

# The use of visual risk communication and its significance for risk understanding and health literacy in out-clinic settings – a literature review

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## Research article

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# Abstract

**Background** Patients frequently experience difficulties understanding communicated risks. The aim of this study was through a literature review to analyze if the use of visual risk communication tools improve risk understanding among patients in outpatient settings or general practice, and if one tool appears more useful than others. **Method** The electronic databases PubMed and PsycINFO were systematically searched. Relevant references were used for chain search to make sure all relevant literature was included. **Results** The main search revealed 1,157 titles. There were 13 eligible studies concerning visual risk communication in outpatient clinical settings. The design, quality and main findings of the studies were heterogeneous. However, most of the analysed studies found a significant positive effect of graphical, interactive and dynamic visual aids on risk communication. **Conclusion** There is currently not enough evidence to endorse one graphical format above others. Personalising the graph format to the type of risk information presented may facilitate a better understanding of risk and contribute to improve health and cost-efficacy.

## Background

Risk communication is an integrated part of standard consultations in general practice and other outpatient clinics. Patients are verbally informed about their individual risks, prognoses and treatment options, often within a short time and sometimes with unfamiliar and quantitative terms.

There can be many factors influencing how well people assess and understand risk, including age, level of education, culture and gender (1). Research has shown that limited understanding of risk, particularly numerical risk information, can jeopardise preventive efforts as well as the understanding of diagnosis and treatment options (2). This is supported by findings where higher levels of verbatim knowledge (the ability to correctly read numbers from graphs) and gist knowledge (the ability to identify the essential points of the information presented) are significantly associated with making medically superior treatment choices (3).

The understanding of risk factors and the awareness of how to change them are important for the patient's motivation and compliance (4). The level of understanding may have an impact on whether the patients wish to change behaviour or participate in treatments, as the intention to change is related to the perception of risks (4). Low health literacy (the ability to understand, obtain and apply healthcare information in order to make appropriate health decisions and follow instructions for treatment (5)) is generally associated with poor health (5). If the patient does not initiate treatment as agreed with the general practitioner (GP) or does not comply with the mutually agreed treatment plan, it may cause health deterioration or reduced quality of life for the individual and increased healthcare expenses for the society (6).

During recent years, the focus on personalised risk communication and shared decision-making has increased (7, 8). The development of online devices has enabled patients to independently access risk information and reflect on questions before consulting a health care provider (9, 10). However, the quality and coherence of the web-based information is often variable (11). Combined with a lexile level above most recommended guidelines, this may cause a reduction in the level of understanding for many patients (12). The introduction of computers in the clinical work has made it more accessible to communicate personalised risk information in a graphical format based on the risk factors and para-clinical tests of the patient (13). This innovative trend has inspired researchers to study if visual graphs impact the patients understanding of health-related issues, risk perception and health literacy in order to respond to information in a health-promoting manner (14).

Focus in this review is to explore the literature on visual communication of quantitative risk factors. We target settings comparable to general practice and thus also include outpatient clinics. Relevant interventions are all visual

communication against usual care and especially numerical communication. We will explore whether visual communication can outweigh limitations in numeracy and comprehension of medical terms and our outcomes of interest is primarily patients' perceptions and understanding of risk factors. We also wish to evaluate if one method of visual communication appears more useful than others in order to recommend directions for future research.

## Method

Systematic reviews within the area of visual risk communication are characterised by heterogeneity (7, 15) and meta-analysis could not be done (7). This might be due to diverse methodological quality, a broad definition of visual communication (e.g. pictures, videos, interactive graphs and 3D phantoms) or inclusion of both primary and secondary settings (15). For the present study we excluded hospital settings, and focused on outpatient settings and general practice, where more than 80% of all prescriptions of medication are initiated in the Danish setting. The outpatient setting and general practice are comparable in relation to time frame, contact and an established longer-term relationship between doctor and patient. Outpatients can be more self-reliant compared to hospital settings, and possibly more confident rejecting a suggested treatment plan, if they do not understand the risks presented (16).

### Search strategy

The electronic databases PubMed and PsycINFO were searched August 21<sup>st</sup> 2018. The search matrix was designed according to the PICO (population, interventions, comparison, outcomes) approach (17). In this study, the research question was transformed into four blocks covering:

1. Population and setting (General practice, outpatient clinic and synonyms),
2. The intention of the intervention (risk communication, explaining risk and words for similar concepts),
3. Tool for communication (different types of graphs, multimedia and visual aids)
4. Outcome (understanding, perception, compliance, etc.).

Each block consisted of 13 to 27 terms including truncation of words. Searches were adapted to each of the databases used.

Several searches were done to reveal, which Medical Subject Headings (MeSH)- or keywords had been used in relevant articles, to promote the most suitable and thorough search matrix. The preparatory search also included searching after studies in PubMed with the subject of specific visual tools such as SCORE risk chart (18) and Visual Analogue Scale that has already been implemented in general practices in Europe. Google scholar was briefly searched for grey literature (19). In PubMed, the search covered MeSH words and All Fields.

The search matrix in PubMed was combined with the methodological search filters recommended by the Medical Research Library, Odense University Hospital. The filters have high recall and sensitivity (20) and are applied to identify randomised controlled trials (21) and reviews (22). To make this study as comprehensive as possible, relevant abstracts and full-text articles were used for chain search on Web of Science. This, to find updates on included articles or similar trials which were not found in the main search because of the heterogeneous field.

### Inclusion and exclusion criteria

The literature search was limited to the most recent 10 years to catch the most recent literature. Reference lists from the recent and relevant papers were then, as stated Figure 1, checked carefully to find relevant older literature

(backwards citation search), based on the argument that if not cited within the last 10 years in the relevant papers we identified, then they probably are not that important to the research field.

Studies were eligible for inclusion if they: 1) were published in peer-reviewed journals written in English, 2) involved adult populations (over 18 years old) and 3) were conducted in conditions similar to the primary care sector, outpatient clinics or diseases managed in general practice.

The visual intervention (VI) had to be actively or intentionally chosen by the participants themselves e.g. by accessing a website or participate in a trial. The VI could also be chosen by the doctor or used in the interaction between a patient and healthcare professionals. Interventions with passive exposure, like commercials or videos in a public area were excluded. To reflect the varying patient groups in general practice, the selection criteria did not include variables like gender, disease, or social demography.

## **Selection and appraisal**

Prior to the selection of the articles, the research group defined inclusion and exclusion criteria. The first author made the preliminary selection based on the agreed inclusion and exclusion criteria. If there were any concerns whether an article should be included or not, it was discussed at a meeting between all authors before the final decision to include or exclude. Generally, the PRISMA framework was followed.

The database search is shown in Figure 1. The database search provided 1258 hits in total, nine duplicates were removed, and 1249 articles were screened by title. 135 abstracts which matched the inclusion and exclusion criteria were reviewed. Of these, 45 papers were assessed in full-text for eligibility. The final analyses included 13 studies. The reason for excluding 90 out of 135 records after reading the abstract was that they focused on e.g. tele healthcare, text reminders on mobile phones, interventions in paediatric care, electronic health records, or were protocols or pilot studies, evaluated imaginary software for doctors, had less than ten participants, or did not have a full-text written in English. Backward citation search by the reference lists of the studies initially included and forward citation search by Web of Science revealed 31 other relevant studies.

After full text retrieval and writing individual 1-2-page summaries with rankings based on publication year, number of participants, study type, methodological approach, outcomes, statistics applied etc. for each of the 76 records, 61 records were excluded. Among reasons to exclude the papers were that the main outcome was measured according to shared decision-making, patient satisfaction or patient anxiety. Other reasons were that the studies explored patient education without explicitly evaluating understanding of risk message, risk perception or patient compliance, or that the intervention was transmitted on a screen in a waiting room without active recipients.

## **Data analysis**

The remaining 15 studies were systematically reviewed focusing on study design, sample size, applicability, category of VI, risk of bias, confounders, statistical analysis, and significant results (23). The aim was to reveal strengths and limitations of the papers to determine the importance of the papers and weight the evidence of their findings. We used the hierarchy of evidence pyramid where high-quality studies (systematic reviews, meta-analyses) were preferred and weighted higher than those lower in the evidence hierarchy. The number of participants, the transparency of the statistical methods and the study types were important elements. If there was doubt about the statistical methods in the studies, a statistician was consulted. Two studies were excluded, the first one since only 27% of the participants were diagnosed with the disease that the intervention was targeting. The second study was excluded due to a

discrepancy between the included population and the outcome measured. Finally, 13 studies met the criteria for the final analysis (Table 1).

## Results

The 13 included studies were reviewed as described in the method section. Design, quality and main findings of the studies are generally heterogeneous as summarised in Table 1, which is reflected when summarizing the findings.

### Study characteristics

Four of the 13 included studies were randomised controlled trials (RCT), seven were randomised trials without controls, one was controlled but not randomized and one consisted of interviews. The studies were published from 2008 to March 2018. Eleven studies examined if the understanding of risk was affected when the numerical information was presented in different graphical formats (3, 24-33). Two studies explored if presenting risk information by a multimedia format influenced the understanding of risk factors (34) or metabolic control of patients (35). The interventions, conditions, and diseases varied but were all relevant to a general practice or outpatient setting (Table 1). Sample size ranged widely with 10 studies having sample size 20 to 351 persons and three studies with sample sizes of respectively 2412, 4198 and 38725 persons. Six studies were conducted in a hypothetical setting or without interpersonal interaction between the participant and a healthcare professional. Seven studies were performed with patients in real-life decisions or interventions.

### Graphical presentation of numerical data with the purpose of communicating risk

The search revealed six randomised studies (3, 26, 28, 29, 31, 32) that evaluated if a graphical presentation of numerical data had an impact on risk understanding. A high-quality multicentre RCT by Peiris et al. (26) with 38725 patients and 60 clinics evaluated a multifaceted computer intervention targeting both the doctor and the patient. The visual intervention addressed the GP and the patient differently as it included a screen pop up for the GP and a graphical risk communication tool addressed to the patients, to improve their understanding of cardiovascular disease (CVD) (Table 1). The VI targeting the GP was associated with a higher rate of patients receiving an appropriate screening for CVD by measurement of their risk factors ( $p = 0.02$ ) (26). There was a significantly higher number of new prescriptions or increase in numbers of medicines for the high risk cohort; antiplatelet ( $p < 0.001$ ), lipid-lowering ( $p < 0.001$ ), and antihypertensive therapy ( $p = 0.02$ ) (26). In the intervention group there was a higher proportion reaching the target set by the national BP guideline compared to the control group ( $p = 0.05$ ) (26). Ruiz et al. (29) also evaluated a computer-based tutorial '*Your Cardiovascular Risk Score*' in a small-scale RCT with 120 patients. The design had several limitations as it was performed in a laboratory setting, and risk perception was measured by self-report without measuring behavioural changes (Table 1). Differing from the study by Peiris et al., Ruiz et al. found that icon arrays may impair short-term recall of CVD risk and therefore not necessarily results in a better recall of medical risk in all patients (29). Risk presented in icon arrays and frequencies resulted in an inferior accuracy of risk perception 20 minutes after the presentation compared to percentages or frequencies only ( $p = 0.001$ ) (29). There were no differences when evaluating immediate risk understanding ( $p = 0.31$ ) or recall at two weeks ( $p = 0.10$ ), and participants with high graphical literacy performed significantly better than those with low graphical literacy at all times ( $p < 0.02$ ) (29).

A study comparing diagnostic inferences (28) (Table 1) between doctors and patients, found that additional presentation of a visual display of the numeric information in shaded blocs improved the diagnostic understanding, measured in accuracy of percentage and natural frequencies, for both doctors and patients (28). The patients estimated the information as less useful when it was provided only numerically, as compared with the same

information provided both numerically and visually ( $p = 0.023$ ) (28). In contrast, the doctors found the information highly useful, with no statistical difference between the numerical or visual display ( $p = 0.322$ ) (28). Overall, doctors had higher numerical skills than their patients ( $p = 0.001$ ) (28). This correlates with results by Goodyear-Smith et al. who examined which presentation of hypothetical risks and benefits that would encourage statin users with a pre-existing heart disease, to take daily medicine and which one they preferred (33). They found that 57 % of the patients preferred information presented graphically ( $p < 0.001$ ) (33).

The VI targeting both the doctor and the patient resulted in a significantly higher proportion of risk factors being measured in the patients, along with a significant increase in prescriptions of medicine for patients in high risk of disease (26). In summary, visual risk communication improved understanding of risks among patients as well as doctors, and the understanding and usefulness was affected by the patients' numeracy and graph literacy skills (3, 28), giving the patients with high level literacy the greatest benefits.

### **The best graphical format to increase risk understanding**

Numerical information can be presented by many different graphic designs (e.g. pie chart, pictograph, bar chart). Hawley et al. studied how six graphical presentations of hypothetical medical risks affected the participant's ability to choose the medically superior treatment option according to its risk profile and benefits (Table 1) (3). Respondents with higher numeracy answered significantly more questions correct for both verbatim (the ability to correctly read numbers from graphs) and gist knowledge (the ability to identify the essential points of the information presented) (3). High verbatim- and gist knowledge were positively associated ( $p < 0.01$ ) with making a medically superior treatment choice. Data presentation by pictographs were associated with adequate levels of both types of knowledge, especially for individuals with lower numeracy. Tables were associated with a higher likelihood of adequate verbatim knowledge vs. other formats ( $p < 0.001$ ), but lower likelihood of having adequate gist knowledge ( $p < 0.05$ ) (3). Pie charts was associated with an adequate gist knowledge vs. other formats ( $p < 0.05$ ) (3).

Zikmund-Fisher et al. (32) studied whether viewing animated icon array pictographs had an impact on the ability to select the treatment with the lowest risk profile (Table 1). None of the animations improved any outcome, and most showed significant performance degradations (e.g. scatter with auto shuffle ( $p < 0.02$ )). Static pictographs that grouped icons at the bottom of the array resulted consistently in better treatment choices and a higher gist knowledge of side effects than the animated icons (32).

McCaffery et al. (31) examined if the size of the numerator had an influence on graphical risk interpretation. The numerator size was categorized into small (<100), medium (100–499) and large (500–999), with the denominator fixed at 1000. The findings suggested that the optimal graph type for communicating risk information depended on the numerator size displayed. For adults with low education and literacy, pictographs were likely to be the best format to use when displaying small numerators as <100/1000 and bar charts for larger numerators as >100/1000 (Table 1) (31).

The optimal graphical format for increasing understanding of risk depends on the message to be conveyed. Static pictographs were highly useful for patients with lower numeracy and overall the best format for enhancing risk understanding across patient categories and educational levels.

### **Graphical presentation of numerical data for supporting health literacy at home**

The search revealed three studies with real-life patients (25, 27, 30) and two hypothetical scenarios (24, 33). An RCT by Chmiel et al. (27) compared daily blood pressure (BP) recording, by the patients, in a green, yellow and red colour-

coded booklet vs. a non colour-coded standard booklet (Table 1). The BP goal (< 140/90 mmHg) was achieved more often in the intervention group with the colour-coded booklet ( $p = 0.037$ ) (27). BP measured by the GP showed a significant decrease after six months in both groups compared with baseline measurements, with no difference between the groups. The antihypertensive therapy was changed overall in 63 % of the patients with no difference between the two groups ( $p = 0.367$ ) (27). Fraccaro et al. tested 20 patients' ability to determine the need for medical attention, after viewing a graphical presentation of hypothetical laboratory tests (24) (Table 1). The results demonstrated the patients' difficulties in interpreting laboratory test results with 65 % of the participants underestimating the need for action across all presentations at least once, and with 70 % of the participants overestimating the need for action at least once even when abnormal values were highlighted using colours and graphical cues (24). The results indicate that care must be taken, when communicating visual health related risks through patient portals, without consulting a doctor.

To summarise the above, visual tools for use at home, must be ensured with an action plan that is easy to understand for the patient, to promote health literacy and support the patient in responding appropriately to the information given.

### **The impact of visual communication on the consultation process**

An RCT by Nieuwkerk et al. (30) compared a nurse-led visual CVD risk factor counselling with routine care. The counselling focused on changing modifiable risk factors (e.g. medication adherence, overweight, and physical activity). The adherence to statins was higher ( $p < 0.01$ ) and low-density lipoprotein was lower ( $p = 0.024$ ) in the intervention group (30). The additional time with interpersonal contact in the intervention group was 30 minutes for each visit (30). Perestelo-Pérez et al. (25) found that the display of risk through 100 dots by a visual decision aid used in primary care improved knowledge ( $p = 0.01$ ) and the perception of the 10-year risk of myocardial infarction without statins ( $p = 0.01$ ) (Table 1) (25). Results showed no variation in consultation time between the groups ( $p = 0.046$ ) and furthermore the variation of the consultation time was significantly lower in the intervention group ( $p = 0.025$ ). The authors suggests that VI to some extent could result in a more systematic and reproducible discussion, and a tendency towards higher adherence to the medication (25).

The use of a VI in a consultation do not necessarily lead to an extension of the consultation time. Instead, it may cause less variation of the consultation time needed and support a standardisation of the information given and received (25).

### **Video as a visual tool**

The database search found two randomised studies with a video intervention (34, 35). The studies had several limitations (Table 1), but were included as an inspiration for further research. Shukla et al. (34) found that the understanding of surgical procedures and unforeseeable risks were significantly higher in patients given conventional verbal information together with an educational DVD ( $p < 0.001$ ), when compared to patients who had received verbal information only (34). Valázquez-López et al. (35) concluded that adding a video-based multimedia education program to nutritional therapy in diabetic care was an effective strategy to lower HbA1c, improve the lipid profiles, and lower body weight in patients with type 2 diabetes in the long term (endpoint at 21 months). There were significant decreases in major metabolic control parameters in both groups, but none of the comparisons between the groups showed consistently and statistically significant differences through the whole study period (35).

## **Discussion**

## **The effect of presenting risk communication visually**

Most of the analysed studies (3, 25-28, 30, 31, 33-35) found a significant positive effect of visual risk communication within all fields; static- and interactive graphs, illustration and video. Hawley et al. showed that viewing pictographs was associated with an adequate level of knowledge, especially for individuals with lower numeracy (3). This was supported by McCaffery et al. (31) who found that for adults with low education and low health literacy, pictographs were the best format to use when displaying small numerators (<100/1000). For larger numerators (>100/1000) bar charts were found to be the optimal choice (31). Comparing the results confirmed that the usefulness of the graphical format depended on the message to be conveyed.

## **Layout and design are of great importance**

The design of the VI is essential to support the patient's understanding. Zikmund-Fisher et al. (32) found that static pictographs with grouped icons in the bottom of the array consistently resulted in a better treatment choice by the patient and improved the ability of the patients to choose the less risky of several treatment options. Results by Fraccaro et al. (24) demonstrated the patients' difficulties in interpreting graphically displayed laboratory tests, as more than 65 % of the patients misjudged the need for action at least once across all scenarios, even though abnormal values were highlighted using colours and graphical cues. These findings emphasize the importance of the graphical design regarding type, colour, cues, complexity, scale and animations in order to inform rather than confuse the patients. Tailoring the graph format to the type of information needed for a particular medical decision would likely produce the most informed patient (3) and thereby hopefully the best decisions. Clear evidence for an association between level of understanding and level of decision-making is still to be investigated.

It is essential that the effects of an intervention can be measured by an outcome. The examination of a colour-coded BP diary showed no significant difference in values of BP, change in antihypertensive treatment or adherence to the diary between the groups after six months (27). Many of the patients (66 %) had already used home BP measurement before the study, which may have reduced the effect that could be measured by introducing the book. The authors highlight that BP control (< 140/90 mmHg) was achieved more often in the intervention group ( $p = 0.044$ ). These results must be interpreted with caution since the study design did not include any guideline or action plan according to the BP values measured at home and the proportion of patients with BP control at baseline had not been measured.

These findings support the importance of the study design, in order to develop a VI that can facilitate a more informed discussion, contribute to shared decision making, and increase health-efficacy. Thus, assisting the patients in the lower sociodemographic groups in making the most beneficial health choices.

Communicating risk through visual tools appears beneficial for the patients' understanding. The optimal type of visual tool for communicating risk depends on the message to be conveyed (gist or verbatim knowledge, the size of the risk etc.), health literacy level, and socioeconomic status of the patient. The results support introducing a personalised approach to risk communication based on graphical/visual risk presentation together with numerical information, like tables, in order to enhance risk understanding.

## **Other aspects of visual communication**

There are many aspects that need to be considered when evaluating the usefulness and benefits of a visual communication tool. It is difficult to measure benefits versus costs such as resources needed for implementation or education, licences etc. vs. benefits such as a more informed patient together with lower health costs if co-morbidity

and the need for hospitalisation or other healthcare services is reduced. Peiris et al. (26) found that a screen pop-up for the GP improved the frequency in which the patients' risk factors were screened ( $p = 0.02$ ). It is known that screening may result in overtreatment (36), but the results showed no significant differences in prescription rates for AHT, statins or antiplatelets for those at low risk of CVD (26) (25). Thus, indicating that VI did not generate unnecessary medication prescriptions for people with low risk of CVD. There were significant escalations of new prescriptions or an increased number of medicines prescribed in the high-risk cohort, but not a significantly higher proportion of patients receiving medication as prescribed by guidelines. It would have been relevant to explore if the significant increase in screening of patients was associated with reduced incidence of CVD in patients who had not yet been diagnosed or classified as high risk according to a cost-efficacy perspective.

The graphical presentation was preferred by 57 % of the patients ( $p < 0.001$ ) (33) and the most complex graphics were the least preferred by the participants (32). This correlates with Garcia-Retamero et al. who report that patients find information less useful when provided only numerically, in contrast to the doctors who perceived the information as highly useful, with no statistical difference between the numerical or visual display (28). Consequently, the doctors may not experience the same benefit from the VI as the patients; which is an important observation as decision aids are most often introduced by the health care specialist. When the level of numeracy was statistically controlled for, the type of participant no longer had a significant impact on the understanding. This suggests that the preference for VI's is not related to profession but to numeracy. The examination of an online visual decision aid used in primary care showed no significant extension of consultation time, and the variation of the duration of the consultations was significantly lower in the intervention group. The authors suggest that the VI to some extent could result in a more systematic and reproducible discussion between the patient and the doctor (24). With these findings in mind, it would be reasonable to evaluate if the use of a validated VI in primary care could result in a more focused dialogue with a well-prepared patient, a standardisation of the information given, and a more informed health choice without requiring additional resources from the GP.

### **The potential of "video" in risk communication**

Shukla et al. (34) found that an educational DVD equalled the understanding of a second-grade reading brochure, and at the same time outperformed the understanding obtained by brochures of higher reading levels. Hence, it is relevant to study if the video format has the potential to compensate for impaired reading skills along with reduced numeracy or graph literacy and enhance risk understanding. Valázquez-López et al.'s findings suggest that adding a multimedia tool to conventional nutritional therapy is associated with an improvement in health outcomes (35). The two studies have only used the DVD at the clinic, but the video has the potential to be used as infinite repetition of information at home and a way to involve family members by sharing the information given. If the VI was watched as a preparation to an appointment at the doctor, it may also have the potential to facilitate a more informed discussion as proposed in the paragraph above (4.3). Since the video only has to be recorded once, it does not require resources consecutively. Based on the limited evidence, it appears that video as a supplemental risk communication tool could be a way of improving health as well as health literacy significantly. Future studies should investigate if the video format has potential to enhance risk understanding, if it will be more cost effective and/or whether it has a potential to be used at home for enhanced understanding and involvement of patients as well as relatives.

### **Perspectives for future research**

This review has revealed a lack of RCT studies in the field of visual risk communication. The majority of studies published has been made in small-scale or with hypothetical scenarios. Studies have shown that tests of hypothetical decisions differ from behavioural change (37). Consequently, it would be beneficial to measure outcomes that relate

to factual behaviour or biochemical parameters instead of risk understanding. This, to make sure that the VI has an impact on the actual health decisions of the patients and not only affects the more theoretical and not so quantifiable risk understanding. Based on the results in Table 1, it would be beneficial to continue studying if visual risk communication can compensate for low educational level, sociodemographic challenges and lack of numerical or graph literacy in order to improve health and prevent disease.

### **Strengths and limitations of this study**

The strengths of this study include the comprehensive search matrix covering the recent ten years and the thorough examination of papers through citation search, which made it possible to extract the current and updated knowledge in the field of visual risk communication in outpatient clinical settings and general practice.

The main limitations of the study are the lack of RCT studies in the field and the heterogeneous nature of the included study designs and outcomes, which made it difficult to make direct comparisons and conclusions. The review may have been limited by including only studies written in English. In case that the search matrix was not adequate in finding all relevant studies, it is likely that relevant RCT's would have appeared through our citation search. Another limitation was that only 1 reviewer screened articles for inclusion, which may have caused undersampling, though this was probably limited due to the backwards citation search.

## **Conclusion**

The design, quality and main findings of the studies are generally heterogeneous. However, most of the analysed studies found a significant and positive effect of visual risk communication on the understanding of risk. There is currently not enough evidence to highlight one specific visual format above others. Personalising the graph format to the type of risk information presented may facilitate a better risk understanding and contribute to improved health and potentially also cost-efficacy.

The variety of the baseline characteristics in the studies analysed (e.g. educational level, age, comorbidity), diseases, and interventions covered limit an overall and aggregate analysis. Since the results indicate a general trend towards an effect of the visual tools across various parameters, the variation ends up reflecting everyday life in primary care and outpatient settings and as such, indicating a possible effect that should be further explored.

The optimal graphical format for increasing understanding of risk depends on the message to be conveyed. Static pictographs were highly useful for patients with lower numeracy and overall the best format for enhancing risk understanding across patient categories and educational levels.

### **Practice implications**

There is a need for more research into the field of visual communication of risk to actual patients in general practice. This review has demonstrated a significant and positive effect of visual risk communication in general. Patients with lower numeracy or education level benefit from graphical risk communication, especially pictographs. Video format showed potential, as it in one study equalled the understanding of a second-grade reading brochure, and outperformed brochures of higher reading levels. Clinicians could try to develop visual risk communication tools to be used in their everyday practice and supplement existing material in order to optimise the patients' understanding of risk messages.

## **List Of Abbreviations**

BP Blood Pressure

CVD CardioVascular Disease  
EC Extended Care  
GP General Practitioner  
HBPM Home Blood Pressure Measurement  
LDL Low Density Lipoprotein  
MCQ Multiple Choice Questionnaire  
MEP Multimedia Education Program  
NT Nutritional Therapy  
RCT Randomized Controlled Trial  
RC Routine Care  
VI Visual Intervention

## **Declarations**

### Ethics approval and consent to participate

Not applicable as this is a literature review

### Consent to publish

Not applicable as this is a literature review

### Availability of data and materials

This is a literature review, and all data presented and analyzed are available in the referenced papers.

### Competing interests

The authors declare that they have no competing interests

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### Authors' contributions

LDJ was responsible for the literature search. All three authors (LDJ, JBN, AEJ) participated in designing the study, analyzing the literature, writing the manuscript, and all approved the final submission

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## Table

Author Year Country	Study design	Disease category and setting	Intervention and comparison	Significant results and conclusions	Comments and analysis
Fraccaro et al., 2018, UK (24)	Controlled trial with 20 patients.	Kidney transplanted patients viewing hypothetical laboratory test results /scenarios at an online patient portal.	<p>Participants viewed three different graphical presentations (of 28 blood tests) representing a low, medium and high-risk clinical scenario.</p> <p>Outcome: Accuracy of the participants' interpretation of the risk, measured by three response options after each scenario:</p> <p>Calling doctor immediately, arrange an appointment within four weeks, wait for next appointment within three months.</p>	<p>Findings were not significantly different. The study confirmed that the participants had difficulties when interpreting laboratory test results. Many participants (65%) underestimated the need for action at least once even when abnormal values were highlighted using colours and graphical cues.</p>	<p><u>Applicability</u></p> <p>This study explored whether a visual presentation using colours and graphical cues can improve the patients' ability to interpret the risk information presented.</p> <p>-</p> <p><u>Limitations:</u></p> <p>Small cohort, limited statistical power.</p> <p>No evaluation of graph literacy or numeracy at baseline.</p> <p>The participants were all used to being monitored by biochemical tests and not comparable to the average population in general practice.</p>
Valázquez-López et al., 2017, Mexico (35)	Randomised clinical trial with four primary care clinics and 351 patients.	Patients with type 2 diabetes (DM-2), without severe complications, in primary care.	<p>Multimedia education program (MEP) and nutritional therapy (NT) compared to a control group who received NT only.</p> <p>The NT was personalised according to comorbidities and nutritional preferences.</p> <p>The NT + MEP group was educated through a MEP named Nutriluv®. A specific MEP module was shown in an informational kiosk prior to the nutritional session. Duration of intervention was 21 months.</p>	<p>Diabetes education with MEP was an effective strategy to improve the HbA1c (glycated haemoglobin), lipid profiles, and body weight in the patients with DM-2 in the long term.</p>	<p><u>Applicability</u></p> <p>DM-2 is a common disease treated in primary care with potentially severe complication.</p> <p><u>Limitations:</u></p> <p>No statistical power calculation, weak statistical analysis e.g. conversion of units to percent, adjustments at baseline even though the groups were randomised.</p> <p>No stratification of baseline characteristics.</p>

					Anthropometry measurements were not blinded.  The completion rates of patients were low (59.5% and 56.5%).
Perestelo-Pérez et al., 2016, Spain (25)	Cluster randomised trial with 29 doctors and 168 patients.	Cardiovascular disease (CVD) prevention in patients with DM-2 in primary care.	<p>“Statin choice”, is an online clinical decision tool used in consultations in primary care. The decision aid calculates the risk of CVD in the next ten years, based on personal health information. The risk is displayed graphically with 100 dots coloured in green, red or yellow.</p> <p>Evaluation of knowledge about statins, perception of CVD risk, decisional conflicts and satisfaction were assessed by questionnaires, immediately after the intervention and at follow up after three months.</p> <p>Comparison: Usual care.</p>	<p>Intervention improved knowledge (<math>p = 0.01</math>), perception of the 10-year risk of myocardial infarction without using statins (<math>p = 0.01</math>) and satisfaction (<math>p = 0.01</math>).</p> <p>The communication tool did not increase the length of consultations when compared with usual care.</p> <p>The variance of consultation time was lower in the intervention group (<math>p = 0.025</math>), which suggests that the use of the decision tool may result in a more systematic and reproducible discussion. The decision tool improved the quality of the decision making about the use of statins.</p>	<p><u>Applicability</u></p> <p>This decision tool and its outcome is relevant to risk communication in primary care.</p> <p>-</p> <p><u>Limitations:</u></p> <p>No calculation of sample power.</p> <p>Unbalanced randomisation regarding age, hypertension and number of patients taking statins at baseline.</p> <p>Survey instruments were not checked for validity and reliability after the translation into Spanish.</p> <p>Adherence after three months was self-reported and therefore may have been less reliable.</p> <p>Doctors and patients were not blinded.</p>
Peiris et al., 2015, Australia (26)	Randomised controlled trial (RCT) with 60 primary healthcare centres and 38725 patients.	Cardiovascular disease (CVD) risk management in primary healthcare.	A computer guided onscreen intervention in primary care. The intervention included a series of traffic light cues, to alert the general practitioner if the patient was not receiving sufficient screening or management. The intervention, for a minimum of 12 months, also included a graphical risk communication tool to assist the patient in understanding their CVD risk and	The intervention was associated with improved measurements of the patients' risk factors (62.8% vs. 53.4%, risk ratio 1.25 (95%	<p><u>Applicability</u></p> <p>The pragmatic implementation of the tool was relevant to primary care. The outcome was clinical and a low level of implementation</p>

			<p>how the risk could be affected by changes of individual risk factors.</p> <p>Comparison: Usual care without the intervention tool or training of the general practitioner. Main outcomes were the fraction of patients receiving appropriate screening of risk factors and the proportion of patients receiving the recommended treatment according to guidelines.</p>	<p>CI, 1.04–1.50) and <math>p = 0.02</math>).</p> <p>No significant differences in the proportions receiving guideline recommended medication prescriptions for the high-risk cohort (<math>p = 0.12</math>). There were significant treatment escalations for the high-risk cohort (new prescriptions or increased numbers of medicines). There was a higher proportion reaching guideline BP targets in the intervention group versus the control group. The intervention improved the CVD risk measurements and required minimal support.</p>	<p>support was required.</p> <p>-</p> <p><u>Strengths:</u></p> <p>Large sample size, power calculation has been made.</p> <p>Adequate representativeness of the clinics included.</p> <p>Sufficient randomisation with stratification.</p> <p>Clinical outcome measures.</p> <p>Outcome analysis were conducted blinded to randomisation.</p> <p>Inclusion criteria were based on national guidelines for vascular screening.</p> <p>-</p> <p><u>Limitations:</u></p> <p>The doctors received training as a part of the intervention.</p> <p>Blinding of participants was not possible.</p> <p>It was not possible to distinguish between the intervention's effect on the patients and the practitioners risk understanding according to the study design.</p>
Chmiel et al., 2014, Switzerland (27)	RCT with 30 general practices and 137 patients.	<p>Patients with hypertension</p> <p>(BP &gt; 140 mmHg systolic and/or &gt; 90 mmHg diastolic), treated in</p>	<p>Daily home BP measurement (HBPM) noted in either a schematic standard non-coloured BP booklet (control group) or a colour-coded booklet (intervention). The scheme in the coloured book was divided into three zones, according to the BP value: green, yellow and red. The duration of the study was six</p>	<p>Findings showed no significant difference between the groups in absolute BP reduction or adherence with HBPM.</p>	<p><u>Applicability</u></p> <p>Simple, low cost and user friendly intervention with low necessity to understand numeracy. Study sample representing adult</p>

general practice.

months. Clinical parameters and medication changes were recorded at 0, 3 and 6 months. The outcome measurements: Adherence to HBPM measurements, BP values at follow up at the general practitioner and prescription of antihypertensive medication.

The target BP (<140/90 mmHg) was achieved more often in the intervention group (43% vs. 25%;  $p = 0.044$ ). No significant differences in adherence with HBPM, decrease in systolic and diastolic BP at end-point or change in Anti-hypertensive therapy (changed in 63 %)

primary care patients with hypertension.

Calculation of statistical power and intention to treat analysis. Computer randomisation at patient level. Randomisation was adequate.

Precise and detailed manual for the HBPM in order to standardise outcome.

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Limitations:

BP can be affected by medicine, exercise, stress, diet, lifestyle etc. The study design did not include guidelines or action plans according to the BP values. Therefore, the patients did not have a standardised way to respond if the BP was above normal value. Their response depended on their own beliefs and health literacy.

The majority of the patients ( $\approx 66\%$ ) had already done HBPM before inclusion in the study.

The doctors and the patients were not blinded. Doctor and patient interaction was not investigated.

Possible Hawthorne effect. The calculated sample size was not attained,

possible type 2 error.

Garcia-Retamero et al., 2013, Spain (28)

Randomised trial with 81 general practitioners and 81 patients from four hospitals.

Questions regarding diagnostic inferences of cancer and diabetes.

Recruitment during an ordinary consultation and subsequent randomisation into four groups (as shown below).

Risk information given as:	Natural frequencies	Probabilities
Numerical	A	B
Numerical + visual tool	C	D

In addition, participants completed a numeracy test with 12 items. After receiving information about the prevalence of the disease, and the sensitivity and false-positive rate of the test for a given task, participants made the diagnostic inference about three medical tests.

The outcome measurements: Improvement in diagnostic inferences measured in probabilities or percentages of people having the disease.

Accuracy, perceived usefulness and perceived difficulty with the data representation were also assessed.

Performance was better when the information was presented in natural frequencies and presented both numerically and visually, as compared to probabilities and only numerical.

Visual tools improved the accuracy of diagnostic inference for medical doctors and their patients regardless of the numerical format.

Numerical format, visual aid, type of participant, level of numeracy as a covariate, and estimates of task difficulty as the only dependent variable, showed a main effect of the visual aid ( $p = 0.016$ )

The patients estimated information as less useful when it was provided only numerically, as compared to the same information provided both numerically and visually ( $p = 0.023$ ). Overall, doctors had higher numerical skills than their

Applicability

Comparison of numeracy for both the patients and doctors and their inferences. Randomisation with stratification.

Limitations:

Small sample size. Statistical section was not adequate and difficult to interpret.

The data analysis was limited by the method used according to data type.

Baseline characteristics: The patients were older and less educated than the general population.

Outcome was based on inference and perception, not actual behaviour.

Ruiz et al., 2013, USA (29)	RCT at an outpatient clinic with 120 male participants	CVD among patients with intermediate or high cardiovascular risk.  Each participant was compensated with 30 dollars.	<p><i>Your Cardiovascular Risk Score</i> is a computer-based tutorial, which contains a sequential presentation of information regarding risk factors for coronary disease, their calculated absolute 10-year CVD (Framingham) and a presentation of individualised risks. The risk of a CVD is presented in three formats: frequencies, percentages or frequencies with icon arrays (red and black male stick figures). The study assessed risk understanding and knowledge by questionnaires immediately (T1), after 20 minutes (T2) and 2 weeks after the intervention (T3). T1 and T2 assessed perception of importance/seriousness, intent to adhere, and self-efficacy. T3 also concerned self-reported adherence.</p> <p>The numeracy and graph literacy were also assessed.</p>	<p>patients (<math>p = 0.001</math>).</p> <p>Icon arrays may impair short-term recall of cardiovascular risk. Accuracy was inferior with frequencies + icon arrays compared to percentages or frequencies at T2 (<math>p = 0.001</math>). Patients with high graphical literacy performed better than those with low graphical literacy at all times.</p>	<p><u>Applicability</u></p> <p>The patients were at high risk of CVD, which may had a positive influence on their motivation for the risk communication assessment, as they may had to make a life changing decision.</p> <p>Statistical analyses explored possible effects of confounding covariates.</p> <p>The person analysing the data was blinded.</p> <p>Completion rate by the patients was high (88%).</p> <p><u>Limitations:</u></p> <p>Small sample size and from one clinic.</p> <p>No sample size/power calculation.</p> <p>Participants had baseline differences.</p> <p>Due to risk perception being self-reported there was no measurement of actual adherence, life-style changes or medical treatments.</p> <p>Short follow up period.</p> <p>The use of two icon arrays: one for actual risk and one for ideal risk may have caused increased cognitive load and</p>
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					thereby reduced encoding.  The patients were paid to participate in the study which may change the incitement to attend.
Nieuwkerk et al., 2012, The Netherlands (30)	RCT with two outpatient clinics and 201 patients.	Patients with indication for statin therapy for primary or secondary prevention of CVD.	<p>Extended care (EC) with nurse-led visual cardiovascular risk factor counselling compared to routine care (RC) at baseline and after 3, 9 and 18 months.</p> <p>Patients in the EC group received multifactorial risk-factor counselling, and a personalised risk-factor book.</p> <p>The book showed modifiable and unmodifiable individual risk factors, a graphical presentation of the calculated absolute 10-year CVD risk (Framingham). It was also showing the target risk that could be reached if all modifiable risk factors were optimally treated and the most recent ultrasound image of the patient's carotid artery</p> <p>Outcome measurements: Statin adherence, quality of life, symptoms, smoking status, blood lipids and the thickness of the carotid intima.</p>	<p>Statin adherence was higher (<math>p &lt; 0.01</math>) and anxiety was lower (<math>p &lt; 0.01</math>) in the EC group. LDL was lower in the EC group compared to the RC group (<math>p = 0.024</math>). Intima thickness decreased from baseline in both groups (<math>p &lt; 0.01</math>). Multifactorial cardiovascular risk-factor counselling resulted in higher levels of adherence to lipid-lowering medication and lower LDL cholesterol concentrations in primary prevention patients, without increasing the patients' anxiety compared to RC.</p>	<p><u>Applicability</u></p> <p>Randomisation by computer to obtain equal baseline characteristics. Intention to treat analysis.</p> <p>Power calculation of sample size.</p> <p>Higher levels of self-reported adherence to lipid-lowering medication was significant and correlated with lower concurrent LDL cholesterol (<math>p = 0.001</math>), thereby supporting the validity of self-reported adherence.</p> <p>-</p> <p><u>Limitations</u></p> <p>There was a difference in baseline risk perception score between the groups.</p> <p>All participants had equal amounts of visits with the study nurse practitioner, but the extra time in the EC group was on average 30 minutes per visit. The positive results might have been affected by the prolonged interpersonal contact instead of being a result solely based on the risk-factor book.</p>

Shukla et al., 2012, USA (34)	Randomised prospective study with 100 patients.	Cataract patients at the department of ophthalmology.	<p>Patients were randomised into one of four groups: 1) Conventional verbal information; 2) conventional verbal information plus second-grade reading level brochure; 3) conventional verbal information plus eighth-grade reading level brochure; 4) conventional verbal information plus an educational DVD made for understanding cataract surgery.</p> <p>All patients completed a multiple-choice questionnaire (MCQ) with 12 questions and four possible answers for each.</p> <p>The MCQ revealed understanding of surgical procedure, its benefits, its foreseeable and unforeseeable risks, and the alternatives to cataract surgery.</p>	<p>Patients in group 2 and 4 scored higher in understanding than patients in group 1 or 3 (<math>p &lt; 0.001</math>). The highest education level had no effect on scores (<math>p &gt; 0.05</math>). Thus, concise informed information sheets at lower reading grade levels and videotape presentation optimised the understanding of the risks, benefits, and treatment alternatives to cataract surgery.</p>	<p><u>Applicability</u></p> <p>Information by video is a reproducible and low cost procedure with potential for implementation in the primary sector.</p> <p>The education level of the patients was assessed.</p> <p><u>Limitations</u></p> <p>No power calculation of sample size.</p> <p>Uneven baseline characteristics of groups e.g. gender and education level. The MCQ was not validated.</p>
McCaffery et al., 2012, Australia (31)	A randomised experimental study with 120 participants.	Adults attending government sponsored basic adult literacy and numeracy classes. They volunteered to participate in the study.	<p>The target was to test optimal graphic risk communication formats when presenting small probabilities using graphics with a denominator of 1000. The experimental computer-based manipulation compared three types of graphics; bar charts and pictographs with blocks or dots across horizontal or vertical orientation. The numerator size was divided into three groups: small &lt; 100, medium 100-499 and large 500-999. Participants were asked two questions concerning the treatment of the medical condition "X". One focussing on gist knowledge and one on verbatim knowledge.</p> <p>Three trainings were completed to ensure that the participants understood the tasks, and how to record their responses before the trial.</p>	<p>For small numerators, pictographs resulted in fewer errors than bar charts.</p> <p>For medium and large numerators, bar charts were more accurate.</p> <p>Accuracy on the gist task was very high across all conditions (&gt; 95 %). Vertical formats were processed slightly faster than horizontal graphs with no difference in accuracy. Most participants preferred bar charts (64 %); however, there was no relationship with performance.</p>	<p><u>Applicability</u></p> <p>Socioeconomic deprivation among the participants can be seen as a limitation as they do not represent the population or as a strength because they represent a group that is in most need for better understanding in health-related issues.</p> <p>The outcome shown as probabilities is a common way of communicating risk and is relevant to the primary care sector.</p> <p>-</p> <p><u>Limitations:</u></p> <p>No direct measure of the participants' literacy or numeracy levels (average age for leaving school was 16.7 years).</p>

					Computer setting, without real patient-physician contact.
					No information about the participants' medical history.
Zikmund-Fisher et al., 2012, USA (32)	Randomised study with a quasi-factorial design and 4198 participants from a survey panel of internet users.	A fictive scenario about two hypothetical treatments for thyroid cancer. Tested by internet users without the disease.	<p>The study evaluated eight different animated risk graphics presented by icons arrays (blocs). They were viewed on a PC screen that incorporated different combinations of three basic animations: 1) building risk one unit at a time, 2) settling scattered risk into a grouping and 3) shuffling scattered risk to reinforce randomness. Participants received all risk information in 1 out of 10 possible pictograph formats.</p> <p>Outcome: To test if animated icon array pictographs, displaying risks of side effects, could improve participants' ability to select the treatment with the lowest risk profile, as compared with seeing static images of the same risks.</p> <p>Outcome measurements: The ability of the participants to choose the less risky treatment (choice accuracy), gist knowledge of side effects (knowledge accuracy), and graph evaluation ratings, controlled for subjective numeracy, and need for cognition.</p>	<p>No animations significantly improved any outcomes, compared to static grouped icon arrays. The most animations showed significant performance degradations (<math>p &lt; 0.02</math>). Displays with scattered icons (static or animated) performed particularly poor unless they included a settled animation that allowed users to see event icons grouped. Static pictographs that grouped event icons at the bottom of the array consistently resulted in an optimal treatment choice, higher knowledge accuracy and better graph evaluation ratings. The most complex graphics were least preferred by the participants.</p>	<p><u>Applicability</u></p> <p>Large sample size, with diversity and without specific diseases. The email invitations were regulated to ensure stratification for sub samples. Calculation of the participants' subjective numeracy.</p> <p>-</p> <p><u>Limitations:</u></p> <p>The internet panel was given a hypothetical medical treatment scenario. This may have had an influence on the participants' motivation to engage in the task.</p> <p>Only representative for a population of internet users.</p> <p>No demographic data on drop outs and non-responders.</p> <p>Completion rate 67.7 %.</p> <p>Graphs of the two conditions were presented side-by-side, making it possible that the dual animation affected the outcome. The animated blocks finished appearing</p>

					in one of the two arrays before the other one, creating a longer motion cue, which may have affected treatment choice.
Hawley et al., 2008, USA (3)	Randomised trial with 2412 participants drawn from a survey panel of internet users.	An online hypothetical medical decision-making scenario about CVD.  Setting: General practice.	Imaginary scenario in general practice with a choice between two different types of medication to avoid a bypass surgery. One treatment was designed as superior according to its risk profile and beneficial effects. Numerical risk information was given in one out of the following six graph formats; bar graph, pictograph, modified pictograph (sparkplug), pie chart, modified pie graph (clock graph) or in a table.  The aim was to evaluate what impact these six graphical formats had on answers about treatment risks and benefits.  The outcome measurements: Verbatim knowledge (the ability to correctly read numbers from graphs) and gist knowledge (the ability to identify the essential points of the information presented).	All formats were positively received, and pictographs were trusted by respondents with both high and low numeracy. High Verbatim and gist knowledge where associated with making a medically superior treatment choice ( $p < 0.01$ ).  Viewing a pictograph was associated with both adequate verbatim and gist knowledge, especially for individuals with lower numeracy.  Respondents with higher numeracy answered more of the questions correctly for both verbatim and gist knowledge regardless of graph type ( $p < 0.007$ ), compared to respondents with low numeracy, none of the graph types were associated with making a correct treatment choice.  Pictographs were the best format for	<u>Applicability</u>  Email invitations were adjusted to ensure stratification for sub samples. Large sample size.  Numerical understanding was translated into the understanding of consequence.  <u>Limitations:</u>  Participants were not personally affected by the risk presented, this may have affected the way risk was interpreted.  Data was only representative for people able to use the internet.  Dropout (23.5 %), may be due to participants who did not understand the graphs. This has not been explored further.  No real patient-physician contact regarding delivery of medical information.  Numeracy was evaluated by using a validated method, however the questions used for gist and verbatim knowledge were not confirmed validated.

				communicating probabilistic information, particularly among individuals with lower numeracy.	
Goodyear-Smith et al., 2008, New Zealand (33)	Questionnaire and telephone interviews with 188 patients invited through four family practices.	Patients with a pre-existing heart disease and users of statin.	Patients were interviewed about their preference for methods expressing the preventive benefit of a hypothetical medication. Benefits were expressed in numerical formats (relative risk, absolute risk, number needed to treat, odds ratio and natural frequency) and one graphical (bar chart). The outcome measurements: Could information presented in a different way encourage the patient to take the medication daily, which method was preferred to express the benefit of the medication and if the patient preferred positively or negatively framed information.	No matter how the risk was expressed, most of the patients (67-89 %) indicated that they would be encouraged to take the medication. A large group of the patients (68 %) preferred one method of expressing benefits over the others, but 32 % of the patients could not decide which presentation they preferred. More than half (57 %) preferred the information presented graphically ( $p < 0.001$ ). The second most preferred option (19%) was relative risk. Most patients (90 %) preferred positive framing (description of the benefits of treatment) above negative framing (description of the harm of not being treated). A graphical representation of the benefits was the method patients preferred the most.	<p><u>Applicability</u></p> <p>Study sample included patients with a known disease, who are familiar with taking medication every day, thus consider positive effects or side effects of medication daily.</p> <p>-</p> <p><u>Limitations:</u></p> <p>Not randomised or controlled design.</p> <p>Small study sample without power calculation.</p> <p>The interviewer was not blinded to the type of format the patient was evaluating.</p> <p>Low response rate: 53 % (100 patients).</p> <p>The questionnaire was not validated.</p> <p>The study was not done at the point of true decision making.</p> <p>The study presumed that the preference for a given format of explanation reflected the ease of the patient to understand the information presented.</p>

Table 1. Design characteristics, main findings and comments on the 13 included studies. The studies are listed by year of publication.

## Figures

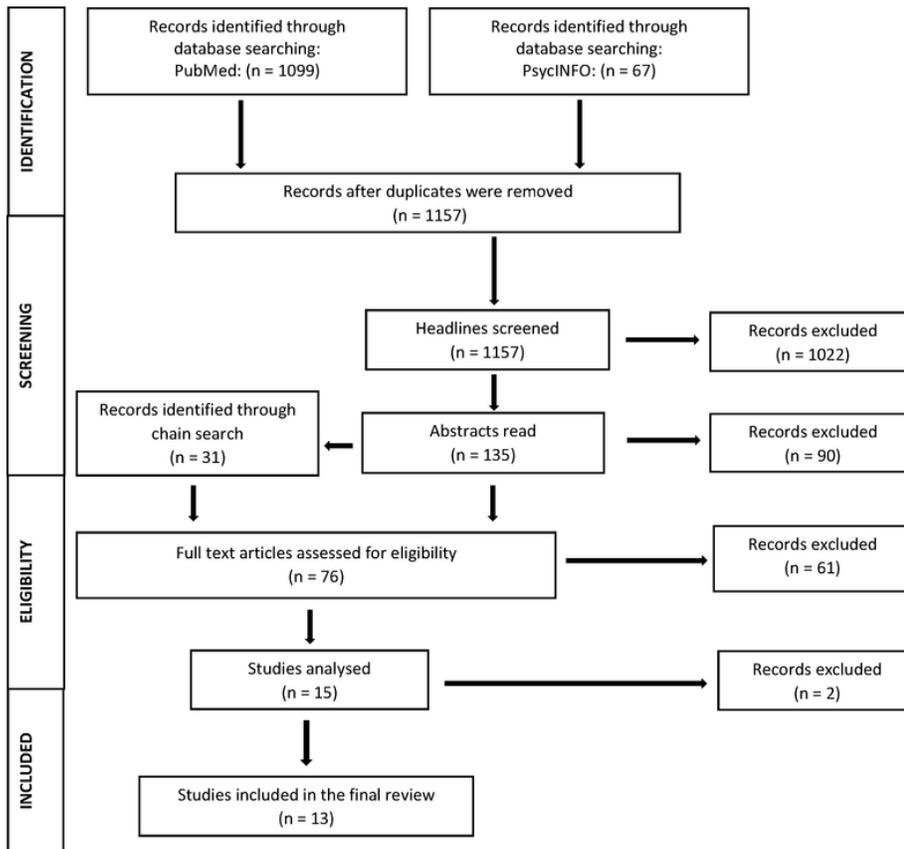


Figure 1

Search history for literature review following the PRISMA framework.