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Evaluation of pictograms for safe medication disposal awareness campaign: A pilot study

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ABSTRACT

Improper disposal of unused and expired medications poses significant environmental and public health risks, yet awareness and appropriate disposal practices remain inadequate in Malaysia. Effective visual communication offers a sustainable approach to addressing this gap by simplifying complex medical information and improving long-term health literacy. Pharmaceutical pictograms, when designed to be simple, culturally relevant, and context- specific, can enhance message clarity, recall, and patient engagement. As low- cost and reusable educational tools, pictograms support sustainable health education by promoting informed behaviors and reducing medication-related environmental contamination. Consequently, pictogram-based educational strategies may improve public understanding and encourage responsible disposal of medication waste. This pilot study aimed to evaluate the comprehensibility of culturally localized pharmaceutical pictograms designed to promote safe medication disposal among the Malaysian population. A cross- sectional study was conducted using interviewer-administered online sessions across 14 states in Malaysia. Fourteen pictograms were evaluated among 50 participants. Comprehension was assessed before and after verbal and textual explanation, using ISO (≥66.7%) and ANSI (≥85%) standards. Demographic data were analyzed descriptively. Prior to explanation, 11 pictograms met ISO criteria and 10 met ANSI criteria. Following explanation, all pictograms met both standards. Pictograms incorporating culturally familiar symbols achieved higher recognition rates, while complex and multi-message pictograms were more prone to misinterpretation. Culturally responsive pictogram design, supported by multimodal communication, enhances comprehension of safe medication disposal practices and supports sustainable healthcare behaviors.

1. INTRODUCTION

Medications play a crucial role in treating illnesses and improving overall health. However, advancements in medicine

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have contributed to a notable rise in medication waste, despite their essential function in healthcare (Alshehri & Banjar, 2022). Reusing medications, particularly antibiotics and other prescriptions, is risky and should only be done under the guidance of a healthcare practitioner. In addition, storing unneeded medications at home poses risks such as drug errors, adverse reactions, and resource wastage (Lee & Schommer, 2022). The increase in the number of unused and expired pharmaceuticals can be related to a variety of factors, including therapeutic failure, improper drug interactions, the patient experience unpleasant side effects, changes or termination of prescribed medications, noncompliance, and overprescription (Jankie et al., 2022).

Improper disposal of unused and expired medications is a growing public health and environmental concern globally. Medications discarded through household waste or wastewater systems may contaminate soil and water, posing risks to ecosystems and human health (Dankwa et al., 2024). Unsafe disposal also increases the risk of accidental poisoning, misuse, and antimicrobial resistance (Karungamye et al., 2022). With increasing medication consumption worldwide, promoting safe disposal practices is critical to protecting public health and the environment (Abbas et al., 2025). From a sustainability perspective, responsible medication disposal aligns with the principles of environmental stewardship and the Sustainable Development Goals, particularly those related to health, clean water, and responsible consumption. Effective communication strategies are therefore essential to encourage environmentally sustainable behaviors at the community level.

In low- and middle-income countries, including Malaysia, public guidance on medication waste disposal is limited. Many households dispose of medicines in trash or sinks, reflecting low awareness and poor access to disposal information. Although medication return programs (MRP) exist in some healthcare facilities (Wang et al., 2021), participation remains low, emphasizing the need for effective educational interventions. This gap highlights the role of visual and design-based communication in translating complex health and environmental messages into accessible and actionable information for the public.

Pharmaceutical pictograms enhance medication safety by providing visual cues that support patient understanding of essential drug information. Used in combination with written or verbal instructions, they improve the communication of critical safety messages and can be integrated into patient education materials and public health campaigns, particularly in populations with limited literacy. By overcoming language barriers, pictograms facilitate comprehension among patients who may struggle with medical terminology (Berthenet et al., 2016). As a form of visual communication, pictograms represent a design- led approach to sustainability education by promoting behavioral change through clarity, simplicity, and universal symbolism (Houts et al., 2006).

Standardized pictograms enhance global medication safety by ensuring consistent safety messages across borders and cultures. However, without careful design, cultural differences in interpretation may lead to miscommunication, and overreliance on pictograms may reduce attention to important textual information. This underscores the importance of context-sensitive design and user-centered evaluation in developing visual communication tools that are both culturally appropriate and effective in supporting sustainable health practices.

This study primarily aims to assess the effectiveness of the developed pharmaceutical pictograms in conveying appropriate safe medication disposal-related information to the Malaysian population. In addition, it evaluates whether the use of pictograms in combination with verbal and textual instruction enhances public understanding. The findings of this study are expected to inform future public health education strategies and support the development of effective interventions to promote safe medication disposal practices. By situating pictogram evaluation within the broader discourse of communication design and sustainability, this study contributes to the growing body of research that recognizes visual communication as a key driver of sustainable public health outcomes.

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2. METHODOLOGY

2.1 Study Design

This pilot study adopted a cross-sectional exploratory design to evaluate the comprehensibility of pharmaceutical pictograms related to safe medication disposal. Data were collected through online, interviewer-administered sessions involving participants from all 14 states in Malaysia. An online questionnaire administered via Google Forms was used to collect demographic information, including age, ethnicity, occupation, area of residence, gender, and highest educational attainment.

The pharmaceutical pictograms evaluated in this study were specifically designed and culturally adapted to reflect Malaysian socio-cultural contexts and visual conventions. Ethical approval for the study was obtained from the Research Ethics Committee of Universiti Teknologi MARA (UiTM) (REC(PH)/UG/168/2024).

Interviews were conducted individually and lasted approximately 20 minutes per participant. Participants were interviewed in their preferred language, either Bahasa Malaysia or English, to minimize language-related comprehension barriers. Language choice was determined by participant preference prior to the interview.

Eligibility criteria included Malaysian residents aged 18 years and above who were able to provide verbal and written informed consent. Individuals with visual or hearing impairments, limited literacy skills, or those belonging to vulnerable groups, including individuals with mental health conditions, terminal illnesses, or physical disabilities, were excluded to avoid potential ethical and interpretive biases during pictogram evaluation.

2.2 Data Collection

A total of 50 participants were recruited using stratified convenience sampling to ensure representation across key demographic categories. Electronic informed consent was obtained from all participants prior to data collection. Before the commencement of data collection, all interviewers underwent standardization training and collectively agreed on predefined criteria for categorizing pictogram interpretations as *completely correct*, *partially correct*, *incorrect*, or *opposite*. This process ensured consistency and reliability in the evaluation of participant responses.

Data collection was conducted between March and July 2025. During the initial phase, participants were presented with 14 pictograms without any accompanying explanations or textual cues. They were asked to verbally interpret the meaning of each pictogram, allowing assessment of spontaneous comprehension. Interviewers categorized responses based on the agreed evaluation rubric.

Following this, the correct meanings of the pictograms were explained verbally by the interviewers, supported by brief textual labels displayed alongside each pictogram. The pictograms were then reshuffled and participants were asked to reinterpret them. This second assessment aimed to evaluate short-term recall and the effect of combined visual, verbal, and textual communication on understanding. Participant interpretations and qualitative feedback regarding pictogram clarity and meaning were recorded.

2.3 Statistical Analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 29. Demographic characteristics were summarized using descriptive statistics. The level of statistical significance was set at a p-value of 0.05 or lower. The recognition rate for each pictogram was calculated using the formula presented in Figure 1.

https://doi.org/10.24191/ijad.v10i1.7arvqw22

A pictogram was considered correctly interpreted based on its recognition rate and evaluated against established international standards. Specifically, pictograms were assessed according to the ISO and ANSI comprehension criteria, with minimum acceptance thresholds of 66.7% and 85%, respectively (ISO, 2014; ANSI, 2011).

$$Recognition\ rate = \frac{Number\ of\ participants\ answer\ correctly}{Total\ number\ of\ participants} \times 100$$

Fig. 1. Recognition rate formula
Source: Tumkur et al., 2025

3. RESULTS

3.1 Participant Characteristics

The study achieved a 100% response rate. Demographic variables collected included gender, age, ethnicity, educational attainment, monthly income, and occupation. Of the 50 participants, 62% (n = 31) were female and 38% (n = 19) were male. The majority of respondents were aged 18–30 years (64%), followed by those aged 31–39 years (20%) and 40–49 years (12%). Only 4% of participants were aged over 50 years.

All participants were Malaysian and represented diverse ethnic backgrounds, comprising 42% Malay, 34% Chinese, 16% Indian, and 8% from other ethnic groups (Bumiputra Sabah and Sarawak). Most participants resided in urban areas (77.3%), while 22.8% were from rural settings. In terms of educational attainment, 36.4% had completed secondary education, 46.4% possessed a diploma or degree, and 17.3% had lower educational levels (uneducated or primary education). Regarding occupation, the majority of participants were employed (86.0%), with a small proportion working as healthcare professionals (6.0%).

3.2 Description of Pictograms

Fourteen pharmaceutical pictograms were developed to communicate key messages related to safe medication disposal in a simple, culturally appropriate, and user-friendly visual format. The pictograms evaluated in this study are presented in Fig. 2.

Fig. 2. Pictograms developed in this study
Source: Author, 2026

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3.3 Interpretation of Pictograms Before and After Explanation

Pictogram comprehension was evaluated using international standards, requiring a minimum correct interpretation rate of 66.7% to meet ISO criteria and 85% to meet ANSI criteria. Prior to any explanation, 11 pictograms met the ISO criterion, while 10 pictograms met the ANSI criterion. Following verbal explanation supported by textual labels, all 14 pictograms achieved both ISO and ANSI comprehension thresholds (Table 1).

Table 1. Initial response comparison of pictograms before explanation (N=50)

Pictogram	Initial response, n (%)				Recognition rate (%)
	Correct Interpretation		Incorrect Interpretation		
	Correct	Partial	Incorrect	Opposite	
P1	33 (66)	16 (32)	1 (2)	0	98
P2	29 (58)	17 (34)	2 (4)	2 (4)	92
P3	31 (62)	14 (28)	4 (8)	1 (2)	90
P4	30 (60)	15 (30)	3 (6)	2 (4)	90
P5	31 (62)	13 (26)	5 (10)	1 (2)	73.3
P6	29 (58)	14 (28)	5 (10)	2 (4)	86
P7	31 (62)	14 (28)	4 (8)	1 (2)	90
P8	24 (28)	9 (18)	15 (30)	2 (4)	66
P9	33 (66)	16 (32)	1 (2)	0	98
P10	35 (70)	15 (30)	0	0	100
P11	17 (34)	11 (22)	20 (40)	2 (4)	56
P12	33 (66)	16 (32)	1 (2)	0	98
P13	16 (32)	12 (24)	15 (30)	7 (14)	56
P14	15 (30)	11 (22)	23 (46)	1 (2)	52

Before explanation, five pictograms which were the P5, P8, P11, P13, and P14, failed to meet the minimum ANSI comprehension criterion. The lowest correct recognition rate prior to explanation was observed for P14 (52%), while the highest recognition rates (98%) were recorded for P1, P9, and P12. After explanation, the lowest recognition rate increased to 83% for P13, and the highest post-explanation recognition rate was 92% for P5. Notably, none of the pictograms achieved a 100% recognition rate, even after explanation.

Regarding partially correct interpretations, P7 demonstrated the highest rate (34%) prior to explanation, suggesting ambiguity in visual interpretation, while P8 recorded the lowest partially correct rate (9%). An intervention phase was conducted for five pictograms that did not meet ISO criteria, during which interviewers provided verbal explanations supported by textual cues.

Post-intervention analysis indicated substantial improvements in comprehension. P14 showed the greatest increase in correct recognition (33%), followed by P11 (29%), P13 (27%), and P8 (21%). P5 exhibited the smallest improvement, with an 18.7% increase in recognition rate (Table 2). Overall, the combined use of pictograms with verbal and textual explanations resulted in a significant enhancement of participant understanding.

Table 2. Comparison of response accuracy of incorrect interpreted pictograms after explanation intervention

Pictogram	Recognition rate (%)		Improvement (%)
	Before explanation	After explanation	
P5	73.3	92	18.7
P8	66	87	21

https://doi.org/10.24191/ijad.v10i1.7arvqw22

P11	56	85	29
P13	56	83	27
P14	52	85	33

Pictograms P1, P2, and P3 communicated prohibitive instructions against disposing of unused medications in household garbage, toilets, or sinks, respectively, thereby addressing improper disposal routes. P4, P5, and P6 conveyed correct handling practices by discouraging dilution, crushing, or burning of unused medications prior to disposal, with the aim of preserving chemical integrity and preventing environmental contamination. P7 and P8 warned against sharing medications with others, highlighting potential health risks and adverse effects. P9 emphasized the importance of checking medication expiry dates prior to consumption to ensure safety and therapeutic effectiveness. P10 focused on checking expiry dates before purchase to reduce financial loss and unnecessary waste. P11 combined both pre-purchase and pre-consumption expiry checks. P12, P13, and P14 presented varied visual representations reinforcing the importance of checking medication expiry dates. Collectively, these pictograms were designed to support user comprehension and minimize misinterpretation, particularly among individuals with limited health literacy. Table 3 described the common misunderstandings in pictogram comprehension among the participants during the interview process.

Table 3. Misunderstandings in pictograms comprehension

Pictogram number with its text explanation	**Misunderstandings in pictogram comprehension**
P1 Don't throw the unused medications as normal garbage	-Don't throw trash -Medications were unidentified because the size is very small -Medications not only in tablets or capsules form, they can also in forms of bottles and liquid
P2 Don't flush the unused medications down the toilet	-Throwing trash into toilet -Medications is harmless
P3 Don't throw the unused medications in the sink	-Hardly recognized the items being poured
P4 Don't dilute the unused medications before discarding	-Soluble medications act fast in water -Finish drinking the diluted medications
P5 Don't crush the unused medications before discarding	-Do not recognized mortar and pestle -Throwing pestle and mortar into the dustbin
P6 Don't burn the unused medications on your own	-Individual handling fire
P7 Don't share your medications with others	-Unable to recognize the capsule -Don't touch each other -Sanitize regularly
P8 Don't share your medications with others	-Tablet is very small -Don't touch each other
P9, 12, 13, 14 Check expiry dates of medications before using	-EXP text to represent 'expiry' should be bold -Sand timer is not understood -Cannot appreciate the color differences as red highlighting avoid or don't -Magnifying glass to highlight the importance is not understood
P10 Check expiry dates of medications before buying	-Clear meaning
P11 Check expiry dates of medications before using and buying them	-Confuse with the flow of instruction

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4. DISCUSSION

The International Pharmaceutical Federation (FIP) emphasizes the necessity of validating and culturally adapting pharmaceutical pictograms to ensure alignment with the target population's cultural norms, beliefs, and behavioral practices, thereby improving comprehension and usability. Previous studies consistently demonstrate that locally developed pictograms result in higher levels of understanding, acceptance, and preference compared to generic or internationally standardized symbols (Shaji et al., 2023). These findings reinforce the role of cultural relevance as a core principle in communication design, particularly in health-related visual messaging.

The comprehensibility of pharmaceutical pictograms is commonly assessed using standards established by the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO), which require minimum correct interpretation rates of 85% and 66.7%, respectively, for validation. Pictograms that meet both criteria are considered acceptable for public use. While United States Pharmacopeia (USP) pictograms are widely implemented, evidence suggests that they may not be universally understood, particularly in multicultural and multilingual contexts. In Malaysia, prior research has shown that the use of non-local pictograms on medication labels did not significantly improve comprehension or adherence (Chan & Hassali, 2014). Consequently, scholars have advocated for culturally responsive design approaches that incorporate local visual language, symbols, and practices to enhance effective communication (Bellamy et al., 2020).

In the present study, 14 newly designed pharmaceutical pictograms were developed to reflect Malaysian socio-cultural contexts with the aim of improving public understanding of safe medication waste disposal. Low health literacy has been widely identified as a major barrier to effective health communication, particularly when information relies heavily on written or technical language. Individuals with limited literacy skills often struggle to interpret conventional medical instructions, underscoring the importance of visual communication strategies that prioritize clarity, familiarity, and accessibility.

The results demonstrate that all pictograms showed statistically significant improvements in comprehension following verbal and textual explanation. This finding aligns with previous studies reporting that pictograms are most effective when used as part of a multimodal communication strategy rather than as standalone elements (Ng et al., 2017). In line with communication design theory, pictograms function as cognitive anchors that support understanding, but their effectiveness is enhanced when reinforced through complementary verbal and textual cues.

Pharmaceutical pictograms serve as visual aids that simplify complex information, enabling users to process and recall key messages related to safe medication disposal. Research in cognitive psychology and visual communication has shown that visual stimuli enhance memory retention and recognition, as the human brain is more efficient at storing and retrieving visual information compared to text alone (Kheir et al., 2014). This supports the use of pictograms as sustainable communication tools that promote long-term behavioral change by improving message recall and reinforcing environmentally responsible practices.

However, the findings also indicate that pictograms presented without supporting text or verbal explanation were the least comprehensible. This reinforces the notion that pictograms should not replace textual or verbal instructions entirely, as overreliance on visuals may lead to ambiguity or misinterpretation. To address this, the pictograms in this study were intentionally designed to be simple, realistic, and content- specific, reflecting key principles of user-centered and inclusive design. Minimizing visual complexity is critical, particularly when conveying specific behavioral instructions related to health and sustainability.

Despite these design considerations, P14 ("Check expiry dates of medications before using") exhibited persistently

https://doi.org/10.24191/ijad.v10i1.7arvqw22

high rates of misinterpretation both before and after explanation. This may be attributed to the inclusion of multiple icons and symbols within a single pictogram, increasing cognitive load and reducing clarity. The findings suggest that complex pictograms require a higher level of visual literacy and abstraction skills, which may not be uniformly distributed across the population.

Similarly, pictograms designed to convey multiple messages such as P11 ("Check expiry dates of medications before buying and using") posed additional interpretive challenges. Prior to intervention, only 22% of participants provided partially correct interpretations, while 40% interpreted the pictogram incorrectly and 4% interpreted it oppositely. These findings highlight the limitations of multi-message pictograms and emphasize the importance of message prioritization in visual communication design. Notably, comprehension improved significantly following verbal and textual explanation, with correct recognition increasing from 56% to 85%, further supporting the effectiveness of multimodal communication.

The predominantly monochromatic design of the pictograms may also have influenced interpretation. Color has been shown to enhance attention, differentiation, and emotional engagement in visual communication. Additionally, cultural beliefs and visual conventions play a crucial role in shaping familiarity and interpretation. As many widely used pictograms originate from Western contexts, caution must be exercised when applying them across diverse cultural settings without localization (Kanji et al., 2018).

In contrast, the pictograms in this study were designed to reflect Malaysian socio-cultural characteristics, resulting in increased familiarity and improved recognition (Phimarn et al., 2019). For example, P10 incorporated the "RM" symbol representing Malaysian Ringgit, which is immediately recognizable to the local population. This pictogram achieved a 100% correct recognition rate prior to intervention, demonstrating the effectiveness of culturally embedded symbols in enhancing comprehension. Similar results were observed for P1, P2, and P3, which utilized familiar domestic settings such as trash bins, toilets, and sinks commonly found in Malaysian households. The use of recognizable everyday objects reinforces meaning and reduces interpretive effort, consistent with findings from previous studies (Lyra Jr et al., 2014).

Education level has also been identified as a factor influencing pictogram comprehension (Saremi et al., 2020). Higher educational attainment is generally associated with improved visual literacy and abstraction skills, leading to better interpretation and recall of pictorial information. Nevertheless, the present study suggests that cultural familiarity and design clarity may play a more decisive role than education alone, particularly in the context of sustainability-related health communication.

The variability in pictogram comprehension observed among Malaysian participants highlights the importance of user-centered design and iterative testing (Dowse, 2021). Initial comprehension results showed that only 10 pictograms met ISO criteria and 9 met ANSI standards prior to explanation.45 Following a brief intervention, all pictograms met both standards, consistent with findings by Houts et al.32 demonstrating the positive impact of verbal reinforcement. This underscores the role of education and contextual explanation in strengthening visual communication outcomes.

From a sustainability perspective, effective pictogram design contributes to responsible medication disposal behaviors, reducing environmental contamination and promoting public health. Visual communication tools that are culturally appropriate, easily understood, and supported by education can play a critical role in advancing sustainable healthcare practices. The findings support the use of multimodal communication strategies that integrate pictograms with concise textual information and pharmacist counselling, as recommended in prior research.21,50 Such approaches enhance patient safety, improve adherence, and align with WHO recommendations for inclusive and accessible health communication (Kheir et al., 2014).

The mixed-methods approach employed in this pilot study provided both quantitative measures of comprehension and

https://doi.org/10.24191/ijad.v10i1.7arvqw22

qualitative insights into user interpretation, offering a holistic understanding of pictogram effectiveness. A key strength of the study lies in its focus on culturally localized design, distinguishing it from research that applies Western-designed pictograms in non-Western contexts. By involving participants from multiple states and age groups, the study highlights the central role of cultural context in shaping interpretation.

Overall, the findings demonstrate that pharmaceutical pictograms are a valuable communication design tool for promoting medication safety and sustainability. However, their effectiveness is maximized when embedded within a broader communication system that includes education, contextual explanation, and continuous usability testing. This study contributes to the growing body of design-led health communication research by demonstrating how culturally responsive visual design can support sustainable public health outcomes.

5. CONCLUSION

This pilot study demonstrates that culturally localized pharmaceutical pictograms are an effective communication design intervention for improving public understanding of safe medication disposal. By embedding Malaysian socio-cultural references into pictogram design and evaluating user comprehension through a participatory, user-centered approach, the findings highlight the capacity of visual communication to translate complex health information into accessible and actionable knowledge. From a design-for- sustainability perspective, the use of pictograms supports environmentally responsible behavior by encouraging proper medication disposal, thereby reducing pharmaceutical waste and associated environmental risks. The results further indicate that pictograms are most effective when integrated with verbal and textual explanations, underscoring the importance of multimodal communication systems in sustaining behavioral change. Importantly, pictograms incorporating familiar symbols and everyday contexts achieved higher recognition rates, reinforcing the necessity of culturally responsive design. In alignment with the Sustainable Development Goals, this study contributes to SDG 3 (Good Health and Well-being), SDG 12 (Responsible Consumption and Production), and SDG 6 (Clean Water and Sanitation), positioning design-led visual communication as a scalable and sustainable public health strategy.

6. LIMITATIONS

This study has several limitations. As a pilot study, the proportion of elderly participants was low (4%), limiting the ability to conduct robust age-related analyses. Additionally, the recall assessment measured only short-term memory due to immediate reassessment, which may not reflect long-term retention. The study also did not examine the impact of pictogram size or legibility on interpretation performance.

Despite these limitations, the findings provide valuable preliminary evidence supporting the role of pictograms as a sustainable communication tool for educating the public on safe medication disposal. The results offer a strong foundation for future large-scale studies incorporating diverse demographic groups, longitudinal recall assessments, and advanced design variables.

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CONFLICT OF INTEREST STATEMENT

The author declares that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHORS' CONTRIBUTIONS

The individual contributions of the authors are specified as follows:
Mohamed Razeef Abdul Razak: Concept and development of pictograms.
Hisyam Abdul Hamid: Recruitment of participants and data integration.
Noreen Husain: Drafting the work and revising it critically for important intellectual content. Zafirah Liyana Abdullah: Provided technical assistance, data collection, and visualization support.
Siti Nooraishah Hussin: Overall project supervision. Responsible for communication with the journal and ensuring the integrity of the final manuscript.

ETHICS STATEMENT

Ethical approval for the study was obtained from the Research Ethics Committee of Universiti Teknologi MARA (UiTM) (REC(PH)/UG/168/2024). All procedures involving human participants were conducted in accordance with institutional ethical standards and the principles of the 1964 Helsinki Declaration. Informed consent was obtained from all participants, and data anonymity was strictly maintained throughout the study.

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