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An overview on factors influencing the development of pictogram & designs in pharmaceuticals

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ABSTRACT

Pharmaceutical pictograms are widely used to improve the communication of medication instructions, precautions, and warnings, particularly among patients with limited health literacy, language barriers, or poor reading skills. Although numerous studies have examined pictogram effectiveness, evidence describing the pharmaceutical pictogram development process remains fragmented. This narrative review aimed to synthesise the evidence on pharmaceutical pictogram development by integrating findings on design approaches, development methods, validation, and evaluation. A literature search was conducted across Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar to identify relevant peer-reviewed journal articles and conference proceedings published between 2004 and 2026. Studies were selected based on their relevance to the design, redesign, modification, development, validation, evaluation, or implementation of pharmaceutical pictograms. Following title, abstract, and full-text screening, 46 studies were included in the thematic synthesis. The extracted evidence was coded, grouped into conceptual categories, and synthesised into five themes: (1) Visual Design Approach, (2) Method, Design Models and Frameworks, (3) Collaborative and User-Centred Design, (4) Design Performance and Validation, and (5) Evaluation and User Acceptance. The review demonstrates that effective pharmaceutical pictogram development depends on integrating evidence-based visual design, multidisciplinary collaboration, progressive user-centred refinement, and rigorous validation rather than relying solely on graphic design principles. The findings support the development of internationally standardised pharmaceutical pictogram guidelines by promoting user-centred design, culturally adapted pictograms, objective evaluation methods, and systematic validation using recognised standards, thereby contributing to safer and more effective medication communication across diverse patient populations.

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1. INTRODUCTION

Medication safety remains a major global public health concern, as medication misuse continues to contribute to medication errors, preventable adverse events, avoidable hospitalisations, and increasing healthcare costs. Patients are often required to interpret complex medication information, including dosage schedules, administration methods, storage instructions, safety precautions, and potential adverse effects. Difficulties in understanding this information are particularly evident among individuals with limited health literacy, language barriers, or reduced cognitive ability, increasing the likelihood of inappropriate medicine use.

This heavy reliance on patient-led instruction highlights a critical vulnerability in the therapeutic process, underscoring the urgent need for enhanced communication strategies to align clinical mandates with patient practice. To mitigate these risks, pharmaceutical pictograms serve as a vital auxiliary strategy, bridging the gap between clinical intent and patient comprehension by providing intuitive visual guidance. Beyond mere comprehension, these visual tools offer a universal language that effectively transcends linguistic and cultural barriers, proving particularly beneficial, especially for elderly populations or individuals with low health literacy (Mourad et al., 2023).

By simplifying complex instructions into stylised graphic representations, these symbols reduce the cognitive effort required to process technical terminology and pharmacological directions (Pedersen et al., 2021). Furthermore, beyond immediate cognitive support, empirical evidence suggests that well-designed pictograms enhance patient recall and long-term adherence to prescribed treatment regimens (Dowse & Ehlers, 1998). However, despite their potential, many existing pictorial aids fail to meet established comprehension criteria, necessitating more rigorous design and validation processes to ensure they align with international standards such as those defined by ISO or ANSI (Tumkur et al., 2025).

Nevertheless, these instructions are often provided in written text that can be difficult to interpret, especially for older adults, those with low health literacy skills, and patients with language limitations. (Dowse, 2022; World Health Organization [WHO], 2022). To communicate these problems, health care systems have begun to use more and more pharmaceutical pictograms, graphic symbols designed to communicate medication information by means of visual images rather than words alone. By leveraging these visual aids, practitioners can mitigate the risks associated with misinterpreting complex regimens, thereby addressing the significant health disparities linked to literacy, numeracy, and cognitive limitations (Wolpin et al., 2016). Indeed, incorporating such visual aids alongside traditional oral and written counselling has been shown to significantly improve medication adherence in patient populations at high risk for non-compliance (Sletvold et al., 2020). Moreover, these pictorial interventions demonstrate efficacy among individuals with limited health literacy compared to conventional text-based or oral methods alone (Menon et al., 2021).

Pictograms are frequently used in pharmaceuticals on labels of medicines, packaging, patient information leaflets and educational materials to support written or verbal instructions. The rationale for their use is that visual information can aid understanding, recall and communication, particularly in cases where patients have difficulty reading or understanding written information (United States Pharmacopeia, n.d.). The United States Pharmacopeial Convention (USP) has developed a series of 81 standard medicinal pictograms that are freely available to anyone. These images are to help people understand written or spoken directions for taking medication from health care professionals. The rising trend of patient-centred communication in healthcare has led to pharmaceutical pictograms becoming an important tool for improving medication safety and supporting an important tool for improving medication safety and supporting appropriate use of medicines.

Despite these advances, the existing literature remains fragmented across different areas of pharmaceutical pictogram research. Considerable variation exists in the design frameworks, validation processes, target populations, evaluation criteria, and theoretical perspectives employed across studies. Some studies primarily focus on the development of new pictograms, whereas others examine redesign, modification, cultural adaptation, comprehension testing, validation, or implementation in clinical practice.

Similarly, researchers use different standards, such as the International Organization for Standardisation (ISO) and the American National Standards Institute (ANSI), to assess pictogram comprehension, making it difficult to compare directly across studies (Malhotra et al., 2023; Tumkur et al., 2025). Furthermore, the acceleration of pictogram research has outpaced the current ability of reviews to synthesise the evidence, driven by recent advances in user-centred design, visual cognition, digital technologies and artificial intelligence. Most published reviews focus on the effectiveness of the pictograms, adherence to medication or patient understanding, with little consideration of the full design development process from concept development to implementation (Dowse, 2021; Sletvold & Nguyen, 2021; Russell et al., 2025; Arshad et al., 2026)

Thus, researchers, designers and healthcare professionals still lack a comprehensive view on how pharmaceutical pictograms should be systematically designed, developed, modified, validated and applied in practice. The available evidence is characterised by substantial methodological heterogeneity, including differences in study designs, pictogram development approaches, theoretical perspectives, validation methods, target populations, and outcome measures. These differences limit meaningful quantitative comparison across studies. Therefore, a narrative review was selected to allow conceptually diverse evidence from graphic design, pharmaceutical sciences, cognitive psychology, and health communication to be integrated and interpreted through thematic synthesis. This approach is particularly appropriate for examining the broader pharmaceutical pictogram development process rather than estimating a single pooled intervention effect. This review aims to synthesise existing evidence on the systematic design, development, and validation of pharmaceutical pictograms, highlighting current methodological challenges and identifying gaps that limit clinical adoption (Russell et al., 2025; Arshad et al., 2026). Unlike previous reviews that have primarily examined pictogram effectiveness, medication adherence, or patient comprehension, this review focuses on the broader process of pharmaceutical pictogram development. It integrates fragmented evidence into five interconnected themes covering visual design approaches, development methods and frameworks, collaborative and user-centred design, design performance and validation, and evaluation and user acceptance. The review also connects graphic design principles with pharmaceutical communication, cognitive processing, and medication safety. Particular attention is given to emerging objective evaluation techniques, including eye-tracking, that can provide empirical evidence of visual attention during pictogram evaluation. By integrating these perspectives, the review provides a structured evidence base for the future development of standardised pharmaceutical pictogram guidelines.

2. PICTOGRAMS AND DESIGN IN PHARMACEUTICALS

2.1 Pharmaceutical pictograms

Pharmaceutical pictograms are visual representations that are standardised to overcome communication barriers by using symbols instead of words to convey essential medication instructions (Russell et al., 2025). These tools use graphical signs to stimulate verbal memory and are designed to improve medication adherence, especially in the elderly, the visually impaired and low-literacy populations (Merks, Cameron, et al., 2021). Clear instructions are crucial because patient misunderstanding is a major factor in medication errors and reduced therapeutic outcomes (Merks et al., 2022; Saif et al., 2024). With the purpose to reduce the ambiguity of linguistic instructions by taking into consideration the different cognitive and cultural needs of patients, such visual aids have been developed (Mourad et al., 2023; Figueroa et al., 2024).

2.2 Pictogrammatic representation in graphic design

The history of pictograms is long, from the ancient ideographic systems to the contemporary standardised visual languages. The design of pictograms is based on Peircean semiotics, which classifies signs as icons, indices or symbols (Shaer & Hornecker, 2010). Beyond this classification, modern cognitive models propose that viewers interpret these signs by merging novel visual experiences with pre-existing learned associations (Hawkins et al., 2023).The interpretive process often utilises semiotic theories to deconstruct the physical signifiers that evoke specific mental concepts (Pelet et al., 2020; Song et al., 2023). thereby bridging the gap between abstract content, factual information and pictorial representation.

The empirical evaluations of this effectiveness are directed towards metrics such as guessability, semantic distance and general comprehensibility for different user groups (Bovea et al., 2021). The graphic economy principle is central to this development, which requires a trade-off between visual simplification and cognitive load reduction to enable accurate transmission of meaning (Lallie et al., 2020). In addition, visual hierarchies support such cognitive processing by grouping elements to reduce ambiguity, enabling users to quickly parse complex information structures according to their intrinsic semantic relationships (Shi et al., 2023). These suggest that the effectiveness of pictograms depends on the interplay of semiotic meaning, cognitive processing and visual design. While previous work has provided useful design elements and principles, further work is needed to understand how these elements and principles affect the users' visual attention and interpretation in real-world medication communication.

2.3 Pictograms overview

Pictograms, which come from the Latin word 'pictus' meaning 'painted' and the suffix 'graph' meaning 'something written', are graphic representations of concepts or ideas that can be used to communicate messages and information in a clear, simple, concise, and expeditious manner to a wide audience irrespective of language, age, or literacy skills (Sorfleet et al., 2009; Montagne, 2013; Vaillancourt et al., 2019; Merks, Świeczkowski, Balcerzak, et al., 2021; Mourad et al., 2023) pictogram is a stylised representation that conveys information in a figurative manner, immediately indicating an object or expressing a concept that serve multiple uses (Tijus et al., 2007).

According to the United States Pharmacopoeia (USP) official web page, pictograms were defined as standardised graphic images that help convey medication instructions, precautions, and warnings to patients and consumers. Pictograms are especially valuable for people with inadequate literacy skills or those who are not fluent in English. A pictogram is a simple visual symbol designed to attract attention and communicate information quickly and clearly without relying on written or spoken language. Sheikh et al. (2019) mentioned that the WHO's Management Team on Research Priorities for Medication Safety has designated the creation and deployment of universally applicable pictograms to mitigate medication-related issues as a critical research goal. Regulatory bodies increasingly emphasise international standardisation to ensure that graphic symbols remain consistent across diverse patient populations, minimising the risks associated with medication errors (Lester et al., 2021).These efforts often necessitate rigorous testing of semantic distance and user recognition to bridge the gap between abstract design, factual information and real-world comprehension setting.

2.4 Visual communication definition and role in knowledge construction

Visual communication is the conscious use of images and symbolic systems to encode, transmit and interpret information, and it is an important link between human cognition and external data (Doğan & Doğan, 2025). This field provides a vehicle for the exchange of complex information through visual symbols, transcending the mere transfer of data to actively constructing knowledge (Amoateng et al., 2022; Wang, 2024). By leveraging the "picture superiority effect", these visual-based interventions facilitate dual-encoding procedures that engage both sensory and verbal systems, significantly reinforcing the cognitive retention of medical instructions compared to purely linguistic formats (Galmarini et al., 2024). This multimodal approach has proven particularly effective in enhancing patient comprehension of complex dosing regimens, where visual cues act as instant reminders of hazardous warnings (Mansukhani, 2015). Furthermore, integrating such graphical elements into informed consent forms and clinical documentation has been shown to improve engagement and patient outcomes by reducing the reliance on overly complex technical language (Jambor et al., 2025).

The Shannon-Weaver Model of Communication (1948) in (Fig. 1) conceptualises communication as the transmission of information from a sender through a communication channel to a receiver, with noise potentially interfering with message transmission. Within this model, communication effectiveness depends on how accurately information is encoded, transmitted, decoded, and understood. However, pharmaceutical pictogram communication also involves the interpretation of visual meaning. Peirce's Semiotic Model (Fig. 2) therefore provides a complementary perspective by explaining how meaning emerges through the relationship between the representamen, object, and interpretant. In pharmaceutical pictogram design, this perspective is particularly relevant because successful communication depends not only on transmitting a visual message but also on whether users interpret the visual sign according to its intended medication meaning. However, current research is increasingly focusing on (Peirce, 1932) Semiotic Model (Triadic Model) and cognitive psychology in order to deal with the complex process of interpretation (Günay, 2021). This (Gao et al., 2024) step recognises that visual dissemination is a triadic interaction between the sender, the message, and the audience and that it is mediated by particular channels that influence the decoding (Gao et al., 2024). Theoretical models today, however, tend to overlook the autonomy of visual design elements, reducing them to decorative adjuncts rather than recognising them as independent systems of meaning generation (Türk, 2023). To address this, recent frameworks propose a visual syntax that treats individual icons as semantic primitives capable of forming complex, language-independent instructions (Rane & Waarde, 2025). This transition shifts the focus from static representation to dynamic information systems, where the web interface serves as the conduit for structured visual data. Within this paradigm, the design of these interfaces must account for human physiological and psychological responses to visual stimuli to ensure that information processing remains both efficient and accurate (Wang, 2024).

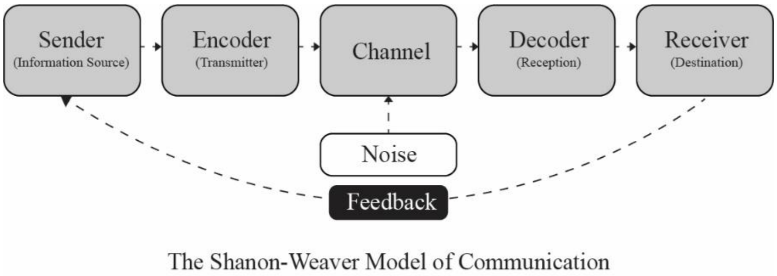

Fig. 1. Shannon-weaver model of communication (Shannon, 1948)

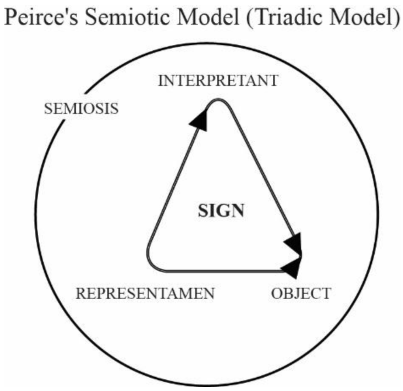

Fig. 2. Peirce's semiotic model (Triadic Model) (Peirce, 1932)

2.5 Graphic design principles overview

Graphic design is a field that uses visual components to convey information, tackle communication issues and shape the audience's view of messages. Graphic design is more than just visuals. It is the arrangement of typography, design elements such as images, colours, forms, shapes, symbols, and layouts to create visual messages that are clear, meaningful, and easy to understand (Frascara, 2004). Good graphic design employs principles such as visual hierarchy, contrast, balance, alignment, proximity, and simplicity to guide the user's attention and reduce cognitive load during information processing (Lupton & Phillips, 2015). These principles are especially relevant in healthcare, as well-designed visual resources enhance understanding, facilitate decision-making, and reduce communication errors. Therefore, graphic design is an essential theoretical basis for producing pharmacological pictograms that are visually clear, recognisable, and easy to grasp for different patient populations (Lidwell et al., 2024). Furthermore, applying Gestalt principles and semiological rules allows designers to structure these elements into rigorous visual languages that reduce the cognitive obstacles inherent in accessing complex healthcare information (Lamy et al., 2008). By synthesising these elements into a cohesive whole, designers can leverage gestalt perception to ensure that information is processed holistically rather than as isolated, and separated data points (Williams, 2024). These organisational theories facilitate the grouping of elements into meaningful "chunks", thereby overcoming the inherent limitations of human sensory processing and enhancing the efficiency of information retention (Jambor & Bornhäuser, 2024).

Besides that, graphic design also is a fundamental visual language, which are based on signs and symbols, to express complex information and solve particular visual problems (Günay, 2021). The field has developed from simple pictographic communication to a sophisticated, technology-driven discipline that uses typography, colour and layout to influence human perception (Chen et al., 2024; Drumeva, 2025). Besides its art background, the field now also stresses the strategic use of visuals mechanic to help solve problems and communicate information to targeted audiences effectively (Liao & Hu, 2023; Alim & Rahim, 2021). This strategic application of visual communication tools aims to achieve a functional Gestalt effect, whereby the harmonised arrangement of elements elicits a psychological and aesthetic response that transcends the sum of its individual components (Ozretić Došen & Brkljačić, 2018). By systematically applying the Gestalt principles of proximity, similarity, and closure, designers can effectively guide the viewer's eye, ensuring that disparate graphical elements are synthesised into a coherent and easily decodable organisational structure (Cavaller, 2021; Khamis et al., 2023).

3. MATERIAL & METHODOLOGY

3.1 Review design

This study adopted a narrative review approach to synthesise the existing literature on pharmaceutical pictogram development. A narrative review was considered appropriate because the available literature encompasses heterogeneous study designs, development methods, theoretical perspectives, validation approaches, target populations, and outcome measures. Such methodological diversity limits direct quantitative comparison and statistical aggregation. The narrative approach therefore allowed evidence from different disciplines and methodological traditions to be conceptually integrated through thematic synthesis. The review focused on obtaining a comprehensive understanding of pharmaceutical pictogram design, development, validation, evaluation, and implementation rather than estimating a pooled intervention effect.

3.2 Literature search

Relevant literature was identified through searches of Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar. These databases were selected because they cover pharmaceutical sciences, healthcare communication, graphic design, human factors, and visual communication. Additional relevant studies were identified through manual screening of reference lists from key publications. The review included peer-reviewed journal articles and conference proceedings published between 2004 and 2026, together with foundational references where relevant to the development of pharmaceutical pictograms.

3.3 Study selection

Studies were included if they investigated the design, redesign, modification, development, validation, evaluation, or application of pharmaceutical pictograms. Research addressing visual communication principles, user-centred design, cognitive processing, medication communication, and pictogram comprehension was also considered when directly related to pharmaceutical pictogram development.

Editorials, opinion papers, duplicate publications, non-English and studies unrelated to pharmaceutical pictograms were excluded.

3.4 Data extraction and synthesis

Information extracted from each study included the study objective, methodology, key findings, and design-related evidence. The extracted data were organised into a master evidence matrix and analysed using thematic synthesis. Similar findings were coded and grouped into conceptual categories, which were subsequently synthesised into five themes: Visual Design Approach; Method, Design Models and Frameworks; Collaborative and User-Centred Design; Design Performance and Validation; and Evaluation and User Acceptance. These themes provide an integrated overview of the current evidence on pharmaceutical pictogram development.

3.5 Framework

Fig. 3 illustrates the evidence-based pharmaceutical pictogram development process synthesised from the reviewed literature. The framework demonstrates that pharmaceutical pictogram development progresses through five interconnected stages. The process begins with the application of appropriate visual design principles, followed by structured development methods and design frameworks. It then incorporates collaborative and user-centred design through active stakeholder involvement before proceeding to empirical validation using recognised evaluation methods. Finally, pictograms are evaluated for user acceptance and implemented in healthcare practice to support safe and effective medication communication.

4. FACTORS INFLUENCING THE DEVELOPMENT OF PHARMACEUTICAL PICTOGRAM DESIGN

4.1 Visual design approach

The popular design approach referred to when designing, redesigning or modifying a pictogram was the semiotic method. This method was used to determine the main graphical elements for each of the safety messages to be communicated. Semiotic analysis is the analysis and deconstruction of the components of an image and how they are received by the population.

This strategy of visual communication is theoretically based on semiotics and cognitive theories of perception. These theories suggest that visual representations are not inherently intuitive and therefore require rigorous design processes to ensure universal readability (Bühler et al., 2022). Previous studies have also indicated that symbol standardisation, colour contrast, and information hierarchy are important factors that affect visual detectability and hazard identification (Weng & Ren, 2025). These factors facilitate hazard detection by improving the visibility, consistency, and prominence of critical visual information, enabling users to locate and recognise hazard symbols more quickly and accurately. Standardised symbols reduce

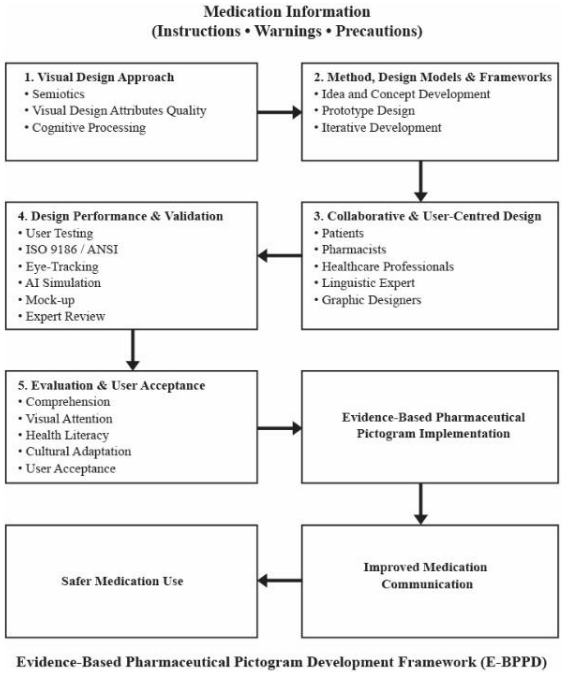

Fig. 3. Evidence-based pharmaceutical pictogram development framework

ambiguity, high colour contrast increases visual salience, and a clear information hierarchy directs attention to essential warning elements. Consequently, these design features enhance message comprehension, reduce interpretation errors, and support safer decision-making in high-risk environments. In addition to these formal features, the empirical literature reveals that the semantic classification of symbols, from monosemic to pansemic, has a large impact on interpretability. This is because users are already experienced with standardised visual languages (Ugaya Mazza et al., 2023).

Moreover, design features, such as concreteness, familiarity, and semantic accuracy, are important cognitive determinants facilitating symbol comprehension (Pedersen et al., 2021; Deng et al., 2025). This is particularly among a variety of user groups. Moreover, research has demonstrated that the combination of pictograms and redundant textual parts generates a more robust information structure, which contributes to understanding the information and carrying out the task at hand (Medina-Córdoba et al., 2021). Additionally, recent research has addressed the spatial arrangement of these graphical components, including the use of divided versus combined layouts as an important factor in the interpretation of complex clinical risks by diverse users with different cognitive abilities and numeracy (Wang & Zheng, 2025). This cognitive processing is supported by the dual coding theory, which states that visual cues are reinforced when processed through sensory and verbal channels simultaneously. This minimises the cognitive load that occurs when processing information (Galmarini et al., 2024). Moreover, other studies complementary to hybrid visualisation show that embedding semantic context in these graphical representations could close the gap between abstract data and intuitive recognition (Xiao et al., 2024).

However, scientific debate often points to a continuing disjunction between empirical evidence and the prescriptive norms that practitioners currently apply (González-Sordé & Matamala, 2024; Kim et al., 2026). And yet, having these insights delivered by Chen et al. (2022) in their study investigating how visual methods can support older adults with cognitive impairment, found that visual communication tools such as video clips, photos, and pictograms also contribute towards increasing participants' understanding, improving communication, and facilitating decision-making. Patients also reported better comprehension of health information, increased engagement during communication, greater confidence in making healthcare decisions, and a stronger feeling of being well informed (Bogza et al., 2020; Chang & Bourgeois, 2020; Reeves et al., 2020; Gruters et al., 2021; Burshnic & Bourgeois, 2022). These findings suggest that visual communication is an effective strategy for enhancing the overall patient education experience. Visual design is an important factor for the effectiveness of pharmaceutical pictograms. Well-designed pictograms help users to find and understand information faster than conventional pictograms (Reijnen et al., 2022). Nevertheless, the mere simplification of graphic elements does not mean a better understanding. This is because design features such as line thinness and thickness, figure-ground contrast, different font sizes, appropriate visual complexity and clear visual organisation are also important in improving pictogram clarity (Pedersen, 2021). This means that a good pictogram design is not simply a question of visual simplification. Successful pictograms rely on a number of visual design attributes which in combination enhance perceptual clarity and visual processing. Several studies also underlined the importance of a structured design and validation process for the development of pharmaceutical pictograms.

Collectively, the reviewed studies demonstrate that pharmaceutical pictograms are most effective when simple graphical representations are integrated with clear textual information and evidence-based visual design principles. Rather than relying solely on graphical simplification, successful pictograms combine semantic clarity, appropriate visual hierarchy, figure-ground contrast, typography, and iterative validation to improve comprehension and medication adherence (Dowse, 2021; Pedersen et al., 2021; Reijnen et al., 2022). They also suggested that further investigation is required on the combination of design principles focused on readability, legibility, visibility by addressing factors such as size, colour, shape, line thickness and figure-background contrast in this study. Repeated user testing and expert review to improve the quality of the pictogram before implementation also need to be implemented. Clear, simple and appropriate visual design helps patients understand medication information (Dowse, 2021; Dowse et al., 2023).

Figueroa et al. (2023) found that physicians considered pharmaceutical pictograms to be most useful for communicating complex medication instructions, particularly those related to treatment, symptom management, and dietary advice. However, pictograms were considered less necessary for simpler patient care instructions, suggesting that pictogram use should focus on information that patients are more likely to misunderstand. In a previous study by Schubbe et al. (2020), they discovered that using pictograms with an average of 14 words per picture helped people learn and understand more; using pictograms with 5 to10 words per picture helped people remember how to give themselves eye medications after surgery; using pictograms with 4 words per picture helped people take their medications as prescribed; and using pictograms with 1 to 24 words per picture improved medication concordance, immunisation status, and dosing accuracy.

This also agreed by Sletvold et al. (2020) that pharmaceutical pictograms can assist patients in taking their medications correctly such pictograms are helpful for patients with low health literacy because they simplify medication information and make it easier to understand and follow. Even pictograms are more useful if used alongside written or spoken instructions, helping patients to better understand and remember how to take their medicines (Dowse, 2021; Bhagat et al., 2026) remain important. However, it does not always result in better medication use because social and cultural factors can also influence patients' behaviour.

In their study on best practices for the design and development of Prescription Medication Information (PMI) materials, Mullen et al. (2018) found that the use of plain language, typographic cues (e.g., bold text and bullet points), standardised formats (e.g., the "Drug Facts" box), quantitative descriptors, explicit and simplified dosing instructions, numeric characters on container labels, and the incorporation of pictograms and illustrations significantly improved the readability and comprehensibility of prescription medication information. These design strategies were most effective when combined with simplified text, concise content, and a lower reading level (≤5th grade) in both written materials and multimedia tools. Collectively, these approaches reduced cognitive burden, facilitated information retrieval, and enabled patients to identify, understand, and apply medication instructions more accurately.

4.2 Method, design models and frameworks

The use of structured frameworks to guide the development of pharmaceutical pictograms is increasingly recommended by researchers. Montagne (2013) introduced systematic models based on design principles, user testing and a combination of iterative design processes, user feedback and testing their level of understanding and usefulness of pictograms in medication information materials. More recent frameworks have taken a human-centred approach, focusing on user needs, inclusivity and ongoing evaluation throughout the design process (Neves et al., 2022). The Universal Pharmaceutical Pictogram Process (UIPP) also proposes a six-step framework based on semiotics, theories of intuitive interaction and visual perception based on visual perception and sensorimotor principles. This includes six steps starting with planning the process, analysing the context of use, specifying the reference relation, specifying the design relation, evaluating the prototypes and discussing the results (Bühler et al., 2022).

Dowse (2021) is another researcher who develops ideas in the first stage. Different methodologies have been used, including Delphi-based processes, focus group discussions, workshops or semi-structured interviews. The graphic artist or designer usually creates initial visuals based on these ideas and concepts. This stage should then be followed by an iterative multi-stage modification and refinement process with the design team. Unlike classic studies, based on questionnaires, interviews or comprehension tests, eye tracking measures the visual attention of users to pictograms while they are being interpreted. Memişoğlu and Girişken (2022) proved that eye tracking can be used as a method to evaluate the placement of pictograms on a pharmaceutical package by analysing the fixation patterns and visual attention. Also, Kovačević et al. (2023) identified that pictogram design elements such as visual prominence had a significant role in attracting users' attention. More recently, Albarrán Morillo et al. (2025) demonstrated that eye tracking can be used to objectively assess visual behaviour in pharmaceutical environments, thus confirming its usefulness as an evidence-based tool to enhance visual design in healthcare settings. This means a more reliable approach to structured development frameworks rather than ad hoc design practices. At the same time, standardised methodologies improve the consistency, usability and overall quality of pharmaceutical pictograms.

4.3 Collaborative and user-centred

This is a common finding from previous research that pharmaceutical pictograms are more easily understood when the intended users are actively involved in the design process as opposed to having the development solely conducted by graphic designers or healthcare professionals. Mansoor et al. (2004) found that when intended users were involved in the design process, the resulting pictograms proved more culturally appropriate and easier to understand, especially among low-literate populations. Since then, this collaborative approach has grown into more general international design practices, involving healthcare experts, designers, and end users through multiple redesign, modification and validation cycles. For example, international consensus methods have been successful in producing pictograms that better represent medication safety information across different health care settings (Vaillancourt et al., 2018, 2019).

Dowse (2021) states that pharmaceutical pictograms are more effective when patients, health professionals, pharmacists and graphic designers collaborate on the design process. The development of new pictograms or improvements to existing ones might be a structured process with several stages, frequent feedback from end users, and cooperation with specialists from various fields. Working together this way helps to make pictograms that are easier to understand and more suitable for people from different literacy and cultural backgrounds. Similarly, Nguyen et al. (2022) and Humphrey et al. (2024) found that co-design with users led to pictograms that were more relevant, interpretable and acceptable for children and healthcare professionals. These findings indicate that including end-users in the design process can enhance the quality, usability and acceptability of pharmaceutical pictograms.

Similarly, participatory design with low-literate adults has shown that users prefer pictograms with familiar and culturally meaningful visual elements over abstract representations, underscoring the importance of engaging end users throughout the design process as well (Jami et al., 2025). End user collaboration is a critical element of pharmaceutical pictogram development. Their involvement helps to ensure that pictograms are culturally appropriate, meaningful and easier to interpret for varied populations. Furthermore, employing iterative design and validation cycles ensures that these visual aids achieve high guessability scores and remain responsive to specific patient feedback (Merks et al., 2018; Dowse, 2021). However, while traditional participatory design is effective, its implementation can be constrained by high costs and time expenditure, leading researchers to explore digital solutions like crowdsourcing as a more scalable alternative (Yu et al., 2013). By facilitating rapid, large-scale engagement with diverse patient groups, these digital platforms can streamline the repeated consultative involvement necessary to refine visual aids for low-literate users (van Beusekom et al., 2017). Furthermore, the quality of this developmental process remains paramount, as international recommendations suggest that rigorous transparency and translucency testing are essential for ensuring the utility of these visual tools (Sedeh et al., 2022). Beyond these validation techniques, effective software and technical solutions can facilitate the implementation of pharmaceutical pictograms within community pharmacy practice (Merks, Świeczkowski, Religioni, et al., 2021).

4.4 Design performance and validation

In this stage, several studies have shown that redesign, modifying and user validation improve the performance of pharmaceutical pictograms. Malhotra et al. (2023) demonstrated that user-centred redesign and validation improved the performance of pharmaceutical pictograms among older adults. Of the 27 pictograms evaluated, 10 were fully validated and five were partially validated, with pictograms representing dose, route of administration, and precautions demonstrating better validation performance than those representing indications and side effects. Pictogram comprehension also varied according to participant characteristics, particularly age and educational level. Moreover, Ho et al. (2023) and Ferreira-Alfaya et al. (2024) point out the need to validate pictograms with the intended population to ensure that they are clear, culturally appropriate and easy to understand. Furthermore, the successful integration of these validated visual aids into clinical settings can significantly reduce medication errors and improve overall adherence among vulnerable patient groups (Malhotra et al., 2023).

Similarly, culturally adapted pictograms were better accepted by adults with low literacy, as they used familiar images and real-life contexts (Jami et al., 2025). The children also demonstrated good understanding of the standardised pharmaceutical pictograms, reinforcing the use of pictograms in medication communication for different age groups, making the pictograms more meaningful when they are culturally adapted and designed based on the needs of the target users (Humphrey et al., 2024).

In addition, redesigning based on user-centred principles, cultural adaptation and empirical validation can greatly improve the effectiveness of the pictograms. It also suggests that structured processes for development and validation are crucial to produce reliable and effective pharmaceutical pictograms. A previous study reported by Gutierrez et al. (2022) revealed that only 17 of 108 (15.74%) pharmaceutical pictograms from the United States Pharmacopoeia (USP) and International Pharmacy Federation (FIP) met the American National Standards Institute (ANSI) criterion of 85% comprehension among Filipino adults. Filipinos had a median score of 71 out of 108 pictograms (interquartile range, 10-96). The study identified education level as the significant predictor of pictogram comprehension, with participants below Grade 12 scoring significantly lower than those with higher education. This suggests that the use of verbal and written instructions to supplement pictograms can improve comprehension. However, the level of education will affect the comprehension. It is recommended to include multiple demographic backgrounds in the validation process.

4.5 Evaluation and user acceptance

Previous years ago, Dowse et al. (2023) conducted a study to investigate the associations between health literacy (HL) and understanding of pharmaceutical pictograms representing indication and side effect information in a lower literacy, limited English proficiency (LEP) population in South Africa. The results indicated that the mean pictogram comprehension score was 7.9/10, with 8/10 pictograms meeting the International Organisation for Standardisation criterion of 66.7% correct comprehension. Only 15.6% of participants had adequate HL, while 53.3% had marginal HL. There was a significant association between HL and pictogram comprehension ($p=0.002$), with higher HL correlating with better comprehension. Lower HL was associated with a higher likelihood of misinterpreting pictograms, while adequate HL was linked to better understanding. Negative association between age and pictogram comprehension ($p<0.006$) and positive association between pictogram comprehension and education ($p<0.001$) and English proficiency ($p<0.001$). This suggests that health literacy is one of the most influential factors on interpretation, as people with higher health literacy tend to have a better understanding of pharmaceutical pictograms. These findings also suggest that applying standardised criteria does not necessarily guarantee universal comprehension, and they emphasise the necessity of constant assessments to enhance the effectiveness of pictograms. This review demonstrated that evaluation is an essential part of pictogram development, but regular testing reveals pictograms that need to be improved and makes sure that designs are understood by different patient groups.

Patient acceptance is important for the effective use of pharmaceutical pictograms in health care in addition to comprehension. In a study in Malaysia, 17 pictograms met the ISO criteria of >67% correct recognition rate, and 7 pictograms met the ANSI criteria of >85% prior to any explanation. The objective of this study was to evaluate the understanding of 22 Malaysian pharmaceutical pictograms prepared by 800 participants from 4 different regions in Malaysia. Twenty-two pictograms met the ISO criteria. After explanations, only 20 pictograms met the ANSI criteria. Patients generally had positive views about pharmaceutical pictograms and were accepting of their use to supplement medication information (Tumkur et al., 2025). Education level, age, ethnicity, residence address, complexity of pictograms and regional differences were the main factors affecting the interpretation performance according to this study. Perhaps they suggest that positive attitudes do not necessarily lead to correct understanding. In conclusion, results clearly demonstrate that the age factor was related to comprehension performance in different ways; thus, pictograms should be evaluated across different patient populations to ensure that they are understood widely and effectively support medication communication.

5. RESULTS

A total of 46 unique studies were included in the thematic synthesis. The analysis generated five interconnected themes: Visual Design Approach, Method, Design Models and Frameworks, Collaborative and User-Centred Design, Design Performance and Validation, and Evaluation and User Acceptance.

Table 1 findings indicate that effective pharmaceutical pictogram design relies on semantic accuracy, visual clarity, structured design processes, and user-centred evaluation. Design attributes such as standardisation, familiarity, colour contrast, layout organisation, readability, legibility, typography, and text-pictogram integration consistently improve comprehension, visual communication, and medication adherence. The studies also emphasise the importance of iterative validation and empirical testing to ensure pictograms accurately communicate medication information across diverse user populations. However, a gap remains between existing design guidelines and empirical evidence, highlighting the need for an evidence-based pharmaceutical pictogram design framework.

In Table 2, findings show that current design frameworks primarily emphasise structured development, user-centred design, and iterative validation. However, recent evidence suggests that objective methods such as eye-tracking provide measurable data on visual attention, pictogram placement, and visual prominence, yet these measures are not consistently incorporated into existing design frameworks. This highlights the need for an evidence-based pharmaceutical pictogram design framework that integrates both structured design principles and objective visual evaluation methods. For collaborative and user-centred factor in Table 3, findings indicate that collaborative and user-centred approaches consistently improve the relevance, comprehensibility, and cultural appropriateness of pharmaceutical pictograms through stakeholder involvement, co-design, and iterative validation. While earlier studies focused on end-user participation and expert review, recent studies extend these approaches by incorporating digital participation, crowdsourcing, and technical infrastructure to support more efficient and scalable pictogram development.

Table 1. Visual design approach factor

No	Study	Key Findings	Code	Category	Theme
1	Bühler et al., 2022	Visual representations are not inherently intuitive; the UIPP proposes planning, context analysis, reference and design specification, prototype evaluation, and discussion	Structured semiotic design; UIPP	Semiotic design approach; UIPP framework	Visual Design Approach
2	Ugaya Mazza et al. (2023)	Semantic classification and prior experience with standardised visual languages influence interpretability.	Semantic classification	Semantic representation	
3	Weng and Ren (2025)	Symbol standardisation, colour contrast, and information hierarchy affect visual detectability and hazard identification.	Visual detectability	Visual standardisation	
4	Deng et al. (2025)	Concreteness, familiarity, and semantic accuracy facilitate symbol comprehension across user groups.	Familiarity and semantic accuracy	Design attributes	
5	Medina-Córdoba et al. (2021)	Combining pictograms with supporting text creates a stronger information structure and improves comprehension and task completion.	Text plus image	Text-pictogram integration	
6	Wang and Zheng (2025)	Spatial arrangement affects interpretation, particularly among users with different cognitive abilities and numeracy levels.	Layout organisation	Layout and spatial arrangement	
7	Galmarini et al. (2024)	Visual and verbal information processed together reinforces understanding and can reduce cognitive load.	Dual-channel processing	Dual coding and cognitive processing	
8	Xiao et al. (2024)	Embedding semantic context can reduce the gap between abstract information and intuitive recognition.	Contextual meaning	Semantic context	
9	González-Sordé and Matamala (2023)	A gap persists between empirical evidence and prescriptive design recommendations used in practice.	Research-practice gap	Evidence-based design	
10	Kim et al. (2026)	Design guidelines are not always aligned with empirical evidence or consistently applied.	Guideline evidence gap	Evidence-based design	
11	Chen et al. (2022)	Videos, photographs, and pictograms can improve understanding, communication, and decision-making.	Visual communication support	Visual communication effectiveness	
12	Burshnic and Bourgeois (2022)	Visual communication was associated with improved comprehension, engagement, confidence, and informed participation.	Communication engagement	Visual communication effectiveness	
13	Chang and Bourgeois (2020)	Visual aids can support communication and decision-making among users with cognitive limitations.	Decision support	Visual communication effectiveness	
14	Reeves et al. (2020)	Visual materials can support communication and reveal differences in cognitive processing.	Visual cognitive support	Visual communication effectiveness	
15	Bogza et al. (2020)	User-centred visual tools can improve communication and participation in healthcare decisions.	User-centred decision aid	Visual communication effectiveness	
16	Gruters et al. (2021)	Interactive visual presentation can facilitate communication and understanding of clinical information.	Interactive visual explanation	Visual communication effectiveness	
17	Reijnen et al. (2022)	Well-designed medical pictograms help users locate information faster than less effective designs.	Search efficiency	Visual clarity	
18	Pedersen et al. (2021)	Simplification alone does not ensure comprehension; figure-ground contrast, visual complexity, and organisation also matter.	Balanced simplification	Visual clarity; Graphic design principles	
19	Dowse (2021)	Effective design requires simple imagery, clear language, legibility attributes, repeated user testing, expert review, and structured development.	Legibility; iterative testing	Legibility attributes; Structured validation; Idea generation; Iterative design	
20	Figueroa et al. (2023)	Pictograms were considered most useful for complex treatment, symptom-management, and dietary instructions.	Complex-instruction support	Suitability for complex instructions	
21	Schubbe et al. (2020)	Different amounts of accompanying text were associated with learning, recall, adherence, concordance, immunisation, and dosing outcomes.	Text quantity	Text density	
22	Sletvold et al. (2020)	Pictograms can support correct medication use, especially for people with low health literacy, but behaviour is also affected by social and cultural factors.	Adherence support; contextual behaviour	Medication adherence; Behavioural influences	
23	Bhagat et al. (2026)	Pictograms are more effective when combined with written or spoken instructions.	Supplementary communication	Medication adherence; Text-pictogram integration	
24	Mullen et al. (2018)	Plain language, typographic cues, standard formats, simplified dosing, numeric characters, pictograms, shorter text, and low reading level improve readability.	Readable medication information	Plain language and typography	

Table 2. Method, design models and frameworks factor

No	Study	Key Findings	Code	Category	Theme
1	Memişoğlu and Girişken (2022)	Fixation patterns and visual-attention measures can evaluate pictogram placement on packaging.	Objective attention measurement	Objective evaluation; Pictogram placement	Method, Design Models and Frameworks
2	Dowse (2021)	Effective design requires simple imagery, clear language, legibility attributes, repeated user testing, expert review, and structured development.	Legibility; iterative testing	Legibility attributes; Structured validation; Idea generation; Iterative design	
3	Kovačević et al. (2023)	Visual prominence significantly influences attention to pictograms.	Prominence and noticeability	Visual prominence assessment	
4	Montagne (2013)	A systematic process should combine design principles, user testing, iterative revision, comprehension testing, and utility assessment.	Systematic development model	Structured development frameworks; Systematic design model	
5	Neves et al. (2022)	Human-centred frameworks prioritise user needs, inclusivity, and ongoing evaluation.	Inclusive human-centred process	Human-centred design	
6	Albarrán Morillo et al. (2025)	Eye tracking provides objective visual-behaviour evidence that can inform visual-design improvements.	Objective visual behaviour	Evidence-based visual assessment	

Moreover, in Table 4, the findings show that pictogram performance depends on systematic validation with the target population, as comprehension is influenced by age, education, and cultural background. Although redesigned pictograms generally achieved better validity, several studies reported that only a limited proportion met established comprehension standards, highlighting the need for continuous user-centred validation and population-specific evaluation. Future validation studies should also incorporate eye-tracking technology to evaluate visual attention using predefined Areas of Interest (AOIs). Eye-tracking provides objective evidence of how users visually interact with individual pictogram elements by measuring metrics such as time to first fixation, fixation duration, and fixation count. These measures can identify whether critical design features successfully attract attention before interpretation occurs, thereby complementing conventional comprehension assessments. Integrating eye-tracking with user-centred validation would provide a more comprehensive understanding of both the visual processing and interpretive performance of pharmaceutical pictograms, supporting the development of more effective and evidence-based pictogram designs.

Table 3. Collaborative and user-centred factor

No	Study	Key Findings	Code	Category	Theme
1	Mansoor et al. (2004)	User involvement produced more culturally appropriate and understandable pictograms.	End-user participation	End-user involvement; Cultural adaptation	Collaborative and User-Centred
2	Vaillancourt et al. (2018)	International consensus and stakeholder involvement improved representation of medication-safety information.	International consensus	Collaborative multidisciplinary design	
3	Dowse (2021)	Effective design requires simple imagery, clear language, legibility attributes, repeated user testing, expert review, and structured development.	Legibility; iterative testing	Legibility attributes; Structured validation; Idea generation; Iterative design	
4	Nguyen et al. (2022)	Co-design produced pictograms described as more relevant, interpretable, and acceptable.	Stakeholder co-design	Co-design with stakeholders	
5	Humphrey et al. (2024)	Co-design and validation improved relevance, interpretation, and acceptance; children showed good understanding.	Pediatric co-design	Co-design with stakeholders; Age-appropriate design	
6	Jami et al. (2025)	Users preferred familiar, culturally meaningful, real-life visual elements over abstract representations.	Culturally familiar imagery	Participatory design; Cultural adaptation	
7	Dowse et al. (2023)	Iterative modification and validation improve guessability and responsiveness to user feedback.	Iterative modification	Iterative design process; Guessability and responsiveness	
8	Merks et al. (2018)	Repeated target-user evaluation supports pictogram refinement and validation.	Older-user testing	Iterative design process; Guessability and responsiveness	
9	Yu et al. (2013)	Crowdsourcing enables rapid, scalable feedback from large and diverse groups.	Scalable participation	Digital participatory approaches	
10	van Beusekom (2017)	Digital consultation can reduce the cost and time constraints of conventional participatory design.	Digital user consultation	Digital participatory approaches	
11	Sedeh et al. (2022)	Transparency and translucency testing are important for confirming utility and comprehensibility.	Transparency testing	Transparency and translucency testing	
12	Merks, Świeczkowski Religioni,et al. (2021)	Specialised software and infrastructure can standardise pictogram deployment in pharmacy workflows.	Workflow infrastructure	Technical infrastructure	

Table 4. Design performance and validation factor

No	Study	Key Findings	Code	Category	Theme
1	Malhotra et al. (2023)	User-centred redesign and validation resulted in 10 fully valid and five partially valid pictograms. Pictograms representing dose, route of administration, and precautions demonstrated better validation performance than those representing indications and side effects, while comprehension remained influenced by participant age and educational level.	User-centred redesign; validation performance; demographic influence	User validation; design performance; age and education	Design Performance and Validation
2	Ho et al. (2023)	Pictograms should be validated with the intended population for clarity, cultural appropriateness, and understanding.	Target-user validation	Target population validation; Structured validation	
3	Ferreira-Alfaya et al. (2024)	Population-specific validation is necessary because cultural and linguistic background affects comprehension.	Cross-cultural validation	Target population validation; Demographic diversity	
4	Gutierrez et al. (2022)	Only 17 of 108 pictograms (15.74%) met the ANSI 85% criterion; education was a significant predictor of comprehension.	Low ANSI pass rate; education effect	Comprehension performance; Educational influence; Supplementary communication; Demographic diversity	

Table 5. Evaluation and user acceptance

No	Study	Key Findings	Code	Category	Theme
1	Dowse et al. (2023)	Mean comprehension was 7.9/10; 8/10 pictograms met ISO; health literacy, education, English proficiency, and age were associated with performance.	Health-literacy effect; ISO performance	Health literacy and comprehension; ISO performance; Demographic influences; Continuous evaluation	Evaluation and User Acceptance
2	Tumkur et al. (2025)	Before explanation, 17/22 met ISO and 7/22 met ANSI; after explanation, 22/22 met ISO and 20/22 met ANSI. Acceptance was positive, but performance varied by demographic and design factors.	ISO-ANSI difference; explanation effect; acceptance	Patient acceptance; ISO and ANSI performance; Effect of explanation; Interpretation factors; Acceptance versus comprehension; Population-based evaluation	

For evaluation and user acceptance factor as stated in Table 5, findings indicate that user acceptance is strongly associated with pictogram comprehension and health literacy. While most pictograms achieved acceptable ISO performance, comprehension varied according to health literacy, education, language proficiency, and age, suggesting that continuous evaluation is necessary to ensure effective communication across diverse patient populations.

6. KNOWLEDGE GAPS REMAIN

Despite the considerable growth in pharmaceutical pictogram research, significant gaps remain. The inconsistent use of design frameworks, validation methods, and comprehension criteria across studies complicates comparisons. Furthermore, research often focuses on pictogram effectiveness rather than the holistic development process from conceptualisation to implementation. Additionally, the impact of specific design features on visual attention during interpretation has rarely been evaluated objectively. Consequently, integrating design theory, human-centred approaches, and objective evaluation methods is essential to establishing standardised guidelines for pharmaceutical pictogram development.

Furthermore, future investigations should prioritise assessing how pictograms influence medication adherence outcomes, as current literature lacks evidence regarding the long-term impact of visual aids on patient behaviour. Moreover, given the low health literacy often observed in vulnerable populations, researchers should distinguish between the initial transparency of a graphic and a patient's ability to retain its intended meaning over time (Vaillancourt et al., 2019). Moreover, while pictograms are frequently integrated into patient materials to bridge literacy gaps, there remains a need to determine if reducing their size for practical inclusion in conventional labels negatively impacts their legibility or clinical utility (Knapp et al., 2005). Additionally, emerging technologies offer new opportunities to enhance pharmaceutical pictogram development and evaluation. Digital tools such as QR codes, mobile health applications, and multilingual multimedia content can improve accessibility and patient engagement, while eye-tracking technology can objectively assess visual attention to predefined Areas of Interest (AOIs). These technologies provide valuable evidence on how users visually process pictograms, supporting more effective, evidence-based design and validation.

7. DISCUSSION

This review underscores that effective pharmaceutical pictogram design extends beyond the creation of visually appealing graphics. Instead, it requires a systematic development process that integrates evidence-based design principles, active user engagement, iterative validation, and continuous evaluation. Beyond initial validation, it is equally vital to monitor how these visual tools perform in real-world clinical environments where high prescription volumes and variable patient literacy levels intersect (Merks et al., 2022). Future efforts should therefore focus on the strategic placement of visual aids within packaging, as empirical studies using eye-tracking techniques have demonstrated that the spatial location of these symbols significantly influences fixation patterns and overall patient comprehension (Memişoğlu & Girişken, 2022). Moreover, stakeholders should consider how the interplay between graphic clarity and instructional context can lower the motivational threshold for patients to engage with pharmaceutical leaflets (van Beusekom et al., 2016). Ultimately, optimising these elements ensures that visual information is not merely decorative but functions as a critical navigational tool for complex medication regimens.

Although pharmaceutical pictograms consistently improve medication communication, differences in comprehension across studies indicate that their effectiveness depends on patient characteristics, including health literacy, educational attainment, cultural familiarity, and the validation methodology employed. Consequently, pharmaceutical pictograms should be regarded as context-dependent communication tools requiring iterative refinement rather than universally applicable visual symbols. (Yılmaz et al., 2025).

The variability in pictogram performance across the reviewed studies may be explained by differences in participant characteristics, cultural context, health literacy, and validation methodologies. Although some pictograms satisfied the ISO 9186 criterion (≥67% correct comprehension), they did not achieve the more stringent ANSI criterion (≥85%), indicating that acceptable comprehension does not necessarily represent optimal performance for safety-critical medication information. Future research should therefore integrate user-centred design, cultural adaptation, and iterative validation with both ISO and ANSI standards. In addition, emerging technologies such as eye-tracking, artificial intelligence (AI), machine learning, and digital design platforms offer promising opportunities to objectively evaluate visual attention, optimise pictogram design, and support evidence-based refinement before clinical implementation. These technologies have the potential to strengthen evaluation methodologies by providing objective, data-driven evidence for pictogram optimisation.

For graphic designers, these findings emphasise the need to move beyond aesthetic considerations toward evidence-based pictogram design. User-centred design, cultural adaptation, and technologies such as eye-tracking and AI can help designers assess visual attention, clarity, and comprehension, allowing visual elements to be systematically refined before implementation.

Moreover, for pharmacists and healthcare professionals, validated pictograms can support clearer communication of medication instructions, precautions, and warnings, particularly for patients with limited health literacy or language barriers. However, pictograms should complement rather than replace verbal counselling, with healthcare professionals confirming that patients correctly understand the intended medication message.

8. FUTURE RECOMMENDATION

Further studies should expand the evaluation of pharmacological pictograms to encompass questionnaires, interviews, and assessments of self-reported understanding. Furthermore, greater attention should be dedicated to formulating evidence-based visual design principles through the objective study of major design constructs, including readability, legibility, accessibility, visibility, noticeability, constructivity, and structurability. Moreover, future research should integrate these visual design principles with verbal and written instructions to determine the most effective communication combinations for enhancing patient comprehension (Gutierrez et al., 2022). Additionally, longitudinal clinical trials are necessary to determine if these integrated interventions facilitate sustained improvements in medication adherence and health outcomes within community pharmacy settings (Merks, Świeczkowski, Religioni, et al., 2021). Additionally, designers must incorporate more familiar, culturally relevant, and concrete elements into graphics to prevent misinterpretation and ensure the intended meaning is accurately conveyed across diverse user groups (Saremi et al., 2020).

Eye-tracking technology offers a practical method for quantifying user visual attention by capturing gaze patterns, fixation duration, fixation count, and time to first fixation as users interpret pictograms. This technology provides empirical evidence of how individuals visually engage with pictograms in real-time, offering insights that transcend subjective self-reporting. Integrating eye-tracking assessments, user-centred design, and validation across diverse patient demographics will facilitate the development of standardised pharmaceutical pictograms that are more intuitive, understandable, and effective in delivering prescription information. Finally, policymakers should leverage these empirical validation results to institutionalise the inclusion of standardised pictograms within national medication labelling regulations, particularly to support vulnerable populations (Hanslo et al., 2019).

9. CONCLUSION

This review underscores that the development of effective pharmaceutical pictograms extends beyond visual aesthetics, requiring a systematic, user-centred process that integrates evidence-based design principles, active stakeholder engagement, and iterative validation (Merks, Świeczkowski, Religioni, et al., 2021). While pictograms possess the potential to enhance medication communication and bridge literacy gaps, their clinical efficacy is inherently shaped by patient variables, including health literacy, education, age, and cultural background (van Beusekom et al., 2017; Yılmaz et al., 2025). Consequently, continuous evaluation in real-world environments is essential to ensure these visual aids function as critical navigational tools rather than purely decorative additions (Peñuelas Gil & Ortego Antón, 2024). The findings synthesised in this review provide a robust framework to guide future research, regulatory policy, and the development of intuitive communication strategies for diverse patient populations (Hanslo et al., 2019). By facilitating a more profound grasp of therapeutic schemes, these refined visual interventions play a pivotal role in minimising medication errors and bolstering overall treatment adherence (Dai & Joshi, 2021). Furthermore, the synergy between text and pictograms serves as a vital instrument in mitigating the risks of inappropriate polytherapy and preventing adverse drug interactions among patients with complex chronic conditions (Medina-Córdoba et al., 2021; Merks et al., 2023). Ultimately, the integration of such standardised pictographic aids into routine pharmaceutical practice addresses critical communication barriers for patients with low health literacy, who are at a significantly higher risk of treatment.

Based on the evidence synthesised across the reviewed studies, future pharmaceutical pictogram research should adopt an internationally standardised, evidence-based development guideline that integrates four essential components. First, user-centred design should be incorporated throughout the entire development process by actively involving patients, pharmacists, healthcare professionals, and graphic designers from concept generation to final validation. Second, pictograms should undergo iterative empirical validation using internationally recognised comprehension standards, including ISO 9186 and ANSI criteria, to ensure consistent interpretation across different populations. Third, cultural adaptation and demographic diversity should be systematically addressed by validating pictograms among users with varying literacy levels, age groups, languages, and cultural backgrounds before implementation. Finally, objective evaluation techniques such as eye-tracking should be integrated alongside conventional comprehension tests to quantify visual attention, fixation behaviour, and information processing, thereby complementing subjective measures with behavioural evidence. Collectively, these recommendations provide the foundation for a standardised pharmaceutical pictogram development framework that can improve the consistency, reliability, and global applicability of medication communication while supporting safer patient-centred healthcare practice.

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CONFLICT OF INTEREST STATEMENT

The authors declare that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest and received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

AUTHORS' CONTRIBUTIONS

Nor Aziyana Abd Rahman: Conceptualisation, methodology, formal analysis, investigation and writing-original draft; **Azhar Abd Jamil**: supervision, writing- review and editing, and validation; **Saiful Azlan Rosli**: supervision.

DECLARATION OF GENERATIVE AI IN THE WRITING PROCESS

During the preparation of this work, the author(s) used Jenni AI, ChatGPT Plus / QuillBot Premium in order to draft, paraphrase, English editing. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

ETHICS STATEMENT

The authors declare that this research did not involve human or animal subjects.

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