Pharmaceutical pictograms for low-literate medication users

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Part III

Development strategies

CHAPTER 7

Patient involvement in the design of pictograms for written drug information: a systematic review

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Abstract

Objectives

To provide insight into the extent and effect of patient involvement in the design and evaluation of pictograms for written drug information.

Design

Systematic, mixed studies review.

Data sources

Pubmed, CINAHL, Cochrane Library, Embase, PsycINFO, Academic Search Premier, and Web of Science.

Eligibility criteria for selecting studies

Original research that described the development and/or evaluation of pictograms for patient drug information. Snowballing was used to supplement the search.

Data extraction

Two researchers independently extracted data on design and evaluation steps, the type and moment of end-user involvement, and the role of end-users in this involvement. To assess the quality of the articles, the Mixed Methods Appraisal Tool was used.

Results

Sixty articles were included for analysis. Usually, non-patient end-users were involved in the design and evaluation of pictograms. Early involvement corresponded with active contributions and uniformly valued pictograms. In particular repeated involvement of (non-)patients in the design helped to create pictograms that were valued, understood well, and aided comprehension and recall of drug information. Different target groups varied in how they evaluated pictogram success.

Conclusions

Involving patients in the design process can help the design of effective pharmaceutical pictograms, but there is limited evidence for such effects on patients' perception of drug information or health behaviour. To gain more insight into the effects of end-user involvement, more participative studies and complete reporting are needed.

Introduction

Patients often struggle to retain verbally communicated medical information [1, 2]. For this reason, written drug information is essential for patients to look up medication instructions at home and has the potential to improve patients' understanding of their medication, adherence, and satisfaction [3]. Unfortunately, patient leaflets are often not suitable for the intended audience [4]. To improve the usability of drug information, informative stylised figurative drawings – pictograms – [5] can help to draw attention to important topics [6, 7] and make information easier to understand and recall [5, 8-10], which can even lead to improved health behaviour [11].

However, pictograms are not necessarily universally understood and comprehension of and preferences for pictograms can be influenced by patient characteristics such as age, literacy levels, and cultural background [12-15]. Therefore, it has been recommended to involve the intended target group in the design and evaluation of pharmaceutical pictograms to gain insight into end-user characteristics and to better tailor the pictogram intervention [16].

Indeed, in the field of design, it is considered good practice to involve the target group during the 'pre-design phase', so that they have a say in determining the initial design strategies, as well as to involve them as active design partners rather than passive test subjects [17, 18]. Ranging from less to more active input, three levels of user involvement have been distinguished [19-21]:

- an informative role ('design for'): involving end-users as passive objects of observation for researchers;
- a consultative role ('design with'): inviting end-users to comment on pre-defined pictogram designs; and
- a participative role ('design by'): involving end-users in a way that they can actively take part in the design and have decision-power regarding the design solution.

Despite extensive reviews on the use of pictures and pictograms in health communication [22-24], very little is known about the state of lay end-user involvement in the design and evaluation of pictograms for written drug information. It has been suggested that some studies do not actually involve the intended target group in effect measurements [25]. Moreover, there is conflicting evidence for the effectiveness of end-user involvement in the development of pharmaceutical pictograms, and most importantly, for the effectiveness of patient involvement. For example, looking at pictogram understandability, there are both studies that involve lay end-users and see either low [26] or high understandability [27, 28], as well as studies that do not involve end-users and also see high pictogram understandability [29].

Therefore, the aim of this review is to find evidence from published literature on whether lay end-user involvement in the design of pharmaceutical pictograms can increase the success of pictograms and pictogram-enhanced drug information, so that future efforts of end-user involvement can be evidence-based.

Methods

Literature Search

On January 19, 2016, the databases Pubmed, CINAHL, Cochrane Library, Embase, PsycINFO, Academic Search Premier, and Web of Science were searched systematically for a combination of the keywords ‘pictogram(s)’ or ‘pictograph(s)’ with ‘medical’ ‘medicine(s)’, ‘medication(s)’, ‘drug(s)’, ‘pharmacy’, ‘pharmacies’, ‘pharmaceutical (appendix 7.1). No limit was set on the time period. This search resulted in 494 articles, of which 243 were unique. Figure 7.1 shows a flowchart of the inclusion process, made in accordance with the PRISMA Statement of transparent reporting of systematic reviews and meta-analyses [30].

Inclusion Process

Titles and abstracts of these 243 articles were read independently by two research-assistants (CM, PD) to determine relevance for the review. To be included, articles had to be original research written in English and describe the development and/or evaluation of pictograms intended for use in patient written drug information. Written drug information included patient information labels, medical pamphlets, labels, and written (discharge) instructions, providing they convey information on use of medicine. To not exclude papers on the development of pictograms, peer-review was not a selection criterion. Cohen’s Kappa for reliability of the inclusion process was 0.77, indicating substantial agreement. Differences were discussed with a third researcher (MvB). Forty-seven articles were included.

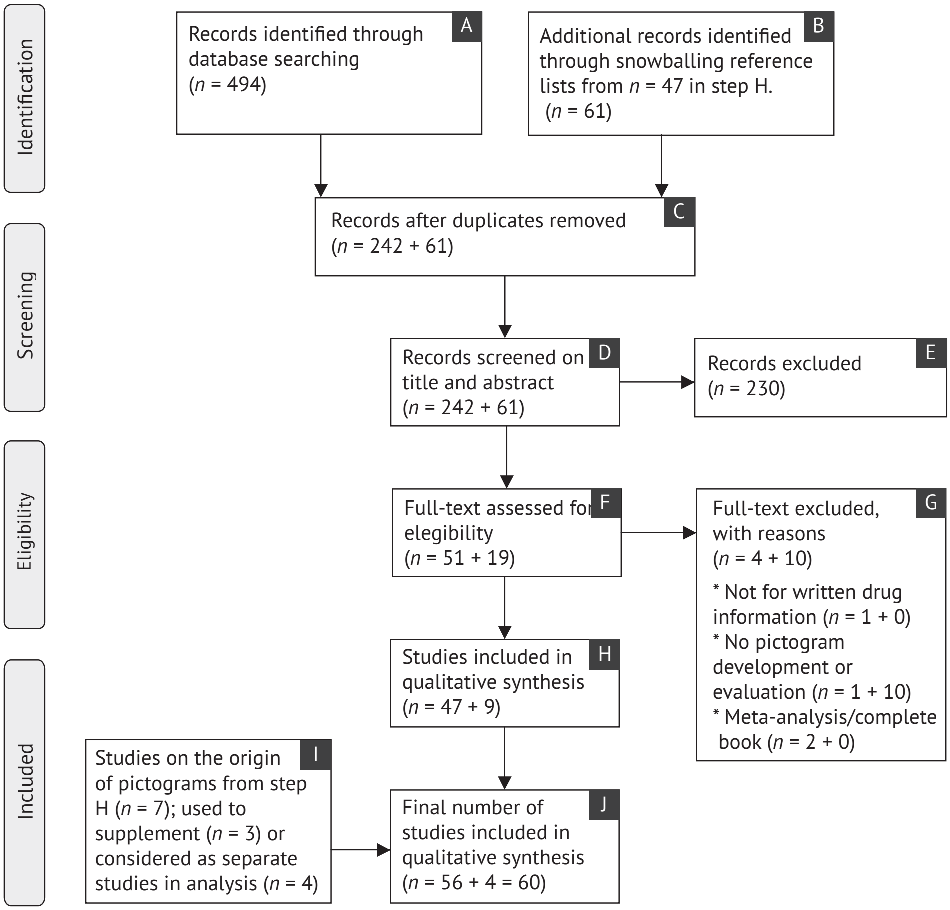

Figure 7.1 PRISMA 2009 Flow Diagram showing the information flow through the different phases of the systematic review.

The reference lists of the 47 articles were explored using a snowball method to find other relevant articles. Articles identified through this method were assessed in a similar manner as described above. This resulted in the inclusion of nine additional articles and later four more that described the development of pictograms mentioned in these nine articles, so that the final number of articles in the analysis is 60.

Data Extraction

Two researchers (MB, AK) independently extracted information from the included articles into a scheme adapted from the Cochrane handbook [31]. As a quality check, articles were assessed using the Mixed Methods Appraisal Tool (MMAT), developed especially for systematic mixed studies reviews [32]. The Cohen's Kappa value for intercoder reliability was 0.76, indicating substantial agreement between the researchers (MB, AK). Discrepancies were resolved through discussion.

For each article, steps in the pictogram development and evaluation process were identified and labelled as part of the pre-design, design, or evaluation phase. To distinguish between preliminary evaluations and the final evaluation that measured the 'success' of the pictograms, the former were considered part of the design phase, while the latter formed the evaluation phase.

Subsequently, for each step, it was determined whether participants that were involved could be considered full end-users of the pictograms, *i.e.*, lay participants with all key characteristics of the described target group, including using the medication relevant to the pictograms or pictogram-enhanced information; potential end-users, *i.e.*, those who share all key characteristics with the target group, but are not relevant patients (yet); partial end-users, *i.e.*, lay participants who miss one or more key characteristics of the target group; or experts, *i.e.*, healthcare professionals, designers, pharmacy students, and researchers.

Lastly, for each group of lay participants, the contribution to the design or evaluation was labelled as informative, consultative or participative, as described previously.

Results

Study Characteristics

All 60 articles (table 7.1; appendix 7.2) were published between 1993 and 2015, with over half in the last four years. Most studies were conducted in the USA and South Africa (14 and 13 studies, respectively), followed by Canada and India (six and five studies, respectively) (figure 7.2). There were 18 randomised controlled trials, six mixed-methods studies, and one fully qualitative study – all other studies made use

Table 7.1 Articles included in the analysis, with MMAT scores, design and evaluation steps, type of participants included in the study and the role of lay end-users in the design or evaluation

Study ID and MMAT score [a]	**Steps described**	**Type of participants**	**Role of end-users**
		USP pictograms	
Advani et al., 2013*** [64]	Evaluation	Potential end-users	Informative, consultative
Barros et al., 2014** [75]	Evaluation	Potential end-users	Informative
Chan et al., 2013** [65]	Evaluation	Potential end-users	Informative, consultative
Hämeen-Anttila et al., 2004** [27]	Evaluation	Potential end-users	Informative
Joshi et al., 2011** [53]	Evaluation	End-users	Informative
Kalsher et al., 1996*** [76]	Evaluation	1) Partial end-users 2) Potential end-users	1) Consultative 2) Consultative
Kassam et al., 2004*** [54]	Design	Experts	*n/a*
	Design	Potential end-users	Informative
	Design	Experts	*n/a*
	Design	Potential end-users	Informative
	Design	Experts	*n/a*
	Evaluation	Potential end-users	Informative
King et al., 2012** [55]	Evaluation	Potential end-users	Informative
Sharaideh et al., 2013*** [14]	Evaluation	Potential end-users	Informative
Soares, 2013*** [12]	Evaluation	Potential end-users	Informative
Wolff et al., 1993** [66]	Design	Potential end-users	Informative
	Design	*Not described*	*n/a*
	Design	Potential end-users	Informative
	Design	Experts	*n/a*
	Design	Potential end-users	Participative
	Design	*Not described*	*n/a*
Yu et al., 2013*** [67]	Evaluation	Potential end-users	Informative
		SA pictograms (developed in Ehlers & Dowse, 2001 – not published)	
Dowse & Ehlers, 2001** [25]	Evaluation	Potential end-users	Informative
Dowse & Ehlers, 2003** [28]	Evaluation	Potential end-users	Informative
Dowse & Ehlers, 2004** [56]	Evaluation	Potential end-users	Informative
Dowse & Ehlers, 2005** [11]	Evaluation	End-users	Informative
Knapp et al., 2005**** [78]	Evaluation	Potential end-users	Informative
Mishra et al., 2011* [68]	Evaluation	Potential end-users	Informative, consultative

Table 7.1 continues on next page

Table 7.1 *Continued*

Study ID and MMAT score [a]	Steps described	Type of participants	Role of end-users
		HIV/aids – ARV	
Mwingira, 2004** (part 1) [33] [b]	Pre-design	*Not described*	*n/a*
	Pre-design	Experts	*n/a*
	(Pre-) design	Expert	*n/a*
	Design	Potential end-users	Consultative
	Evaluation	Potential end-users	Informative
Mwingira & Dowse, 2006*** [34] [suppl. with Mwingira, 2004 [33] [b]]	Design	*Not described*	*n/a*
	Design	Potential end-users	*n/a*
	Design	Potential end-users	Consultative
	Evaluation	Potential end-users	Informative, consultative
Mwingira & Dowse, 2007** [35]	Evaluation	Potential end-users	Informative, consultative
Dowse et al., 2010** [36]	Pre-design	*Not described*	*n/a*
	(Pre-) design	Experts	*n/a*
	Design	Experts	*n/a*
	Design	Potential end-users	Consultative
	Evaluation	Potential end-users	Informative
Dowse et al., 2011** [37] [suppl. with Ramela, 2009 [85]]	Design	*Not described*	*n/a*
	Design	Potential end-users, end-users, experts	Consultative
	Evaluation	Potential end-users [Potential end-users]	Informative, consultative
Dowse et al., 2014** [38]	Design	*Not described*	*n/a*
	Evaluation	End-users	Informative
		HIV/aids - Nystatin	
Mansoor & Dowse, 2003*** [39]	Design	Unclear	*Unclear*
	Design	Partial end-users	*Unclear*
	Evaluation	Potential end-users	Informative, consultative
Mansoor & Dowse, 2004** [40]	(Pre-) design	Experts	*n/a*
	Design	Expert, potential end-users	*n/a, unclear*
	Design	Potential end-users	Informative, consultative

Table 7.1 *Continued*

Study ID and MMAT score [a]	Steps described	Type of participants	Role of end-users
		HIV/aids - Nystatin	
	Design	Potential end-users	Consultative
	Design	Experts	*n/a*
	Evaluation	Potential end-users	Informative, consultative
Mansoor & Dowse, 2006*** [41]	Design	*Not described*	*n/a*
	Evaluation	End-users	Informative
Mansoor & Dowse, 2007** [10]	Design	*Not described*	*n/a*
	Evaluation	End-users	Informative
		Glyph system	
Zeng-Treitler et al., 2008** [9]	Pre-design	Experts, potential end-users	Experts: *n/a;* potential end-users: participative
	Design	Expert	*n/a*
	Design	Experts	Consultative
	Evaluation	Potential end-users	Informative
Kim et al., 2009* [74]	Evaluation	Potential end-users	Informative
Nakamura et al., 2011** [42]	(Pre-) design	Experts	*n/a*
	Design	Experts	*n/a*
	Design	Unclear	*n/a*
	Evaluation	Unclear	Informative
Nakamura et al., 2012[n/a] [69]	Design	Experts	*n/a*
Bui et al., 2012* [43] [b]	Design	Experts	*n/a*
	Evaluation	Experts	*n/a*
Zeng-Treitler et al., 2014*** [70]	Design	*Not described*	*n/a*
	Evaluation	Potential end-users	Informative
		FIP	
Sorfleet et al., 2009* [29]	Design	Experts	*n/a*
	Evaluation	Potential end-users	Informative, consultative
Grenier et al., 2013*** [79]	Pre-design	Experts	*n/a*
	Pre-design	Potential end-users	Participative
	Design	Experts	*n/a*
	Evaluation	Potential end-users	Participative

Table 7.1 continues on next page

Table 7.1 *Continued*

Study ID and MMAT score [a]	Steps described	Type of participants	Role of end-users
Driving warnings			
Monteiro et al., 2013*** [44] [suppl. with Meesmann et al., 2011 [86] [b]; Orriols et al., 2010 [87])	[(Pre-) design]	[DRUID: Experts, potential end-users; French: Experts]	*n/a*
	Evaluation	Potential end-user	Informative, consultative
Emich et al., 2014*** [45]	Evaluation	End-users	Informative
Fierro et al., 2013*** [46]	Evaluation	Potential end-users	Informative, consultative
Smyth et al., 2013** [47]	Design	Experts	*n/a*
	Evaluation	Potential end-users	Informative
HELPix			
Yin et al., 2008*** [57]	Evaluation	Potential end-users	Informative
Yin et al., 2011*** [58]	Evaluation	Potential end-users	Informative
Webb & Wolf			
Webb et al., 2008*** [59]	Evaluation	Potential end-users	Informative, consultative
Wolf et al., 2010*** [7]	Evaluation	Potential end-users	Informative
Stand-alone articles			
Bernardini et al., 2000*** [71]	(Pre-) design	Potential end-users	Participative
	Evaluation	Potential end-users	Consultative
Braich et al., 2011** [48]	Evaluation	End-users	Informative
Chan et al., 2014**** [49]	(Pre-) design	End-users	Consultative/ participative
	Design	End-users	*Unclear*
	Evaluation	End-users	Informative, consultative
Chuang et al., 2010*** [60]	(Pre-) design	*Not described*	*n/a*
	Design	*Not described*	*n/a*
	Design	Partial end-users	Informative, consultative
	Design	Potential end-users	Informative, consultative
	Design	*Not described*	*n/a*
	Evaluation	Potential end-users, experts	Consultative

Table 7.1 *Continued*

Study ID and MMAT score [a]	Steps described	Type of participants	Role of end-users
	Stand-alone articles		
Dotson, 2009*** [61] [b]	Pre-design	Experts	*n/a*
	Design	Experts	*n/a*
	Design	Experts, potential end-users	Experts: *n/a;* potential end-users: Informative, consultative, participative
	Evaluation	End-users	Informative, consultative
Hwang et al., 2005*** [72]	Evaluation	End-users	Informative
Kheir et al., 2014*** [62]	Pre-design	Potential end-users, experts	Consultative
	Pre-design	Potential end-users, experts	Consultative/ participative
	Design	Experts	*n/a*
	Design	Potential end-users	*Unclear*
	Evaluation	Potential end-users	Informative
Korenevsky et al., 2013*** [77]	Design	Experts	*n/a*
	Evaluation	Potential end-users	Consultative
Kripalani et al., 2007** [50]	(Pre-) design	Experts	Consultative
	Design	Experts	Consultative
	Evaluation	End-users	Informative, consultative
Mateti et al., 2015**** [51]	(Pre-) design	Experts	*n/a*
	Design	*Not described*	*n/a*
	Evaluation	End-users	Informative, consultative
Mbuagbaw et al., 2012*** [73]	Evaluation	Potential end-users	Informative, consultative
Richler et al., 2013* [15]	Design	Experts	*n/a*
	Design	*Not described*	*Unclear*
	Evaluation	Potential end-users	Consultative

Table 7.1 continues on next page

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Table 7.1 *Continued*

Study ID and MMAT score [a]	Steps described	Type of participants	Role of end-users
Stones et al., 2013* [26]	Design	Experts, potential end-users	Informative
	Evaluation	Potential end-users	Informative
Thompson et al., 2010*** [8]	(Pre-) design	*Not described*	*n/a*
	Design	End-users	*Unclear*
	Evaluation	Potential end-users	Informative, consultative
Van Beusekom et al., 2015*** [63]	(Pre-) design	Experts	*n/a*
	Design	Partial end-users	Consultative
	Evaluation	Potential end-users	Consultative
Wilby et al., 2011*** [52]	Evaluation	End-users	Informative

of quantitative non-randomised or quantitative descriptive methods. MMAT scores ranged from 25% to 100% (mean 61.9%, median 75%). Most commonly, patients and medication users were described as the target group for pictograms or pictogram-enhanced drug information [8, 10, 26, 33-52], followed by 22 studies that specifically targeted patients with low (health) literacy [7, 11, 25, 36-41, 48, 50, 53-63], 15 studies that aimed to target 'patients in general' [9, 12, 15, 29, 64-74], and 6 studies that targeted a specific age group [14, 27, 75-78].

Type and Role vs. Moment of User Involvement

Six of the sixty studies described a pre-design process of pictograms that was clearly distinguishable from the design phase [9, 33, 36, 61, 62, 79]. In three articles, this pre-design phase involved lay participants – in all cases non-patient (potential) end-users [9, 62, 79]. Early involvement corresponded with active roles for participants, ranging from consultative to participative input, in the form of asking end-users about their information needs [62], having them identify topics that require visualisation in written drug information [9], and giving end-users decision-power on what pictograms to work with [79].

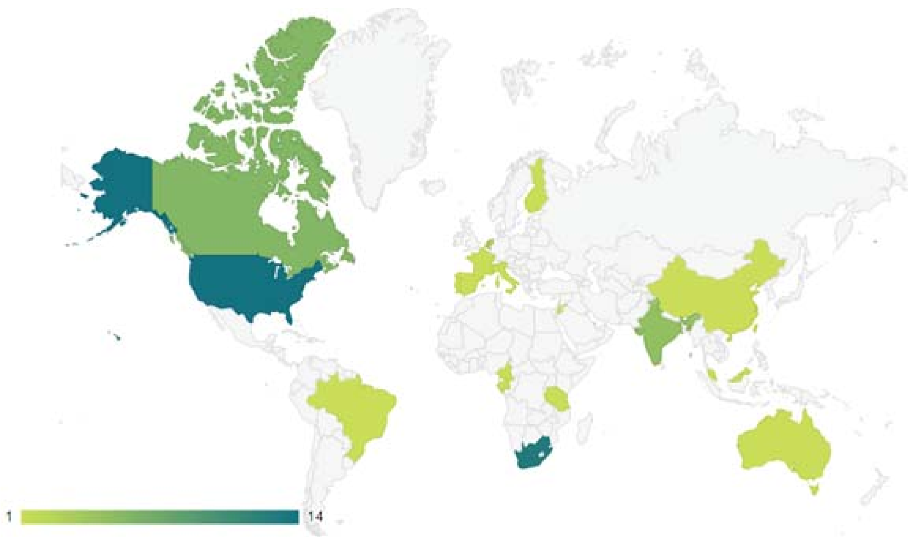

Figure 7.2 Geographic spread of pictogram studies published.

Also during the actual design phase, usually non-patient end-users were involved [9, 33, 34, 36, 37, 40, 44, 54, 60-62, 66, 71]; in a third of the cases even during multiple redesign steps. Patient end-users were involved only twice [8, 49]. Four other studies worked with partial end-users, since they targeted a low-literate audience, but recruited from a general sample [39, 50, 60, 63]. Most articles focussed on a consultative role for lay participants in the design phase [33, 34, 36, 37, 40, 49, 50, 60-63]. Only two studies involved participants participatively [61, 66]. While five studies involved end-users in a passive, informative role in the design [40, 54, 60, 61, 66], in four of these studies, end-users were involved in a more active manner in the design phase as well [40, 60, 61, 66].

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Final measures of pictogram success were again usually carried out with potential end-users [7-9, 12, 14, 15, 25-29, 33-37, 39, 40, 44, 46, 47, 54-60, 62-65, 67, 68, 70, 71, 73-79]. Only one article evaluated with partial end-users [76] and twelve articles made use of patient end-users [10, 11, 38, 45, 48-53, 61, 72]. For the final evaluation of pictograms, 46 studies involved end-users in an informative role [7-12, 14, 25-29, 34-42, 44-56, 59, 61, 62, 64, 65, 67, 68, 70, 72, 73, 75, 78] and 28 in a consultative role [8, 11, 15, 25, 28, 29, 34, 35, 37, 39, 40, 44, 46, 49-51, 56, 59-61, 63-65, 68, 71, 73, 76, 77]. One study involved end-users in a participative role by letting them decide on the final pictogram versions [79].

Pictogram Success

The included studies most commonly measured pictogram success in terms of pictogram understandability [12, 14, 25-29, 33, 36, 40, 42, 44, 46, 52-54, 56, 59, 61, 65-68, 74, 75, 78]. Also participants' opinion about pictograms was evaluated frequently, including preference for one pictogram version over another [15, 25, 28, 40, 56, 60, 63, 68, 71, 76], acceptability of pictogram design [29, 33, 36, 44, 46], and perceived usefulness of pictograms [11, 28, 40, 56, 59, 71].

Many articles also considered effects of pictograms in the context of written drug information. The majority of these studies examined the effect of pictograms on participants' understanding and recall of information [7, 9-11, 37-39, 48, 49, 51, 52, 55, 61, 62, 70, 72, 73]. Other studies considered effects on patients' attention to [7, 26] or opinion on drug information, including preference for a leaflet or label version [8, 39, 49, 51, 73], acceptability of leaflet or label design [8, 34, 35, 37, 39, 51, 59, 61] and perceived effectiveness of the label or leaflet [8, 50, 64]. In addition, a dozen articles evaluated effects of pictograms on participants' (pre-)intenders of health behaviour and actual health behaviour, such as risk perception, intention to change behaviour, and dosing accuracy [11, 38, 41, 44-49, 57, 58, 61].

User Involvement and Pictogram Success

An overview of the main finding per outcome with respect to whether or not an effect of end-user involvement on pictogram success could be detected is presented in table 7.2.

Pictogram understandability

Involvement of end-users in the development of pictograms was seen to lead to pictograms that were understood better than those developed by experts-only [44] or than those designed for a population with a different cultural background [25, 28]. The results from three studies with an extensive design phase indicate that in particular repeated involvement of either patient or non-patient end-users could help to optimise pictogram understandability [40, 54, 66].

At the same time, for U.S. Pharmacopeia Convention (USP) pictograms, reportedly developed by USP staff and redesigned in an iterative process with non-native speakers of English, elderly, and people with varying literacy levels [16, 33], varying results were

Table 7.2 Effects of end-users involvement in design and final evaluation for different outcomes

Outcome	Effect of end-user involvement in design?
Pictogram understandability	Yes
Opinion on pictograms	Yes
Information understanding and recall	Yes
Attention to information	Unclear - possible
Opinion on label or leaflet	Unclear - possible
(Pre-)intenders of health behaviour	Unclear - likely
Health behaviour	Unclear - contradictory

seen for understandability, and the groups involved in the redesign did not appear to have an advantage in understanding [53, 66, 67, 75]. However, none of the studies evaluated the pictograms on end-users who met all these characteristics, so that the success of the pictograms for the actual target group is unclear.

Some evidence was also found for an effect of the type of user involvement on understandability. Of non-USP pictograms, pictograms with high understandability involved potential end-users in a consultative role [33, 37, 61], while the least well-understood series were developed with potential end-users in an informative role [26]. It should be noted that the only study in which all pictograms were sufficiently understood at initial exposure did not involve lay end-users in the design at all. However, compared to other studies, this article provided little information on the development process and had a low MMAT score [29].

Opinion on pictograms

Involvement of potential end-users in the design led to pictograms that were preferred by that specific target group, but were not necessarily universally preferred to other pictograms, which became apparent from several studies that compared USP pictograms to pictograms developed with South African (SA) populations: when evaluated in South Africa, SA pictograms were consistently preferred to USP pictograms [25, 28, 56]. An Indian study, on the other hand, found preference for USP over SA pictograms [68] Preferences for pictograms did not just differ between different cultural groups, but also varied between patients and medical staff [60], or those with adequate and low literacy levels [63]. Two studies that involved non-patient end-users as early as in the pre-design phase found that their pictograms were uniformly valued within the target group [71, 79].

All studies that measured participants' perceived usefulness of pictograms and described a development process involved potential end-users in the design and, regardless of the exact moment or type of involvement, found that the resulting pictograms scored well on perceived usefulness [11, 28, 40, 56, 59, 71]. In particular low-literate (non-)patient end-users considered pictograms to be useful [11, 28, 40, 56].

Information understanding and recall

The pictogram development processes of studies that found a positive effect on understanding or recall of information [9-11, 38, 49, 70], suggesting the importance of an iterative design process to optimise pictograms for understanding or recall of information. Studies that found a relatively high difference between understanding or recall between the control group and the pictogram-intervention group all made use of pictograms that had been redesigned repeatedly with involvement of usually potential end-users in both informative and consultative roles [9-11, 38]. On the other hand, studies that did not find an effect on understanding or recall either described no development process [48, 73], used USP pictograms without adaptations [55], or described only one moment of redesign with end-users [8].

Attention to information

All studies that evaluated the effect of pictograms on attention to information involved either potential or patient end-users in the design phase, in informative or consultative roles, and found that pictograms contributed positively to leaflet appeal [8], attention to warnings [7], as well as the leaflet noticeability and likelihood of reading [76]. Not enough data were available to compare effectiveness of lay involvement in the design process. However, with respect to evaluating the effect of pictograms on attention to drug information, it was seen that samples with different characteristics, such as different cultures [47] or personal interests in the drug information [26] varied in how perceptive they were to pictograms.

Opinion on label or leaflet

A similar effect of sample characteristics on pictogram success was observed for outcomes relating to the perceived effectiveness and user-friendliness of drug information, as well as to preferences for different information forms. This was illustrated by two studies that evaluated USP pictograms in the US: one study found no difference in perceived effectiveness between leaflets with and without USP pictograms in a general group of patients [64]; another study found that young participants perceived pictogram-enhanced information as more effective than text-only information, but did not see this effect back in the intended target group of elderly participants [76]. These results showed that examining a subgroup within a group of general patients provided more specific information on how pictograms affect patients' perception of a drug label or leaflets, as was also confirmed by a study that found that a general group of patient end-users preferred a font-enlarged label to a pictogram label, but that elderly participants within this sample and those with a higher number of morbidity preferred the pictogram label [49].

With respect to the effect of lay involvement in pictogram development on how patients value resulting pictogram leaflets or labels, it could be seen that regardless of whether or not end-users had been involved in the design process, or in what role, pictogram information generally had a high acceptability with respect to lay-out, liking of pictograms, amount of information [34, 35, 37, 50, 51, 59, 61]. In studies where pictogram information was found to be preferred to or perceived as more effective than non-pictogram options [8, 39, 49, 64, 73]), when the development process was described, either potential or patient end-users were involved; however, none of these studies described in what role.

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(Pre-)intenders of health behaviour

Although there was little data on effects of end-user involvement in the design of pictograms on patients' intentions towards health behaviour, a study in which a pictogram-leaflet successfully increased patients' self-efficacy involved non-patient end-users repeatedly in an informative and consultative role in an iterative design process [38]. In addition, a study that compared risk pictograms found that those developed in a project with patient representatives could convey a broader range of risk severity levels and corresponded with a higher intention to change behaviour compared to pictograms developed with experts only [44]. With respect to user-involvement in the evaluation of pictograms in terms of effects on (pre-)intenders of health behaviour, it was seen that the same pictograms could have different effects on risk perception and intention to change health behaviour between end-users with different interests in the information presented [46].

Health behaviour

There was mixed evidence for the effect of end-user involvement on health behaviour, such as dosing errors and adherence: two studies that made use of the SA pictograms, developed with the target population, found better adherence in the pictogram leaflet group compared to the text-only group or those without a leaflet [11, 41]. At the same time, a study that involved local patients from the very start of the pictogram development found no difference in adherence between a pictogram, standard, or font-enlarged label [49]. A common factor for pictogram success in terms of effect on health behaviour appeared to be the involvement of low-literate end-users in the evaluation [11, 41, 48, 57, 58].

Discussion

This review provides evidence that involving lay end-users in the design of pharmaceutical pictograms helps to increase the likelihood that the pictograms are well-understood, well-received, and aid understand and recall of drug information they support. There is limited evidence for an effect of lay involvement on whether the developed pictograms help to improve patients' perceptions of drug information or their health behaviour. It is essential to involve (non-)patient end-users in the evaluation of pictograms and pictogram-enhanced information, as it was seen that different audiences can vary considerably in how they perceive and respond to pictograms.

Many studies that develop or evaluate pharmaceutical pictograms sample non-patient participants. This has been described as a less 'challenging' strategy when other characteristics of the target group already considerably narrow the sampling pool, such as when targeting low-literate patients [8]. In addition, access to a bigger group of participants can improve the cost-effectiveness and representativeness of a sample [67]. At the same time, several authors have expressed the concern that people who do not have to use a particular treatment may not have the same interest to, for example, recall pictogram-enhanced written drug information as patients would

[24, 35, 37], so that evaluating with non-patient end-users may underestimate the effectiveness of pictograms.

In this review we could not show a clinical effect of involving either patients or non-patients in the design of pictograms. However, with respect to evaluation of pictogram success, it was seen that samples with different personal interests in drug information can differ in how perceptive they are to pictograms [26]. Together, these findings suggest that while involving non-patient end-users in the development of pictograms is likely to lead to successful pictograms also for patient end-users, it is advisable to perform at least the final evaluation of pictogram success with actual patients.

Based on a limited number of studies, some evidence was found that inviting end-users to participate in the pre-design phase can contribute to the development of pictograms that are uniformly valued by the target group [71, 79]. When end-users are involved in the 'fuzzy front end' of the design, *i.e.*, before initial design strategies are determined [17], designers have more opportunity to incorporate preferences of the target group in the design in a more profound way compared to when they can only make adaptations to pictograms at a later stage of the development based on end-user feedback. This is supported by evidence that early involvement of the target group in the development of pictograms corresponds with a more active type of input by these end-users. Targeting end-users' preference with respect to design is essential, since pictograms that are viewed as appealing can act as peripheral cues for patients to process and be persuaded by information on therapy with low elaboration [80, 81].

However, the most successful strategy to optimise pictograms for the target group appears to be a repeated involvement of the target group, in an iterative design-evaluation-redesign process. This strategy works well to develop pictograms that are easily understood and valued by the target group, and possibly also helps to develop pictograms that have a positive effect on patients' perception and understanding of written drug information, as well as on their sense of self-efficacy. Every design step that involves end-users is an opportunity to gain more insight into how pictograms can be improved to better match the target group's information needs and preferences. Iterative design has been a widely-adopted strategy in other fields for decades, in particular in computer system design [82-84].

It is apparent from the review that relatively few studies involve end-users in a truly participative role with creative freedom and decision-power; the recommended strategy in design [17]. In addition, one of the few studies that did attempt to involve end-users in a participative role found that their participants had no suggestions [9]. For this reason, conclusions concerning the effectiveness of the type of end-user involvement should be made with care. There is, however, some indication that a consultative role can be helpful to optimise pictogram understandability [26, 33, 37, 61].

Strengths and Limitations of the Study

This review is the first to systematically look at effects of end-user involvement on the success of pharmaceutical pictograms. A strength of the review is that all data were extracted by two independent researchers and the difficulty of scoring the quality of mixed methods studies was overcome by using the Mixed Methods Appraisal Tool.

There were some limitations to this review. First, many articles provide an incomplete description on samples, materials, and outcomes of evaluations, especially for intermediate steps in the design process. For example, the size in which pictograms were presented to participants was only described infrequently, while it is known that pictogram size can greatly affect how well they are understood [78]. In addition, using the MMAT showed that criteria to score participants' interpretations of pictograms as correct or incorrect are rarely provided.

Secondly, there is the possibility of a publication bias towards articles that describe the evaluation of pictograms and pictogram intervention in more detail and focus less on pictogram development, as most journals that were included in the analysis are health-related and, consequently, more likely to be interested in effect measurements of pictograms than in their development processes. Since this review relied mainly on information presented in the published articles, it is possible that some authors did involve end-users in a way that is unknown due to limited descriptions in the articles.

To counter these limitations, also non-peer reviewed publications that focussed on the development process of pictograms were included in the analysis, as indicated in table 7.1. However, the information gaps that remain limit the understanding of the context in which findings should be considered and as well as the comparability between studies, making it more difficult to detect effects of end-user involvement.

This is a particular concern since very few articles in the review directly compare different forms of end-user involvement within one study, so that conclusions mainly relied on similarities and differences between studies.

Implications and Future Research

The findings of this review can be used by health professionals who want to select or design pharmaceutical pictograms for their patients, by providing insight into the effects of end-user involvement on pictogram success. When existing pictograms are used, care should be taken to select pictograms that have been designed for and evaluated on a population with similar characteristics to the patient group, in particular with respect to age, literacy levels, and cultural background. Based on the available evidence, designers of new pictograms are advised to clearly define their intended target group, to involve the target group early to determine initial design strategies and in an iterative design process, and to involve relevant patients or medication-users at least in the final evaluation of pictogram success.

Limitations in our understanding of end-user involvement in the context of pharmaceutical pictograms may be overcome by:

- The development of instruments that lower the cognitive load for end-users to contribute in a participative role.
- Consistent descriptions of materials, methods and outcomes of intermediate design and evaluation steps, including: pictogram size, pictogram examples, sample characteristics, measurements, and key findings.

Conclusion

Despite an increased focus in the field of design on end-user involvement during the pre-design phase and in a participative role [17], based on this study it cannot be concluded that these strategies are commonly adopted in the development of pharmaceutical pictograms. While involving patients in the development of pharmaceutical pictograms may seem like an obvious recommendation to optimise the effectiveness of pictograms, there is limited evidence for this strategy with respect to effects on health behaviour. However, involving (non-)patient members of the target group – in particular, early in the design, repeatedly, and in an active manner– can help to improve the quality of pictograms. More complete descriptions of pictogram development in published articles and more research on participative involvement are required to further advance the field.

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Appendix

Appendix 7.1 Search String per Database

PubMed

("pictograms" [tw] OR "pictogram" [tw] OR "pictograph" [tw] OR "pictographs" [tw]) AND ("medical" [tw] OR "medicine" [tw] OR "medicines" [tw] OR "medication" [tw] OR "medications" [tw] OR "drug" [tw] OR "drugs" [tw] OR "pharmacy" [tw] OR "pharmaceutical" [tw] OR "pharmacies" [tw])

Academic Search Premier

(TI(("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies"))) OR (KW(("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies"))) OR (SU(("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies")) OR (AB(("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies"))

Embase

For title/abstract/key words:

("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies")

Web of Science

TS=(("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies"))

Cochrane

(("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies"))

CINAHL

For ti/su/mw/ab:

(("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies"))

PsycINFO

For ti/su/mj/ab/kw:

(("pictograms" OR "pictogram" OR "pictograph" OR "pictographs") AND ("medical" OR "medicine" OR "medicines" OR "medication" OR "medications" OR "drug" OR "drugs" OR "pharmacy" OR "pharmaceutical" OR "pharmacies"))

Appendix 7.2 Data extracted from included articles

Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
			USP pictograms		
Advani et al., 2013*** [64]	Patients in general (USA)	*Evaluation* of leaflets with and without USP pictograms.	Potential end-users: *n* = 84 pharmacy visitors	C: text-only leaflet I: leaflet C with pictograms. Size not described.	**Leaflet user-friendliness, perceived effectiveness** and **perceived understanding**[2]: no difference between C and I. **Likelihood to refer to leaflet**[1]: Bigger for I than C. Site 1: C: 2/2, I: 2/2. Site 2: C: 1/2, I: 2/2 (p = 0.03).
Barros et al., 2014** [75]	Elderly patients (Brazil)	*Evaluation* of 15 USP pictograms.	Potential end-users: *n* = 116 elderly Brazilians	Pictograms: separately, without text. Size: 28×28 mm	**Pictogram understanding**[1]: 1/15 pictogram ⩾67% [b]. Mean 25.9% (SD 18.1).
Chan et al., 2013** [65]	Patients in general (China)	*Evaluation* of 25 USP pictograms	Potential end-users: *n* = 160 Hong Kong students	For understanding: 3 practice pictograms, then 25 pictograms: separately, without text. Size not described. For features: meaning of pictograms is given.	**Pictogram understanding**[1]: 12/25 pictograms ⩾67%. Mean 64.8% (SD 17.1). **Pictogram features**[2]**:** Semantic closeness (mean 72.0, SD 10.1) is best predictor of understanding, then simplicity (66.3, SD 8.2), concreteness (66.6, SD 8.8), meaningfulness (67.9, SD 8.8), and familiarity (53.5, SD 9.7).
Hämeen-Anttila et al., 2004** [27]	Children and adolescent patients (Finland)	*Evaluation* of 15 USP pictograms	Potential end-user: *n* = 90 elementary school children	C: 1) 15 pictograms without text. Size 80x80 mm. 2) text-only leaflet. I: 1) as in C. 2) leaflet with text and pictograms.	**Pictogram understanding**[1]: 13/15 pictograms ⩾67%. Mean 79.5% (SD 17.2). **Information understanding**[1]: 73-100% without probing, 80-100% with probing. No wrong answers in I after probing.
Joshi et al., 2011** [53]	Illiterate patients (India)	*Evaluation* of 9 USP pictograms and 1 other pictogram at baseline and follow-up.	End-users: *n* = 200 illiterate outpatients, *n* = 164 at follow-up	Three steps: 1) Pictograms: separately, without text. Size not described. 2) Like 1, with verbal explanation. 3) Follow-up, like 2.	**Pictogram understanding**[1]: At baseline prior to explanation: 0/10 pictograms ⩾67%. Mean 40.4% (SD 18.7). After explanation: 5/10 pictograms ⩾67%. Mean 69.7% (SD 13.9). At follow-up: 7/10 pictograms ⩾67%. Mean 70.7% (SD 15.6).

Kalsher et al., 1996*** [76]	Patients, especially elderly (USA)	*Evaluation* of different types of medication labels, with and without USP pictograms.	1) Partial end-users: *n* = 84 undergraduate students 2) Potential end-users: *n* = 58 elderly participants.	C) Control label, no pictograms C-P) C plus pictograms T) Tag label, no pictograms. T-P) T plus pictograms F) Fold-out label, no pictograms. F-P) F plus pictograms. Pictogram size not described, but example labels shown.	**1) Pictogram preference**[2]: Significant main effect of pictorials F(1,83) = 32.33, 213.03, 115.87, 71.2 and 122.02 for readability, noticeability likelihood of reading, preference, and likelihood of recommending ($p < 0.0001$). Labels with pictorials: higher ratings than without. **Pictogram perceived effectiveness**[2]**:** T-P and F-P more effective than C-P (M=3.00, 2.77 and 1.38). **2) Pictogram preference**[2]: Significant main effect of pictorials F(1,57) = 15.86 and 10.51 for noticeability and likelihood of reading ($p < 0.002$). Labels with pictorials: higher ratings for these measures than without. **Pictogram perceived effectiveness**[2]**:** No significant differences.
Kassam et al., 2004*** [54]	Low-literate patients from non-European descent (Canada).	*Design* modifications to the USP based on feedback of humanitarian relief mission personnel	Experts: DART personnel	n/a	Pictograms shown in article [n/a].
		Design: evaluation of 16 modified USP pictograms (Set A)	Potential end-users: *n* = 7 Punjabi, *n* = 7 Cantonese, *n* = 5 Somali. Low-literate	Pictograms: without text, size not described.	**Pictogram understanding**[1]: Set A: 4/16 pictograms ≥67%. Mean 46.9% (SD 28.1).
		Design modifications of 12 pictograms (> Set B)	Experts: research team	n/a	Pictograms shown in article [n/a].
		Design: evaluation of set B + 3 of A	Potential end-users: *n* = 8 low-literate Cantonese	Pictograms: without text, size not described.	**Pictogram understanding**[1]: Set B: 5/12 pictograms ≥67%. Mean 54.9% (SD 28.0). Overall mean understanding: 58.4%.
		Design: modifications of 4 pictograms (> Set C)	Experts: research team	n/a	Pictograms shown in article [n/a]
		Evaluation of set C + 3 of A	Potential end-users: *n* = 7 Punjabi, *n* = 5 Somali. Low-literate	Pictograms: without text, size not described.	**Pictogram understanding**[1]: Set C: 0/3 pictograms ≥67%. Mean 30.3% (SD 21.1). Overall mean understanding: 67.15%.

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
King et al. 2012** [55]	Low health-literate patients (USA)	*Evaluation* of 3 leaflets, one with USP pictograms	Potential end-users: *n* = 161 adults with low literacy (REALM)	C: Text-only leaflets I-P Leaflet with pictograms. Size not described. I-TP: Leaflet with text and pictograms. Size not described.	**Information recall**[1]: C: mean 6.54 (SD 1.40). I-P: 6.65 (SD 1.40). I-TP: 6.36 (SD 1.43). No significant difference (p = 0.392).
Sharaideh et al., 2013*** [14]	Primary school aged-patients (Jordan)	*Evaluation* of 15 USP pictograms	Potential end-user: *n* = 200 children aged 7-9	Pictograms: separately, without text. Size not described.	**Pictogram understanding**[1]: 8/15 pictograms ≥67%. Mean 70.6% (SD 12.1).
Soares, 2013*** [12]	Patients in general (Portugal)	*Evaluation* of 15 USP pictograms selected by a panel of pharmacists	Potential end-user: *n* = 751 pharmacy clients	Pictograms: separately, without text. Size not described.	**Pictogram understanding**[1]: 10/16 pictograms ≥67%. Mean 75.8% (SD 20.3).
Wolff et al., 1993** [66]	Patients in general (USA)	*Design:* Testing of 28 USP pictograms	Potential end-users: *n* = 143 from Rensselaer Polytechnic Institute and the Troy, NY community.	Shown in groups of 6-8, without text. Size not described.	**Pictogram understanding**[1]: 10/16 pictograms ≥85%. Problem areas: poor depictions, ambiguous language, passage of time.
		Design: Redesign of pictograms	Not described	n/a	Example pictograms shown in article [n/a].
		Design: Testing of redesigned pictograms	Potential end-users: *n* = 112 from Rensselaer Polytechnic Institute and the Troy, NY community.	Shown in a booklet, without text. Size not described.	**Pictogram understanding**[1]: 14/16 pictograms ≥85%.
		Design: Re-examination of concepts, verbal labels and scoring criterion	Expert: coders, expert in pharmaceuticals, *n* = 3 pharmacy students.	n/a	With stricter criteria, more pictograms show difficulties [n/a].

		Design: Drawing of alternative designs of 'problem concepts'	Potential end-users: *n* = 34 with various ethnic backgrounds.	No pictograms shown, but concepts described.	Drawings not shown in article[3].
		Design of alternative pictograms	Not described	n/a	Example pictograms shown in article [n/a].
Yu et al., 2013*** [67]	Patients in general (USA)	*Evaluation* of USP pictograms	Potential end-user: *n* = 100 Mechanical Turk Workers	Pictograms: separately, without text. Size not described.	**Pictogram understanding**[1]: 12/20 pictograms ≥67%. Mean 72.5% (SD 18.9).
SA pictograms (developed in Ehlers & Dowse, 2001 – not published)					
Dowse & Ehlers, 2001** [25]	Low-literate Xhosa patients (South Africa)	*Evaluation* of USP and locally developed (SA) pictograms (in Ehlers & Dowse, 2001 – not published). Follow-up evaluation after 3 weeks.	Potential end-user: *n* = 46 Xhosa people, most low-literate	Two pictogram sets: USP and SA. All shown separately without text. Size 11.5x11.5 cm.	**Pictogram understanding[1]:** At baseline: 12/23 of SA (mean 66.5, SD 25.1) and 9/23 of USP (mean 55.9, SD 26.0) ≥67%; 7/23 SA score better (p<0.05) than USP. At follow-up: 20/23 of SA (mean 85, SD 20.4) and 19/23 USP (mean 76.6, SD 21.6) ≥67%. **Pictogram preference**[2]: 21/23 SA over USP (p < 0.05).
Dowse & Ehlers, 2003** [28]	Xhosa patients (South Africa)	*Evaluation* of 23 USP vs 23 SA pictograms.	Potential end-user: *n* = 130 Xhosa people, 52.3% low-literate	Two pictogram sets: USP and SA. All shown separately without text. Size 11.5x11.5 cm.	**Pictogram understanding[1]:** 5/23 USP ≥85%, 10/23 SA ≥85%. Influence of education significant for 24/26. [a] **Pictogram preference**[2]: 17/23 SA over USP (p < 0.05). **Pictogram usefulness**[2]: 98.5%: good addition, 99.2%: valuable reminder aid.
Dowse & Ehlers, 2004** [56]	Low-literate patients (South-Africa)	*Evaluation* of 23 USP vs 23 SA pictograms.	Potential end-users: *n* = 304 South African people, most low-literate	Two pictogram sets: USP and SA. All shown separately without text. Size 11.5x11.5 cm.	**Pictogram understanding[1]:** 2/23 USP ≥85%, 12/23 SA ≥85%. 16/23 SA score better (p<0.05) than USP. [a] **Pictogram preference**[2]: 22/23 SA over USP (p < 0.05). **Pictogram usefulness**[2]: 98%: good addition, 96%: valuable reminder aid.
Dowse & Ehlers, 2005** [11]	Low-literate Xhosa patients (South-Africa)	*Evaluation* of SA pictograms selected for antibiotics labels.	End-users: *n* = 87 Xhosa users/care-givers of antibiotics, a third low-literate.	C: standard text-only labels I: C plus pictograms. Size not described.	**Information understanding**[1]: Better for I (mean 95.2%) than C (mean 69.5%), p<0.01. **Adherence**[1]: Better for I (mean 89.6%) than C (mean 71.5%), p<0.01. **Pictogram usefulness[2]:** almost all: good addition and valuable reminder aid.

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
Knapp et al., 2005**** [78]	(A) Adults patients (UK), (B) Elderly patients (UK)	*Evaluation* of (A) 10 USP and 10 SA pictograms, and (B) 10 USP at baseline and 14 day follow-up.	Potential end-user: (A) n = 160 adults of mixed-income urban area, (B) n = 67 older adults	(A) Pictograms: separately, without text. Size 90x90 mm (B) Pictograms: separately, without text. Size 90x90 mm and 30x30 mm.	**Pictogram understanding**[1]: (A) 4/10 SA pictograms ⩾67%. Mean 55.5% (SD 21.1). 4/10 USP pictograms ⩾67%. Mean 50.3% (SD 28.9). For 2/10, SA was understood better than USP (p = 0.01, p = 0.002). (B) At baseline: 1/10 large pictograms ⩾67%. Mean 30.7% (SD 18.0). 0/10 small pictograms ⩾67%. Mean 19.7% (SD 12.1). At follow-up: 2/10 large pictograms ⩾67%. Mean 43.9% (SD 21.5). 0/10 small pictograms ⩾67%. Mean 35.9% (SD 18.7). Correct interpretation is more likely for larger (p = 0.037) pictograms and at second presentation (p < 0.001).
Mishra et al., 2011* [68]	Patients in general (India)	*Evaluation* of 20 USP and 20 SA pictograms.	Potential end-user: n = 140 non-pharmacy students	Pictograms: shown in USP-SA pairs, without text. Size not described.	**Pictogram understanding**[1]: Undergraduates: 61%, postgraduates: 56% for USP and SA combined. **Pictogram preference**[2]: 53% of undergraduates and 61% of postgraduates prefer USP over SA.
			HIV/aids - ARV		
Mwingira, 2004** (part 1) [33] [c]	ARV patients (Sub-saharan Africa)	*Pre-design*: selection of topics for visualisation	Not described.	n/a	**Topics**: when and how to use the medicine, storage, and use with alcohol [n/a].
		Pre-design: selection and adaptations of pictograms: five SA pictograms (Dowse & Ehlers, 2001) and one new.	Experts: n = 40 2[nd] year pharmacy students	n/a	Sketches and adaptations shown in article [n/a]
		(Pre-)design: Discussion and production of first pictogram	Graphic designer	n/a	Pictograms shown in article [n/a]

		Design: Evaluation and adaptations of pictograms	Potential end-user: 4x n = 5 Xhosa participants	Not described.	**Pictogram acceptability**[2]: need for minor changes. Pictograms shown in article
		Evaluation of 10 pictograms: 7 existing, 3 new.	Potential end-user: n = 30 Xhosa participants	Shown separately. Size not described.	**Pictogram understanding**[1]: 5/10 pictograms ≥67%. Mean 64.0% (SD 26.4)
Mwingira & Dowse, 2006*** [34] [suppl. with Mwingira, 2004 [33] [c]]	HIV/aids patients on ARV (South Africa)	*Design:* of leaflet incorporating pictograms of Mwingira, 2004.	Not described.	n/a	A two-page A4 size leaflet, not shown in article. [n/a]
		Design: modifications of leaflet.	Potential end-users: 4x n = 5 [Xhosa participants]	n/a	[Leaflet shown in suppl. article][n/a]
		Design: Pilot test of leaflet and modifications.	Potential end-users: n = 20 Xhosa participants	Pictograms: presented in leaflet, with text. Size not described.	**Leaflet acceptability**[2]: minor modifications to leaflet content and layout. Resulting leaflet not shown in article.
		Evaluation of final version after translation to isiXhosa.	Potential end-users: N = 60 Xhosa speakers who can read	Pictograms: presented in leaflet, with text. Size not described.	**Information understanding**[1]: Average reading time: 9 minutes. Average understanding: 80%. All except one of instructions with pictograms scored 100% understanding. **Leaflet acceptability**[2]: Good readability (33.3%), text size large enough (100%), length of sentences appropriate (95%), adequate space between lines (96.7%), adequate amount of information (88.3%), understanding of all words (8.3%), presence of pictograms desirable (100%), pictograms help understanding and recall (100%).
Mwingira & Dowse, 2007** [35]	ARV users (Tanzania)	*Evaluation* of final version of leaflet after translation to Kiswahili, continuing from pilot test of leaflet in Mwingira & Dowse, 2006.	Potential end-users: n = 60 Tanzanian ARV-naïve people of different tribes	Pictograms: presented in leaflet, with text. Size not described, but leaflet shown in article.	**Information understanding**[1]: Average reading time: 9 minutes. Average understanding: 95%. **Leaflet acceptability**[2]: Good readability (30.0%), text size large enough (100%), length of sentences appropriate (96.7%), adequate space between lines (91.7%), adequate amount of information (96.7%), understanding of all words (16.7%), presence of pictograms desirable (100%), pictograms help understanding and recall (100%).

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
Dowse et al., 2010** [36]	Low-literate HIV/AIDS patients (South Africa)	*Pre-design:* Identification of 12 ARV side effects for illustration.	Not described	n/a	Two groups: A) nausea and vomiting, skin rash, abdominal pain, nightmares, lipodystrophy, peripheral neuropathy. B) dizziness, fever, headache, diarrhoea, lipoatrophy, lactic acidosis. [n/a]
		(Pre-)design of pictograms A) after seeing example (North American and South African) pictograms. Design of pictograms B) from photos or textbook images.	A) Experts: *n* = 130 mainly Southern African pharmacy students. B) Expert: graphic designer.	n/a	Pictograms shown in article [A) n/a, B) n/a]
		Design: A+B) Evaluation of drafts, redesign into multiple drafts of each image until ready for further testing.	A) Experts: *n* = 1 researcher, pharmacist, illustrator. B) Experts: graphic designers.	Not described	Pictograms shown in article. [n/a]
		Design: Preliminary evaluation of the 6 pictograms of set A and B separately.	Potential end-user: 2x *n* = 6 Xhosa-speaking adults, max 10 years of schooling	Pictograms: separately, without text. Size 100x100mm or 45x45mm.	**Pictogram acceptability[2]:** Qualitative description of suggested changes by participants.
		Evaluation of 15 pictograms illustrating 12 side effects (some two versions).	Potential end-user: *n* = 40 Xhosa-speaking adults, max 10 years of schooling	Pictograms: separately, without text. Size not described.	**Pictogram understanding[1]:** 4/7 pictograms ≥67%. Mean 66.3% (SD 23.0). More results in Ramela, 2009, in total: 12/15 ≥67%. Mean 78.6% (SD 20.3).

Dowse et al., 2011** [37] [suppl. with Ramela, 2009 [85]]	Low-literate HIV/AIDS patients (South Africa)	*Design:* Redesign of leaflet based on Mwingira and Dowse, 2007. Added pictograms from Dowse et al., 2010 and Mwiringa & Dowse, 2007.	n/a Not described	n/a	Removal of product description section; reduction of number of words from 980 to 317. Increased number of pictograms to 20. Two leaflet versions, shown in article: A) Landscape version, three-column layout B) Portrait version, combination of single and double column layout
		Design: evaluation of leaflets A and B in three focus group discussions.	Potential end-users: *n* = 3 not taking ARVs. End-users: *n* = 4 HIV/aids patients recently initiated on ARVs. Experts: *n* = 8 local healthcare providers		**Leaflet acceptability[2]:** Healthcare providers: concerned about CD4 count pictogram. Lay participants: positive, landscape version preferred, CD4 count pictogram understood and valued.
		Evaluation of the landscape layout PIL version	Potential end-users: *n* = 39 low-literate, South African, antiretroviral-naïve adults. [Potential end-users: *n* = 80 low-literate, South African, antiretroviral-naïve adults.]	[C: pictogram leaflet I: C + pictograms of side effects.] Pictograms: presented in leaflet, with text. Size not described, [but leaflets shown].	**Leaflet understanding[1]**: [C and I:] 4/7 questions scored over 90%, all of which illustrated with pictograms. [For most questions no difference between C and I.] **Leaflet acceptability[2]**: Good readability ([C:] 48.7%, [I: 31.7%]), text size large enough ([C:] 100%, [I: 97.6%]), length of sentences appropriate ([C:] 84.6%, [I:95.1%]), adequate space between lines ([C:] 94.9%, [I:100%]), adequate amount of information ([C:] 87.2%, [I: 90.2%), understanding of all words ([C:] 53.8%, [I: 85.4%]), understanding of all pictograms ([C:] 71.8%, [I: 90.2%]), pictogram size acceptable ([C:] 94.2%, [I: 97.2%]), presence of pictograms desirable ([C:] 100%, [I:] 97.6%), pictograms help understanding and recall ([C:] 100%, [I: 100%]).
Dowse et al., 2014** [38]	Low-literate HIV patients (South-Africa)	*Design*: Modification of leaflets from Dowse et al., 2011.	Not described	n/a	Leaflet with pictograms shown in article.[n/a]

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
		Evaluation of leaflets	End-users: isiXhosa HIV/AIDS patients. At baseline: n = 116, at 1st follow-up: n = 94; at 2nd follow-up: n = 83, at 3rd follow-up: n = 64	C: standard care I: standard care + pictogram leaflet. Pictograms: presented in leaflet, with text. Size not described, but example shown in article. Verbal explanation of leaflet sections.	**Information knowledge**[1]: Baseline C: 70.0%, I: 62.0% (p = 0.001), 1-month C: 68.8%, I: 88.5% ($p < 0.001$), 3-month C: 72.8%, I 93.9% ($p < 0.001$), 6-month C: 76.1%, I: 94.4% ($p < 0.001$) **Self-efficacy**[1]: Similar between I and C. No change for C over 6 months; I improved from 9.11 (SD 0.46) to 9.71 (SD 0.72), p = 0.008.
HIV/aids - Nystatin					
Mansoor & Dowse, 2003*** [39]	Low-literate IsiXhosa patients on nystatin (South-Africa)	*Design* of leaflets and labels with pictograms (most from Dowse & Ehlers, 2001) and iterative testing/redesign.	Unclear: members from the target population.	Not described	Not described. [unclear]
		Design: Evaluation of pictogram and control leaflet. Various minor modifications.	Partial end-users: n = 20 Xhosa participants	Pictograms: presented in leaflet, with text. Pictogram size not described.	Leaflets and labels with pictograms shown in article. [unclear]
		Evaluation of the two leaflets	Potential end-users: n = 60 low-literate Xhosa participants.	C: text-only leaflet/label I: leaflet/label with pictograms. Pictograms: presented in leaflet/label, with text. Pictogram size not described, but example leaflet/label shown in article.	**Label understanding**[1]**:** For I, better understanding (all but two questions 100% understanding) than C (40% of participants 100% understanding), p = 0.001. **Leaflet understanding**[1]**.** Locating information similar for C and I. For I, higher understanding of leaflet (73%) compared to C (53%), p = 0.005. **Leaflet preference** and **acceptability**[2]**:** 98.3% of participants preferred pictogram leaflet, thought it was easier to read, liked pictures, and thought the writing was big enough. 7.5% thought the pictogram leaflet contained more words than the text-only version.

Mansoor & Dowse, 2004** [40]	Low-literate patients on nystatin (South Africa)	*(Pre-)design* of pictogram sequences using concepts and ideas from the USP and SA pictograms.	Experts: *n* = 40 3rd year pharmacy students	n/a	Initial sketches not shown in article [n/a].
		Design: Examination and modification of pictogram sketches.	Expert: graphic designer. Potential end-users: 'from target population'	Not described.	Modification process shown in article [n/a].
		Design: Evaluation of 9 SA pictograms, plus pictogram version 1. Redesign to version 2.	Potential end-users: *n* = 30 Xhosa people ≤7 years of schooling.	Pictograms shown separately, without text. Size: 115x115mm.	**Pictograms acceptability**[2]: no hair on figure confusion, swirling action unclear, throat unclear, pictures too small. Pictograms shown in article. **Pictogram understanding**[1]: SA: 6/9 pictograms ≥67%. Mean 78.2% (SD 22.3). Version 1: 66.7%. **Pictogram usefulness**[2]: every participant felt pictograms could help them remember to take the medicine.
		Design: Evaluation of version 2, redesign into version 3.	Potential end-users: Xhosa people ≤7 years of schooling.	Pictograms shown separately, without text. Size: 115x115mm.	**Pictograms acceptability**[2]: two central frames unclear, added oesophagus outline in first frame. Pictograms shown in article.
		Design: evaluation of version 3, redesign into version 4a and 4b.	Experts: graphic designer, researchers, pharmacy students	Not described.	Final versions shown in article [n/a].
		Evaluation of 4 SA pictograms, plus pictogram version 4a and 4b.	Potential end-users: *n* = 20 Xhosa people ≤7 years of schooling.	Pictograms shown separately, without text. Size: 115x115mm.	**Pictogram understanding**[1]: SA: 4/4 pictograms ≥67%. Mean 98.8% (SD 2.5). Version 4a: 95.0%. 4b: 95.0% **Pictogram preference**[2]: 100% preferred 4a, showing the outline of the oesophagus. **Pictogram usefulness**[2]: every participant felt pictograms could help them remember to take the medicine.
Mansoor & Dowse, 2006*** [41]	Low-literate HIV/AIDS patients (South-Africa)	*Design* of two leaflets, one with pictograms, based on Mansoor & Dowse, 2003.	Not described	n/a	Leaflets and pictograms not shown in article, but described in detail.

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
		Evaluation of the two PILs	End-users: $n = 120$ isiXhosa HIV-positive patients	C: no leaflet I-T: text-only leaflet I-P: simple leaflet with pictograms. Pictograms: size not described, but leaflet shown.	**Adherence**[1]: Self-reported 100% adherence: significantly more in group I-P (92.5%) than in C (70%) or I-T (77.5%), $p < 0.05$. Tablet count 100% adherence: significantly more in I-P (35%), than in I-T (2.5%) or C (2.5%), $p < 0.05$.
Mansoor & Dowse, 2007** [10]	HIV-positive patients (South-Africa)	*Design* of simple leaflets, with addition of pictograms from Mansoor & Dowse, 2004 and Mwingira, 2004.	Not described	n/a	Leaflets and pictograms shown in article.
		Evaluation of leaflets.	End-users: $n = 120$ isiXhosa HIV-positive patients on co-trimoxazole therapy	C: no leaflet I-T: text-only leaflet I-P: simple leaflet with pictograms. Pictograms: size not described, but leaflet shown.	**Information understanding**[1]: Higher in I-P (76.3%) than in C (43.3%) and I-T (50.9%). For 9/11 questions this difference was significant with $p < 0.05$.
		Glyph system			
Zeng-Treitler et al., 2008** [9]	Patients in general USA)	*Pre-design:* identification of instructions to improve with visual aids, help to design pictographs.	Experts: $n = 2$ nurses and potential end-users: $n = 2$ consumers.	n/a	**Topics:** Nurses: 32/38 instructions require pictograms. [n/a] Consumers: nothing in particular. 20/32 instructions were targeted for design.[3]
		Design of pictogram sketches	Expert: $n = 1$ investigator	n/a	Example shown in article. [n/a]
		Design: discussion of pictograms	Experts: $n = 2$ nurses and potential end-users: $n = 2$ consumers.	Not described.	Pictograms revised based on comments on semantics and improvements[2]. Example shown in article. Medication shown as either a photo or icon.

		Evaluation of pictograms	Potential end-users: *n* = 13 not healthcare professionals.	C: text-only discharge instruction I: C plus pictograms. Pictogram size not described.	**Information recall**[1]: Immediate: higher for I (53.5%) than C (44.28%), $p < 0.001$. Delayed: higher for I (33.03%) than C (15.95%), $p < 0.001$.
Kim et al., 2009* [74]	Patients in general (location not described)	*Evaluation* of 20 Glyph pictographs against 20 Hablamos Juntos public information symbols	Potential end-user: *n* = 37 colleagues/ acquaintances of authors		**Pictogram understanding**[1]: Glyph pictograms scored better (71.81%, p<0.001) than the Hablamos Juntos symbols (57.27%), $p < 0.001$.
Nakamura et al., 2011** [42]	Cardiology patients (USA)	*(Pre-)design* of initial version of pictograms	Experts: graphic designers	n/a	Pictograms not shown in article. [n/a]
		Design: iterative evaluation and redesign.	Experts: members of research team	Not described	Not described. [n/a]
		Design: building pictogram leaflets using a pictogram lexicon, syntax and the Pictogram Builder	Unclear: volunteer with no background in graphic design.	n/a	25 instructions were converted with the Pictogram Builder. Two examples of pictograms are shown in the article. [n/a]
		Evaluation of pictograms	Unclear: *n* = 14 participants	C: pictograms created by graphic designer I: pictograms created with the Pictogram Builder. Pictograms shown with answer options. Size 25.4x25.4mm to 25.4x76.2 mm.	**Pictogram understanding**[1]: [From Bui et al., 2012:] 49/50 pictograms ≥67%. No difference between C and I ($t = 0.18$, $p = 0.85$, df = 24).

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
Nakamura et al., 2012[n/a] [69]	Patients in general (USA)	*Design* of a taxonomy of icons based on 846 health-related pictographs	Experts: the authors	n/a	**Lexical classification**[n/a]: Transitive senses of verbs and most modifiers cannot be graphically represented on their own. **Semantic classification**[n/a]: Entity, event, physical Object, conceptual entity, phenomenon or process, activity. **Representation strategies**[n/a]: Visual similarity, arbitrary convention, semantic association
Bui et al., 2012* [43] [c]	Cardiology patients (USA)	*Design:* iterative testing and adjustments of Glyph system with instructions, continuing from Nakamura et al., 2011.	Experts: development team	Not described.	Not described, but examples shown in article [n/a].
		Evaluation of 49 instructions for cardiology patients.	Experts (n = 1 nurse, n = 1 graphic designer, n = 1 software engineer)	Pictograms shown with some text. Size not described.	**Pictogram completeness**[n/a]**:** 66.2% of the semantic units correctly represented, 20.2% not represented, 13.5% wrongly or partially.
Zeng-Treitler et al., 2014*** [70]	Patients in general (USA)	*Design:* exclusion of 7 Glyph instructions with incorrect semantic units, continuing from Bui et al., 2012.	Not described.	n/a	Example of pictogram instruction shown in article [n/a].
		Evaluation of Glyph pictograms	Potential end-users (n = 84 non-clinical USA participants)	Discharge instruction with text, half of the topics with pictograms. Pictogram size not described.	**Information recall**[1]: 47% (SD 0.23) without pictographs, 52% with pictographs (SD 0.22). (95% CI 0.03 to 0.06, p < 0.001)

FIP					
Sorfleet et al., 2009* [29]	Patients in general (Gabon)	*Design* of storyboard concept	Experts: graphic design students, n = 2 nurses, researchers	n/a	Pictograms in storyboard shown in article [n/a]
		Evaluation of storyboard	Potential end-user: n = 767 'target group'	Pictograms: shown in storyboard, with a few words. Size not described.	**Pictogram understanding**[1]: At dispense: 14/14 pictograms ≥67%. Mean 83.0% (SD 3.3). At follow-up: 12/14 pictograms ≥67%. Mean 71.9% (SD 31.1). **Pictogram acceptability**[2]**:** results for improvements not described.
Grenier et al., 2013*** [79]	Patients of first nation communities (Canada)	*Pre-design:* selection of pictograms drafts by FIP (Sorfleet et al., 2009), plus one from USP	Experts	n/a	Pictograms shown in article [n/a]
		Pre-design: selection of best pictograms and evaluation of acceptability and proposed modifications	Potential end-users: focus groups with first nation communities.	Pictograms: multiple per labelling instruction. Not described if with text or not. Size not described.	Results not described. [3]
		Design of 16 adapted and new pictograms	Experts: Transfer Nursing Consultant, n = 2 pharmacists, research coordinator, graphic designer	n/a	Pictograms shown in article. [n/a]
		Evaluation of 21 pictograms.	Potential end-users: n = 66 people from first nation communities.	Pictograms: not described if separate or not, or with text or not. Size not described.	**Pictogram selection**[3]**:** Consensus on all pictograms. Eleven new pictograms were created, five existing required minor changes, five remained unchanged.

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
			Driving warnings		
Monteiro et al., 2013*** [44] [suppl. with Meesmann et al., 2011 [86][c]; Orriols et al., 2010 [87])	Patients on driving-impairing medicines (DIM) (the Netherlands)	[*(Pre-)design*: risk categorisation, DRUID Rating Model (RM) (Meesmann et al., 2011) and French Triangle Model (TM) (Orriols et al., 2010) pictogram design.]	[DRUID RM: Experts and potential end-users: various stakeholders. French TM: Experts: multidisciplinary group of experts]	DRUID RM: not described. French TM: not described.	Pictograms shown in article[n/a]
		Evaluation: Comparison of the French TM pictograms versus the DRUID RM pictograms, and the added value of side-text.	Potential end-users: n = 270 pharmacy visitors with a driver's license and actively participating in traffic with motorised vehicles.	Nine test groups: Rating model (RM) without text, three levels of risk; RM with text, three levels of risk; Triangle model (TM) pictograms with text, three levels of risk. Pictograms: shown separately. Size not described.	**Pictogram understanding**[1]: full understanding by<10% for TM, 36% for RM. No added value of side-text found. **Pictogram acceptability**[2]: No difference between pictogram systems **Risk perception**[1]: Interaction effect between risk category and pictograms $F(1.116) = 6.062$, $p = 0.015$ $\eta^2 = 0.05$. Low-risk of RM: lower level of driving risk than low-risk TM. High risk of RM: higher level of driving risk than high risk of TM. **Behaviour change intention**[1]: higher for higher risk level (mean 4.43, SD 0.68 vs. 3.37, SD 0.95) for RM, but not TM.
Emich et al., 2014*** [45]	Patients on DIM (the Netherlands)	*Evaluation* of the DRUID RM pictogram vs. the Dutch yellow/ black (YB) label.	End-users: n = 298 patient with 1st DIM dispensing	Three groups based on risk level: C1: YB label, and RM level 1 +/- text. C2: YB label, and RM level 2 +/- text. C3: YB label, and RM level 3 +/- text. Pictograms: size not described.	**Risk perception**[1]: YB: same for all categories. RM: higher when risk more severe ($p < 0.001$). RM with text: higher for all categories ($p = 0.03$- $p < 0.001$). **Behaviour change intention**[1]**:** RM + text: higher for all categories ($p = 0.03$-$P < 0.001$). Higher when risk level is higher ($p < 0.001$).

Fierro et al., 2013*** [46]	Patients using medicine that may affect driving (Spain)	*Evaluation* of the Spanish pictogram on medicines and driving (Agencia Española de Medicamentos y Productos Sanitarios, 2012).	Potential end-users: *n* = 1385 drivers (79.3%) and non-drivers (20.7%)	Pictograms: presented on medication packaging, with some words. Size not described.	**Pictogram understanding**[1]: Correct: 90.5% of drivers, 67.4% of non-drivers ($p < 0.0001$). **Risk perception**[1]: High risk: 45.2% of drivers, 60.1% of non-drivers ($p < 0.0001$). **Behaviour change intention**[1]: 14.6% would not reduce driving frequency. Drivers less inclined to change habits ($p < 0.0001$). **Pictogram acceptability**[2]**:** Usefulness: mean 8.31 (SD 1.70), information 7.69 (SD 1.90), comprehensibility 7.76 (SD 1.91), simplicity 7.80 (SD 1.94), global evaluation 7.98 (SD 1.58).
Smyth et al., 2013** [47]	Drivers on psychotropic mediation (Australia, France)	*Design* of Australian warning labels (Australian pharmacist, 2006).	Experts	n/a	Pictograms shown in article [n/a]
		Evaluation of Australian versus French warning labels (Orriols et al., 2010).	Potential end-users: *n* = 357 Australian and *n* = 75 French hospital outpatients.	A1: Australian label 1 A1a: Australian label 1a A12 Australian label 12 F1: French label, level 1 F2: French label, level 2 F3: French label, level 3 Pictograms shown together, with text. Size not described, but examples are shown.	**Visual impact**[1]**:** Greatest impact: Australia: combination of elements (37%), colour of warning (20%). France: pictogram (85%), red colour (82%), triangle (78%), size of label (68%). **Label readability**[1]**:** Easiest to read: Australia: A1 (37.3%). France: superseded pictogram-only label (51.4%). **Risk perceptions**[1]**:** Stronger for F than A (effect size: r=0.52, p<0.001). Strongest: Australia F3 (51.2%). France: F3 (68.5%) **Behavioural intention**[1]**:** Australia: differences for 5/7 intentions (p<0.001) between A1 and F3. No differences between Australia and France for F3.

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
			HELPix		
Yin et al., 2008*** [57]	Low-literate parents/ caregivers of young patients (USA)	*Evaluation* of 2-page medication information sheets generated with HELPix software.	Potential end-users: *n* = 245 parents/ caregivers of children, approximately a third low-literate (TOFHLA) *n* = 227 at follow-up.	C: Routine, unstandardised counselling by physician, nurse, and pharmacy. I: C, plus plain language, pictogram-based medication instruction sheets in English and Spanish.	**Dosing accuracy[1]:** Fewer errors in dosing accuracy in I than C. Daily dose: 5.4% vs 47.8%, absolute risk reduction (ARR) 42.4% (24.0%-57.0%, 95% CI). Dose as needed: 15.6% vs 40.0%; ARR 24.4% (8.7%-38.8%, 95% CI). **Adherence[1]:** Non-adherence lower in I (9.3%) than C (38%). ARR 28.7% (11.4%-43.7%, 95% CI). **Knowledge of medication[1]**: Improvements for knowledge of medication preparation and frequency.
Yin et al., 2011*** [58]	Low-literate parents/ caregivers of young patients (USA)	*Evaluation* of Helpix leaflets with pictograms.	Potential end-user: *n* = 299 low-health literate (NVS) parents with their child.	C: Textual dosing instruction on index card. I: C, plus pictograms. Size not described.	**Dosing accuracy[1]**: C: 59.0% error, I: 43.9%. ARR 15.2% (3.8–26.0, 95% CI). C: 5.6% larger overdose error, I: 0.6%. ARR 4.9% (0.9–10.0, 95% CI). Difference in dosing error between C and I only for low health literate: 50.4% vs 66.4% ($p = 0.02$).
			Webb & Wolf		
Webb et al., 2008*** [59]	Patients, especially low-literate (USA)	*Evaluation* of existing pictograms and iterative redesign.	Potential end-users: *n* = 85 adult participants, half low-literate.	Pictograms shown within warning labels on bottles, textual messages given. Size not described.	**Pictogram understanding[1]**: 6/10 pictogram sequences ⩾67%. Mean 70.1% (SD 24.0). **Label acceptability[2]**: Adjustments to text, icons, selection of universal warning symbols, removal of colours, optimising fonts for clarity. Labels shown in article. **Pictogram usefulness[2]:** Considered especially useful for warnings. Better to have icons specific for each warning than a general warning sign.
Wolf et al., 2010*** [7]	Patients, especially low-literate (USA)	*Evaluation* of enhanced drug warning labels from Webb et al., 2008.	Potential end-users: *n* = 500 primary care clinic outpatients, >50% marginal literacy.	C: standard drug warning label, includes pictograms. I-T: label with simplified text I-TP: I-T with pictograms. Pictogram size not described.	**Attention to warning[1]:** higher for I-T (73.4%) and I-TP (78.3%) than I-C (70.2%), and for I-TP than I-T, $p < 0.001$. **Information understanding[1]**: I-T (90.6%) and I-TP (92.1%) more likely to be correct than C (80.3%). No difference between I-T and I-TP ($p = 0.20$)

Stand-alone articles					
Bernardini et al., 2000*** [71]	Patients in general (Italy)	*(Pre-)design* of 4 symbols/ pictograms per topic based on participants' suggestions.	Potential end-user: n = 20 non-researchers at University.	n/a	Symbols and pictograms shown in article[3]
		Evaluation of the symbols/ pictograms, plus a fifth from Maery et al., 1995.	Potential end-users: n = 1004 pharmacy patients	Five pictograms shown together, without text. Size not described.	**Pictogram usefulness** and **preference**[2]: 74.3% found symbols/pictograms helpful. Uniformity in answers for 4/6 topics.
Braich et al., 2011** [48]	Low-literate patients with postoperative cataract regimens (India)	*Evaluation* of pictograms	End-users: n = 225 patients referred for cataract surgery	Three test groups: C: verbal instructions I-P: same as 1, plus two pictogram sets with text. Size not described. I-P2: same as 2, but pictograms to take home.	**Information understanding**[1]: No differences 15 minutes post-instruction. Day 7: I-P and I-P2 (7.33 and 7.62/10) score better ($p<0.001$) than C (5.77/10). Day 28: I-P2 (7.17/10) scores better ($p<0.001$) than C (4.37/10) and I-P (5.44/10). **Adherence**[1]: Higher understanding was associated with greater medication consumption ($p < 0.001$).
Chan et al., 2014**** [49]	Patients on anti-hypertensive and antidiabetic treatment (Malaysia)	*(Pre-)design* of pictograms in a focus group discussion.	End-users: 'local patients'	n/a	Results not described.[2/3]
		Design: Pictogram evaluation	End-users: 'local patients'	Not described	Results not described. [unclear]
		Evaluation of labels with and without pictograms at baseline and follow-up.	End-users: at start n = 126 hypertensive patients, most with other chronic diseases. At follow-up n = 110.	Three test groups: C: Standard label I-F: Font-enlarged label I-P: Pictogram-incorporated label, with a few words. Size not described.	**Adherence**[1]: increased for all groups (mean: 0.35, 0.58, 0.67, all $p<0.05$), but did not differ between groups (p = 0.573). **Information understanding**[1]: increased only for I-P (0.37, p = 0.01). **Label preference**[2]: 56.4% preferred I-F. More elderly and those with a higher number of morbidity preferred I-P (55.6%, p = 0.013 and 59.5%, p = 0.008).

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
Chuang et al., 2010*** [60]	Low-literate patients	*(Pre-)design:* Pictographs drafted based on report by the Taiwan Society of Health-System Pharmacists.	Not described	n/a	Pictograms not shown in article. [n/a]
		Design of 3 alternatives for each medication instruction.	Not described	n/a	Pictograms not shown in article. [n/a]
		Design: pilot study to evaluate pictograms.	Partial end-users: $n = 5$ patients. Experts: $n = 5$ pharmacists.	Not described	**Pictogram accuracy**[1]**, preference**[2] and **understanding**[1]**:** Inconsistency between patients and pharmacists.
		Design: preliminary evaluation of pictograms	Potential end-users: $n = 100$ low-literate visitors of an outpatient and pharmacy department	Not described	**Pictogram preference**[2] and **understanding**[1]: relatively low comprehension of all pictographs in all 3 categories, especially those for the time of day for medication administration.
		Design: Redesign to a new pictograph edition	Not described	n/a	Three sets of pictograms for four categories of medication instructions. Pictograms shown in article. [n/a]
		Evaluation of pictograms	Potential end-users: $n = 250$ ow-literate visitors of an outpatient and pharmacy department Experts: $n = 250$ medical staff.	Pictograms: shown together, with their meaning. Size unknown, but actual size.	**Pictogram preference**[2]**:** Different between patients and medical staff for all pictograms ($p < 0.001$). **Pictogram perceived understanding**[2]**:** Above 83.% for all pictograms. For 3/12 categories understanding differed between patients and medical staff ($p < 0.01$).

Dotson, 2009*** [61] [c]	Low-literate pregnant women (India)	*Pre-design:* Selection of topics for visualisation	Experts: n = 5 local physicians, Traditional Birth Attendants (TBAs)	n/a	Topics described [n/a]
		Design of pictograms for drug indication	Experts: Graphic designer, freelance artist, professional full-time artist, local artist	n/a	Pictogram sketches not shown in article. [n/a]
		Design: Pre-evaluation and modifications of pictograms and label.	Focus Group (FG)1: Experts: n = 7 health professionals. FG2 & FG3: potential end-users: n = 27 & n = 15 local women. Interviews: Experts: physician, health trainer, TBAs, health educator.	Pictograms: first shown separately. Size 'slightly enlarged'. Also shown in label, size 89x44mm.	**Pictogram understanding**[1] and **label acceptability**[2]**:** Selection of pictograms from two artists. Pictograms shown in article[3].
		Evaluation of pictogram labels	End-users: n = 137 pregnant women. n = 112 at follow-up.	C: standard care I-L: label with local pictograms I-NL: label with non-local pictograms. Label size: 89x 36mm.	**Pictogram understanding**[1]: I-L 11/14 pictograms ≥67%. Mean 82.2% (SD 18.7). I-NL: 10/15 pictograms ≥67%. Mean 69.8% (SD 23.4). In one case, I-L (100%) significantly (p = 0.01) better than I-NL (60%). **Information understanding**[1]: Dosage correctness: no differences. Drug indication: better in both I-L (mean 0.71, SD 0.33, p = 0.001) and I-NL (0.65, SD 0.36, p = 0.006) than in C (0.39, SD 0.37). **Adherence**[1]**:** I-NL significantly higher than I-L (p = 0.005) **Label acceptability**[2]**:** Pictogram usefulness: dosage: 92%, indication: 89%. Easier to take medicine with pictograms: >75%. No differences between I-L and I-NL. Empowering effect of labels: 88%.

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
Hwang et al., 2005*** [72]	Patients in general (Canada)	*Evaluation* of prescription medication instruction labels	End-users: n = 130 family practice clinic patients	C: text-only labels I: labels with text and pictograms. Labels shown together. Size: 80x20mm.	**Label understanding**[1]: 3/5 labels: 100% correct interpretation. 2/5: 34-55% correct. Compared to C, I better for 5-7% and worse for 7-9%.
Kheir et al., 2014*** [62]	Low-literate migrant workers (Qatar)	*Pre-design:* assessing information needs of end-users.	Potential end-users: 'members of target population'. Experts: clinic staff (interpreters) and pharmacists	n/a	**Information needs[2]:** Workers experience embarrassment, have to return to pharmacist for information. Pharmacist experience frustration with limited communication. Selection of 11 most commonly encountered and challenging instructions.
		Pre-design: discussion of cultural adaptions of pictograms found in literature	Potential end-users: n = 4 from target population Experts: research team, local graphic artist	n/a	Results not described in article. [2/3]
		Design of pictogram sketches and discussion.	Experts: graphic designer, research team.	n/a	Pictograms not shown in article. [n/a]
		Design: iterative evaluation and adaptations of pictograms	Potential end-users: members of target population	n/a	Pictograms shown in article. [unclear]
		Evaluation of medicine label instructions formats	Potential end-users: n = 123 foreign employees. >70% low-literate in English/ Arabic.	C: standard text labels with verbal instructions I: Pictogram-only labels I-V: I plus verbal instructions Pictogram size not described.	**Label understanding**[1]: For 10/11 labels I-V score higher than C; for 8/11 labels C scores higher than I ($p \leq 0.05$).

Korenevsky et al., 2013*** [77]	Young patients (Canada)	*Design:* Analysis of convenience sample of pictograms (27% from FIP/USP) to determine key graphic elements	Experts: *n* = 4 researchers	n/a	**Common elements** [n/a]: Qualitative description of elements found in over 50% of each pictogram category.
		Evaluation of pictograms	Potential end-users: *n* = 86 12-18 y/o adolescents.	Pictograms: shown grouped per category, with meaning. Size not described.	**Key elements**[2]**:** Qualitative description of elements found in over 50% of each pictogram category of which >80% of participants agreed that they conveyed the intended meaning. For each category, >80% agreed the FIP storyboard conveyed the intended meaning.
Kripalani et al., 2007** [50]	Low-literate patients with coronary heart disease (USA)	*(Pre-)design:* Draft of pill cards with visuals based on search for similar interventions	Experts: *n* = 2 physician experts in medication adherence, patient education, and literacy.	n/a	Pill cards and pictograms not shown in article[2].
		Design: review and adjustments of pill cards.	Experts: healthcare providers Partial end-users: *n* = 12 patients	Not described.	Pill cards and pictograms shown in article[2].
		Evaluation of pill cards.	End-users: *n* = 209 patients with coronary heart disease, most low-literate (REALM)	Pictograms: shown within pill card, with words. Size not described, but example shown.	**Use of pill card**[1]: initially: 83%, at 3-month follow-up: 60%. **Card perceived effectiveness**[2]**:** Easy to understand: 92%, helpful for remembering important information: 94%. **Process evaluation**[2]**:** 79% kept card with their medication. Feedback: create wallet-sized card, increase font size, add strength of medication, include other medication types, add check-off box for medication taken, laminate card.
Mateti et al., 2015**** [51]	Kidney disease patients on haemodialysis (HD) (India)	*(Pre-)design:* Development of leaflets' content based on literature. Validation of (visual) content.	Experts: *n* = 3 nephrologists and *n* = 2 academic pharmacists	n/a	Leaflets and pictograms not shown in article. [n/a]

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
		Design of visual leaflet using the Baker Able Leaflets Design method	not described	n/a	**Baker Able Leaflet Design assessment score** [n/a]**:** 28 for English, 26 for Kannada version (>25 good leaflet). Leaflets and pictograms not shown.
		Evaluation of leaflet at baseline and after 1 week.	End-users: n = 81 HD patients. n = 24 at follow-up.	Pictograms: shown within leaflet, with text. Size not described.	**Information understanding**[1]: User-testing knowledge increased with 25.37 (SD 13.24), $p < 0.001$. **Leaflet acceptability** and **preference**[2]: Legibility and content: 81.14%. 61.72% chose Kannada version, 38.27% English.
Mbuagbaw et al., 2012*** [73]	Patients in general (Cameroon)	*Evaluation* of prescription instructions, one with pictograms.	Potential end-users: n = 204 outpatients in Cameroon, speaking Pidgin English.	C: Written-out prescription I-L: Latin abbreviations I-S: Symbols I-P: Pictograms: shown in a leaflet with descriptive words. Size not described, but leaflet shown.	**Information understanding**[1]**:** Best with I-S (89.7%), worst with I-L (26.9%). C: 87.7%, I-P: 75.9%. **Instruction preference**[2]**:** Most preferred I-P 40.7% and C: 30.9%.
Richler et al., 2013* [15]	Patients in general (international)	*Design* of two images for all 28 side effects	Experts: graphic design students.	n/a	Pictograms not shown in article. [n/a]
		Design: selection of 4-13 images for each side effect/indication	Not described.	n/a	Pictograms shown in article. [unclear]
		Evaluation of 28 medication side effect or indications pictograms.	Potential end-users: n = 3145 participants	Pictograms of the same concept were shown together, with their meaning. Size not described.	**Pictogram preference**[2]: 7/28 pictogram series were selected by >50% of participants, including: 'rash', 'insomnia', 'heartburn', 'dizziness', 'dizzy when getting up', 'coughing', and 'pregnancy'. Differences between countries, but 'Weight gain' and 'do not drive' same preference for 'Western culture', 'China', 'India', and 'Australia'.

Stones et al., 2013* [26]	Patients who use codeine (UK)	*Design:* Iterative design of six pictogram sequences	Experts: research team. Potential end-users: *n* = 26 lay people.	Pictograms shown in sequences, without text, but with introduction that they concern codeine. Size not described.	Pictograms shown in article[1].
		Evaluation of pictograms.	Potential end-users: *n* = 182 students/ university staff, of which 139 drivers	Pictograms shown in sequences, without text, but explained that they concern codeine. Size not described.	**Pictogram understanding**[1]: 2/6 pictogram sequences ≥67%. Mean 53.0% (SD 26.6). **Attention to warning**[1]: Drivers were more likely (25.2%, Fishers Exact Test, p =0.032) to notice the warning sign than non-drivers (9.3%).
Thompson et al., 2010*** [8]	Patients with rheumatoid arthritis (RA) (Canada)	*(Pre-)design* of pictorial and prose-based information pamphlets, by adhering to best-principles guidelines.	Not described.	n/a	Pamphlets not shown in article.
		Design: Evaluation of pamphlets and redesign.	End-users: *n* = 10 patients with RA.	Not described.	**Leaflet acceptability**[unclear]**:** Redesign to wo pamphlets: one pictures and text; the other text alone. Pamphlets not shown in article. [unclear]
		Evaluation of pamphlets.	Potential end-users: *n* = 100 not-completers of high school. 20% low-literate.	C: Text-only information sheet. I: Text plus pictograms information sheet. Pictogram size not described.	**Information recall**[1]: No difference between C and I for free, cued, immediate, or delayed recall. **Information understanding**[1]: No difference between C and I. 80% of important info was comprehended completely and correctly. **Leaflet acceptability** and **usefulness**[2]: No differences for organisation, ease of reading, utility or perceived general knowledge. I: more appealing than C (mean 4.1, SD 1.0; 3.5, SD 1.1; p=0.004). I: more comfortable in knowledge than C (4.8, SD 0.5; 4.6, SD 0.5; p=0.03). **Leaflet preference**[2]: I: more appealing (86%, Z=3.60, p<0.001), more useful (77%, Z=5.24, p<0.001), easier to read (61%, Z=3.38, p=-0.001), rather receive (75%, Z=4.14, P<0.001) than C.

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Study ID + MMAT [a]	Targeted end-user pictograms	Steps in pictogram design and evaluation	Extent to which participant is end-user	Context of pictogram evaluation	Pictogram-related outcomes, level of end-user involvement
Van Beusekom et al., 2015*** [63]	Low-literate patients (the Netherlands)	*(Pre-)design:* Development of icons for pictograms based on Gestalt laws of perceptual organisation	Experts: graphic designer; biomedical, pharmaceutical and communication scientist.	n/a	Icons not shown in article. [n/a]
		Design: Evaluation and adjustments of drafts during design process.	Partial end-users: lay people. Experts: biomedicine, visual communication.	Not described.	Icons shown in article.[2]
		Evaluation of icons	Potential end-user: n = 191 pharmacy visitors, 15.7% low-literate	Pictograms: shown in groups of 3 or 4, meaning given. Size 65x65mm or 65x120mm.	**Pictogram preference**[2]: For 3/4 organs, low-literate participants preferred to see less of the body frame than literate participants (Fisher's=15.47, Fisher's=16.37, $\chi^2(3)$=16.11, all $p < 0.01$).
Wilby et al., 2011*** [52]	HIV patients (Canada)	*Evaluation* of Pharmaglyph intervention	End-users: n = 82 HIV-positive patients on ARV, n = 72 at follow-up	C: standard verbal and written information I: C, plus pictogram-enhanced label. Pictogram size not described.	**Information recall**[1]: I: 88% correctly identified targeted information, C: 2% (Fisher exact test; $p < 0.0001$) **Pictogram understanding**[1]: Overall: 36.3%. No difference between I and C (OR 0.73; 95% CI 0.50 to 1.07; p = 0.103).

Roles of end-user involvement: [1] Level 1: informative, [2] Level 2: consultative, [3] Level 3: participative, [n/a] not applicable: no end-user.
[a] MMAT scores: * = 25%, ** = 50%, *** = 75%, **** = 100%.
[b] When possible, scores for pictogram understanding were recalculated to how many pictograms reach the commonly used cut-off of 67% understanding to facilitate comparisons between studies.
[c] Not a peer-reviewed publication.