 Why or why not was this a valuable interview? Please explain:

6.4.3 Do you have any additional questions or suggestions?

End of Module 6

DEBRIEFING

Instructions:
Now is the time to answer questions and explain anything the Participant did not understand or would like more information about.

Read to Participant:

This is the end of our testing exercise.

Thank you very much for your effort and time.

This testing has been part of a project to see how people use labels and Safety Data Sheets to improve chemical safety. Your answers will help us to see in which areas additional training may be need to order to improve and communicate hazard information to workers and other people.

Your help has been much appreciated.

Thank you.

GHS PICTOGRAMS & MEANINGS

The Global Harmonized System of Classification & Labelling of Chemicals (GHS) is a new system with the objective of harmonizing information on labels & SDS. The goal is to protect human health & the environment.

GHS Pictograms and Hazard Classes		
		
• Oxidizers	• Flammables • Self-reactives • Pyrophorics • Self-heating • Emits flammable gas • Organic peroxides	• Explosives • Self-reactives • Organic peroxides
		
• Acute toxicity (severe)	• Corrosive to metals • Skin corrosion • Serious eye damage	• Gases under pressure
		
• Carcinogenicity • Respiratory sensitization • Reproductive toxicity • Specific target organ toxicity (repeated) • Germ cell mutagenicity • Aspiration hazard	• Aquatic toxicity (acute) • Aquatic toxicity (chronic)	• Acute toxicity (harmful) • Skin/eye irritation • Skin sensitization • Specific target organ toxicity (single) • Hazardous to the ozone layer

Ethylene oxide

Ingredient : Ethylene oxide 100%
CAS No. 75-21-8 UN No. 1040
Content : 30kg

DANGER

HAZARD STATEMENTS

Extremely flammable gas
Contains gas under pressure; may explode if heated
Toxic if swallowed
Toxic if inhaled
Causes skin irritation
May cause genetic defects
May cause cancer
May damage fertility or the unborn child
Causes damage to central nervous system
May cause respiratory irritation
Causes damage to central nervous system, peripheral nervous system and blood through prolonged or repeated exposure
May cause damage to kidney and respiratory system
Harmful to aquatic life

Precautionary Statements

Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Keep away from heat/sparks/open flames/ hot surface. – No smoking.
Use personal protective equipment as required.
Do not eat, drink or smoke when using this product.
Avoid release to the environment.

Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
Eliminate all ignition sources if safe to do so.
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
IF exposed or concerned: Get medical advice/attention.

Store in well ventilated place.
Store locked up.

Training on GHS Co. Ltd.,
Peace Rd., Geneva, Switzerland
Tel. (022) 7111 000

Label 1

All Chemicals Ltd.
123 Any Street
Anywhere
Tel: 123 456 7890
Fax: 123 654 0987

Contains: Tetrapropylene Benzene sulphonate-Ca-salt, Isobutanol

Emulso GM3

Danger

Flammable liquid and vapor. Toxic in contact with skin. Causes severe skin burns and eye damage. Causes serious eye damage. Harmful to aquatic life. Harmful to aquatic life. Harmful to aquatic life with long lasting effects.

Keep container tightly closed. Keep away from heat/ sparks open flame/hot surfaces No smoking. Ground/bond container and receiving equipment. Use explosion- proof electrical/ ventilation/lighting/ Equipment. Take precautionary measures against static discharge. Use only non-sparking tools. Use only outdoors or in a well ventilated area. In case of fire use dry chemical, foam, water spray jet for extinction.

Wear protective clothing/gloves and eye/face protection. Do not breathe dust/fume/mist/spray. Remove/take off immediately all contaminated clothing IF ON Skin: Wash with plenty of soap and water. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. IF Swallowed, rinse mouth. Do not induce vomiting. If Inhaled: Remove to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTRE or doctor/physician if you feel unwell.

Store locked up. Store in cool/ well-ventilated place. Avoid release to environment. Dispose of contents/container to authorized companies.

CORROSSIVE LIQUID, Flammable, N.O.S.
ADR: UN 2920/8/11
IMDG UN 2920/8/11

Label 2

Table 1

GHS Pictograms		
		
		
		

SDS 1

Safety Data Sheet

according to Globally Harmonised System of Classification and Labelling

Printing date: 24.11.2007

1 IDENTIFICATION

GHS product identifier: **SHARP'S DO-IT-ALL**

Article number: 6285

Recommended use of the substance/mixture and restrictions on use

A combined lubricant, dewatering fluid, penetrating oil and a rust inhibitor.

Supplier:

SHARP CHEMICALS Ltd
Any Street
Anytown
AT1 1AT
UK
Tel: (UK) 1234 1234567
Fax: (UK) 1234 1234568
e-mail: info@sharpchemicals.co.uk

Emergency phone number:

(UK) (UK) 1234 1234567 (24hrs)

2 Hazards Identification

2a. Classification

Aspiration hazard, Hazard Category 1
Flammable liquids, Hazard Category 1
Hazardous to the aquatic environment – Chronic Hazard, Category 1

2b. Labelling

Signal Word: DANGER

Hazard Statements:

H304: May be fatal if swallowed and entered airways
H224: Flammable liquid and vapour
H411: Toxic to aquatic life with long lasting effects

Precautionary Statements:

Prevention

P233:	Keep container tightly closed
P210:	Keep away from heat/sparks/open flame – No smoking
P240:	Ground container and receiving equipment
P241:	Use explosion-proof electrical/ventilating/lighting/heating equipment
P242:	Use only non-sparking tools
P243:	Take precautionary measures against static discharge
P273:	Avoid release to the environment
P280:	Wear protective gloves/clothing

Response

P301+P310:	**IF SWALLOWED**: Immediately call a POISON CENTRE or doctor/physician
P302+P361:	**IF ON SKIN**: Remove/Take off immediately all contaminated clothing
P331:	Do NOT induce vomiting
P350:	Gently wash with plenty of soap and water
P370+P378:	In case of fire use CO2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam for extinction

Storage

P403	Store in well ventilated place
P405:	Store locked up

Disposal

P501:	Dispose of contents/container in accordance with national and international regulations.

3 Composition/information on ingredients

Chemical characterization:

Description: Mixture of substances below with nonhazardous ingredients.

Dangerous components:

CAS: 64742-88-7	**Solvent naptha (petroleum) medium aliph.** DANGER H304: May be fatal if swallowed and entered airways H224: Flammable liquid and vapour H411: Toxic to aquatic life with long lasting effects	50-100%
CAS: 92062-35-6	**Light mineral oil** DANGER H304: May be fatal if swallowed and entered airways	2.5-10%
CAS: 1330-20-7	**Xylene.** DANGER H311: Toxic in contact with the skin H224: Flammable liquid and vapour H332: Harmful if inhaled H315: Causes skin irritation	<2.5%
CAS: 108-67-8	**Mesitylene** WARNING H224: Flammable liquid and vapour H335: May cause respiratory irritation H411: Toxic to aquatic life with long lasting effects	<2.5%
CAS: 95-63-6	**1,2,4-Trimethylbenzene.** WARNING H224: Flammable liquid and vapour H332: Harmful if inhaled H315: Causes skin irritation H319: Causes serious eye irritation H335: May cause respiratory irritation H411: Toxic to aquatic life with long lasting effects	<2.5%
CAS: 95-38-5	**Oleyl hydroxyethyl imidazoline** DANGER H301: Toxic if swallowed H314: Causes severe skin burns and eye damage H410: Very toxic to aquatic life with long lasting effects	<2.5%
CAS: 110-25-8	**n-Oleyl sarcosine** DANGER H318: Causes serious eye damage H410: Very toxic to aquatic life with long lasting effects H315: Causes skin irritation	<2.5%
CAS: 9016-45-9	**Nonylphenol polygycol ether** WARNING H315: Causes skin irritation H319: Causes serious eye irritation H411: Toxic to aquatic life with long lasting effects	<2.5%
CAS: 98-82-8	**Cumene** DANGER H304: May be fatal if swallowed and entered airways H224: Flammable liquid and vapour H335: May cause respiratory irritation H411: Toxic to aquatic life with long lasting effects	<2.5%

4 First aid measures

General information:
Immediately remove any clothing soiled by the product.

After inhalation:
Supply fresh air or oxygen; call for doctor.
In case of unconsciousness place patient stably in side position for transportation.

After skin contact:
Immediately wash with water and soap and rinse thoroughly.
If skin irritation continues, consult a doctor.

After eye contact:
Check for and remove any contact lenses.
Rinse opened eye for several minutes under running water. Then consult a doctor.

After swallowing:
Wash mouth out with water
Do not induce vomiting; call for medical help immediately.

Information for doctor:
Contains petroleum distillates.

Treatment
Following ingestion, vomiting should not be induced, because of the danger of aspiration into the lungs. Gastric lavage should only be given when aspiration into the lungs can be avoided by the use of a cuffed endotracheal tube.

Important symptoms/effects Effects

ACUTE

Exposure to high vapour concentrations can lead to headache, dizziness and fatigue. CNS depression may result in lack of coordination and extended response time.
If the mixture is swallowed, droplets can enter the lungs and cause pneumonitis. Symptoms usually take several hours to become apparent and are aggravated by physical effort. Rest and observation are therefore essential.

CHRONIC

Prolonged or repeated skin contact may cause dermatitis and skin disease.

5 Fire-fighting measures

Suitable extinguishing agents:
CO_2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.

For safety reasons unsuitable extinguishing agents:
Water with full jet.

Protective equipment:
Wear self-contained respiratory protective device.
Wear fully protective suit.
Do not inhale explosion gases or combustion gases.

Additional information
Cool endangered receptacles with water spray.

6 Accidental release measures

Person-related safety precautions:
Particular danger of slipping on leaked/spilled product.
Wear protective equipment. Keep unprotected persons away.

Measures for environmental protection:
Inform respective authorities in case of seepage into water course or sewage system.
Do not allow to enter sewers/ surface or ground water.
Do not allow to penetrate the ground/soil.

Measures for cleaning/collecting:
Ensure adequate ventilation.
Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sawdust).
Send for recovery or disposal in suitable receptacles.

7 Handling and storage

Handling:

Information for safe handling:
Ensure good ventilation/exhaustion at the workplace.
Use solvent-proof equipment.
Avoid splashes or spray in enclosed areas.

Information about fire - and explosion protection:
Keep ignition sources away - Do not smoke.
Protect against electrostatic charges.

Storage:

Requirements to be met by storerooms and receptacles:
Prevent any seepage into the ground.
Store in a cool location.

Information about storage in one common storage facility:
Store away from oxidizing agents.

Further information about storage conditions:
Store in cool, dry conditions in well sealed receptacles.
Store receptacle in a well ventilated area.

8 Exposure controls/personal protection

Control Parameters

Ingredients with limit values that require monitoring at the workplace:

1330-20-7 Xylene

EH40-WEL (UK 2005)	Short-term value: 441 mg/m³, 100 ppm
	Long-term value: 220 mg/m³, 50 ppm

108-67-8 Mesitylene

EH40-WEL (UK 2005)	Long-term value: 125 mg/m³, 25 ppm

95-63-6 1,2,4-Trimethylbenzene

EH40-WEL (UK 2005)	Long-term value: 125 mg/m³, 25 ppm

Appropriate Engineering Controls:

Processes should be fully enclosed wherever possible.
The work area should be provided with suitable and sufficient ventilation.
Facilities storing or utilising this material should be equipped with an eyewash facility and a safety shower.

Individual Protection Measures

Personal protective equipment:

Select PPE appropriate for the operations taking place taking into account the product properties.

General protective and hygienic measures:

Do not carry product impregnated cleaning cloths in trouser pockets.
Do not eat, drink or smoke while working.
Avoid close or long term contact with the skin.
Keep away from foodstuffs, beverages and feed.
Wash hands before breaks and at the end of work.
Avoid contact with the eyes.

Respiratory protection:

In case of brief exposure or low pollution use respiratory filter device. In case of intensive or longer exposure use self-contained respiratory protective device.

Protection of hands:

Protective gloves
The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.

Eye protection:

Tightly sealed goggles.

Body protection:

Solvent resistant protective clothing

9 Physical and chemical properties

General Information

Form: Fluid

Colour: Brown

Odour: Solvent like

Change in condition:
Melting point/Melting range: Undetermined
Boiling point/Boiling range: Undetermined

Flash point: 40°C

Ignition temperature: >200°C

Self-igniting: Product is not selfigniting.

Danger of explosion:
Product is not explosive. However, formation of explosive air/vapour mixtures is possible.

Explosion limits:
Lower: 0.6 Vol %
Upper: 6.5 Vol %

Vapour pressure at 20°C: 6.6 hPa

Density at 20°C: 0.805 g/cm³

Solubility in / Miscibility with water at 20°C: Not miscible or difficult to mix.

Viscosity:
Kinematic at 40°C: 4 cSt

10 Stability and reactivity

Chemical stability:
No decomposition if used and stored according to specifications.

Hazardous reactions
No dangerous reactions known.

Incompatible materials:
Strong oxidising agents

Hazardous decomposition products:
Carbon monoxide and carbon dioxide

11 Toxicological information

Likely routes of exposure

- **Inhalation** of vapour or mist.

LD/LC50 values relevant for classification:

64742-88-7 Solvent naphtha (petroleum), medium aliph.
Oral LD50: >6500 mg/kg (rat)
Dermal LD50: >3000 mg/kg (rab)
Inhalative: LC50/4 h >14 mg/l (rat)

95-63-6 1,2,4-Trimethylbenzene
Oral LD50: 5000 mg/kg (rat)

Sensitisation: No sensitising effects known.

ACUTE effects

Eye:
No irritant effect

Skin:
No irritant effect

Ingestion:
Small amounts of liquid aspirated into the respiratory system during ingestion of from vomiting may cause bronchopneumonia or pulmonary oedema.

Inhalation:
Exposure to high vapour concentrations can lead to headache, dizziness and fatigue. CNS depression may result in lack of coordination and extended response time.

CHRONIC effects

Prolonged dermal exposure to the mixture, e.g., resulting from wearing clothes that have been soaked or moistened for a significant time, may produce irritation and dermatitis.

12 Ecological information

Ecotoxicicity
Very toxic for fish

Persistence and degradability
When released into the soil or into water, the substance is not expected to persist in the environment.
Only as a result of spillage are substantial amounts likely to be found in the environment.
However, most of the constituent compounds evaporate fairly rapidly.

Bioaccumulation potential
The substance is not expected to significantly bioaccumulate.

Mobility in soil
The less volatile constituents partition to soil and sediment; this lowers the bioavailability and reduces the uptake by organisms.

General notes:
Water hazard class 2 (German Regulation) (Assessment by list): extremely hazardous for water
Do not allow product to reach ground water, water course or sewage system, even in small quantities.
Danger to drinking water if even extremely small quantities leak into the ground.
Also poisonous for fish and plankton in water bodies.
Toxic for aquatic organisms

13 Disposal considerations

Product:

Recommendation

Must not be disposed together with household garbage. Do not allow product to reach sewage system.
Contact waste processors for recycling information.
Used, degraded or contaminated product may be classified as hazardous waste. Anyone classifying hazardous waste and determining its fate must be qualified in accordance with state and international legislation.

Uncleaned packaging:
Recommendation:

Container remains hazardous when empty. Continue to observe all precautions.
Disposal must be made according to official regulations.

Recommended cleansing agents:

Water and detergent.

14 Transport information

Land transport ADR/RID (cross-border)

ADR/RID class: 3 Flammable liquids.
Danger code (Kemler): 30
UN-Number: 1300
Packaging group: III
Hazard label: 3
Description of goods: 1300 TURPENTINE SUBSTITUTE (mixture)

Maritime transport IMDG:

IMDG Class: 3
UN Number: 1300
Label: 3
Packaging group: Iii
EMS Number: F-E,S-E
Marine pollutant: No
Proper shipping name: TURPENTINE SUBSTITUTE (mixture)

Air transport ICAO-TI and IATA-DGR:

ICAO/IATA Class: 3
UN/ID Number: 1300
Label: 3
Packaging group: III
Proper shipping name: TURPENTINE SUBSTITUTE (mixture)

15 Regulatory Information

The mixture does not contain any substances that:

- deplete the ozone layer as defined by the Montreal Protocol
- are persistent organic pollutants as defined by the Stockholm Convention
- are hazardous chemicals or pesticides as defined by the Rotterdam Convention
- are subject to any prohibitions or restrictions in the countries/regions into which it is supplied.

The mixture is classified as a flammable liquid and is therefore subject to the requirements of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). Employers have a duty to control the risks to safety from fire and explosions under this legislation.

The mixture may be hazardous to health and is therefore subject the requirements of the Control of Substances Hazardous to Health Regulations 2002 (COSHH) (as amended). Employers have a duty under this legislation to protect both employees and others who may be exposed.

16 Other Information

Abbreviations/acronyms used in the SDS:

ADR:	The European Agreement concerning the International Carriage of Dangerous Goods by Road.
CAS number:	Chemical Abstract Services number.
EU:	European Union.
GHS:	Globally Harmonised System of Classification and Labelling.
IATA	The International Air Transportation Association.
ICAO:	The International Civil Aviation Organisation.
IMDG:	International Maritime Dangerous Goods.
LD_{50}:	Median lethal dose.
UN number:	the United Nations (UN) four-digit identification number assigned to a hazardous material that is recognised for use in international and domestic commerce and transportation.
WEL:	Workplace exposure limit.

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

Department issuing MSDS: Product Safety Department.

Contact name: Gordon Sharp

Printing date: 24.11.2007

Revision: 2; supersedes revision 1

Revision date: 17.10.2007

Reasons for revision: Change in supplier contact details.

SDS 2

Safety Data Sheet according to GHS **All Chemicals Ltd.**

Emulso GM3

Substance Key: GHS-PR001	Revision Date: 30.09.2009
Version. 1	Date of Printing:13.09.2009

1. Identification of the substance/preparation and company

Trade name

Emulso GM3

Use of the substance/preparation

Industry sector: Textile Processing Industry

Type of use: Textile auxiliary

Identification of the company

All Chemicals Ltd

123 Any Street

Anywhere

Tel: 123 456 7890

Fax: 123 654 0987

Information about the substance/preparation

All Chemicals Ltd – Division PS

Product safety Tel: 123 456 7890

Emergency telephone number:

111 222 7890

2. Hazard identification

Classification of the substance or mixture

Flammable liquids (Category 3)

Acute toxicity: Skin (Category 3)

Skin corrosion/ irritation (Category 1B)

Serious eye damage/ eye irritation (Category 1)

Aquatic toxicity- acute (Category 3)

Aquatic toxicity- chronic (category3)

GHS label elements, including precautionary statements

Flame

Skull and crossbones

Corrosion

Pictogram/Hazard symbols

Signal word

Danger

Hazard statements

Flammable liquid and vapor

Toxic in contact with skin

Causes severe skin burns and eye damage

Causes serious eye damage

Harmful to aquatic life

Harmful to aquatic life with long lasting effects

Precautionary statements

Keep container tightly closed.

Keep away from heat/sparks/open flame/ hot surfaces, No smoking.

Ground/bond container and receiving equipment.

Use explosion-proof electrical/ventilating/lighting/ equipment.

Take precautionary measures against static discharge.

Use only non-sparking tools.

Use only outdoors or in a well-ventilated area.

In case of fire use dry chemical, foam, water spray jet for extinction.

Wear protective clothing/gloves and eye/face protection.

Do not breathe dust /fume/gas/mist/vapors/spray.

Remove/takeoff immediately all contaminated clothing.

IF ON SKIN: Wash with plenty of soap and water.

IF SWALLOWED: Rinse mouth. Do not induce vomiting.

IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

IF INHALED: Remove to fresh air and keep at rest in a position comfortable breathing.

Call a POISON CENTRE OR DOCTOR/PHYSICIAN IF YOU FEEL UNWELL.

Store locked up.

Store in cool/well-ventilated place.

Avoid release to the environment. Dispose of contents/container to authorized companies.

Other hazards which do not result in classification

None

3. Composition/information on ingredients

Chemical characterization

Ethoxlated derivatives and organic sulphonated salt

INCI NAME: None

CAS number: None

EINECS number: None

ELINCS number: None

Hazardous ingredients

Component	CAS number	Concentration
Tetrapropylene benzene sulphonate-Ca salt	11117-11-6	45-60%
Iso butanol	78-83-1	15-30%

4. First aid measures

General information

Remove soiled soaked clothing immediately

If the patient is likely to become unconscious, place and transport in the recovery position

Adhere to personal protective measures when giving first aid

After inhalation

Immediately remove to fresh air. Consult a physician afterwards.

After contact with skin

In case of contact with skin, clean with soap and water.

After contact with eyes

Rinse immediately with gently running water for 15 minutes, maintaining eyelids open. Consult at once an ophthalmologist or a physician.

After ingestion

If the victim is conscious let him drink plenty of water; immediately call a medical doctor.

Most important symptoms/effects acute and delayed

No information

Symptoms

Acute symptoms: No information available

Delayed symptoms: No information available

Hazards

No information available

Indication of immediate medical attention and special treatment needed

No information available

5. Fire. Fighting measures

Suitable extinguishing media

All

Extinguishing media that must not be use for safety reasons

No restrictions

Specific hazards arising from the chemical

In case of fires, hazardous combustion gases are formed:

Nitrogen oxides (NOx)

Carbon monoxide (CO)

Special protective equipment and precautions for fire fighters

Wear full protective suit.

Use self contained breathing apparatus.

Further information

Cool container and metallic parts with a water spray jet

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

Keep people away and stay on the upwind side.

Wear personal protective equipment. Unprotected persons must be kept away.

Ensure adequate ventilation.

Environmental precautions

Do not let the liquid drain into rivers, ponds or sewer systems.

Methods and material for containment and cleaning up

Pick up rest with suitable absorbent materials

Additional information

None

7. Handling and storage

Precaution for safe handling

Keep container tightly closed.

Avoid spillage!

Avoid contact with skin and eyes.

Hygiene measures

Do not eat, drink or smoke when using this product.

Wash thoroughly after use (or handling).

Change contaminated clothes immediately.

Advice on protection against fire and explosion

Keep away sources of ignition.

Provide good ventilation of working area (local exhaust ventilation if necessary).

Vapours may form explosive mixtures with air.

Take precautionary measures against electrostatic charges- earthing necessary during loading operation.

Dust explosion class: Not applicable

Conditions for safe storage, including any incompatibilities

Requirements for storage rooms and vessels

Storages will have to fulfill the requirements of national regulations into force.

Storage class: All Chemicals Limited storage class B. 01: Flammable liquids

Advice on storage compatibility

Do not store together with oxidizing agents.

Further information on storage conditions

Protect from direct sunlight

Keep container in a well-ventilated place

Storage stability

May be kept indefinitely in stored properly

8. Exposure Controls /personal protection

Control parameters

None

Appropriate engineering controls

Provide good ventilation of working area (local exhaust ventilation if necessary).

General protective measures

Eye/face protection: Wear eye/face protection.

Skin/Hand protection: Wear suitable gloves.

Respiratoryprotection:

Use respiratory protection if exposed to vapours/dust/aerosol.

Thermal hazards / Body protection: Use a chemical-resistant apron

9. Physical and chemical properties

Form:	liquid, clear
Colour:	Brown
Odour:	Solvent
Odour threshold:	Data not available.
PH. Value:	6.5-8.5 (5% at 30°C)
Melting point:	Data not available.
Boiling point:	Data not available.
Sublimation point:	Data not available.
Flash point:	40°C
Evaporation rate:	Data not available.
Oxidizing properties:	Data not available.
Self ignition temperature:	Data not available.
Lower explosion limit:	Data not available.
Upper explosion limit:	Data not available.
Vapour pressure:	Data not available.
Density:	1.01 g/cm3 (30)
Relative Density:	Data not available.
Bulk density:	Data not available.
Vapour density in relation to air:	Data not available.
Solubility in water:	Soluble
Miscibility with water:	Not applicable
Soluble in Ethanol 50%:	Soluble

Solubiluty/qualitative:	Data not available.
Ocatanol/water partition coefficient (log Pow):	Data not available.
Auto-ignition temperature:	Data not available.
Thermal decomposition:	Data not available.
Viscosity (dynamic):	Data not available.
Viscosity (Kinematic:	Data not available.
Viscosity (Efflux time):	Data not available.
Acid number(mgKOH/g):	Data not available.
Saponification number(mgKOH/g)	Data not available
Surface tension:	Data not available.
Impact sensitivity:	Data not available.
Combustion number:	Data not available.
Thermal conductivity:	Data not available.
Secific resistance/electrical conductivity:	Data not available.
Further information:	None

10. Stability and reactivity

Chemical stability:

Stable at ambient temperature.

Possibility of hazardous reactions:

Reactions with oxidizing agents.

Conditions to avoid:

None

Incompatible materials:

Strong oxidizing agents

Hazardous decomposition products:

No decomposition if used as intended.

11. Toxicological information

Acute oral toxicity:	Data not available.
Acute inhalation toxicity:	Data not available.
Acute dermal toxicity:	1100-1700 mg/kg Method : Calculated The data on toxicology refer to the active ingredient.
Skin corrosion/irritation:	Corrosive Method: Calculated The data on toxicology refer to the active ingredient.
Seious eye damage/irritation:	Corrosive Method: Calculated The data on toxicology refer to the active ingredient.
Respiratory or skin sensitization:	Data not available.
Germ cell mutagenicity:	Data not available.
Carcinogenicity:	Data not available.
Reproductive toxicity:	Data not available.
STOST - Single exposure:	Data not available.
STOST - repeated exposure:	Data not available.
Aspiration hazard:	Data not available.
Remarks:	None

12. Ecological information

Physico-chemical eliminability:	Data not available.
Biodegradability:	Data not available.
Bioaccumulation:	Data not available.
Fish toxicity:	10- 110 mg/l (96h, zebrafish) Method: Calculated

	The data on toxicology refer to the active ingredient.
Daphnia toxicity:	Data not available.
Algae toxicity:	Data not available.
Bacteria toxicity:	>1000 mg/l Method: calculated The data toxicology refer to the active ingredient.
Dissolved Organic carbon (DOC):	Data not available.
Chemical oxygen demand (COD):	Data not available.
Biochemical oxygen demand (BOD5):	Data not available.
Toxicity to soil dwelling organisms:	Data not available.
Toxicity to terrestrial plants:	Data not available.
Toxicity to other non mammal terrestrial species:	Data not available
Remarks:	None

13. Disposal considerations

Product

In accordance with regulations for hazardous waste, must be taken to a hazardous waste disposal site.

Uncleaned packaging

Contaminated packaging should be emptied as far as possible and after appropriate cleansing may be taken for reuse.

Packaging that cannot be cleaned should be disposed of as product waste.

14. Transport information

IATA

Proper Shipping Name	CORROSIVE LIQUID, FLAMMABLE, N.O.S (Tetapropylen benzene sulphonate-Ca-salt, Isobutanol)
Class:	8
Packing group:	II

UN/ID number	2920
Primary risk:	8
Secondary risk:	3
Remarks	None

IMDG

Proper Shipping Name	CORROSIVE LIQUID, FLAMMABLE, N.O.S (Tetapropylen benzene sulphonate-Ca-salt, Isobutanol)
Class:	8
Packing group:	II
UN no.	2920
Primary risk	8
Secondary risk:	3
Remarks	None
EmS:	No information available

ADR

Proper Shipping Name:	CORROSIVE LIQUID, FLAMMABLE, N.O.S (Tetapropylen benzene sulphonate-Ca-salt, Isobutanol)
Class:	8
Packing group:	II
UN no.	2920
Primary risk:	8
Secondary risk:	3
Hazard no.:	83
Remarks	None

15. Regulatory information

Safety, health and environmental regulations for the product in question

Import country regulations

The product is classified and labeled in accordance with GHS adopted by local authority.

Restriction of occupation

None

Other regulations

Storages will have to fulfill the requirements of national regulations into force.

Storage class: 3A: Flammable liquids

16. Other information

The data are based on the current state of our knowledge, and are intended to describe the product with regard to the requirements of safety. The data should not be taken to imply any guaranteed of a particular or general specification. It is suitable for the intended purpose and method of use. We do not accept responsibility for any harm caused by the use of this information. In all cases, our general conditions of sale apply.

APPENDIX B

ONLINE SURVEY

Chemical Safety (GHS) Comprehensibility

Welcome to My Survey

Hello! I am conducting research as a PhD student at Southern Illinois University. I need to collect data for my dissertation related to chemical safety. I propose to explore to what extent factors affect workers' comprehension of chemical hazards in the workplace when utilizing the new Global Harmonization System (GHS) chemical labels and Safety Data Sheets (SDS).

If you have questions please email me at mmiller4@murraystate.edu, or call (270)293-0737 or you may contact my supervising professor, Dr. Robert McDermott, Department of Health Education and Recreation, SIUC, Carbondale, IL 62901; robert.mcdermott@siu.edu or call (618) 453-1841.

This project has been reviewed and approved by the SIUC Human Subjects Committee. Questions concerning your rights as a participant in this research may be addressed to the Committee Chairperson, Office of Sponsored Projects Administration, SIUC, Carbondale, IL 62901-4709. Phone (618) 453-4533, E-mail: siuhsc@siu.edu

1. Thank you for participating in my survey. Your feedback is very important. Please answer all the questions truthfully and as best you can. All information collected will be kept confidential and anonymous. You have the right to stop the survey at any time if you so wish. Do you agree to take part in this study?

   - Yes
   - No

2. Have you worked with chemicals as part of your previous or current work-related duties?

   - Yes
   - No

Chemical Safety (GHS) Comprehensibility

Demographics

3. What is your gender?

- ◯ Female
- ◯ Male

4. What is your age?

- ◯ 0-19 years
- ◯ 20-29 years
- ◯ 30-39 years
- ◯ 40-49 years
- ◯ 50-59 years
- ◯ 60-69 years
- ◯ 70-79 years
- ◯ 80 years and above

5. What is the highest level of education you completed?

- ◯ Did not complete high school
- ◯ High school or G.E.D.
- ◯ Associate's degree
- ◯ Some college
- ◯ Bachelor's degree
- ◯ Master's degree
- ◯ Terminal degree

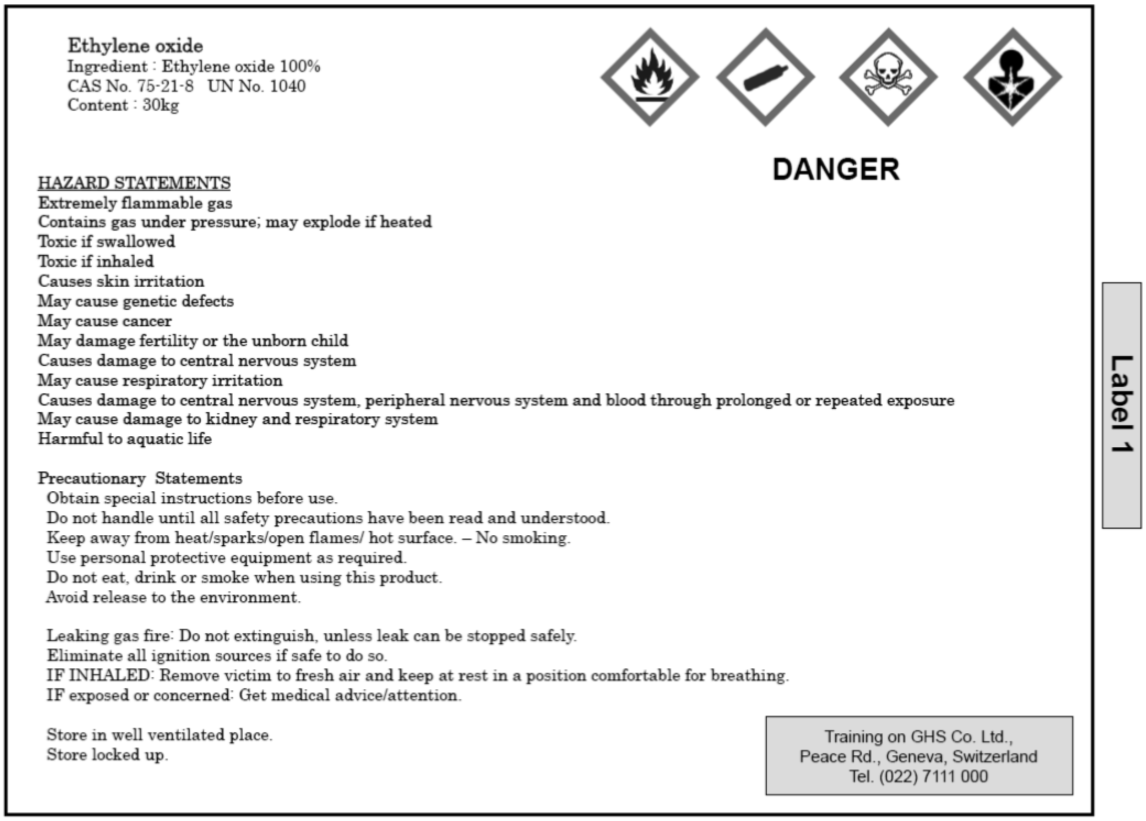
6. How many years have you been in the workforce?

- Less than one year
- 1-5 years
- 5-10 years
- 10-20 years
- 20-30 years
- More than 30 years

Chemical Safety (GHS) Comprehensibility

Label General Comprehensibility

7. Have you ever seen a document like this before?



Ethylene oxide
Ingredient : Ethylene oxide 100%
CAS No. 75-21-8 UN No. 1040
Content : 30kg

DANGER

HAZARD STATEMENTS
Extremely flammable gas
Contains gas under pressure; may explode if heated
Toxic if swallowed
Toxic if inhaled
Causes skin irritation
May cause genetic defects
May cause cancer
May damage fertility or the unborn child
Causes damage to central nervous system
May cause respiratory irritation
Causes damage to central nervous system, peripheral nervous system and blood through prolonged or repeated exposure
May cause damage to kidney and respiratory system
Harmful to aquatic life

Precautionary Statements
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Keep away from heat/sparks/open flames/ hot surface. – No smoking.
Use personal protective equipment as required.
Do not eat, drink or smoke when using this product.
Avoid release to the environment.

Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
Eliminate all ignition sources if safe to do so.
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
IF exposed or concerned: Get medical advice/attention.

Store in well ventilated place.
Store locked up.

Training on GHS Co. Ltd.,
Peace Rd., Geneva, Switzerland
Tel. (022) 7111 000

Label 1

- Yes
- No

8. If yes, what do you call this document?

- safety manual
- safety data sheet
- chemical label

9. How many times have you read chemical labels in the past year?

- Never
- A few times (less than 10)
- Many times/regularly (more than 10)

10. How many times in the past year have you used any information from a chemical label?

- Never
- A few times (less than 10)
- Many times/regularly (more than 10)

11. When would you most likely use a chemical label? Check all that apply.

- Every time I use a chemical
- First time I use a chemical
- Unsure of chemical's hazards
- Unsure of precautions to take

12. Look at the chemical label again and refer back to it to answer the following questions as needed.

Ethylene oxide
Ingredient : Ethylene oxide 100%
CAS No. 75-21-8 UN No. 1040
Content : 30kg

DANGER

HAZARD STATEMENTS
Extremely flammable gas
Contains gas under pressure; may explode if heated
Toxic if swallowed
Toxic if inhaled
Causes skin irritation
May cause genetic defects
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Causes damage to central nervous system, peripheral nervous system and blood through prolonged or repeated exposure
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Precautionary Statements
Obtain special instructions before use.
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IF exposed or concerned: Get medical advice/attention.

Store in well ventilated place.
Store locked up.

Training on GHS Co. Ltd.,
Peace Rd., Geneva, Switzerland
Tel. (022) 7111 000

Label 1

What is the name of the chemical on this label?

- ○ GHS Co Ltd.
- ○ Ethylene Oxide
- ○ CAS No

13. How easy do you think it would be for you to use this label to learn about the hazards of this chemical?

○ Not easy to understand

○ Understandable

○ Very easy to understand ○

Do not know

14. Assuming the chemical is dangerous, list the things on the label that you think indicate the chemical is dangerous? Check all that apply.

- ☐ Skull and crossbones pictogram
- ☐ Flammable pictogram
- ☐ Corrosive pictogram
- ☐ Compressed gas pictogram
- ☐ Health hazard pictogram
- ☐ Environmental pictogram
- ☐ Oxidizer pictogram
- ☐ DANGER
- ☐ WARNING
- ☐ Hazard statement
- ☐ Precautionary statement
- ☐ CAS No
- ☐ Content

15. What are the hazards of this chemical? Check all that apply.

- ☐ Flammable
- ☐ Corrosive
- ☐ Toxic
- ☐ Gas under pressure
- ☐ Radioactive
- ☐ May cause cancer
- ☐ May cause frostbite
- ☐ None

16. What kind of preventative measures should be taken with this chemical? Check all that apply.

- [ ] Keep away from heat/sparks
- [ ] Avoid skin contact
- [ ] No smoking
- [ ] Do not use in direct sunlight
- [ ] Use personal protective equipment as required

17. What should be done if the chemical is inhaled? Check all that apply.

- [ ] Immediately transport victim to hospital
- [ ] Start mouth-to-mouth resuscitation
- [ ] Remove victim to free air and keep comfortable
- [ ] Give victim water to drink

18. How should the chemical be stored? Check all that apply.

- [ ] Store in well ventilated place
- [ ] Store locked up
- [ ] Store in flammable cabinet
- [ ] Store on side
- [ ] Store with other corrosives

Chemical Safety (GHS) Comprehensibility

SDS General Comprehensibility

19. Have you ever seen this type of document before?

Safety Data Sheet

according to Globally Harmonised System of Classification and Labelling

Printing date: 24 11 2007

1 IDENTIFICATION

GHS product identifier: SHARP'S DO-IT-ALL

Article number: 6285

Recommended use of the substance/mixture and restrictions on use

A combined lubricant, dewatering fluid, penetrating oil and a rust inhibitor

Supplier:

SHARP CHEMICALS Ltd
Any Street
Anytown
AT1 1AT
UK
Tel: (UK) 1234 1234567
Fax: (UK) 1234 1234568
e-mail: info@sharpchemicals.co.uk

Emergency phone number:

(UK) (UK) 1234 1234567 (24hrs)

- Yes
- No

20. What is this document called?

- safety data sheet
- chemical label
- chemical safety data
- job hazard analysis

21. How many times have you read a Safety Data Sheet in the last year?

- Never
- A few times (less than 10)
- Many times/regularly (10 or more)

22. How many times in the last year have you used information from a Safety Data Sheet?

- Never
- A few times (less than 10)
- Many times/regularly (10 or more)

23. When do you use or need a Safety Data Sheet? Check all that apply.

- Every time you work with a chemical
- First time you work with a chemical
- When you have questions about the chemical

24. Review the document again. How easy is it to understand the information on this Safety Data Sheet?

Safety Data Sheet
according to Globally Harmonised System of Classification and Labelling

Printing date: 24.11.2007

1 IDENTIFICATION
GHS product identifier: SHARP'S DO-IT-ALL
Article number: 6285

Recommended use of the substance/mixture and restrictions on use
A combined lubricant, dewatering fluid, penetrating oil and a rust inhibitor

Supplier:
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Any Street
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AT1 1AT
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Tel: (UK) 1234 1234567
Fax: (UK) 1234 1234568
e-mail: info@sharpchemicals.co.uk

Emergency phone number:
(UK) (UK) 1234 1234567 (24hrs)

- Not easy to understand
- Understandable
- Very easy to understand

25. What is the name of the chemical that this Safety Data Sheet is for?

- ◯ Sharpie Marker
- ◯ Sharp's Do-It-All
- ◯ Solvent Naptha
- ◯ Xylene

26. Where can you find first aid information on the Safety Data Sheet?

4 FIRST AID MEASURES

General Information:
Immediately remove any clothing soiled by the product.

After Inhalation:
Supply fresh air or oxygen, call for doctor
In case of unconsciousness place patient stably in side position for transportation.

After skin contact:
Immediately wash with water and soap and rinse thoroughly
If skin irritation continues, consult a doctor

After eye contact:
Check for and remove any contact lenses
Rinse opened eye for several minutes under running water. Then consult a doctor

After swallowing:
Wash mouth out with water
Do not induce vomiting; call for medical help immediately

Information for doctor:
Contains petroleum distillates.

Treatment
Following ingestion, vomiting should not be induced, because of the danger of aspiration into the lungs. Gastric lavage should only be given when aspiration into the lungs can be avoided by the use of a cuffed endotracheal tube.

Important symptoms/effects Effects

ACUTE
Exposure to high vapour concentrations can lead to headache, dizziness and fatigue. CNS depression may result in lack of coordination and extended response time.
If the mixture is swallowed, droplets can enter the lungs and cause pneumonitis. Symptoms usually take several hours to become apparent and are aggravated by physical effort. Rest and observation are therefore essential.

CHRONIC
Prolonged or repeated skin contact may cause dermatitis and skin disease.

5 Fire-fighting measures

Suitable extinguishing agents:
CO2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam

For safety reasons unsuitable extinguishing agents:
Water with full jet

Protective equipment:
Wear self-contained respiratory protective device
Wear fully protective suit
Do not inhale explosion gases or combustion gases

Additional information
Cool endangered receptacles with water spray.

- Hazards Identification
- Composition on Ingredients
- First Aid Measures
- Fire Fighting Measures
- Accidental Release Measures
- Handling and Storage
- Exposure Controls
- Physical and Chemical Properties
- Stability and Reactivity
- Toxicological Information
- Ecological Information

27. What should you do if this chemical comes in contact with someone's eye? Check all that apply.

4 FIRST AID MEASURES

General information:
Immediately remove any clothing soiled by the product.

After inhalation:
Supply fresh air or oxygen; call for doctor.
In case of unconsciousness place patient stably in side position for transportation.

After skin contact:
Immediately wash with water and soap and rinse thoroughly.
If skin irritation continues, consult a doctor.

After eye contact:
Check for and remove any contact lenses.
Rinse opened eye for several minutes under running water. Then consult a doctor.

After swallowing:
Wash mouth out with water.
Do not induce vomiting; call for medical help immediately.

Information for doctor:
Contains petroleum distillates.

Treatment
Following ingestion, vomiting should not be induced, because of the danger of aspiration into the lungs. Gastric lavage should only be given when aspiration into the lungs can be avoided by the use of a cuffed endotracheal tube.

Important symptoms/effects Effects

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CHRONIC

Prolonged or repeated skin contact may cause dermatitis and skin disease.

5 Fire-fighting measures

Suitable extinguishing agents:
CO2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.

For safety reasons unsuitable extinguishing agents:
Water with full jet.

Protective equipment:
Wear self-contained respiratory protective device.
Wear fully protective suit.
Do not inhale explosion gases or combustion gases.

Additional information
Cool endangered receptacles with water spray.

- ☐ Keep eye closed for 10 minutes
- ☐ Check for and remove contact lenses
- ☐ Supply fresh air or oxygen
- ☐ Rinse opened eye for several minutes under running water
- ☐ Lay victim down and elevate their feet

28. How would you protect your respiratory system and hands when working with this chemical? Check all that apply.

8 Exposure controls/personal protection

CONTROL PARAMETERS

Ingredients with limit values that require monitoring at the workplace:

1330-20-7 Xylene
EH40-WEL (UK 2005) Short-term value: 441 mg/m^3, 100 ppm
Long-term value: 220 mg/m^3, 50 ppm

108-67-8 Mesitylene
EH40-WEL (UK 2005) Long-term value: 125 mg/m^3, 25 ppm

95-63-6 1,2,4-Trimethylbenzene
EH40-WEL (UK 2005) Long-term value: 125 mg/m^3, 25 ppm

APPROPRIATE ENGINEERING CONTROLS:

Processes should be fully enclosed wherever possible.
The work area should be provided with suitable and sufficient ventilation.
Facilities storing or utilising this material should be equipped with an eyewash facility and a safety shower.

INDIVIDUAL PROTECTION MEASURES

Personal protective equipment:
Select PPE appropriate for the operations taking place taking into account the product properties.

General protective and hygienic measures:
Do not carry product impregnated cleaning cloths in trouser pockets.
Do not eat, drink or smoke while working.
Avoid close or long term contact with the skin.
Keep away from foodstuffs, beverages and feed.
Wash hands before breaks and at the end of work.
Avoid contact with the eyes.

Respiratory protection:
In case of brief exposure or low pollution use respiratory filter device. In case of intensive or longer exposure use self-contained respiratory protective device.

Protection of hands:
Protective gloves
The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.

Eye protection:
Tightly sealed goggles

Body protection:
Solvent resistant protective clothing

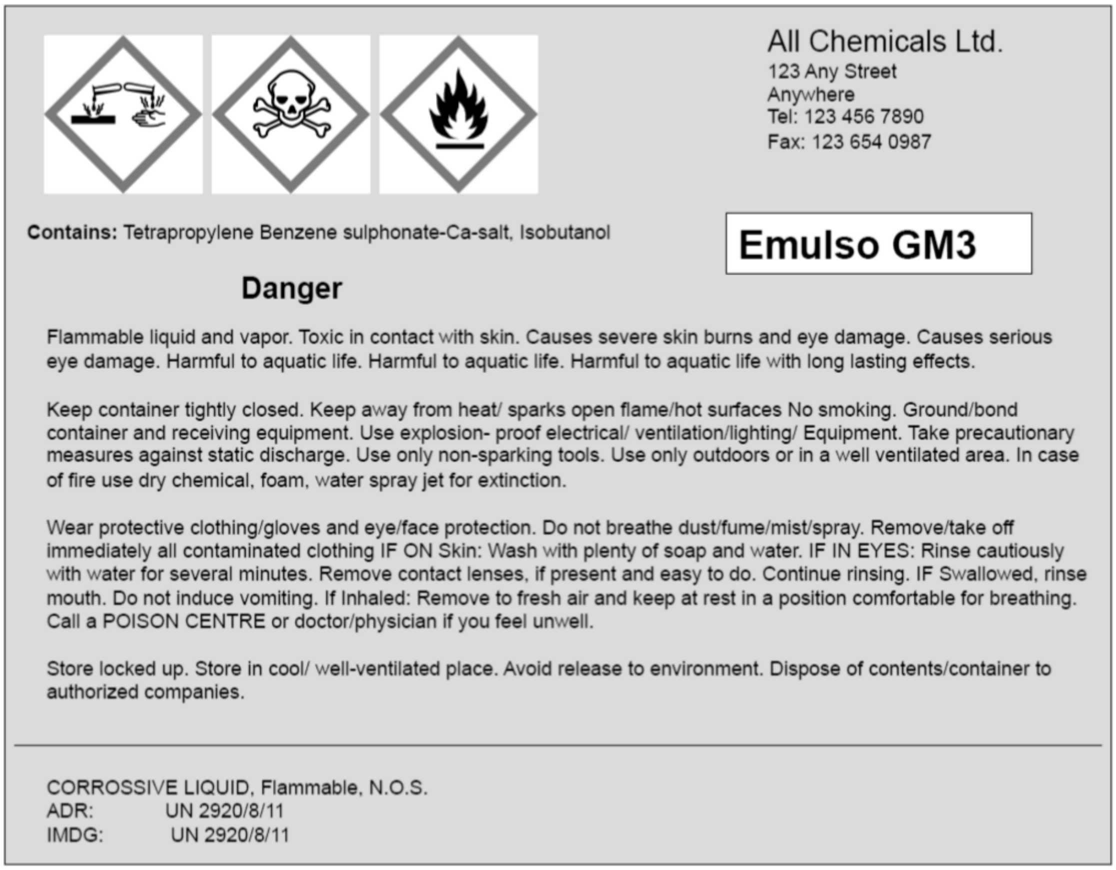
- ☐ For brief exposures use respiratory filter device
- ☐ No respiratory protection needed
- ☐ For extended exposures use self-contained respiratory protective device
- ☐ Always use dust mask
- ☐ Wear chemical protective gloves
- ☐ Wear leather gloves
- ☐ No hand protection needed

Chemical Safety (GHS) Comprehensibility

SDS & Label

You will now see a Safety Data Sheet (SDS) and label for the same chemical. You can use either to answer the following questions.

29.



All Chemicals Ltd.
123 Any Street
Anywhere
Tel: 123 456 7890
Fax: 123 654 0987

Contains: Tetrapropylene Benzene sulphonate-Ca-salt, Isobutanol

Emulso GM3

Danger

Flammable liquid and vapor. Toxic in contact with skin. Causes severe skin burns and eye damage. Causes serious eye damage. Harmful to aquatic life. Harmful to aquatic life. Harmful to aquatic life with long lasting effects.

Keep container tightly closed. Keep away from heat/ sparks open flame/hot surfaces No smoking. Ground/bond container and receiving equipment. Use explosion- proof electrical/ ventilation/lighting/ Equipment. Take precautionary measures against static discharge. Use only non-sparking tools. Use only outdoors or in a well ventilated area. In case of fire use dry chemical, foam, water spray jet for extinction.

Wear protective clothing/gloves and eye/face protection. Do not breathe dust/fume/mist/spray. Remove/take off immediately all contaminated clothing IF ON Skin: Wash with plenty of soap and water. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. IF Swallowed, rinse mouth. Do not induce vomiting. If Inhaled: Remove to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTRE or doctor/physician if you feel unwell.

Store locked up. Store in cool/ well-ventilated place. Avoid release to environment. Dispose of contents/container to authorized companies.

CORROSSIVE LIQUID, Flammable, N.O.S.
ADR: UN 2920/8/11
IMDG: UN 2920/8/11

Label 2

SDS 2

Safety Data Sheet according to GHS

All Chemicals Ltd.

Emulso GM3

Substance Key: GHS-PR001	Revision Date: 30.09.2009
Version. 1	Date of Printing: 13.09.2009

1. Identification of the substance/preparation and company

Trade name

Emulso GM3

Use of the substance/preparation

Industry sector: Textile Processing Industry

Type of use: Textile auxiliary

Identification of the company

All Chemicals Ltd

123 Any Street

Anywhere

Tel: 123 456 7890

Fax: 123 654 0987

Information about the substance/preparation

All Chemicals Ltd – Division PS

Product safety Tel: 123 456 7890

Emergency telephone number:

111 222 7890

2. Hazard identification

Classification of the substance or mixture

Fammable liquids (Category 3)

Acute toxicity: Skin (Category 3)

Skin corrosion/ irritation (Category 1B)

Serious eye damage/ eye irritation (Category 1)

Aquatic toxicity- acute (Category 3)

Aquatic toxicity- chronic (category3)

What is the name of the chemical?

- ◯ All Chemicals Ltd
- ◯ GHS-PR001
- ◯ Tetrapropylene benzene sulphonate-Ca salt
- ◯ Emulso GM 3

30. What is the active ingredient in the chemical?

- ◯ Isobutanol
- ◯ Tetrapropylene benzene sulphonate-Ca salt
- ◯ Emulsifier extract

31. What hazards are associated with the chemical? Check all that apply.

Safety Data Sheet according to GHS — **All Chemicals Ltd.**

Emulso GM3

Substance Key GHS-PR001	Revision Date: 30.09.2009
Version. 1	Date of Printing 13.09.2009

GHS label elements, including precautionary statements

Flame
Skull and crossbones
Corrosion

Pictogram/Hazard symbols

Signal word

Danger

Hazard statements

Flammable liquid and vapor
Toxic in contact with skin
Causes severe skin burns and eye damage
Causes serious eye damage
Harmful to aquatic life
Harmful to aquatic life with long lasting effects

Precautionary statements

Keep container tightly closed.
Keep away from heat/sparks/open flame/ hot surfaces, No smoking.
Ground/bond container and receiving equipment.
Use explosion-proof electrical/ventilating/lighting/ equipment.
Take precautionary measures against static discharge.
Use only non-sparking tools.
Use only outdoors or in a well-ventilated area.
In case of fire use dry chemical, foam, water spray jet for extinction.
Wear protective clothing/gloves and eye/face protection.
Do not breathe dust /fume/gas/mist/vapors/spray.

- ☐ Compressed gas
- ☐ Corrosive
- ☐ Health hazard
- ☐ Toxic
- ☐ Explosion
- ☐ Flammable
- ☐ Environmental
- ☐ Oxidizer

32. Which document did you use to answer the hazard question above?

- Label
- Safety Data Sheet
- Both
- Neither

33. What should you do if the chemical is accidentally released? Check all that apply.

Safety Data Sheet according to GHS — **All Chemicals Ltd.**

Emulso GM3

Substance Key: GHS-PR001	Revision Date: 30.09.2009
Version. 1	Date of Printing: 13.09.2009

Specific hazards arising from the chemical

In case of fires, hazardous combustion gases are formed:

Nitrogen oxides (NOx)

Carbon monoxide (CO)

Special protective equipment and precautions for fire fighters

Wear full protective suit.

Use self contained breathing apparatus.

Further information

Cool container and metallic parts with a water spray jet

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

Keep people away and stay on the upwind side.

Wear personal protective equipment. Unprotected persons must be kept away.

Ensure adequate ventilation.

Environmental precautions

Do not let the liquid drain into rivers, ponds or sewer systems.

Methods and material for containment and cleaning up

Pick up rest with suitable absorbent materials

Additional information

None

7. Handling and storage

Precaution for safe handling

Keep container tightly closed.

Avoid spillage!

Avoid contact with skin and eyes.

Hygiene measures

Do not eat, drink or smoke when using this product.

- [ ] No personal protection is needed
- [ ] Keep people away and stay upwind
- [ ] Wear personal protective equipment
- [ ] Wear full protective suit
- [ ] Let liquid drain into rivers, ponds, and sewer
- [ ] Pick up with absorbent materials
- [ ] Dilute with water

Comprehension of Pictograms

Chemical Safety (GHS) Comprehensibility

34. What does this symbol mean to you?

- ◯ Toxic
- ◯ Corrosive
- ◯ Flammable
- ◯ Compressed Gas

35. What does this symbol mean to you?

- ◯ Toxic
- ◯ Corrosive
- ◯ Flammable
- ◯ Compressed Gas

36. What does this word mean to you?

- Lowest chemical hazard
- Highest chemical hazard

37. What does this symbol mean to you?

- Toxic
- Compressed gas
- Health hazard
- Explosive

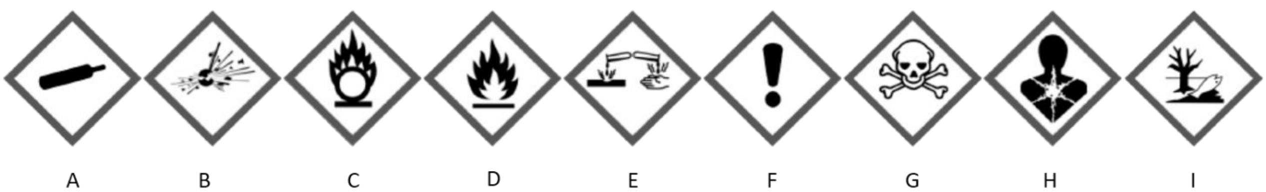
38. What does this symbol mean to you?

- Oxidizer
- Flammable
- Explosive
- Corrosive

39. What does this symbol mean to you?

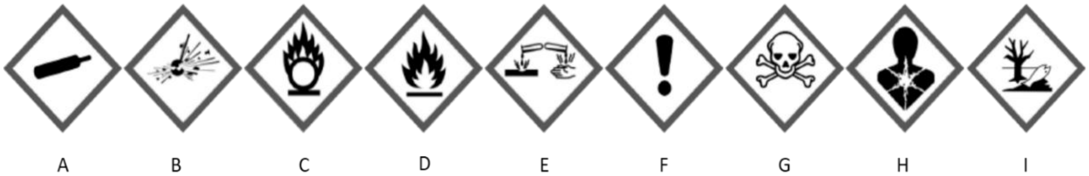
- Harmful/Irritant
- Toxic
- Environmental
- Compressed gas

40. Which symbol do you think identifies a chemical that is oxidizing? (An oxidizing chemical can react, even in the absence of air, with other chemicals and cause fire.)



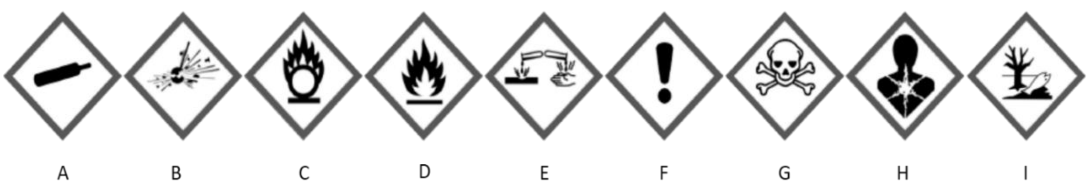
- A
- B
- C
- D
- E
- F
- G
- H
- I

41. Which symbol do you think identifies a chemical that is corrosive to metal? (A corrosive chemical is one that can cause severe damage to eyes, skin, metal, and other materials.)



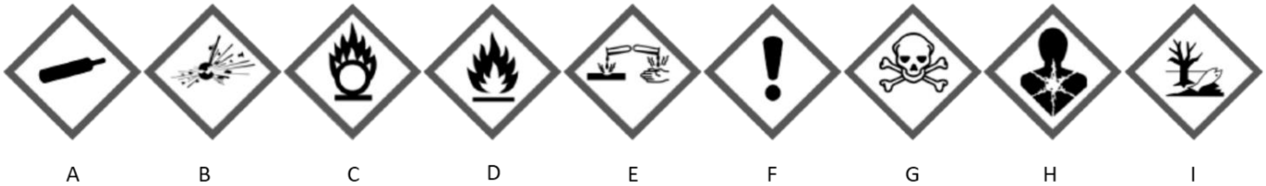
- A
- B
- C
- D
- E
- F
- G
- H
- I

42. Which symbol do you think identifies a chemical that is severely acutely toxic? (A chemical that is severely acutely toxic can be fatal.)



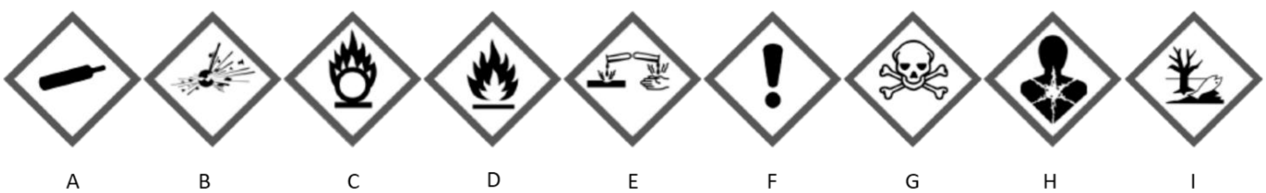
- A
- B
- C
- D
- E
- F
- G
- H
- I

43. Which symbol do you think identifies a chemical that is a skin irritant? (A chemical that is a skin irritant can cause skin rashes and irritation.)



- A
- B
- C
- D
- E
- F
- G
- H
- I

44. Which symbol do you think identifies a chemical with a reproductive effect? (A chemical that is a reproductive hazard can cause problems for a person's ability to have children or cause birth defects in offspring.)



- A
- B
- C
- D
- E
- F
- G
- H
- I

Chemical Safety (GHS) Comprehensibility

Hazard Ranking and Interpretation

45. If you saw a chemical label with the signal word "warning" and one with the signal word "danger," which would you consider to be the more hazardous chemical?

- Warning
- Danger
- Unsure

46. If you saw two chemical labels each with these two pictograms, which chemical would you consider to be


more hazardous?

- Exclamation mark pictogram
- Corrosive pictogram
- Unsure

47. If you saw two chemical labels each with these two pictograms, which chemical would you consider to be


more hazardous?

- Exclamation mark pictogram
- Skull and crossbones pictogram
- Unsure

Chemical Safety (GHS) Comprehensibility

Follow Up

48. In your previous or current job, how often do you use chemicals?

- ◯ Not at all/never
- ◯ Sometimes (less than 10 times a year)
- ◯ Often (10 or more times a year)

49. In your previous or current job, how often are you exposed to a chemical that someone else is using?

- ◯ Not at all/never
- ◯ Sometimes (less than 10 times a year)
- ◯ Often (10 or more times a year)

50. Please select the type of training you have received in your current job.

- ☐ Health and safety of chemicals
- ☐ Reading and using chemical labels
- ☐ Reading and using chemical safety data sheets
- ☐ Self taught
- ☐ No chemical safety training

Chemical Safety (GHS) Comprehensibility

Survey Complete

This is the end of the survey. Thank you very much for your time and effort. This survey is part of a research project to see how people use labels and safety data sheets to improve chemical safety awareness. Your participation will help researchers to see in which areas additional training or changes may be needed in order to improve and more effectively communicate hazard information to workers. Your help has been much appreciated. Thank you.

APPENDIX C

SIU HSC APPROVAL LETTER

SIU Southern Illinois University
CARBONDALE

HUMAN SUBJECTS COMMITTEE
OFFICE OF RESEARCH COPLIANCE
WOODY HALL - MAIL CODE 4344
900 SOUTH NORMAL AVENUE
CARBONDALE, ILLINOIS 62901

siuhsc@siu.edu
618/453-4533
618/453/4573 FAX

HSC Approval letter (exempt 2)

To: Susan Miller

From: M. Daniel Becque
Chair, Human Subjects Committee

Date: March 16, 2020

Title: *Comprehensibility of the Globally Harmonized Chemical System in the U.S.*

Protocol Number: 20125

The revisions to the above referenced study have been approved by the SIUC Human Subjects Committee. This approval includes all aspects of the project. The study is determined to be exempt according to 45 CFR. 46.101(b)2. This approval does not have an expiration date; however, any future modifications to your protocol must be submitted to the Committee for review and approval prior to their implementation.

Best wishes for a successful study.

This institution has an Assurance on file with the USDHHS Office of Human Research Protection. The Assurance number is 00005334.

MDB:ssw

Cc: Robert McDermmott

SIU.EDU

APPENDIX D

CORRESPONDENCE

From: Susan Miller <mmiller4@murraystate.edu>
Sent: Thursday, January 24, 2019 5:58 PM
To: ghs <ghs@unitar.org>
Subject: GHS Comprehensibility Testing Manual

Hello-

I am currently a PhD student at Southern Illinois University working on my dissertation. I would very much like to use UNITAR's GHS Comprehensibility Testing Manual from 2010 (with some changes) to conduct my own research on GHS label and SDS comprehensibility on workers in the United States. Would your organization be agreeable to allowing me to use the GHS Comprehensibility Testing Manual to conduct my own research towards completing my dissertation on the topic? I expect to make some minor changes to the survey tool itself to better fit my research question and purposes. Please let me know if you have any additional questions or need additional information. I look forward to hearing from your agency soon.

Thank you,

Susan Miller | Assistant Director | Environmental Safety & Health
Murray State University | 615 Gilbert Graves Drive | Murray, KY 42071
Tel 270.809.3974 | http://www.murraystate.edu/headermenu/Offices/esh/index.aspx

MURRAY STATE
UNIVERSITY

From: Oliver WOOTTON <Oliver.WOOTTON@unitar.org>
Sent: Friday, January 25, 2019 2:01 AM
To: mmiller4@murraystate.edu
Cc: Ester HERMOSILLA <Ester.HERMOSILLA@unitar.org>
Subject: RE: GHS Comprehensibility Testing Manual

Hi Susan,

Thanks for your message.

In principle this is fine, as it is a publicly-accessible document. It would be great to have more research done on this. We often talk about the "science-policy interface" and therefore how such research could inform changes to policy, such as the GHS. You may wish to consider (of course, you may already be doing so) how immigrants cope with the system, compared to those who "grew up" with the former systems upon which the GHS is based. You could also consider the use of risk (noting it would go beyond hazard) management pictograms, which I know one of the experts on the GHS is trying to promote. There are UNECE meeting documents on this for information.

There is always a large delegation of US representatives at the UN sub-committee of experts on the GHS who you could also contact.

On the basis that it is a publicly-accessible document I have no problem with you using this as a guide for your research. Please reference it as per usual and feel free to get in touch if that would be helpful along the way. We do not have specific plans to update it, but would be interested in hearing from you if you have any comments/ suggestions on changes, and we could consider doing so.

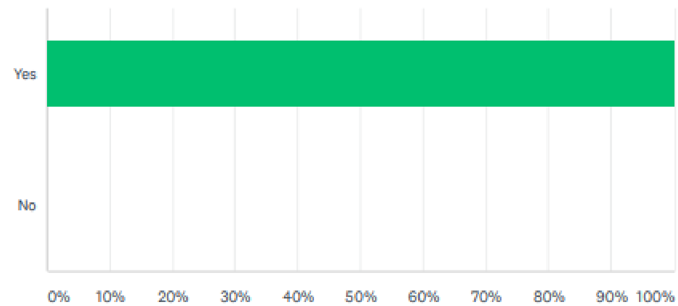
Thanks,
Oliver Wootton
UNITAR,
Chemicals and Waste Management Programme

APPENDIX E

PILOT TEST QUIZ SUMMARY

Q1 Thank you for participating in my survey. Your feedback is very important. Please answer all the questions truthfully and as best you can. All information collected will be kept confidential and anonymous. You have the right to stop the survey at any time if you so wish. Do you agree to take part in this study?

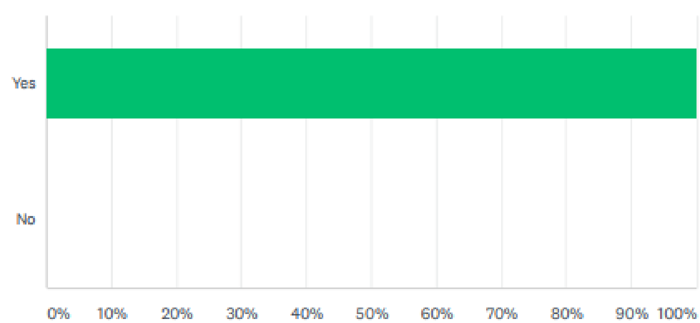
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	100.00%	31
No	0.00%	0
TOTAL		31

Q2 Have you worked with chemicals as part of your previous or current work-related duties?

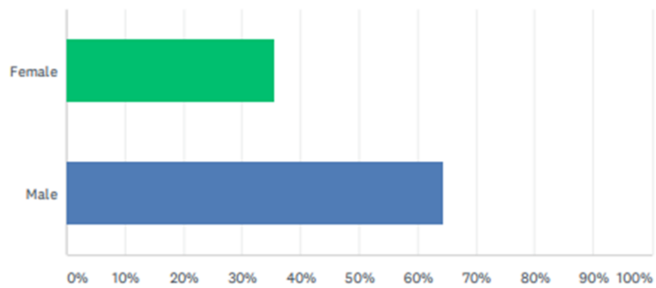
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	100.00%	31
No	0.00%	0
TOTAL		31

Q3 What is your gender?

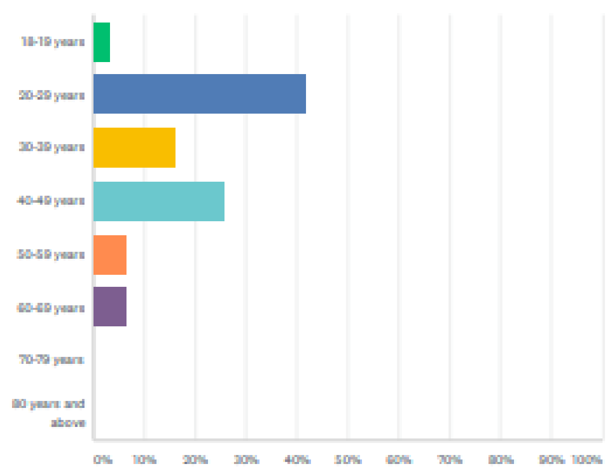
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Female	35.48%	11
Male	64.52%	20
TOTAL		31

Q4 What is your age?

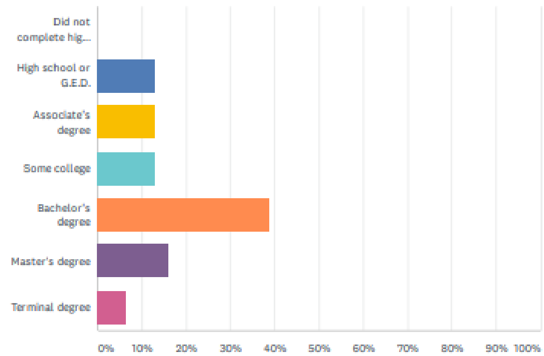
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
18-19 years	3.23%	1
20-29 years	41.94%	13
30-39 years	16.13%	5
40-49 years	25.81%	8
50-59 years	6.45%	2
60-69 years	6.45%	2
70-79 years	0.00%	0
80 years and above	0.00%	0
TOTAL		31

Q5 What is the highest level of education you completed?

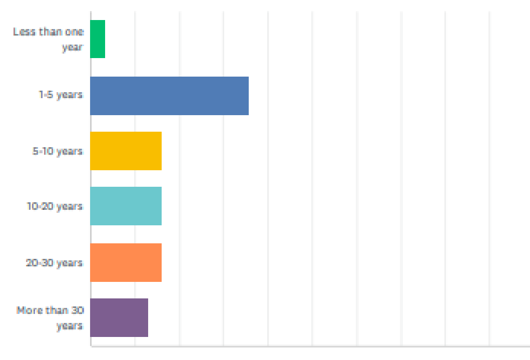
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Did not complete high school	0.00%	0
High school or G.E.D.	12.90%	4
Associate's degree	12.90%	4
Some college	12.90%	4
Bachelor's degree	38.71%	12
Master's degree	16.13%	5
Terminal degree	6.45%	2
TOTAL		31

Q6 How many years have you been in the workforce?

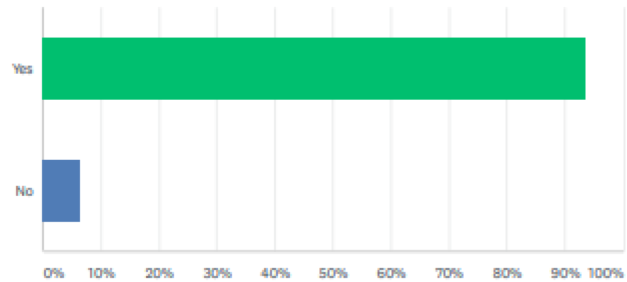
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Less than one year	3.23%	1
1-5 years	35.48%	11
5-10 years	16.13%	5
10-20 years	16.13%	5
20-30 years	16.13%	5
More than 30 years	12.90%	4
TOTAL		31

Q7 Have you ever seen a document like this before?

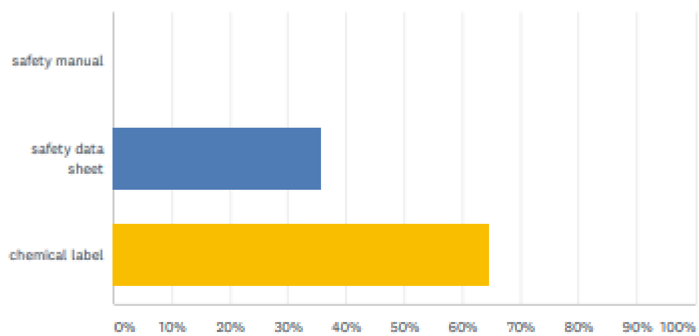
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	93.55%	29
No	6.45%	2
TOTAL		31

Q8 If yes, what do you call this document?

Answered: 31 Skipped: 0

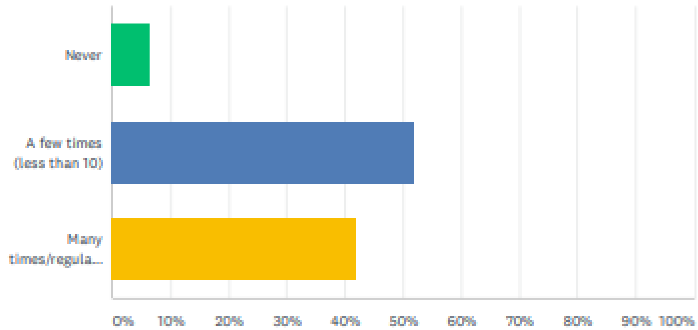


QUIZ STATISTICS			
Percent Correct 65%	Average Score 0.6/1.0 (65%)	Standard Deviation 0.49	Difficulty 2/30

ANSWER CHOICES	SCORE	RESPONSES	
safety manual	0/1	0.00%	0
safety data sheet	0/1	35.48%	11
✓ chemical label	1/1	64.52%	20
TOTAL			31

Q9 How many times have you read chemical labels in the past year?

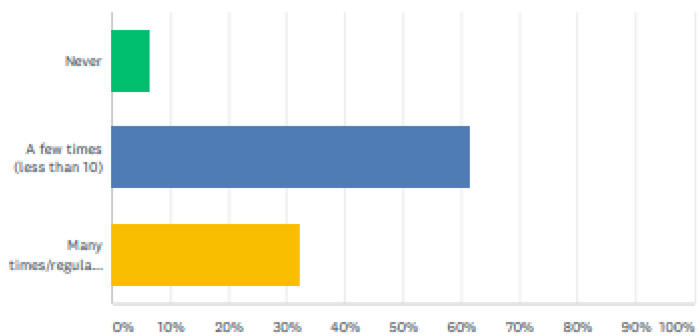
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Never	6.45%	2
A few times (less than 10)	51.61%	16
Many times/regularly (more than 10)	41.94%	13
TOTAL		31

Q10 How many times in the past year have you used any information from a chemical label?

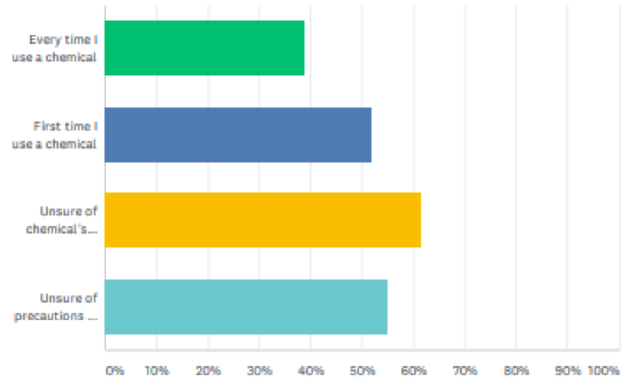
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Never	6.45%	2
A few times (less than 10)	61.29%	19
Many times/regularly (more than 10)	32.26%	10
TOTAL		31

Q11 When would you most likely use a chemical label? Check all that apply.

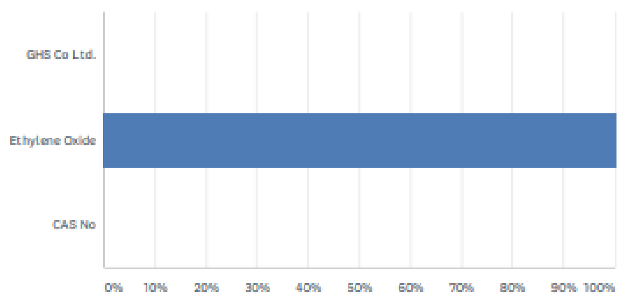
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Every time I use a chemical	38.71%	12
First time I use a chemical	51.61%	16
Unsure of chemical's hazards	61.29%	19
Unsure of precautions to take	54.84%	17
Total Respondents: 31		

Q12 Look at the chemical label again and refer back to it to answer the following questions. What is the name of the chemical on this label?

Answered: 31 Skipped: 0

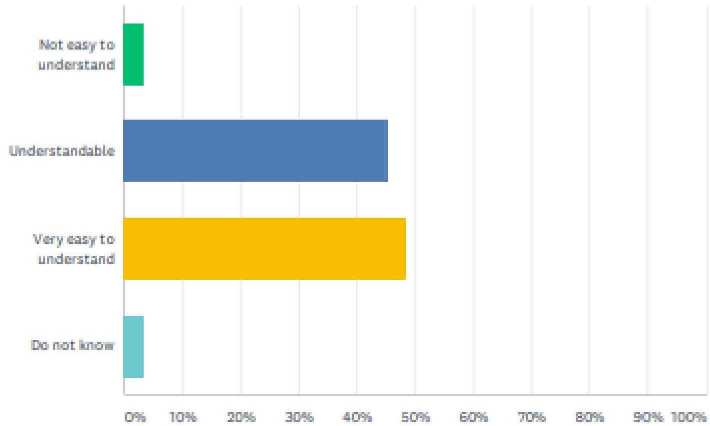


QUIZ STATISTICS			
Percent Correct 100%	Average Score 1.0/1.0 (100%)	Standard Deviation 0.00	Difficulty 23/30

ANSWER CHOICES	SCORE	RESPONSES	
GHS Co Ltd.	0/1	0.00%	0
✓ Ethylene Oxide	1/1	100.00%	31
CAS No	0/1	0.00%	0
TOTAL			31

Q13 How easy do you think it would be for you to use this label to learn about the hazards of this chemical?

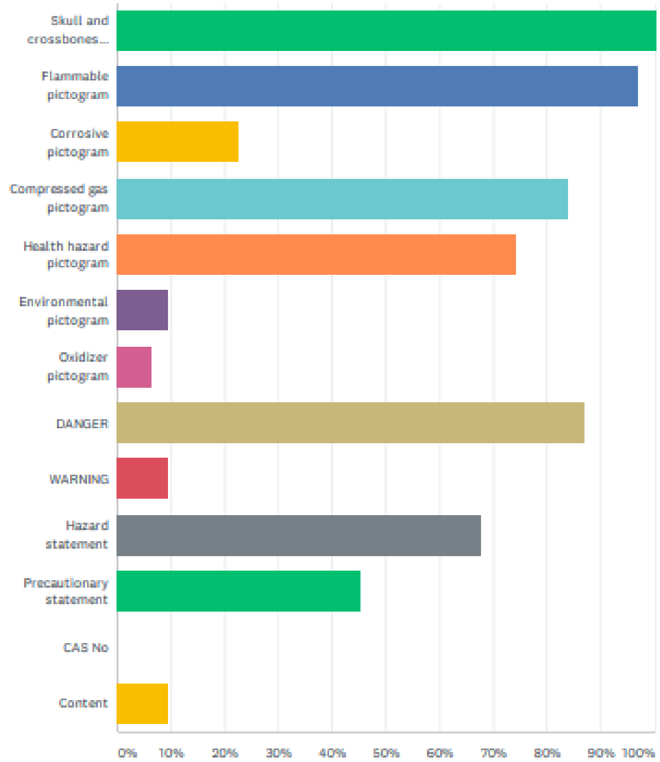
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Not easy to understand	3.23%	1
Understandable	45.16%	14
Very easy to understand	48.39%	15
Do not know	3.23%	1
TOTAL		31

Q14 Assuming it is dangerous, check all the items on the the label that you think indicate the chemical is dangerous? Check all that apply.

Answered: 31 Skipped: 0



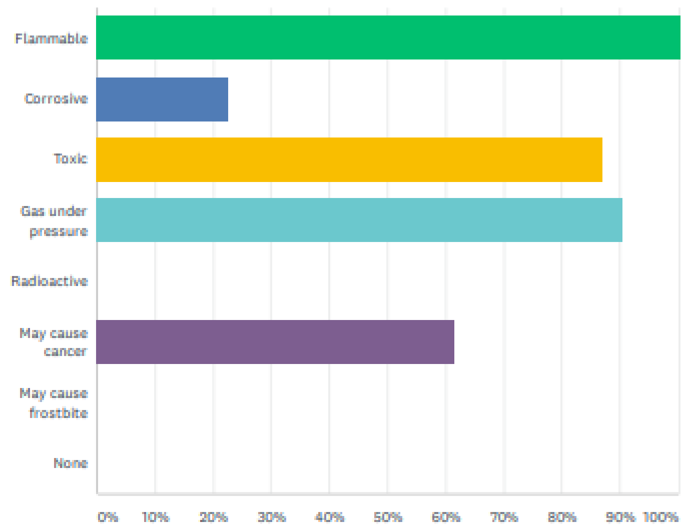
QUIZ STATISTICS

Percent Correct	Average Score	Standard Deviation	Difficulty
29%	5.5/7.0 (79%)	1.29	5/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ Skull and crossbones pictogram	1/7	100.00%	31
✓ Flammable pictogram	1/7	96.77%	30
Corrosive pictogram	0/7	22.58%	7
✓ Compressed gas pictogram	1/7	83.87%	26
✓ Health hazard pictogram	1/7	74.19%	23
Environmental pictogram	0/7	9.68%	3
Oxidizer pictogram	0/7	6.45%	2
✓ DANGER	1/7	87.10%	27
WARNING	0/7	9.68%	3
✓ Hazard statement	1/7	67.74%	21
✓ Precautionary statement	1/7	45.16%	14
CAS No	0/7	0.00%	0
Content	0/7	9.68%	3
Total Respondents: 31			

Q15 What are the hazards of this chemical? Check all that apply.

Answered: 31 Skipped: 0

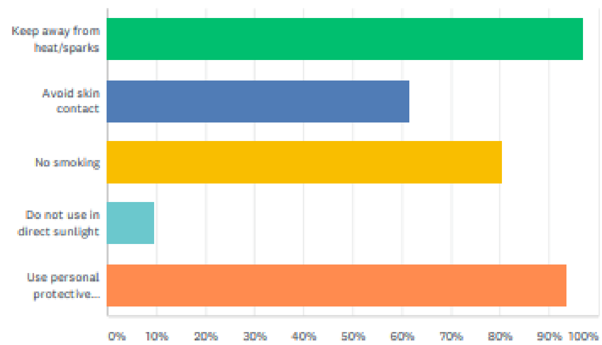


QUIZ STATISTICS			
Percent Correct 48%	Average Score 3.4/4.0 (85%)	Standard Deviation 0.67	Difficulty 8/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ Flammable	1/4	100.00%	31
Corrosive	0/4	22.58%	7
✓ Toxic	1/4	87.10%	27
✓ Gas under pressure	1/4	90.32%	28
Radioactive	0/4	0.00%	0
✓ May cause cancer	1/4	61.29%	19
May cause frostbite	0/4	0.00%	0
None	0/4	0.00%	0
Total Respondents: 31			

Q16 What kind of preventative measures should be taken with this chemical? Check all that apply.

Answered: 31 Skipped: 0

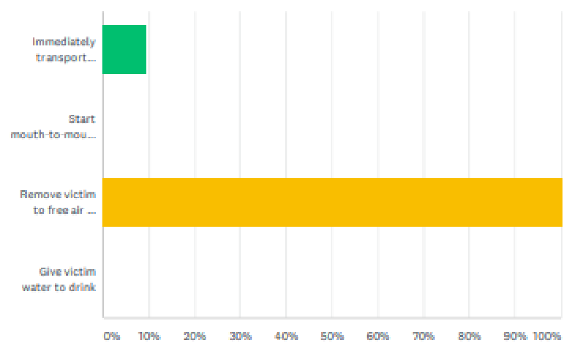


QUIZ STATISTICS			
Percent Correct 74%	Average Score 2.7/3.0 (90%)	Standard Deviation 0.53	Difficulty 13/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ Keep away from heat/sparks	1/3	96.77%	30
Avoid skin contact	0/3	61.29%	19
✓ No smoking	1/3	80.65%	25
Do not use in direct sunlight	0/3	9.68%	3
✓ Use personal protective equipment as required	1/3	93.55%	29
Total Respondents: 31			

Q17 What should be done if the chemical is inhaled? Check all that apply.

Answered: 31 Skipped: 0

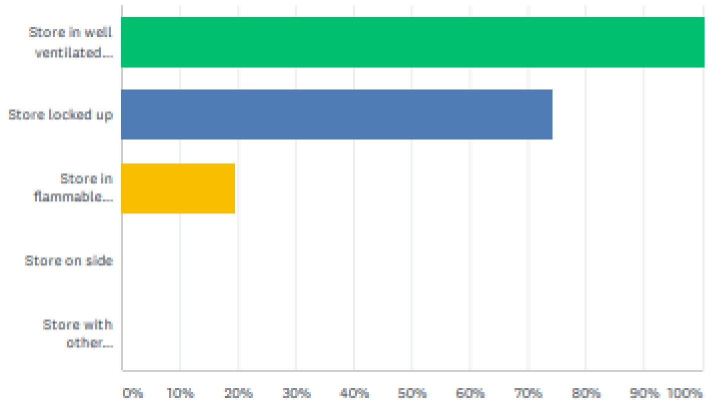


QUIZ STATISTICS			
Percent Correct 100%	Average Score 1.0/1.0 (100%)	Standard Deviation 0.00	Difficulty 23/30

ANSWER CHOICES	SCORE	RESPONSES	
Immediately transport victim to hospital	0/1	9.68%	3
Start mouth-to-mouth resuscitation	0/1	0.00%	0
✓ Remove victim to free air and keep comfortable	1/1	100.00%	31
Give victim water to drink	0/1	0.00%	0
Total Respondents: 31			

Q18 How should the chemical be stored? Check all that apply.

Answered: 31 Skipped: 0

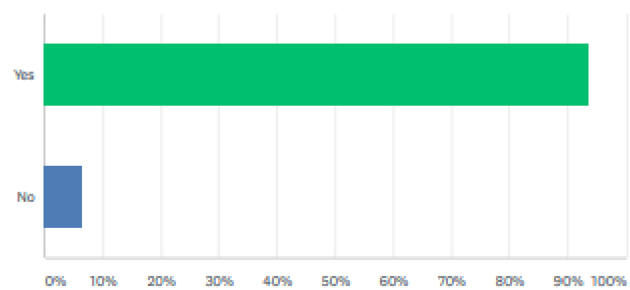


QUIZ STATISTICS			
Percent Correct 74%	Average Score 1.7/2.0 (87%)	Standard Deviation 0.44	Difficulty 9/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ Store in well ventilated place	1/2	100.00%	31
✓ Store locked up	1/2	74.19%	23
Store in flammable cabinet	0/2	19.35%	6
Store on side	0/2	0.00%	0
Store with other corrosives	0/2	0.00%	0
Total Respondents: 31			

Q19 Have you ever seen this type of document before?

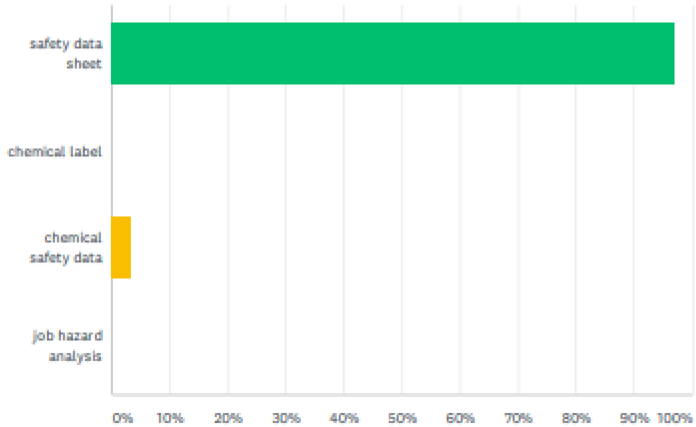
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	93.55%	29
No	6.45%	2
TOTAL		**31**

Q20 What is this document called?

Answered: 31 Skipped: 0

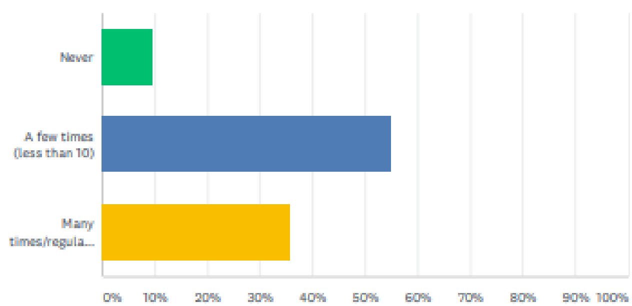


QUIZ STATISTICS			
Percent Correct 97%	Average Score 1.0/1.0 (97%)	Standard Deviation 0.18	Difficulty 20/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ safety data sheet	1/1	96.77%	30
chemical label	0/1	0.00%	0
chemical safety data	0/1	3.23%	1
job hazard analysis	0/1	0.00%	0
TOTAL			31

Q21 How many times have you read a Safety Data Sheet in the last year?

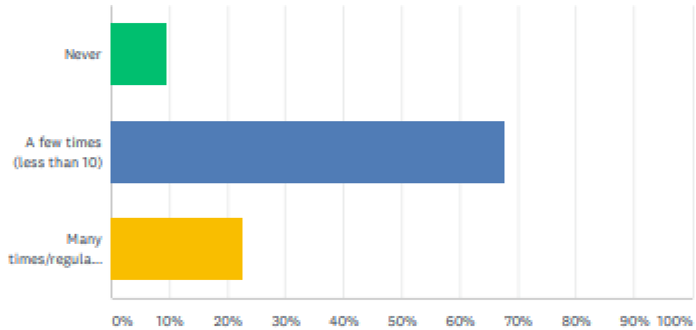
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Never	9.68%	3
A few times (less than 10)	54.84%	17
Many times/regularly (10 or more)	35.48%	11
TOTAL		31

Q22 How many times in the last year have you used information from a Safety Data Sheet?

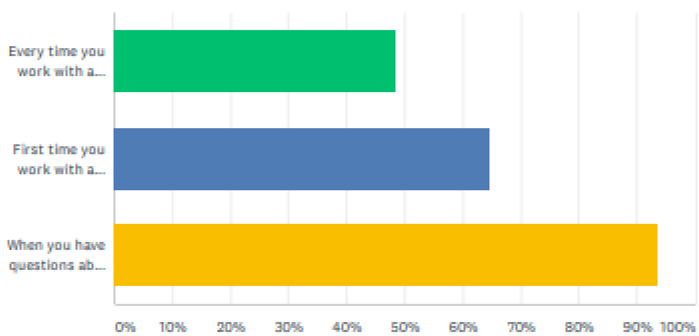
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Never	9.68%	3
A few times (less than 10)	67.74%	21
Many times/regularly (10 or more)	22.58%	7
TOTAL		31

Q23 When do you use or need a Safety Data Sheet? Check all that apply.

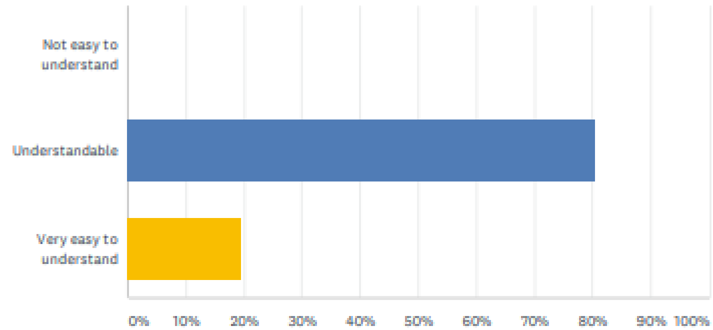
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Every time you work with a chemical	48.39%	15
First time you work with a chemical	64.52%	20
When you have questions about the chemical	93.55%	29
Total Respondents: 31		

Q24 How easy is it to understand the information on this Safety Data Sheet?

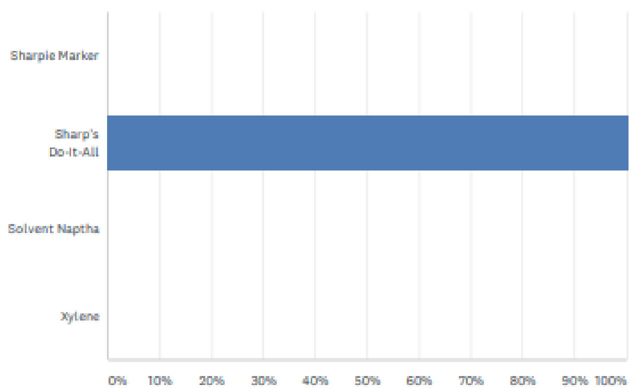
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Not easy to understand	0.00%	0
Understandable	80.65%	25
Very easy to understand	19.35%	6
TOTAL		31

Q25 What is the name of the chemical that this Safety Data Sheet is for

Answered: 31 Skipped: 0

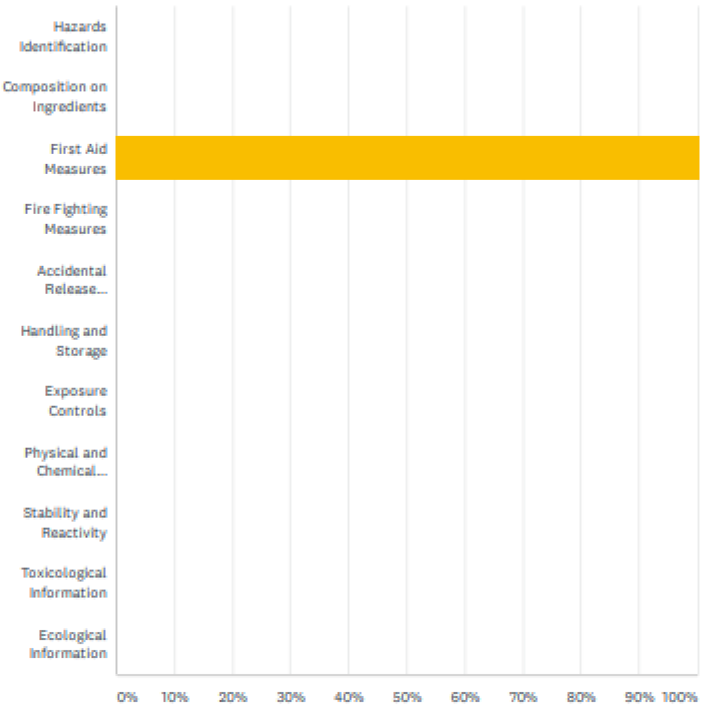


QUIZ STATISTICS			
Percent Correct 100%	Average Score 1.0/1.0 (100%)	Standard Deviation 0.00	Difficulty 23/30

ANSWER CHOICES	SCORE	RESPONSES	
Sharpie Marker	0/1	0.00%	0
✓ Sharp's Do-It-All	1/1	100.00%	31
Solvent Naptha	0/1	0.00%	0
Xylene	0/1	0.00%	0
TOTAL			31

Q26 Where can you find first aid information on the Safety Data Sheet?

Answered: 31 Skipped: 0

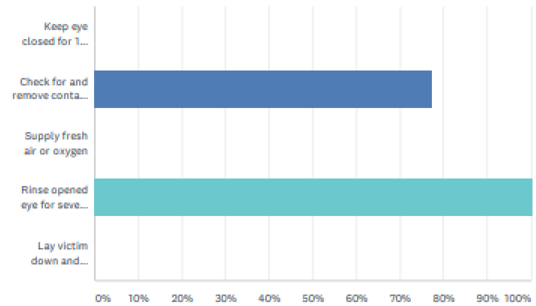


QUIZ STATISTICS			
Percent Correct 100%	Average Score 1.0/1.0 (100%)	Standard Deviation 0.00	Difficulty 23/30

ANSWER CHOICES	SCORE	RESPONSES	
Hazards Identification	0/1	0.00%	0
Composition on Ingredients	0/1	0.00%	0
✓ First Aid Measures	1/1	100.00%	31
Fire Fighting Measures	0/1	0.00%	0
Accidental Release Measures	0/1	0.00%	0
Handling and Storage	0/1	0.00%	0
Exposure Controls	0/1	0.00%	0
Physical and Chemical Properties	0/1	0.00%	0
Stability and Reactivity	0/1	0.00%	0
Toxicological Information	0/1	0.00%	0
Ecological Information	0/1	0.00%	0
TOTAL			31

Q27 What should you do if this chemical comes in contact with someone's eye? Check all that apply.

Answered: 31 Skipped: 0

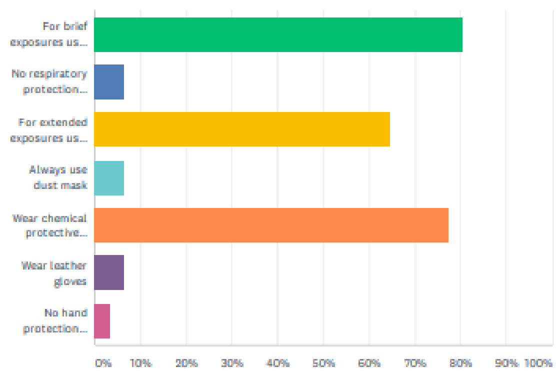


QUIZ STATISTICS			
Percent Correct 77%	Average Score 1.8/2.0 (89%)	Standard Deviation 0.43	Difficulty 12/30

ANSWER CHOICES	SCORE	RESPONSES	
Keep eye closed for 10 minutes	0/2	0.00%	0
✓ Check for and remove contact lenses	1/2	77.42%	24
Supply fresh air or oxygen	0/2	0.00%	0
✓ Rinse opened eye for several minutes under running water	1/2	100.00%	31
Lay victim down and elevate their feet	0/2	0.00%	0

Q28 How would you protect your respiratory system and hands when working with this chemical? Check all that apply.

Answered: 31 Skipped: 0

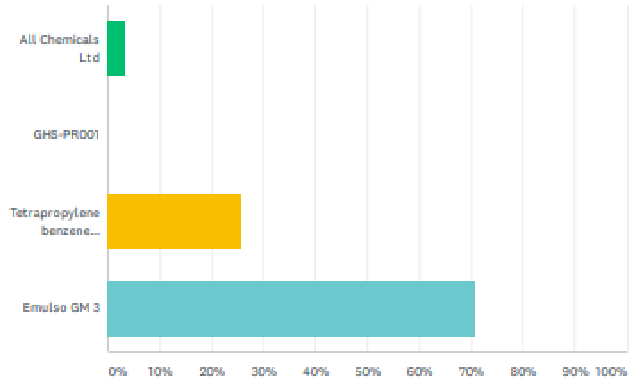


QUIZ STATISTICS			
Percent Correct 48%	Average Score 2.2/3.0 (74%)	Standard Deviation 0.92	Difficulty 4/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ For brief exposures use respiratory filter device	1/3	80.65%	25
No respiratory protection needed	0/3	6.45%	2
✓ For extended exposures use self-contained respiratory protective device	1/3	64.52%	20
Always use dust mask	0/3	6.45%	2
✓ Wear chemical protective gloves	1/3	77.42%	24
Wear leather gloves	0/3	6.45%	2
No hand protection needed	0/3	3.23%	1
Total Respondents: 31			

Q29 Use both the label and SDS above to answer the following questions. What is the name of the chemical?

Answered: 31 Skipped: 0

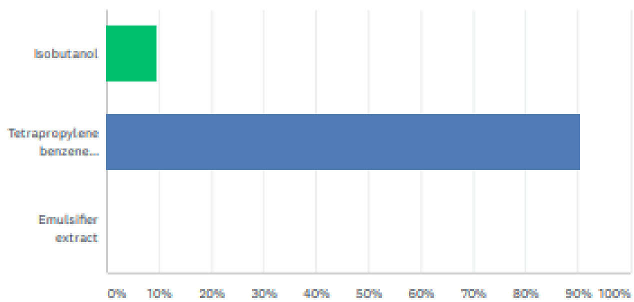


QUIZ STATISTICS			
Percent Correct 71%	Average Score 0.7/1.0 (71%)	Standard Deviation 0.46	Difficulty 3/30

ANSWER CHOICES	SCORE	RESPONSES	
All Chemicals Ltd	0/1	3.23%	1
GHS-PR001	0/1	0.00%	0
Tetrapropylene benzene sulphonate-Ca salt	0/1	25.81%	8
✓ Emulso GM 3	1/1	70.97%	22
TOTAL			31

Q30 What is the active ingredient in the chemical?

Answered: 31 Skipped: 0

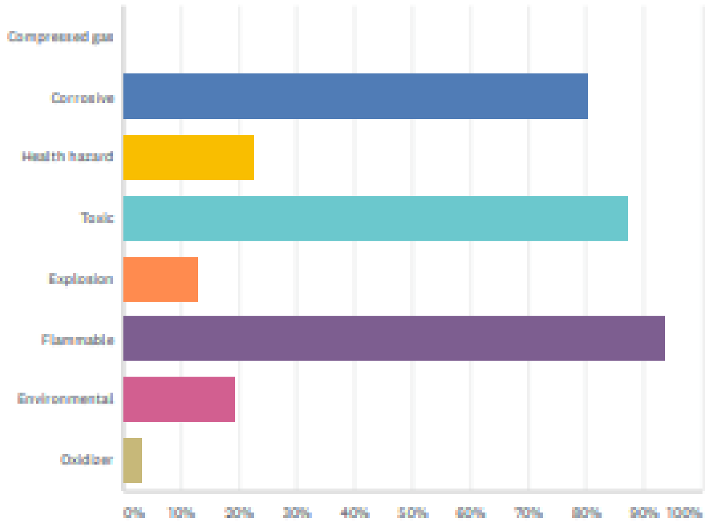


QUIZ STATISTICS			
Percent Correct 90%	Average Score 0.9/1.0 (90%)	Standard Deviation 0.30	Difficulty 13/30

ANSWER CHOICES	SCORE	RESPONSES	
Isobutanol	0/1	9.68%	3
✓ Tetrapropylene benzene sulphonate-Ca salt	1/1	90.32%	28
Emulsifier extract	0/1	0.00%	0
TOTAL			31

Q31 What hazards are associated with the chemical? Check all that apply.

Answered: 31 Skipped: 0

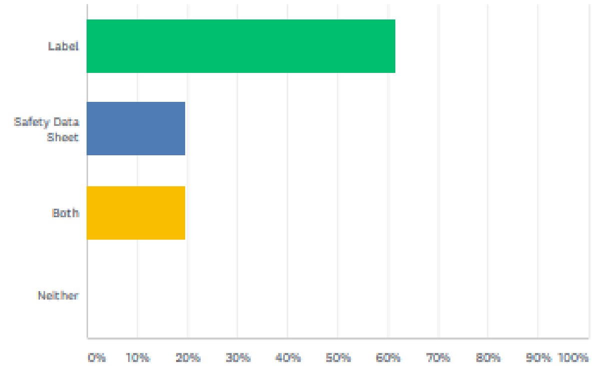


QUIZ STATISTICS			
Percent Correct 65%	Average Score 2.6/3.0 (87%)	Standard Deviation 0.56	Difficulty 9/30

ANSWER CHOICES	SCORE	RESPONSES	
Compressed gas	0/3	0.00%	0
✓ Corrosive	1/3	80.65%	25
Health hazard	0/3	22.58%	7
✓ Toxic	1/3	87.10%	27
Explosion	0/3	12.90%	4
✓ Flammable	1/3	93.55%	29
Environmental	0/3	19.35%	6
Oxidizer	0/3	3.23%	1
Total Respondents: 31			

Q32 Which document did you use to answer the hazard question above?

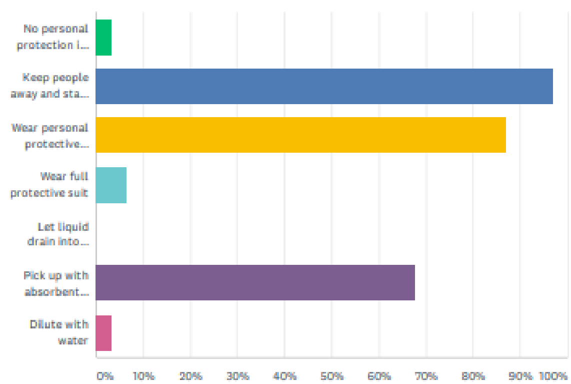
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Label	61.29%	19
Safety Data Sheet	19.35%	6
Both	19.35%	6
Neither	0.00%	0
TOTAL		31

Q33 What should you do if the chemical is accidentally released? Check all that apply.

Answered: 31 Skipped: 0

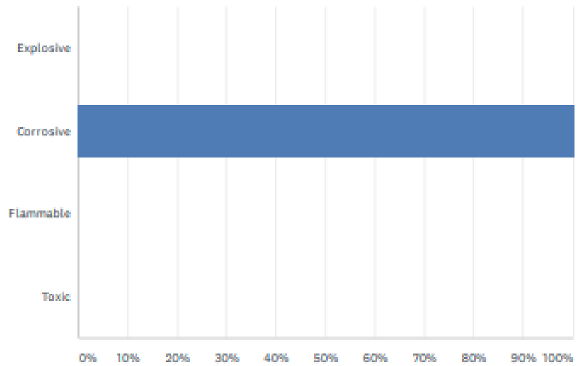


QUIZ STATISTICS			
Percent Correct 58%	Average Score 2.5/3.0 (84%)	Standard Deviation 0.63	Difficulty 7/30

ANSWER CHOICES	SCORE	RESPONSES	
No personal protection is needed	0/3	3.23%	1
✓ Keep people away and stay upwind	1/3	96.77%	30
✓ Wear personal protective equipment	1/3	87.10%	27
Wear full protective suit	0/3	6.45%	2
Let liquid drain into rivers, ponds, and sewer	0/3	0.00%	0
✓ Pick up with absorbent materials	1/3	67.74%	21
Dilute with water	0/3	3.23%	1
Total Respondents: 31			

Q34 What does this symbol mean to you?

Answered: 31 Skipped: 0

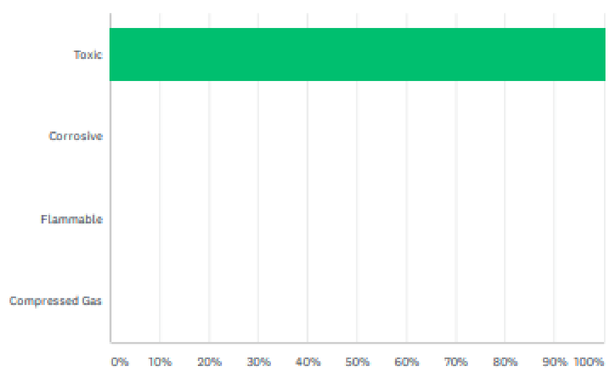


QUIZ STATISTICS			
Percent Correct 100%	Average Score 1.0/1.0 (100%)	Standard Deviation 0.00	Difficulty 23/30

ANSWER CHOICES	SCORE	RESPONSES	
Explosive	0/1	0.00%	0
✓ Corrosive	1/1	100.00%	31
Flammable	0/1	0.00%	0
Toxic	0/1	0.00%	0
TOTAL			**31**

Q35 What does this symbol mean to you?

Answered: 31 Skipped: 0

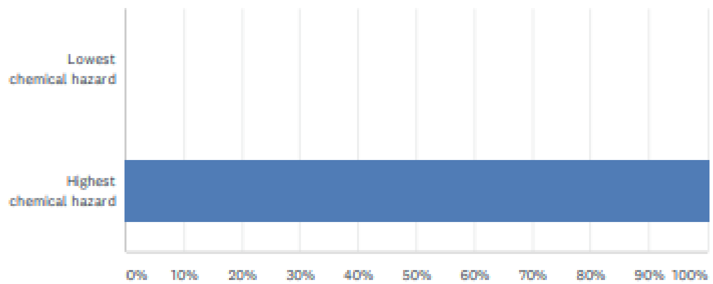


QUIZ STATISTICS			
Percent Correct 100%	Average Score 1.0/1.0 (100%)	Standard Deviation 0.00	Difficulty 23/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ Toxic	1/1	100.00%	31
Corrosive	0/1	0.00%	0
Flammable	0/1	0.00%	0
Compressed Gas	0/1	0.00%	0
TOTAL			**31**

Q36 What does this word mean to you?

Answered: 31 Skipped: 0

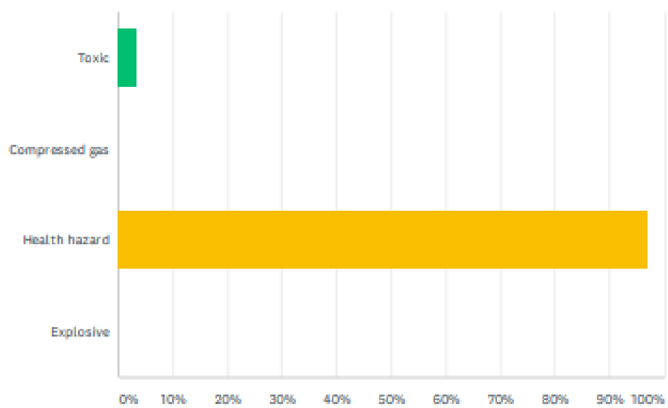


QUIZ STATISTICS			
Percent Correct 100%	Average Score 1.0/1.0 (100%)	Standard Deviation 0.00	Difficulty 23/30

ANSWER CHOICES	SCORE	RESPONSES	
Lowest chemical hazard	0/1	0.00%	0
✓ Highest chemical hazard	1/1	100.00%	31
TOTAL			31

Q37 What does this symbol mean to you?

Answered: 31 Skipped: 0

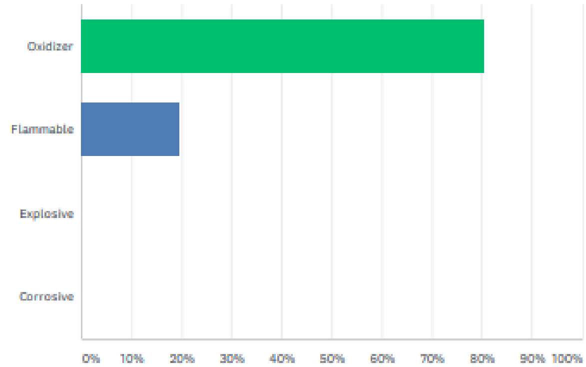


QUIZ STATISTICS			
Percent Correct 97%	Average Score 1.0/1.0 (97%)	Standard Deviation 0.18	Difficulty 20/30

ANSWER CHOICES	SCORE	RESPONSES	
Toxic	0/1	3.23%	1
Compressed gas	0/1	0.00%	0
✓ Health hazard	1/1	96.77%	30
Explosive	0/1	0.00%	0
TOTAL			31

Q38 What does this symbol mean to you?

Answered: 31 Skipped: 0

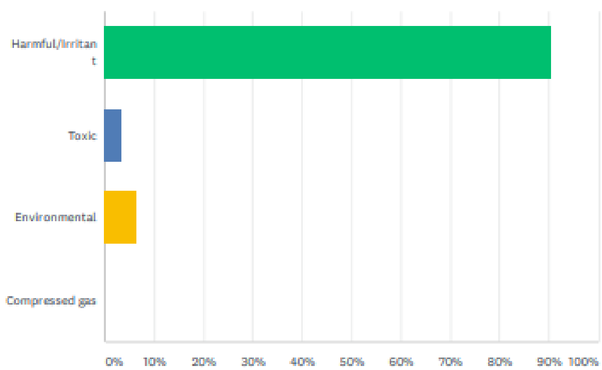


QUIZ STATISTICS			
Percent Correct 81%	Average Score 0.8/1.0 (81%)	Standard Deviation 0.40	Difficulty 6/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ Oxidizer	1/1	80.65%	25
Flammable	0/1	19.35%	6
Explosive	0/1	0.00%	0
Corrosive	0/1	0.00%	0
TOTAL			31

Q39 What does this symbol mean to you?

Answered: 31 Skipped: 0

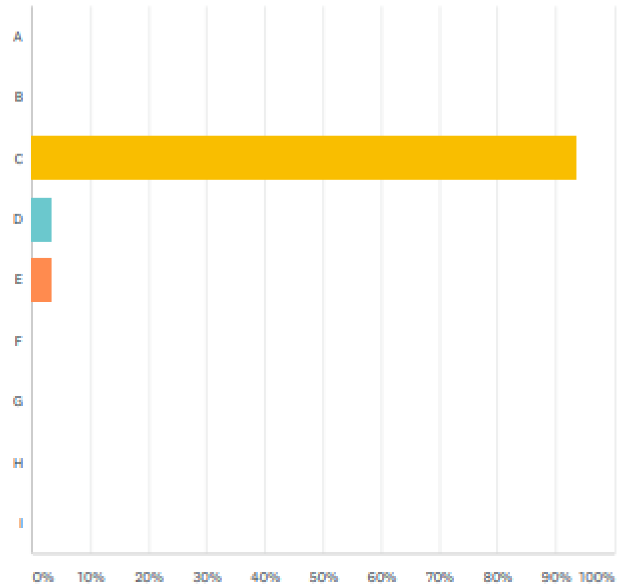


QUIZ STATISTICS			
Percent Correct 90%	Average Score 0.9/1.0 (90%)	Standard Deviation 0.30	Difficulty 13/30

ANSWER CHOICES	SCORE	RESPONSES	
✓ Harmful/Irritant	1/1	90.32%	28
Toxic	0/1	3.23%	1
Environmental	0/1	6.45%	2
Compressed gas	0/1	0.00%	0
TOTAL			31

Q40 Which symbol do you think identifies a chemical that is oxidizing? (An oxidizing chemical can react, even in the absence of air, with other chemicals and cause fire.)

Answered: 31 Skipped: 0

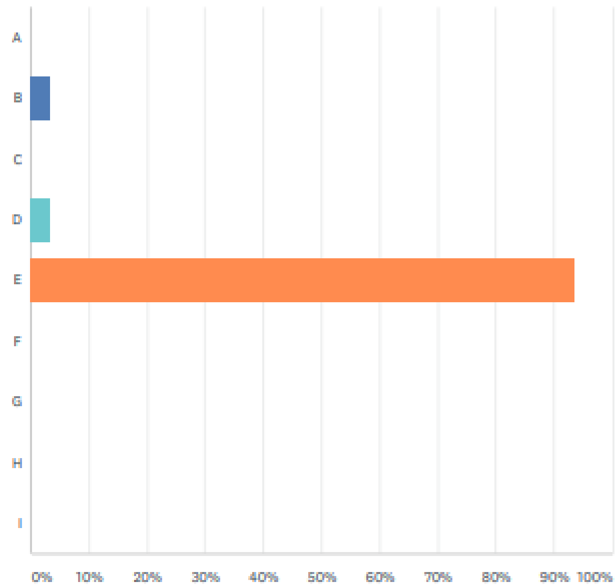


QUIZ STATISTICS			
Percent Correct 94%	Average Score 0.9/1.0 (94%)	Standard Deviation 0.25	Difficulty 16/30

ANSWER CHOICES	SCORE	RESPONSES	
A	0/1	0.00%	0
B	0/1	0.00%	0
✓ C	1/1	93.55%	29
D	0/1	3.23%	1
E	0/1	3.23%	1
F	0/1	0.00%	0
G	0/1	0.00%	0
H	0/1	0.00%	0
I	0/1	0.00%	0
TOTAL			31

Q41 Which symbol do you think identifies a chemical that is corrosive to metal? (A corrosive chemical is one that can cause severe damage to eyes, skin, metal, and other materials.)

Answered: 31 Skipped: 0

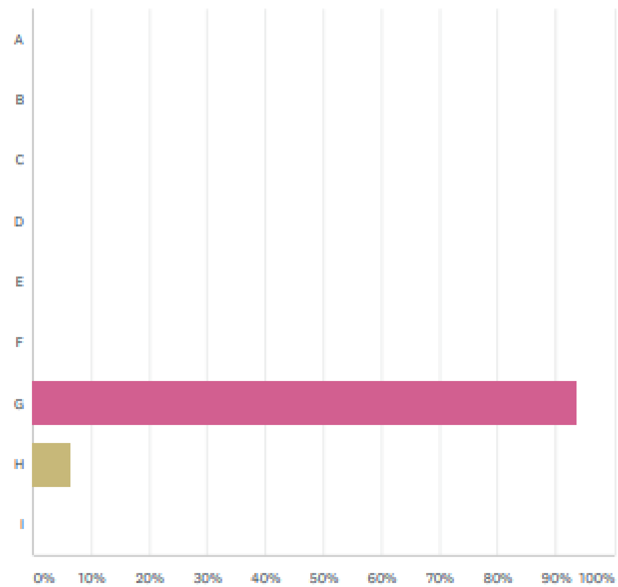


QUIZ STATISTICS			
Percent Correct 94%	Average Score 0.9/1.0 (94%)	Standard Deviation 0.25	Difficulty 16/30

ANSWER CHOICES	SCORE	RESPONSES	
A	0/1	0.00%	0
B	0/1	3.23%	1
C	0/1	0.00%	0
D	0/1	3.23%	1
✓ E	1/1	93.55%	29
F	0/1	0.00%	0
G	0/1	0.00%	0
H	0/1	0.00%	0
I	0/1	0.00%	0
TOTAL			31

Q42 Which symbol do you think identifies a chemical that is severely acutely toxic? (A chemical that is severely acutely toxic can be fatal.)

Answered: 31 Skipped: 0

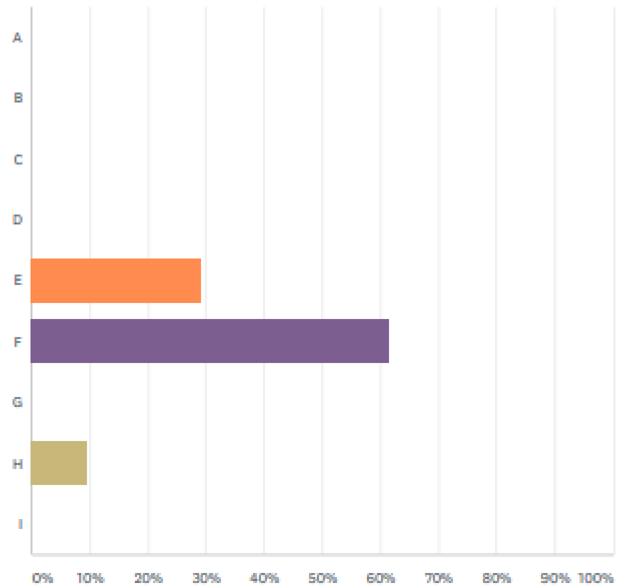


QUIZ STATISTICS			
Percent Correct 94%	Average Score 0.9/1.0 (94%)	Standard Deviation 0.25	Difficulty 16/30

ANSWER CHOICES	SCORE	RESPONSES	
A	0/1	0.00%	0
B	0/1	0.00%	0
C	0/1	0.00%	0
D	0/1	0.00%	0
E	0/1	0.00%	0
F	0/1	0.00%	0
✓ G	1/1	93.55%	29
H	0/1	6.45%	2
I	0/1	0.00%	0
TOTAL			31

Q43 Which symbol do you think identifies a chemical that is a skin irritant? (A chemical that is a skin irritant can cause skin rashes and irritation.)

Answered: 31 Skipped: 0

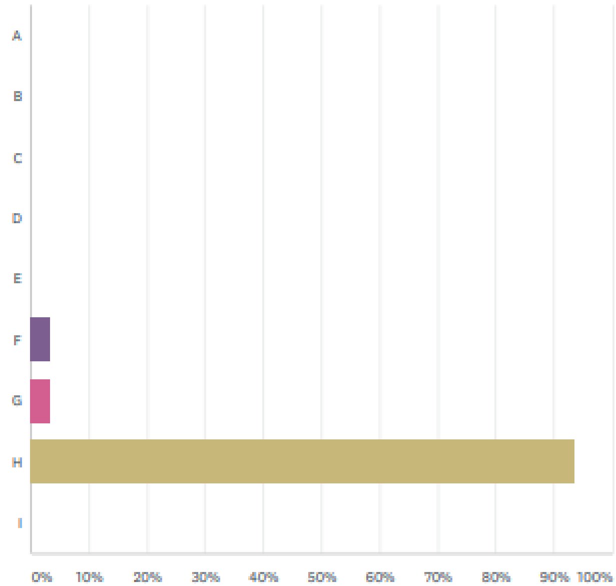


QUIZ STATISTICS			
Percent Correct 61%	Average Score 0.6/1.0 (61%)	Standard Deviation 0.50	Difficulty 1/30

ANSWER CHOICES	SCORE	RESPONSES	
A	0/1	0.00%	0
B	0/1	0.00%	0
C	0/1	0.00%	0
D	0/1	0.00%	0
E	0/1	29.03%	9
✓ F	1/1	61.29%	19
G	0/1	0.00%	0
H	0/1	9.68%	3
I	0/1	0.00%	0
TOTAL			31

Q44 Which symbol do you think identifies a chemical with a reproductive effect? (A chemical that is a reproductive hazard can cause problems for a person's ability to have children or cause birth defects in offspring.)

Answered: 31 Skipped: 0

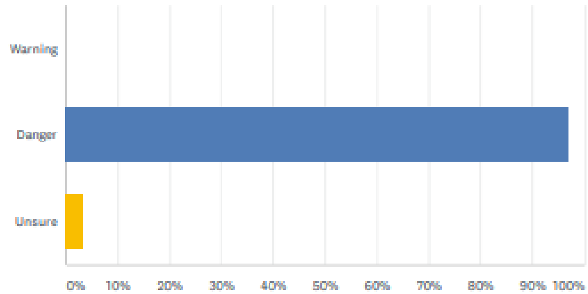


QUIZ STATISTICS			
Percent Correct 94%	Average Score 0.9/1.0 (94%)	Standard Deviation 0.25	Difficulty 16/30

ANSWER CHOICES	SCORE	RESPONSES	
A	0/1	0.00%	0
B	0/1	0.00%	0
C	0/1	0.00%	0
D	0/1	0.00%	0
E	0/1	0.00%	0
F	0/1	3.23%	1
G	0/1	3.23%	1
✓ H	1/1	93.55%	29
I	0/1	0.00%	0
TOTAL			31

Q45 If you saw a chemical label with the signal word "warning" and one with the signal word "danger," which would you consider to be the more hazardous chemical?

Answered: 31 Skipped: 0

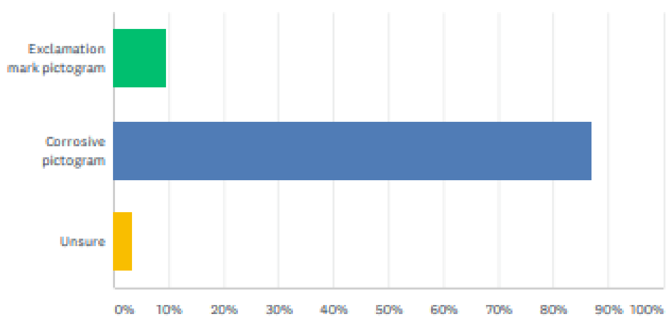


QUIZ STATISTICS			
Percent Correct 97%	Average Score 1.0/1.0 (97%)	Standard Deviation 0.18	Difficulty 20/30

ANSWER CHOICES	SCORE	RESPONSES	
Warning	0/1	0.00%	0
✓ Danger	1/1	96.77%	30
Unsure	0/1	3.23%	1
TOTAL			31

Q46 If you saw two chemical labels each with these two pictograms, which chemical would you consider to be more hazardous?

Answered: 31 Skipped: 0

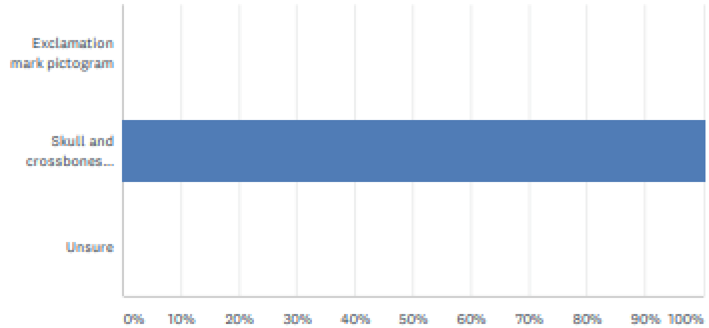


QUIZ STATISTICS			
Percent Correct 87%	Average Score 0.9/1.0 (87%)	Standard Deviation 0.34	Difficulty 9/30

ANSWER CHOICES	SCORE	RESPONSES	
Exclamation mark pictogram	0/1	9.68%	3
✓ Corrosive pictogram	1/1	87.10%	27
Unsure	0/1	3.23%	1
TOTAL			31

Q47 If you saw two chemical labels each with these two pictograms, which chemical would you consider to be more hazardous?

Answered: 31 Skipped: 0

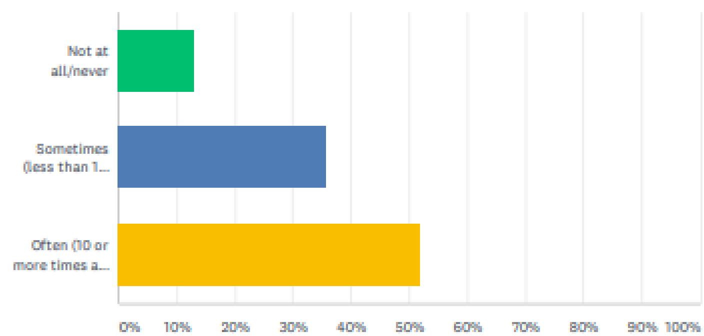


QUIZ STATISTICS			
Percent Correct 100%	Average Score 1.0/1.0 (100%)	Standard Deviation 0.00	Difficulty 23/30

ANSWER CHOICES	SCORE	RESPONSES	
Exclamation mark pictogram	0/1	0.00%	0
✓ Skull and crossbones pictogram	1/1	100.00%	31
Unsure	0/1	0.00%	0
TOTAL			31

Q48 In your previous or current job, how often do you use chemicals?

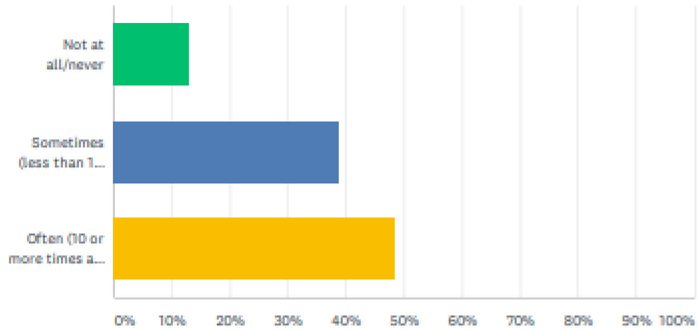
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Not at all/never	12.90%	4
Sometimes (less than 10 times a year)	35.48%	11
Often (10 or more times a year)	51.61%	16
TOTAL		31

Q49 In your previous or current job, how often are you exposed to a chemical that someone else is using?

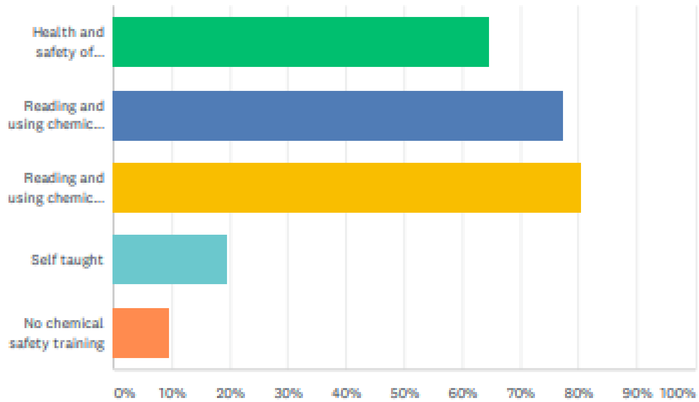
Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Not at all/never	12.90%	4
Sometimes (less than 10 times a year)	38.71%	12
Often (10 or more times a year)	48.39%	15
TOTAL		31

Q50 Please select the type of training you have received in your current job. Check all that apply.

Answered: 31 Skipped: 0



ANSWER CHOICES	RESPONSES	
Health and safety of chemicals	64.52%	20
Reading and using chemical labels	77.42%	24
Reading and using chemical safety data sheets	80.65%	25
Self taught	19.35%	6
No chemical safety training	9.68%	3
Total Respondents: 31		

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Dissertation Paper Title:

Factors Affecting Comprehensibility of the Globally Harmonized System of Chemicals in the United States

Major Professor: Dr. Robert J. McDermott