

The Role of Equipment Warning Labels in the Industrial Workplace

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Among the many ways in which workers can get safety information, the role of equipment warning labels has not been well articulated. Presumably, warning labels help prevent accidents, but questions remain about how well those labels can be expected to work. This essay describes how contextual analysis can assist our understanding of warning label effectiveness. A contextual approach was conceptualized in terms of underlying communication variables and an exploratory study was conducted in which workers were asked if they noticed and remembered warning labels on an industrial table saw that they used over a 3-month period. Results showed that equipment warning labels had a limited impact on workers. The contextual approach explained the relative effectiveness of multiple sources of information. Implications for safety training and accident liability are discussed.

communication context message safety information warning labels

1. INTRODUCTION

Every day in the USA, 9000 people suffer “disabling injuries on the job, 16 workers die from an injury suffered at work, and 137 workers die from work-related diseases” [1]. Although all workplace risks cannot be eliminated, company and manufacturer safety information programs—including face-to-face instruction, safety meetings, videos, manuals, websites, e-mails, posters, and equipment warning labels—can reduce the risk of serious injury or death. Because employee safety depends on how well these various forms of communication work, it is important to evaluate safety programs in terms of the relative effectiveness of each source of information. Furthermore, when accidents happen, liability may be assessed in terms of the adequacy of warnings and instructions provided by employers and manufacturers.

This essay examines the role of equipment warning labels in the safety information program of a woodworking operation. A contextual analysis approach is employed to understand warning label effectiveness. In connection with this approach, an

exploratory study was conducted in an industrial setting to assess whether workers noticed and could recall warning labels on a table saw they used regularly over a 3-month period.

2. BACKGROUND

Much research on warning labels has focused on label message characteristics, such as color, format, size, signal words, symbols, type of information, and location. This research has evolved into a set of guidelines for warning label design, known as the American National Standard Institute (ANSI) Z535.4-2007 standard [2], and a number of private companies offer manufacturers and employers ready-made labels that are ANSI compliant. For example, labels are available for warning employees about the risks of electric shock or about the importance of wearing protective goggles when operating machinery. The relevance of message characteristics is evident when comparing a label that blends into its background and is confusing to one that uses bright, contrasting colors and is precise, explicit,

and understandable. Research in this area can be summarized in terms of three basic categories: signal word, symbol, and text.

2.1. Signal Word

Signal words, such as Danger, Warning, and Caution, call attention to the hazards and have been classified for use according to the perceived level of risk associated with them. Danger is used to indicate “an imminently hazardous situation which, if not avoided, could result in death or serious injury”; Warning indicates “a potentially hazardous situation which, if not avoided, could result in death or serious injury”; and Caution indicates “a potentially serious situation which, if not avoided, may result in minor or moderate injury” (p. 4) [2].

A number of studies have gauged how people interpret the meaning of signal words, particularly in relation to ANSI definitions. For example, a study of Indian industrial workers found that Danger received the highest hazard rating, followed by Warning and then Caution, a finding that supports ANSI guidelines, including their relevance for international populations [3]. In other research, Danger has been shown to have a stronger connotation for perceived risk than Warning or Caution, though Warning and Caution are not as clearly distinguishable from one another as the ANSI recommendation suggests [4, 5, 6, 7, 8]. Although studies have found that people do not always perceive differences between the level of hazard implied by Danger, Warning, and Caution, enough evidence suggests that the ANSI standard can be a useful guideline.

2.2. Symbol

Symbols, also called pictorials or pictograms, are graphical representations of hazards. Symbols can convey a lot of information quickly and may be more noticeable than warnings without symbols [9]. Graphical representations serve as quick reminders and may be helpful to product users who speak a different language. A symbol can serve as a standalone warning (when a hazard is easily understood) or they can enhance the understanding of written text [10]. However, symbols can be

misinterpreted, and some types of information can be difficult to communicate in graphic form, such as how to perform a complex task.

Symbols may be understood by one culture or population, but not another, so the target audience’s frame of reference should be considered [11, 12]. For example, in one study U.S. participants consistently provided higher ratings of perceived hazards with regard to warning symbols than did Chinese participants [13]. Testing symbols on specific populations prior to use and training product users on how to interpret symbols has led to improved symbol comprehension [14, 15, 16]. Existing symbols and symbol forms are available in commercial safety catalogs and in the annexes of Standard No. ANSI Z535.3-2002 [17].

2.3. Text

The text of a warning label may identify the hazard, how to avoid it, and the consequences of not avoiding it. Explicit warnings, or those that contain specific information about the nature of the hazard, have been shown to increase perceived risks for products [18, 19]. Including statements about the consequences of a hazard has also led to higher likelihood-of-injury ratings [20]. Recent research on prescription drug labels demonstrates that warnings have been awkwardly worded and confusing, particularly for patients with lower literacy rates. Explicit, simple, and concise wording, along with understandable icons improved warning label comprehension [21, 22]. Readability may be enhanced by bulleting each type of information or by separating sets of statements with white space, and using familiar words that are active rather than passive; using concrete rather than abstract words can also enhance such messages [2].

Message content often involves balancing how much information to include. For example, long and detailed warnings are less likely to be read than shorter, pointed messages, and there may be space limitations depending on the product or equipment. Because it may be unrealistic to include all of the possibilities for injury, priority should be given to the most severe hazards and the ones that are most likely to occur.

Although research has advanced our understanding of the content of warning labels, the influence of context on message transmission and reception is less well defined. Indeed, most warning label studies have been conducted in laboratory or other artificial settings where contextual influences are difficult or impossible to consider. Laboratory studies provide good information about such things as the meaning of words and symbols, impressions of contrasting colors, and importance of using precise and explicit language, but they offer much less information about how workers respond to warning labels on the job or how workers may be influenced by other channels of information. More workplace research is needed that involves the intended recipients of warnings. The following section explicates various ways in which context may influence the effectiveness of a message.

3. CONTEXT

Context is the physical and psychological environments in which communication takes place and, therefore, is a key component of understanding message transmission and reception. All communication occurs within some context that influences the meaning and effectiveness of a message [23].

A description of the physical environment of a workspace could include the layout and temperature of a room, or even room cleanliness. For example, if a warning label is physically covered in wood dust, the context (rather than the message content) acts as the primary negative influence on the message getting through to the equipment user.

If a workspace includes other channels of safety information besides warning labels, those channels may have a negative or positive influence on warning label effectiveness. For example, if workers receive face-to-face instruction regarding the safe use of equipment, warning labels may seem redundant. However, if an instructor calls attention to warning labels and tells workers to read them, that channel of information may have a positive influence on the other channel.

Work environments have different psychological contexts related to safety, often described as safety cultures [24, 25]. Stronger safety cultures promote safety-first attitudes or otherwise prioritize and reward safe behavior, whereas weaker safety cultures have a lax attitude toward safety, fewer resources devoted to safety, and may even develop the norm of permitting unsafe behavior. Indeed, research has linked weaker safety cultures with higher accident rates [26]. Fortunately, safety cultures can be influenced, and a number of intervention strategies have successfully promoted stronger safety cultures and correspondingly lower accident rates [27, 28]. Psychological context may influence all types of safety channels, including warning labels.

3.1. Audience Characteristics

Context can also be described in terms of audience members' or workers' characteristics, such as level of experience in using a product or piece of equipment. Some research suggests that product users who are familiar with the product on the basis of past experience may be less likely to notice warning labels than unfamiliar users [29, 30, 31]. Less experienced workers may be inclined to seek out information, such as that contained on warning labels, to understand how something works. On the other hand, highly trained and experienced workers may not read warning labels because they believe they are knowledgeable about the risks associated with their jobs. One study suggested that younger workers are more receptive to safety messages and preventions than older workers because older workers develop long standing habits that may be inconsistent with newer safety preventions [32].

Attitudes toward risk may also influence communication. Some groups are higher risk takers than others and, therefore, may have the propensity to ignore safety information. One study found cultural differences in risk perception and thrill seeking between Ghanaian and U.S. industry workers. Ghanaian workers tended to have lower perceptions of risk and engaged in higher thrill-seeking behaviors than did U.S. industrial workers, which, in turn,

reduced their compliance to warnings [33]. This study, as well as the studies mentioned earlier involving Indian and Chinese populations, reinforce the idea that warning messages should take into account the cultural similarities and differences among the audiences for which the messages are intended. Moreover, in the increasingly global economy in which we live, the need for international guidelines for warnings has never been more apparent.

3.2. Sender Characteristics

Research on warning label source has not lead to any consistent recommendations for label content. One warning label study did show that naming the source (e.g., Government Warning) positively influenced perceptions of the effectiveness of the label [34]. Research on face-to-face communication has shown that perceptions of source credibility, immediacy, likability, and power (the ability to administer rewards and punishments) can influence behavioral outcomes. For example, high-credibility sources are more likely to influence behavior than are low-credibility ones [35].

A review of literature on warning sources concluded that researchers and practitioners have neglected the possibility that source characteristics can enhance the effectiveness of warning labels because of the impersonal nature of the medium and because warning labels simply rarely identify the source explicitly. The authors point to the well documented influence of source characteristics, such as expertise and trustworthiness, on behavior in other forms of health risk messages (e.g., face-to-face, television commercials), and argue that warning labels may indeed benefit from the addition of source information [36]. Considering the different perceptions of information sources is an important part of understanding the context in which safety information is communicated.

3.3. Channel Characteristics

The channel is the method or medium for communicating safety information. The efficacy of using a warning label as a channel must

be considered in light of the other possible methods of communication in a particular context, including manuals, face-to-face training, posters, videos, safety meetings, and Internet-based technologies. In the workplace, because of the many ways that people access, learn, and respond to information, multiple methods of communicating safety are favored over a single method [37]. An obvious yet important feature of a warning label as channel is that it does not provide the opportunity for feedback and, therefore, in some cases, it cannot substitute for face-to-face communication. For example, a complex task involving industrial equipment may involve a number of steps for safe operation. Demonstration, verbal instruction, and an opportunity for two-way communication (such that users can clarify meaning) may be an essential component of the safety program. Warning labels may logically serve as a secondary information source rather than as a primary information source.

The process of developing and evaluating warning labels, or any other method of disseminating safety information, can be informed by examining the relevance of context, which includes audience, sender, and channel characteristics. Context is as important as message content, but no studies have centered on the function of warning labels in an on-site industrial setting. In one sense, this gap in research is understandable given both ethical and logistical difficulties involved with conducting on-site studies; as such, researchers cannot manipulate different warnings on industrial equipment or change the dimensions of context for an experimental design when worker safety is at stake. One way of overcoming this problem is through the unobtrusive method of examining current practice and subsequently asking workers about their exposure to warning messages.

The exploratory study reported here was part of an ongoing comprehensive evaluation of a safety program. The specific purpose was to see if workers noticed and could recall any of the five manufacturer warning labels that appeared on a table saw, and to see if worker experience level was related to their ability to recall warning labels. Workers were also asked to rate the effectiveness of various forms of safety information.

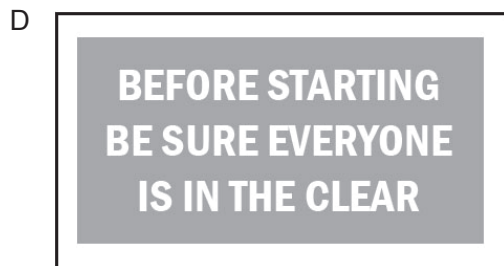
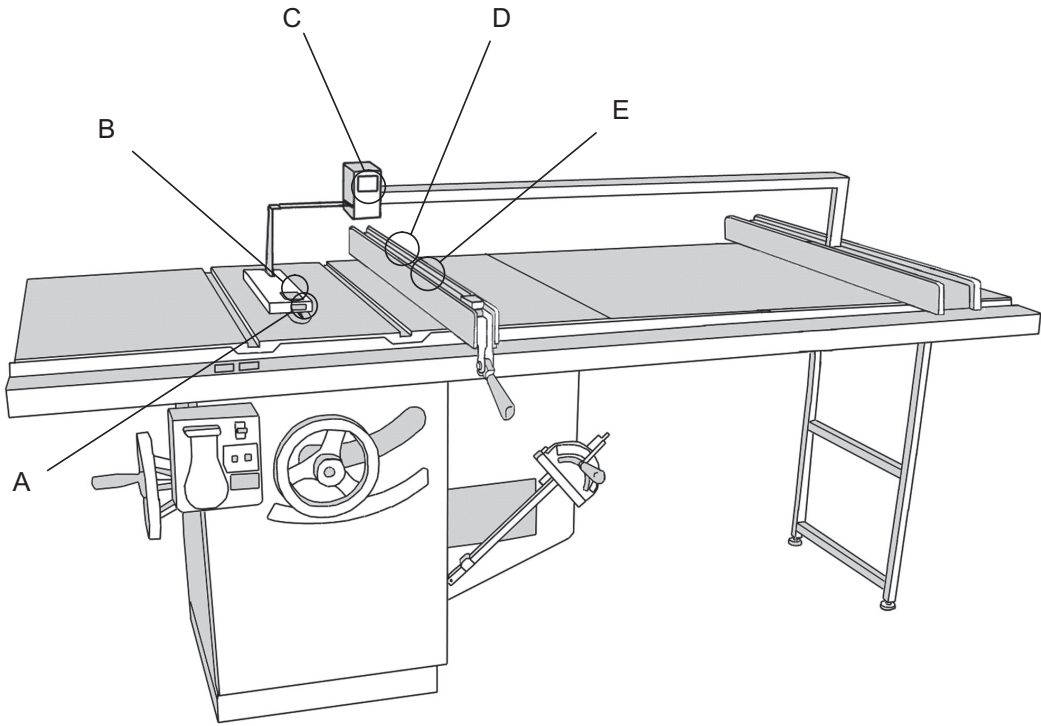


Figure 1. Locations of warning labels on table saw. Notes. Illustrations by Rachael Anderson.

4. PROCEDURE

The setting for the study was a university scene shop, where student workers were involved in constructing set designs that were used in upcoming theatre productions. All workers used industrial equipment common to many woodworking operations. The warning labels and their location on the table saw are depicted in Figure 1.

In order not to influence any aspect of the normal working environment, workers were not told about the warning label study and the warning labels on the table saw were not manipulated in any way. At the beginning of the semester, workers received their usual training, which included instructions and warnings regarding the safe use of the equipment in the form of 30 min of instructor-provided face-to-face training, watching a 20-min training video, and reading safety handouts. In addition, all of the woodworking equipment contained manufacturer warning labels, but as was normally the case in this particular workplace, no attempt was made to point out the warning labels during training. Workers began to use the table saw immediately after their training, and throughout the semester they received periodic on-the-job training from their instructor. At the end of the semester on the last day of class, workers were simply asked to fill out a short questionnaire on workplace safety. Participation was voluntary and the study was approved by a University Human Subjects Committee. None of the participants were injured using the table saw during the time frame of this study.

It is important to note that this study tested workers' ability to recall warning labels after repeated exposures to them over an extended amount of time in a naturalistic setting. Although the design did not control for the multitude of variables that can influence recall, it realistically emulates the process that would occur had there been an accident. To prevent future accidents and to assess liability, an accident analysis would include assessing what workers knew about the safe use of equipment and the source of that information. The sample and

questions also prevent the results from being generalizable. Therefore, the study is an initial attempt to study the use of warning labels in context and is appropriately termed exploratory and nonexperimental, with the idea of it leading to future research questions, hypotheses, and controlled experimental designs.

5. SUBJECTS AND QUESTIONNAIRE

The study was conducted over two separate 3-month-long semesters. Some students were members of a class on set design; others had already taken the class and volunteered their services over the course of more than one semester but were allowed to participate in the study only once. Accordingly, a total of 36 workers participated: 19 in the first semester and 17 in the second semester. Subjects included 20 males and 16 females who ranged in age from 19 to 23, with an average age of 20.4. Twenty students had worked in the shop for one semester, 12 for two semesters, and 4 for over four semesters. Although the set design class met three times per week, students had the option of working there outside of regular classroom times. For the purpose of this study, those who had worked in the shop for one semester were deemed novice users ($N = 20$), and those who worked in the shop for more than one semester were deemed experienced users ($N = 16$).

To estimate the frequency with which workers used the table saw, they described their use over the previous 3 months in terms of daily ($n = 5$), 2–3 times a week ($n = 8$), once a week ($n = 9$), once every 2 weeks ($n = 7$), or once a month ($n = 7$).

Participants were asked if they noticed, read, and could remember any warning labels that may have appeared on the table saw. The questionnaire contained separate boxes for “notice”, “read”, and “remember”, with participants placing an $\times$ in the boxes where their answer was *yes* and leaving blank the boxes where their answer was *no*. If they placed an $\times$ in all three boxes, they were instructed to indicate

the location of the label(s), color of the label(s), and what the label(s) looked like and said.

To gather information about global perceptions of effectiveness, participants rated the effectiveness of different methods of communicating safety, including the training video, face-to-face communication from the instructor, handouts, and warning labels on equipment. They did so by utilizing a 1 (*ineffective*) to 10 (*effective*) Likert-type scale for each method.

6. RESULTS

Of the 36 respondents, 23 (64%) indicated that they had noticed a warning label on the table saw, 12 (33%) indicated they had noticed and read the label, and 8 (22%) indicated they had noticed, read and remembered it. Only two respondents (5%) indicated that they noticed more than one label. The 11 respondents in the “notice-only” group did not describe the warning label(s). The 12 respondents that indicated “notice and read” and/or “notice, read, remember” described the warning label(s) to some degree in terms of location, color, and content. Those responses are given in Table 1.

In comparing responses to the actual warning labels that appeared on the table saw, 8 respondents correctly noted that a warning label appeared on the saw guard, and 2 of those 8 correctly indicated the color of that label. Further analysis of the open ended responses indicated that only 5 respondents remembered any specific content from the warning labels. Recalled content was linked to just one of the four warning labels that appeared on the saw, and it dealt with the dangers associated with getting your fingers cut off. It is interesting to note that while most workers (23, 64%) reported noticing a warning label, only 5 (14%) could remember any of the warning label content, and only 2 (5%) reported that there was more than warning label on the saw. Experienced workers were more likely than novice workers to remember the content of a warning label $\chi^2(1, N = 36) = 7.2, p = .00$.

Workers’ average ratings of the different methods of communicating safety information on the 10-point Likert-type scale are reported in Table 3. A repeated measures ANOVA revealed that there were significant differences in average rating by method $F(3,102) = 56.66, p = .00$. A least-squares means for each method using Tukey adjustments revealed that the rating for

TABLE 1. Written Responses From Workers who Indicated That They “Notice and Read” and/or “Notice, Read, Remembered” the Warning Label(s)

Respondent	Location	Color	Content
1	on the guard	white	a small unobtrusive label that said don't put your fingers under the guard
2	by the guard	white and orange	picture of fingers being cut off. Do not put hand under guard thing
3	on guard	black and yellow	small square label describing use of the saw guard and what to avoid doing
4	<i>none cited</i>	yellow	<i>none cited</i>
5	on the fence	black and yellow	<i>none cited</i>
6	on arm	white	hand with finger getting cut off
7	on the saw	black or red	cut off fingers
8	by the start button	green	<i>none cited</i>
9	by the safety cover blade	<i>none cited</i>	<i>none cited</i>
10	on the saw guard	<i>none cited</i>	picture of hand with fingers cut off and instructions on moving (raise and lower) guard
11	on the guard	red	don't remember but the label was big enough to be noticed fairly quickly
12	on the edge of the table part and on the shield raiser and lower part	<i>none cited</i>	<i>none cited</i>

TABLE 2. Cross-Tabulation of Noticing and Remembering Warning Labels by Experience

Experience Level	Notice and Remember?		Total
	No	Yes	
Novice	20	0	20
Experienced	11	5	16
Total	31	5	36

face-to-face training was significantly higher than the other three methods, that the mean rating for video training was significantly higher than for handouts and labels, and there was no significant difference for mean ratings between handouts and warning labels.

TABLE 3. Mean Ratings by Method Utilizing a 1 (ineffective) to 10 (effective) Likert-Type Scale for Each Method

Method	M
Face-to-face	9.22
Video	6.61
Handout	4.78
Label	4.81

7. DISCUSSION

Approximately two thirds of this sample noticed at least one warning label on the table saw and one third of those respondents described some aspect of the warning label(s), and only 5 respondents were able to recall specific content (fingers getting caught in the saw blade). This suggests that noticing a warning label does not mean it will be read and remembered, even after multiple exposures, and drawing attention to a warning label also provides no guarantee that it will be read and remembered. If noticing a label is considered to have some beneficial impact, perhaps communicating a generalized message to use caution when operating the saw, then warning labels achieved at least a degree of effectiveness for the majority of the sample. However, if effectiveness is defined in terms of noticing, reading, and remembering what a warning label says, then warning labels were ineffective for the vast majority of workers. Although this study did not assess

causal relationships, an analysis of message characteristics and the contextual dimensions mentioned earlier sheds light on possible explanations for the results.

The only recalled label warned about a finger-cutting danger and it followed ANSI guidelines in terms of format, signal word, and graphic representation [2], suggesting that message characteristics may have some influence on salience. It was also the largest label and was prominently located on the saw guard (see Figure 1, label B). In short, according to the ANSI standard, the label was well designed and conspicuous.

On the other hand, the fact that only 5 out of 36 workers recalled this label shows that even very conspicuous warnings are often not noticed or remembered. Moreover, another ANSI-style label on the saw guard that characterized a different danger was not reported by any respondents (see Figure 1, label A). It could be that utilizing well-designed warning labels is a good practice in the sense that getting a safety message through to even a small number of workers is better than no salience at all. However, following ANSI guidelines provides no guarantee that a label will be noticed or remembered. In fact, there is no way of knowing if the message characteristics were the reason that some workers recalled the label in this study. It seems clear that warning labels play only a minor role in communicating safety information in the workplace, and that judging how well workers are instructed and warned cannot be based solely on message characteristics of labels.

As noted earlier, workers received face-to-face instruction and hands-on training over a 3-month period in an industrial work setting. This type of instruction was made possible by the context and was the primary information source regarding the safe use of equipment. Because of the advantages of face-to-face communication, workers may have relied on that channel more than other channels of information. For example, if questions about the safe use of the table saw have been answered, workers may rely less on, or even ignore, warning labels if they perceive them as addressing information that has already been

covered. In contrast, in the absence of face-to-face instruction, workers would have to rely on written instructions and warnings, but that would define a different context than the one examined here or the one that exists in most industrial woodworking settings.

The ability to tailor a message to an audience increases the effectiveness of the message and, thus, points to another advantage of face-to-face communication over written equipment warnings. A warning label is intended to communicate to a generic audience of equipment users. Although not measured in this study, an instructor can potentially estimate a specific audience's characteristics (e.g. age, maturity level and experience) to make language choices and to give examples that resonate with that particular audience; one that is more specific and less generic.

It is interesting to note that in this study, the 5 participants that recalled a warning label on the table saw had worked in the scene shop for more than one semester, suggesting that more experienced workers are more likely to recall warning labels. This variable is worth pursuing with a larger sample size, particularly because previous research has suggested that more experienced workers are less likely to notice and remember warning labels. Nonetheless, 69% of the experienced workers were not able to recall and remember a label, suggesting that even for this group warning labels were not an effective primary information source.

The fact that workers stated a clear preference for face-to-face communication from an instructor also points to the relevance of considering sender characteristics when evaluating safety information. In particular, sender characteristics of credibility and immediacy may explain the effectiveness of verbal instructions over written warnings. Senders' credibility, which, in communication research, is defined as a sender's expertise and good will toward receivers, is linked to greater message salience. If it is fair to assume that students in a set design class perceive their instructor as someone who is knowledgeable about woodworking operations, and that it is in

that instructor's and students' best interest that no one gets hurt, then the instructor may be viewed as a credible source. The credibility of senders of warning labels is difficult to assess, but it obviously would not be a factor if the label goes unnoticed.

Face-to-face instruction also involves immediacy, or the verbal and nonverbal prompting of workers to pay attention to the source and message. Receivers are more likely to pay attention to a verbally prompted message than an unprompted written message, such as a warning label. Face-to-face communication also creates the opportunity for feedback, questions, and demonstrations, all necessary for the safe use of most industrial equipment.

This contextual analysis of warning label effectiveness also has implications for assessing liability during accident reconstruction. In so-called failure-to-warn claims, the message characteristics of a warning label are often the sole focus of litigation. When accidents happen, the assumption may be that a well-designed label would have been noticed, read, and remembered and would have affected workers' behavioral change and, thereby, prevented the accident from occurring. A contextual approach challenges this assumption by pointing to the importance of considering all of the variables that influence message transmission and reception. Indeed, assessments of behavioral influence in product liability litigation may lack this fundamental communication perspective.

Injuries that result from inadequate warnings and instructions should focus on worker training and not only on equipment labels. This does not relieve equipment manufacturers from the responsibility of supplying well-designed warning labels but, instead, points to a realistic expectation about whether workers will attend to those labels. Workplace warning labels should be considered a secondary information source that may serve as a reminder about safety information that workers have already received verbally. That most of the workers in this study noticed at least one warning label supports the idea of warning labels serving a reminder function rather than a primary information

source function. Considering warning labels as only one of many channels for communicating safety in an industrial work place, thus, is vital to understanding how well they can be expected to work.

Finally, given the limited effectiveness of equipment warning labels, safety specialists and researchers should investigate alternative methods for communicating risk information not considered here. In particular, advances in information technology have led to improved communication systems in a virtually all types of organizations in the industrialized world. For example, one promising application to work place safety is known as augmented reality technology. This technology allows for computer generated messages, including warning symbols and text, to appear on the visual field of safety glasses that are worn at industrial work stations. Warning messages can remain in the visual area while equipment operators focus on the task at hand, overcoming the disadvantages of traditional warning labels in that they are often fixed outside the task visual field and they can also become obstructed by machine dust or other equipment [38].

8. SUMMARY

This essay argues that message characteristics of warning labels constitute only one factor that may influence whether warning labels are noticed and understood. The exploratory study examined warning label effectiveness through the lens of contextual analysis. It makes the point that focusing on message characteristics alone may lead to erroneous conclusions about how well warnings can be expected to work. Industrial equipment warning labels may provide an important safety reminder for some workers but they do not function as a primary information source. Moreover, a causal link between warning labels and accidents is difficult to establish given all of the factors that impinge on human behavior in the workplace. In closing, there is no effective substitute for face-to-face training in the industrial workplace, and when questions arise concerning how well employees are instructed

and warned, this primary information source may be the one most likely to influence behavior.

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