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Comprehension of labels of hazardous chemical household products among consumers

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ABSTRACT

This study investigated the comprehension of chemical hazard labels according to the globally harmonized system of classification and labeling of chemicals (GHS), aiming to determine the factors associated with comprehension of GHS labels. The study participants included 310 Bangkok residents. Individuals were surveyed regarding demographics, use of hazardous chemical household products, and perceptions and comprehension of GHS labels. The results indicated that only 11.9% of the participants had a proficient level of correct perception of GHS labels, and 11.6% possessed a proficient level of comprehension. A significant association was found between proficient perception of the GHS labels, employment in government or private sectors, and comprehension of the GHS labels. This study's results can be used to develop more effective risk communication strategies that effectively convey product hazards to consumers, thereby reducing potential dangers from hazardous chemical household products.

Keywords: comprehension; perception; hazardous chemical household products; globally harmonized system; GHS label; chemical hazard communication

1. INTRODUCTION

Daily-use household and health products, such as cleaning products, disinfectants, and public health pesticides, often contain hazardous chemicals that can adversely affect the body. For example, cleaning products like dishwashing and laundry detergents may cause allergies and skin and eye irritation, while toilet cleaners may contain corrosive chemicals that can burn soft tissue (Kathare et al., 2022). Disinfectants, including antimicrobial agents and public health pesticides utilized for insect control and repellence, frequently contain hazardous chemicals that could harm the environment and pose potential health risks to humans and animals (Dewey et al., 2022). Hazardous chemicals in household and health products can be classified into several categories, including explosives, flammables, oxidizers, irritants, and other substances that can harm humans, animals, plants, or the environment (Department of Industrial Works, 1992).

In Thailand, the Food and Drug Administration (FDA) has approved 3,133 hazardous chemical household products (Food and Drug Administration, 2021). Additionally, statistics from 2013 to 2017 show that household products were the third most frequent cause of poisoning incidents among Thai citizens (Child Safety Promotion and Prevention Research Center and Ramathibodi Poison Center, 2018). The global spread of the novel coronavirus disease (COVID-19), including in Thailand, has notably increased the use of hazardous chemical household products, such as cleaning products and disinfectants (Dewey et al., 2022). This increase in usage can help prevent the transmission of the disease; however, it has also resulted in a higher risk of chemical poisoning (Çelebi et al., 2021; Rai et al., 2020).

Consumers risk exposure to hazardous chemicals due to poor understanding of a product's potential dangers, leading to inadequate caution, improper product usage, and insufficient awareness of the associated risks (Sathar et al., 2016). Thus, the Thai FDA has implemented the globally harmonized system of classification and labelling of chemicals (GHS) to ensure clear and consistent communication of chemical hazard information. Developed by the United Nations, this internationally recognized system provides a standardized approach for classifying and labeling chemicals (United Nations, 2009). To comply with the GHS system, product labels for household hazardous chemicals must display essential elements, such as hazard pictograms, signal words, and hazard statements (Ministry of Public Health Announcement on the Labeling of Hazardous Substances under the Responsibility of the Food and Drug Administration B.E. 2558, 2015). Determining whether consumers can understand the chemical hazard information presented on these labels and their precautions is crucial and can help assess the effectiveness of implementing the GHS system.

Relevant literature on understanding chemical hazard labels according to the GHS system includes a European Commission (2011) study, which determined that European consumers were often confused by GHS hazard symbols. This finding is consistent with research in Thailand (Soontornchai, 2011), which revealed that before implementing the GHS system in Thailand, university students did not understand the GHS symbols displayed on sample labels of hazardous chemical household products. A recent study (Soontornchai, 2019), which included stakeholder surveys and focus groups, also concluded that Thailand still lacks public comprehension of the GHS labeling system. The lack of comprehension of chemical hazard labels can result in inappropriate use or handling of hazardous products (Sathar et al., 2016), leading to accidents or adverse health effects (Petré, 1996), thereby increasing health-related costs and impacting public health (Meyer et al., 2007). Poor comprehension also leads to environmental contamination via improper usage or disposal of hazardous chemicals, negatively affecting ecosystems and living organisms (Arbastan & Gitipour, 2022).

Comprehension of chemical hazard labels is influenced by several factors, including individual perception, which forms the crucial foundation that fosters cognitive processes and results in effective decision-making (Laughery & Wogalter, 2014; Padilla et al., 2018; Wogalter et al., 1999). Gaining a correct perception of chemical hazard labels through training is a key factor that significantly enhances understanding of hazard symbol labels (Wogalter et al., 1997), enabling users to comprehend the dangers and potential impacts and leading to safe practices (Lesch, 2003).

Soontornchai (2011) researched the understanding of hazard labels among university students before implementing GHS in Thailand; however, a significant knowledge gap exists regarding the comprehension of GHS labels among the general consumer population following the full implementation of GHS in Thailand. This study investigates consumers' comprehension of chemical hazard labels according to the GHS and the factors associated with the comprehension. The findings can aid consumer protection organizations in acquiring comprehensive data to enhance and refine communication strategies for household hazardous items, making them more suitable and focused on consumers.

2. MATERIALS AND METHODS

2.1 Study design and participants

This cross-sectional study was conducted in the Bangkok metropolitan area, with data collection carried out between October and November 2021. It included 310 Thai individuals who were 18 years or older, could speak, read, and write Thai, and had experience using at least one hazardous chemical household product. The sample size was calculated using the G*Power program, which utilized logistic regression analysis (Faul et al., 2009). This study employed convenience sampling for both offline and online surveys. Respondents were invited to participate at locations throughout Bangkok, such as residences, office buildings, shopping malls, and universities. The researcher invited participants online via social media platforms, including Line and Facebook. The Ethics Committee of Silpakorn University, Thailand, approved the study on 5 May 2021 (COE 64.0505-062).

2.2 Data collection tool and procedure

A questionnaire was developed that passed a content validity test with high reliability to collect data from participants. The questionnaire comprised four sections: (1) Demographics included gender, age, education level, job, income, marital status, and work related to hazardous household chemicals. (2) Use of hazardous chemical household products comprised frequency of use, past incidents of harm and adverse effects, and previous exposure to chemical hazard symbols. (3) Perception of the GHS labels included nine color pictograms. This section presented the pictograms and their respective meanings; the participants were asked to match the pictogram with their explanation. (4) Comprehension of the GHS label involved 10 multiple-choice questions, nine color pictograms, and a signal word to evaluate practices and precautions related to GHS labels. The participants were asked to select the practices or precautions associated with each pictogram. For sections 3 and 4, the "correct" answer received a score of one, while "incorrect" responses received a score of zero. The perception of the GHS label was divided into two levels based on overall scores: limited (below 80%) and proficient (at least 80%).

2.3 Data analysis

Descriptive statistics were used (i.e., frequencies, percentages, means, and standard deviation) to describe sociodemographic data, the use of hazardous chemical household products, and the perception and comprehension of GHS labels. The relationship between factors and the comprehension of GHS labels for hazardous products was analyzed using binary logistic regression at a *p*-value of 0.05.

3. RESULTS

3.1 Sociodemographic of participants

Table 1 presents the sociodemographic characteristics of the participants. Most were female (71.6%), with an average

age of 46.6 years (SD = 13.8). Most held a bachelor's degree or above (71.3%); 50.6% were employed in government or private sectors, with their work generally unrelated to hazardous chemical household products (76.1%); 49% were married; and 47.1% earned less than 20,000 THB per month.

Table 1. Sociodemographic characteristics (n = 310)

Characteristics	n (%)
Gender	
Female	222 (71.6)
Male	88 (28.4)
Age (mean 46.6, SD 13.8, min 18, max 80)	
≤ 30	44 (14.2)
31–45	101 (32.6)
46–59	101 (32.6)
≥ 60	64 (20.6)
Education level	
Primary school	16 (5.2)
Secondary school	73 (23.5)
Bachelor or above	221 (71.3)
Job	
Employed	157 (50.6)
Self-employed	87 (28.1)
Unemployed	66 (21.3)
Work related to hazardous chemical household products	
No	236 (76.1)
Yes	56 (18.1)
Unknown	18 (5.8)
Income (THB/month)	
< 20,000	146 (47.1)
20,001–50,000	131 (42.3)
> 50,000	33 (10.6)
Marital status	
Married	152 (49)
Single	127 (41)
Divorced	31 (10)

3.2 Sociodemographic of participants

Most participants frequently used dishwashing products (93.2%), while bathroom cleaning products were moderately used (60.32%). Most participants rarely used mosquito repellent, mosquito coils, insecticides, laundry disinfectants, bleach laundry detergents, disinfectant wipes or sprays for surfaces, and bathroom disinfectants (Figure 1).

3.3 Experience in harm from hazardous chemical household products

Of all participants, 14.8% reported experiencing injuries from household products containing hazardous chemicals. The problem was attributed to a range of hazardous chemical household products. Among 46 individuals who experienced harm from hazardous chemical household products, bathroom cleaning products had the highest incidence (56.5%). Dishwashing agents were second (26.1%), followed by bleach laundry detergents (19.6%). Other harm-related products included insecticides (8.7%), bathroom disinfectants (8.7%), anti-mosquito coils (8.7%), mosquito repellent (8.7%), fabric cleaners (6.5%), laundry disinfectants (2.2%), and disinfectant wipes/ sprays for surfaces (2.2%) (Figure 2).

Skin rashes or itching (58.7%) was the most common adverse effect experienced by users, followed by nasal irritation or difficulty breathing (41.3%), headaches or dizziness (21.7%), nausea or vomiting (10.9%), skin peeling or dryness (6.5%), skin burns (6.5%), and coughing or throat irritation when inhaling vapors (2.2%) (Table 2).

3.4 Perception of the GHS labels

Of all participants, 90.3% had previously encountered or seen the GHS symbols. The perception of chemical hazards on GHS labels was examined by determining the participants' ability to match chemical hazard symbols to their respective hazard categories. Only 11.9% of the participants had a proficient level (over 80%) of correct perception of the GHS labels, with an average score of 4.8 (SD = 2.2) out of 9 points. Figure 3 shows the participant's responses to each hazard symbol. The most correctly interpreted symbol was symbol 1 (environmental hazards), with 86.8%. Following this, symbols 2 (flammable) and 3 (acute toxicity) were correctly perceived by 79.7% and 75.5% of participants, respectively. The correct perception rates for the remaining symbols were symbol 4 (explosive) (72.6%), symbol 5 (corrosive) (54.2%), symbol 6 (compressed gas) (36.5%), symbol 7 (oxidizing) (29.4%), and symbol 8 (carcinogenicity/reproductive toxicity) (27.4%). Symbol 9 (skin/eye/respiratory irritants) had the lowest correct perception rate (15.5%). These results highlight the varying levels of correct perception among participants.

3.5 Comprehension of the GHS labels

Comprehension of GHS labels was assessed by testing if the participants could correctly answer questions about the precautions related to the GHS chemical hazard symbols and whether they could accurately compare the hazards of chemical household products with different signal words on the labels.

Only 11.6% of the participants possessed a proficient comprehension of GHS labels, with an average score of 5.5 (SD = 1.7) out of 10 points. Figure 4 presents the responses to each query. Almost all participants encountered difficulty with symbol 8 (carcinogenicity/ reproductive toxicity), which had the precaution "if exposed, seek medical advice." Symbol 8 had the lowest correct comprehension rate at 13.2%. Symbol 3 (acute toxicity) had the precaution "do not inhale vapors" and had only 31.9% correct responses. Correct comprehension for the other symbols was as follows: symbol 6 (compressed gas) with the precaution "store away from heat" (39.0%); symbol 9 (skin/eye/respiratory irritants) with the precaution "If contact skin, wash with plenty of soap and water, avoid inhaling vapors" (42.6%); symbol 7 (oxidizing) with the precaution "keep away from heat sources, away from fabrics, plastic, paper" (58.1%); symbol 4 (explosive) with the precaution "avoid impacts and friction, keep away from flame and heat" (61.6%); symbol 2 (flammable) with the precaution "keep away from heat sources" (64.2%); and symbol 5 (corrosive) with the precaution "wear protective

gloves while using" (77.4%). Participants had a strong comprehension of symbol 1 (environmental hazards) with the precaution "avoid leakage into the environment" (89.4%). Regarding signal words, 68.7% of respondents correctly identified "danger" as indicating higher hazard levels than "warning."

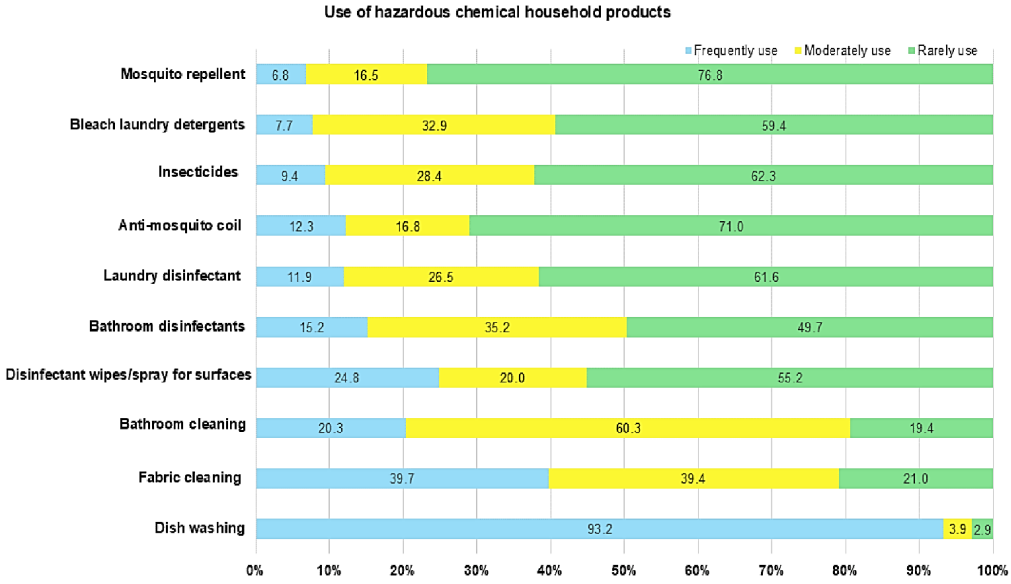

Figure 1. Use of hazardous chemical household products categorized by type of products (n = 310)

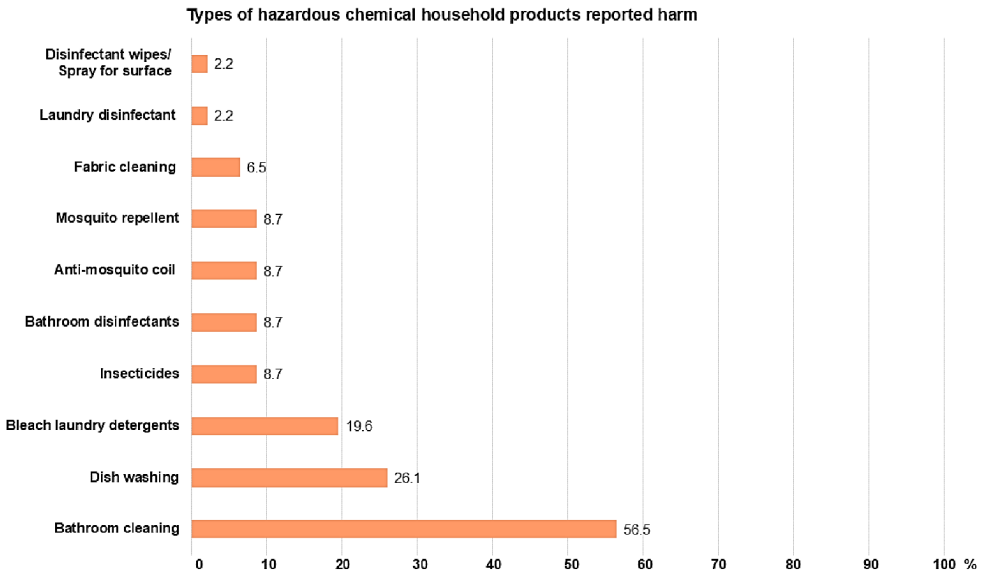

Figure 2. Types of hazardous chemical household products that caused harm

Table 2. Adverse effects previously experienced from hazardous chemical household products (n = 46)

Adverse effects	n (%)
Skin rashes/itching	27 (58.7)
Nasal irritation/difficulty breathing	19 (41.3)
Headaches/dizziness	10 (21.7)
Nausea/vomiting	5 (10.9)
Skin peeling/dryness	3 (6.5)
Skin burns	3 (6.5)
Coughing or throat irritation when inhaling vapors	1 (2.2)

Note: A single participant may have experienced more than one adverse effect from hazardous chemical household products

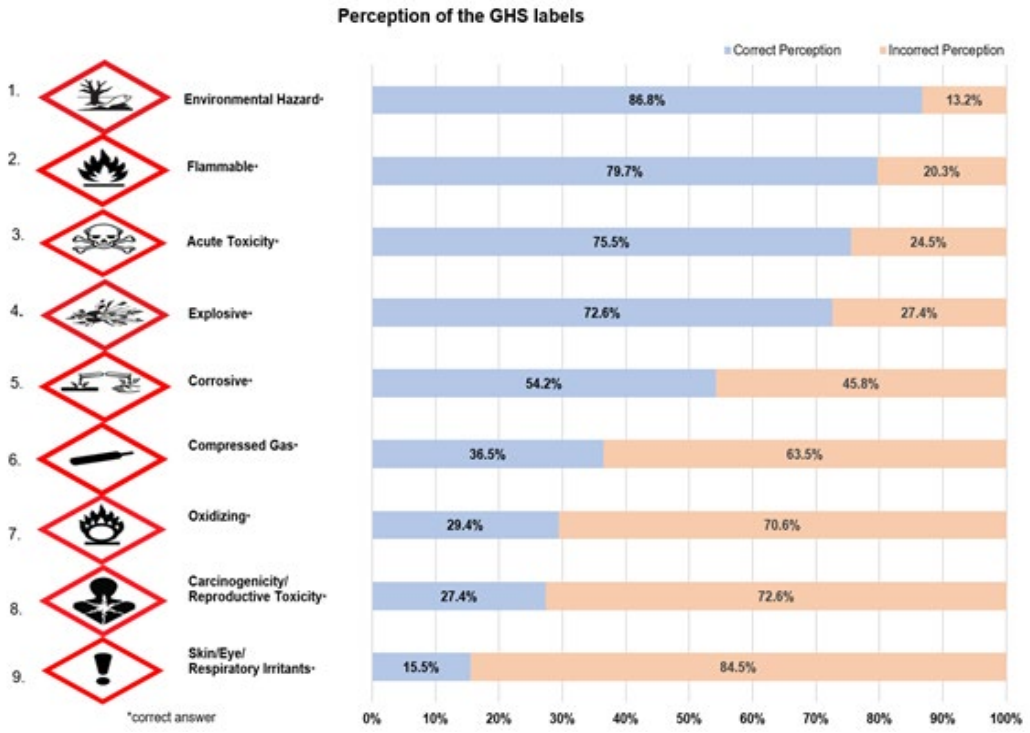

Figure 3. Perceptions of the GHS labels (n = 310)

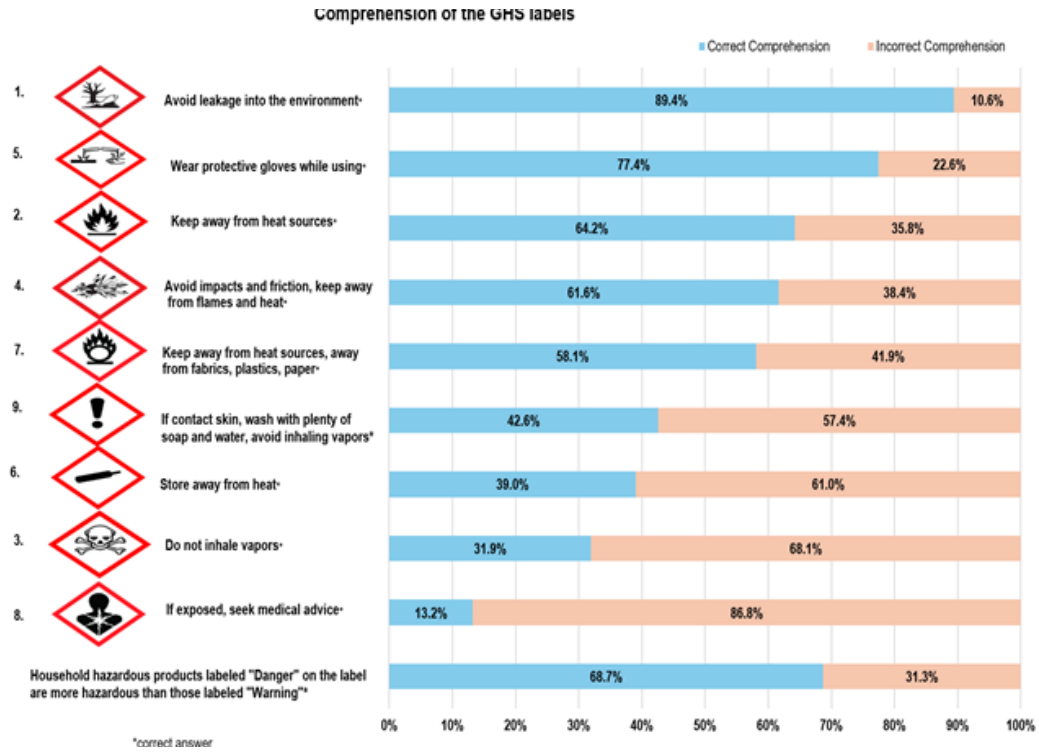

Figure 4. Comprehension of the GHS labels (n = 310)

3.6 Relationship between factors and the comprehension of the GHS labels

The results showed a significant association between perception of the GHS labels, job, and comprehension of the GHS labels. Identification of the GHS labels showed a statistically significant association with comprehension of the GHS labels. Participants with a proficient perception of the GHS label had a more proficient comprehension of GHS labels than those with a limited level (adjusted odds ratio [AOR] = 5.63, 95% confidence interval [CI] 2.43–13.05, and $p<0.05$). Furthermore, participants who were government or company employees had a more proficient level of

comprehension of GHS labels than those who were unemployed (AOR = 3.72, 95% CI 1.06–13.08, and p=0.04). This outcome means that government or company employees are 3.72 times more likely to comprehend GHS labels proficiently than unemployed individuals (after adjusting for other potential confounding variables) (Table 3).

Table 3. Factors associated with the comprehension of GHS labels (n = 310)

Factors	Comprehension of the GHS label		Adjusted OR (95% CI)	*p*-value
	Limited	Proficient		
Perception of GHS label				
Limited level	250 (91.6)	23 (8.4)	1.00	
Proficient level	24 (64.9)	13 (35.1)	5.63 (2.43–13.05)	<0.05*
Job				
Unemployed	63 (95.5)	3 (4.5)	1.00	
Employed	130 (82.8)	27 (17.2)	3.72 (1.06–13.08)	0.04*
Self-employed	81 (93.1)	6 (6.9)	1.38 (0.32 –5.99)	0.67

Note: *Statistical significance at p-value = 0.05, adjusted for gender and education level

4. DISCUSSION

4.1 Perception of the GHS labels

Our study found that the "environmental hazard" symbol had the highest correct identification (86.8%). This finding is consistent with Mehrifar et al. (2023), who found that the "harmful to environment" symbol had the highest correct identification (88.2%). This symbol depicts a straightforward graphic design involving a dead fish and a tree, symbolizing two specific types of environmental harm. Young and Wogalter (1990) found that effective symbol design could enhance information delivery. However, only 15.5% of the participants correctly identified the "skin/eye/respiratory irritants" symbol, characterized by a graphic design with an exclamation mark. This result agrees with the findings of Mehrifar et al. (2023), who found that the "skin irritant" symbol was associated with the lowest correct identification (25%). This finding is further strengthened by Monteiro et al. (2016), who found a significant degree of confusion in interpreting the "exclamation mark" symbol, implying that the design may not effectively convey hazard information. Other studies determined varying levels of correct identification for different symbols. For example, Dalvie et al. (2014) found the highest correct identification with the "acute toxicity" symbol (98%), while the "compressed gas" symbol had the lowest (7%). Jahangiri et al. (2018) reported the highest correct identification with the "flammable material" symbol (91%). The level of accurate identification is also influenced by label design and differences in training (Su & Hsu, 2008), education styles, attitudes, and the nature of people's jobs (Mehrifar et al., 2023).

4.2 Comprehension of the GHS labels

In this study, the "Environmental hazard" symbol received the highest level of comprehension (89.4%), consistent with the findings of Kalsher and Mont'Alvão (2010), which indicated that symbols depicting tangible hazards, such as environmental hazards, received the highest comprehension. This study found that the "carcinogenicity/reproductive toxicity" symbol had the lowest comprehension (13.2%). This result aligns with Hesse et al. (2010), who found that symbols depicting relatively abstract hazards, such as the "carcinogenic/reproductive" hazard symbol, had the lowest comprehension. This symbol features a graphic design resembling a starman, representing various hazards, including reproductive and carcinogenic, mutagenic, and respiratory hazards (Hesse et al., 2010). The ambiguity in the symbol leads to consumer confusion in comprehending precautions to prevent harm; therefore, redesigning the symbol is recommended. Efforts should also focus on improving the correct comprehension of the symbol through public training and education.

Based on the study results, bathroom cleaning products caused the highest incidence of harm from usage (56.5%), followed by dishwashing products (26.1%); these rankings align with the highest usage rates reported for these two product categories. Most respondents frequently used dishwashing products, while bathroom cleaning products were moderately used. The most commonly reported adverse effects were skin rashes or itching (58.7%) and nasal irritation or difficulty breathing (41.3%). This study revealed that 84.5% of the sample group had an incorrect perception of this pictogram (symbol 9), and only 57.4% comprehended it, which may contribute to the high number of reported incidents involving these products. Symbol 9 (Figure 3) is an exclamation mark, which can convey various meanings. Chemical household products with this pictogram can cause various impacts, such as skin, eye, and respiratory irritants. Moreover, this pictogram is also used for products hazardous to the ozone layer (Koulaouzidou et al., 2020), which may confuse consumers. Therefore, improving consumers' perception and comprehension of GHS labels, particularly symbol 9 (Figure 3), could reduce harm from product usage and enhance consumer safety.

4.3 Relationship between factors and the comprehension of the GHS labels

This study's results demonstrate a significant positive relationship between correct identification and comprehension of GHS labels. This finding indicates that their comprehension can increase when consumers correctly identify the labels. This comprehension leads to adopting appropriate precautions to reduce risks and accidents associated with using household hazardous substances in their daily lives. By addressing the various

elements that contribute to correctly identifying the GHS labels, such as prior knowledge or training, proper label design (Gungor, 2024; Su & Hsu, 2008), and familiarity with the pictogram (Mehrifar et al., 2023), stakeholders can develop strategies to increase comprehension.

Furthermore, this study found that job types could significantly influence the comprehension of GHS labels. Individuals employed in government or private sectors comprehend GHS labels better than unemployed people. This disparity may be due to increased access to GHS communications in these jobs, particularly in chemical industries, where regular interaction with GHS labels, communication, and training reinforce understanding (Handcock et al., 2004; Wogalter et al., 1997). In contrast, unemployed individuals do not have such exposure, resulting in lower comprehension.

This study is the first to investigate comprehension after implementing the GHS in Thailand and examine factors influencing comprehension among general consumers who have used hazardous chemical household products. Nevertheless, this investigation is constrained by its cross-sectional survey design, which covers a limited period, and its dependence on questionnaire data, which may incorporate bias. Future researchers should conduct longitudinal studies to monitor consumer perception and comprehension changes. Furthermore, data collection should encompass alternative methodologies, such as observational studies that examine consumers' perceptions and comprehension of GHS hazard labels.

This study found no significant association between education level and comprehension of GHS labels, unlike Ta et al. (2010). This discrepancy may be due to the convenience sampling method and online data collection used in this study during the COVID-19 pandemic. These factors could have led to an inadequate sample distribution and affected demographic characteristics, particularly education, which is a factor in this study; therefore, future research should consider using random sampling to address this limitation.

Based on our findings, regulatory agencies for hazardous chemical household products should implement strategies to increase consumer comprehension, such as enhancing consumer education and supporting future research to inform potential improvements in GHS label communication, especially among non-government and non-company employees. Furthermore, manufacturers of hazardous chemical household products should collaborate with regulatory agencies to improve GHS label communication and support consumer education initiatives. Consumers should read GHS labels on hazardous household products and actively seek education or utilize available educational resources to ensure correct perception and improve comprehension.

5. CONCLUSION

Comprehension of chemical hazard labels based on GHS is critical in enabling consumers to understand the risks associated with hazardous chemical household products. This understanding empowers consumers to take necessary precautions and encourages safe and proper use of such products. Consumer protection organizations, such as the FDA, can utilize this study's findings to enhance their risk communication strategies for hazardous chemical household products, thereby ensuring more effective consumer protection. Regulatory agencies should thoroughly examine ambiguous chemical hazard symbols and work with manufacturers to create more easily understood labels, ensuring that consumers accurately and consistently comprehend the potential dangers. Furthermore, regulatory agencies must educate consumers via different platforms, such as educational courses or online media, to improve their accurate perception and comprehension. This approach can result in improved product management or mitigation, decreasing consumer detriment probability.

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DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

ChatGPT was used in the writing process of this manuscript to enhance language quality. The authors reviewed and edited AI-generated outputs to ensure accuracy and integrity. The authors take full responsibility for the publication content.

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