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Communicating Health Risks With Visual Aids

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Abstract

Informed decision making requires that people understand health risks. Unfortunately, many people are not risk literate and are biased by common risk communication practices. In this article, we review a collection of studies investigating the benefits of visual aids for communicating health risks to diverse vulnerable people (e.g., varying in abilities, ages, risk characteristics, and cultural backgrounds). These studies show that appropriately designed visual aids are often highly effective, transparent, and ethically desirable tools for improving decision making, changing attitudes, and reducing risky behavior. Theoretical mechanisms, open questions, and emerging applications are discussed.

Keywords

visual aids, risk perception, risk communication, medical decision making, risk literacy, numeracy

To effectively participate in decision making, patients and health care professionals need to understand the risks and benefits of different medical treatments, screenings, and lifestyle choices (Garcia-Retamero & Galesic, 2013). Unfortunately, research indicates that people often struggle to grasp numerical concepts that are essential for understanding and communicating health-relevant information (Peters, 2012; Reyna, Nelson, Han, & Dieckmann, 2009). In short, the general public lacks basic numeracy, which limits their risk literacy—the ability to accurately interpret and make good decisions on the basis of information about risk (Cokely, Galesic, Schulz, Ghazal, & Garcia-Retamero, 2012; Galesic & Garcia-Retamero, 2010).[1]

Visual aids are simple graphical representations of numerical expressions of probability and include icon arrays and bar and line graphs, among others (see Fig. 1). Visual aids have long been known to confer benefits when communicating health-relevant risk information. As the saying goes, "a picture is worth a thousand words." However, not all visual aids are equally effective. Visual aids tend to be most effective when they are *transparent*—when their elements are well defined and they accurately and clearly represent the relevant information by making part-to-whole relationships in the data visually available.[2] Appropriately designed visual aids can improve comprehension of risks associated with different medical treatments, screenings, and lifestyles (Waters, Weinstein, Colditz, & Emmons, 2007; Zikmund-Fisher, Fagerlin, & Ubel, 2008). Visual aids also increase appropriate risk-avoidance behaviors, promote healthy behaviors, and reduce errors induced by anecdotal narratives (Cox, Cox, Sturm, & Zimet, 2010; Fagerlin, Wang, & Ubel, 2005; Schirillo & Stone, 2005). Moreover, risk information presented visually is judged as easier to understand and recall, and requires less viewing time than the same information presented numerically (Feldman-Stewart, Brundage, & Zotov, 2007; Gaissmaier et al., 2012; Goodyear-Smith et al., 2008). Nevertheless, the benefits of visual aids are different for different people.

Using Visual Aids to Communicate Risks to Vulnerable Populations

People with high numeracy can often understand risks even if visual aids are not provided (Galesic, Garcia-Retamero, & Gigerenzer, 2009; Keller & Siegrist, 2009). The challenge is to reach vulnerable people who are less risk literate and more likely to make errors or avoid

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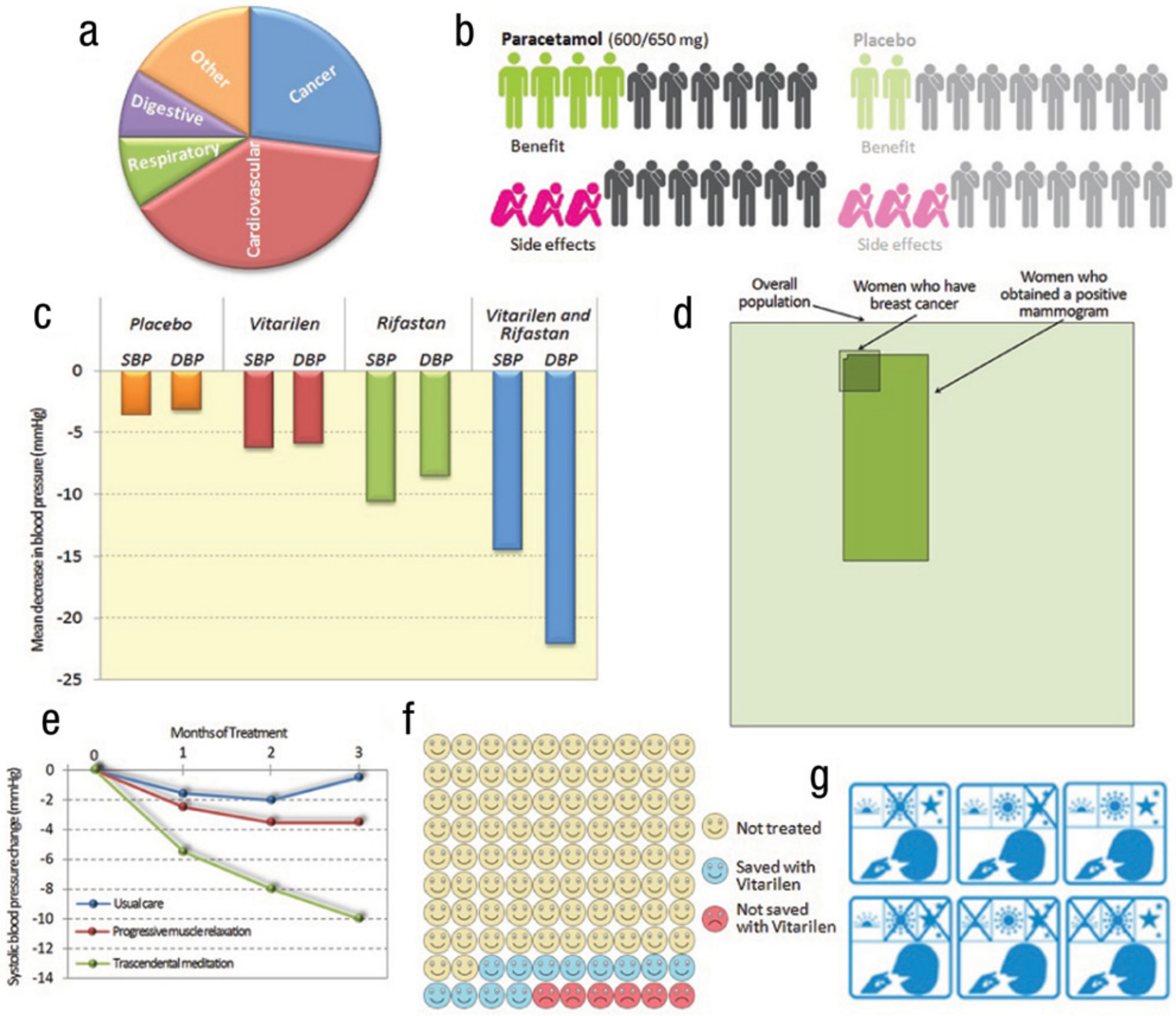

Fig. 1. Examples of transparent visual aids. A pie chart reports the proportion of deaths by cause of death (a). Icon arrays represent benefits and side effects of a medical treatment and a placebo (b). A bar chart compares the efficacy of two medical treatments (SBP = systolic blood pressure; DBP = diastolic blood pressure) (c). A visual grid is used to help infer the predictive value of mammography screening (d). A line plot compares the efficacy of several therapies (e). Icon arrays are used to communicate treatment-risk reduction (f). Pictograms report dosage, timing, and action information about prescribed medications (g).

decision making altogether. Visual aids offer one of the most promising methods for efficiently communicating with diverse people who are at risk (Hawley et al., 2008; Peters et al., 2009). To illustrate, Garcia-Retamero and Galesic (2010) showed that visual aids are particularly beneficial for people who have low numeracy as long as they have moderate-to-high graph literacy (i.e., if they are able to understand basic graphical representations of quantitative information; Galesic & Garcia-Retamero, 2011b). Examining probabilistic national samples in the United States and Germany, the authors found that providing visual aids in addition to numerical information about the effectiveness of medical treatments increased accuracy from less than 20% to nearly 80% among people who were moderately graph literate, even when they had very low levels of numeracy. In fact, providing visual aids eliminated differences in accuracy between this group of people and the most numerate group. Unfortunately, people with both low numeracy and low graph literacy did not benefit from visual aids.

Visual aids are also helpful to other vulnerable populations with limited risk literacy. Because of age-related cognitive decline and other cohort effects, older adults often struggle with numerical and complex reasoning (Finucane et al., 2002). Given that older adults frequently suffer chronic diseases and confront health-related decision making, the challenges when dealing with health risks are magnified. A study by Garcia-Retamero, Galesic, and Gigerenzer (2010) showed that visual aids can help less numerate older adults make accurate assessments of the effectiveness of medical treatments. Unfortunately, visual aids confused rather than helped some older adults who were low in both numeracy and graph literacy.

Visual aids also improve risk communication for people with limited language skills and limited medical knowledge. Immigrants are one such group of people who are often at high risk for illness and death (James, Hawkins, & Rowel, 2007). These groups can also have problems understanding concepts such as "risk factors" and "being at risk," and they have special difficulties with numerical health risks (Groman, Ginsburg, & the American College of Physicians, 2004). A study conducted by Garcia-Retamero and Dhami (2011) showed that translated resources offer a helpful, but not sufficient, approach to communicating health information to immigrants. However, results further revealed that providing visual aids in addition to numerical information about the effectiveness of medical treatments eliminated differences between native and immigrant samples, even when the information was not presented in the immigrant participants' native language. Visual aids can also reduce errors and biases that affect accuracy of perceptions of the effectiveness of medical treatments.

Using Visual Aids to Reduce Biases

A bias with important consequences for many health decisions is *denominator neglect*—the tendency to focus on the number of times a target event has happened (i.e., the numerator) and ignore the overall number of opportunities for it to happen (i.e., the denominator; Reyna, 2004). To illustrate, the number of patients who receive a certain drug is often smaller than the number of patients who do not (e.g., 100 and 800, respectively). If people disregard denominators, neglecting the overall number of treated and nontreated patients, they might perceive the drug to be more effective than it actually is. In other words, people might compare only absolute numbers of treated and nontreated patients who die (e.g., 5 versus 80, respectively) rather than the proportion of treated and nontreated patients who die (e.g., 5 of 100 and 80 of 800; Fig. 2).

Past research examining perceptions of treatment-risk reduction did not use ecologically valid stimuli, because participants often received samples of treated and nontreated patients of the same size. To address this concern of ecological validity, Garcia-Retamero and Galesic (2009) conducted a study reporting numerical information about the effectiveness of medical treatments using unequal samples. The authors found that participants—especially those with relatively low numeracy—exhibited denominator neglect. That is, they overestimated treatment-risk reduction when the overall number of treated patients was lower than the overall number of patients who did not receive the treatment. However, denominator neglect was effectively eliminated by using visual aids representing the information about the effectiveness of the medical treatment. Likewise, a study by Okan, Garcia-Retamero, Cokely, and Maldonado (2012) showed that visual aids are effective for reducing denominator neglect

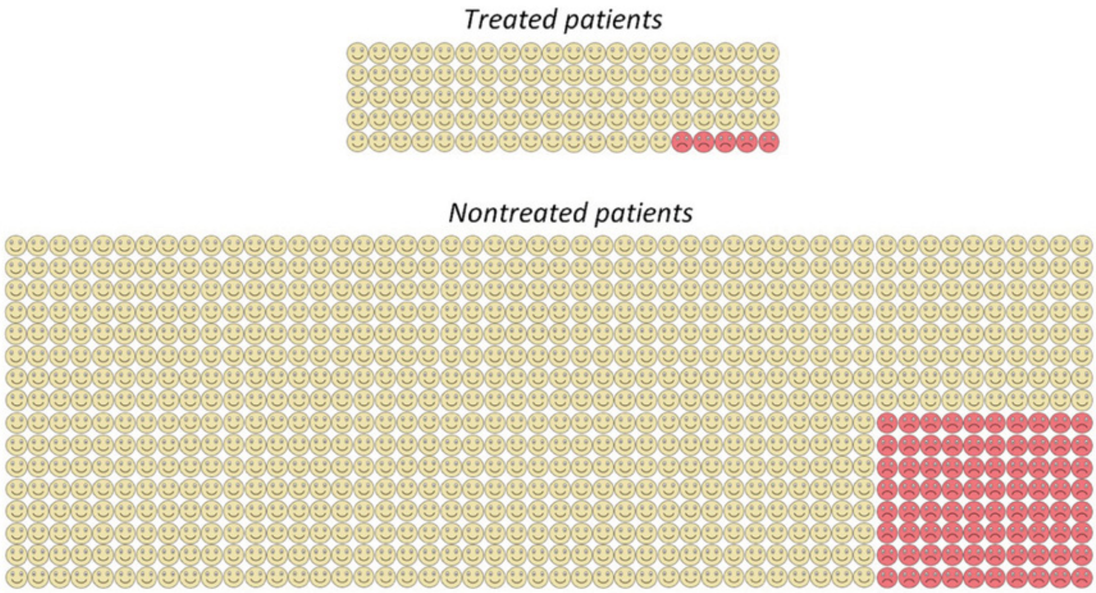

Fig. 2. Icon arrays representing a treatment-risk reduction of 50% with unequal samples of treated and nontreated patients. Patients who died are represented in red; healthy patients are represented in yellow.

in participants with relatively high—but not low—graph literacy. Recent research also showed that visual aids can help promote healthy behavior.

Behavioral Interventions Involving Visual Aids

Health information can be framed in terms of the benefits afforded by adopting a behavior (a *gain-framed appeal*; e.g., using condoms helps prevent sexually transmitted diseases, STDs) or in terms of the costs associated with failing to adopt the behavior (a *loss-framed appeal*; e.g., failing to use condoms increases the risk of contracting STDs; Rothman, Martino, Bedell, Detweiler, & Salovey, 1999). In a longitudinal study, Garcia-Retamero and Cokely (2011) examined the effects of a brief risk awareness intervention in a large sample of sexually active young adults at high risk. The authors showed that gain-framed messages induced greater adherence for a prevention behavior (e.g., condom use), whereas loss-framed messages were more effective for promoting an illness-detecting behavior (e.g., STD screening). This was the case even if the two types of framed messages were comparable. However, when visual aids reporting numerical information about STDs were added to the health information, both the gain- and loss-framed messages became equally and highly effective for promoting prevention and detection of STDs (i.e., the framing bias was eliminated). In contrast, providing the same information in numbers did not reduce the effect of the framed messages. Follow-up interventions conducted in large samples of sexually active young adults showed that well-constructed visual aids were as effective as an extensive 8-hr educational intervention for promoting condom use (Garcia-Retamero & Cokely, in press b). Young adults disadvantaged either by their lack of knowledge about STDs or their low numeracy benefited more from the visual aids than those who had considerable knowledge or higher numeracy as long as they were moderately graph literate (Garcia-Retamero & Cokely, in press a, in press b).

Recent work also indicates that visual aids can encourage patients' trust in their own physician and willingness to participate in decision making. Visual aids seem particularly beneficial for patients who have relatively low numeracy or knowledge about medical facts—a group that generally tends to be more passive in medical decision making (Galesic & Garcia-Retamero, 2011a). Moreover, visual aids can boost accuracy beyond the effect of other transparent information formats. For instance, people often have difficulties inferring the predictive value of medical tests from information about the prevalence of diseases and the sensitivity (true-positive rate) and specificity (true-negative rate) of the tests. Communicating information about the tests in natural frequencies compared with conditional probabilities improves diagnostic inferences (Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000). However, our research shows that visual aids improve the accuracy of these inferences in doctors and their patients above and beyond the effect of natural frequencies (Garcia-Retamero & Hoffrage, 2013; see also Lloyd & Reyna, 2001). This research also indicates that doctors tend to be more accurate in their diagnostic inferences than their patients; however, differences in accuracy are fully mediated by differences in numerical skills.

What Have We Learned So Far?

The research reviewed in this article focuses on the interplay between individual differences and the effectiveness of visual aids. This research shows that well-designed visual aids can be especially useful for vulnerable people who typically have problems understanding information about health risks (i.e., people with low numeracy, low knowledge about medical facts or both but relatively high graph literacy; older adults; immigrant populations; and patients at high risk). As long as vulnerable people have moderate levels of graph literacy, appropriate visual aids tend to dramatically improve comprehension and decision making.

The conclusions presented here are based on a wide range of studies conducted in the general public (e.g., large, probabilistic national samples) and diverse groups of patients from countries with different medical systems (e.g., the United States, Germany, Great Britain, and Spain). These studies examined risk communication in different ecologically valid tasks that accurately reproduce the problems that patients encounter when they face health decisions. These ecological studies covered many topics, including estimates of risk and risk reduction; diagnostic inferences and perceptions of treatment effectiveness; confidence and accuracy; and changes in attitudes, behavioral intentions, actual behaviors, and decision making. In addition, results hold across different types of visual aids (e.g., icon arrays, bar charts, and line plots). Results also hold when visual aids differ in iconicity (see Gaissmaier et al., 2012) and when visual aids are provided either in addition to or instead of numerical information (see Garcia-Retamero & Galesic, 2013, for a review). Although our research is the central focus of the current article, it is important to note that it is part of a large, active interdisciplinary field (see Ancker, Senathirajah, Kukafka, & Starren, 2006; Lipkus, 2007; Peters, 2012; Reyna et al., 2009; Zikmund-Fisher et al., 2008). Overall, research in this field converges to suggest that well-constructed visual aids often offer an effective, transparent, fast, memorable, and ethically desirable means of risk communication.

Our research adds to the literature by showing that problems associated with risk illiteracy are not simply the result of limited cognitive capacities or inherent biases that prevent good decision making. Instead, errors occur because ineffective information formats can complicate and mislead adaptive decision makers (see also Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz, & Woloshin, 2007). Good decision making results from an appropriate fit between people's skills, processes, and environments (Cokely & Kelley, 2009). To the extent that information formats leverage people's inherent capacity to recognize and contextualize relationships in naturally occurring tasks, they are likely to confer benefits.

In this regard, transparent visual aids can improve risk understanding by making part-to-whole relations in the data visually available, helping people understand and represent superordinate classes, even if they have limited risk literacy (Ancker et al., 2006; Reyna & Brainerd, 2008). Visual aids can also increase the ability of less numerate persons to derive affective meaning from the comparison of risk-related numerical information (Peters, 2012). Indeed, superior risky decisions often follow from more elaborative encoding of contextual and relevant risk information (Cokely & Kelley, 2009; see also Woller-Carter, Okan, Cokely, & Garcia-Retamero, 2012). By influencing encoding and contextualization, visual aids give rise to enduring changes in attitudes and behavioral intentions, which in turn affect actual behavior and risky decision making. For example, by encoding and representing risks and benefits of medical screenings in a more elaborative and integrated way, visual aids modify attitudes toward medical screenings. These more enduring attitudes, in turn, help foster the intention to participate in screenings, which increases the likelihood of engaging in the detection behavior (Garcia-Retamero & Cokely, 2011). However, some caution is warranted, because visual aids can also misrepresent risk information (Ancker, Weber, & Kukafka, 2011; Stone et al., 2003). Researchers should avoid using misleading visual aids by adhering to standards[3] and validating their graphs before conducting an intervention (Trevena et al., 2012).

Where Do We Go Next?

Although our studies shed some light on how and when visual aids improve decision making, more research is needed to model underlying individual differences in the cognitive processing of visually represented health risks. Theories of graph comprehension (e.g., Carpenter & Shah, 1998) provide a foundation for this understanding, and current graph-design and decision-aid standards are being used to help researchers make predictions about which visual aids will be more effective in certain situations. Ongoing research is also working to identify suitable strategies for communicating health risks to patients who are neither graph literate nor numerate. To illustrate, research using analogies from people's everyday lives shows that these analogies are relatively undemanding in terms of risk literacy and may be useful as a means of custom-tailored risk communication (Galesic & Garcia-Retamero, 2013). In order to identify strategies for communicating health risks to people who are neither graph literate nor numerate, we will need to refine our theoretical understanding of the underlying mechanisms of risk perception (Slovic & Peters, 2006; Volz & Gigerenzer, 2012).

Modifying risky behavior is difficult. To the extent that our results generalize, visual aids might offer a relatively efficient means of reaching other vulnerable people, including children, adolescents, people in the criminal justice system, people with mental illnesses, and people in rural and inner-city areas. For example, visual aids can provide low-cost supplements for individual, community-based, or school-based interventions with potentially long-lasting effects. To maximize potential benefits, more research on these groups and other applications of visual aids is needed, as are more prospective studies investigating the comparative effects of visual aids in the long term (e.g., years after interventions).

Looking forward, risk communication will increasingly be integrated with information technology. As we mentioned earlier, there are well-established standards for the construction of decision aids (IPDAS; see Feldman-Stewart, Brennenstuhl, et al., 2007), and theories of risk literacy and graph literacy are now starting to be embodied in adaptive tests and software. Some such programs provide free online tools allowing anyone to build better graphs (e.g., http://www.iconarray.com). Other online programs provide fast, free, validated assessments of risk literacy for use by researchers and the public alike (e.g., http://www.riskliteracy.org). The use of similar instruments may eventually help health care professionals quickly assess individual differences in risk literacy, with only a couple of questions. Adaptive, internet-based tutoring programs and custom-tailored educational brochures are also under development. These interactive educational and decision aid technologies hold great promise for leveraging what we already know about communicating risk, improving risk literacy and supporting informed decision making.

Recommended Reading

Ancker, J. S., Senathirajah, Y., Kukafka, R., & Starren, J. B. (2006). (See References). A comprehensive, clearly written review for readers who wish to expand their knowledge

on the influence of visual aids on quantitative reasoning, behavioral intentions, and behaviors.

Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012). (See References). Describes the Berlin Numeracy Test—a psychometrically sound instrument that assesses statistical numeracy in 2 to 3 minutes. The instrument is validated for prediction of domain-general risk literacy (http://www.RiskLiteracy.org).

Garcia-Retamero, R., & Galesic, M. (2013). (See References). Provides an extensive review of how visual aids improve risk communication and medical decision making in people with limited risk literacy.

Gigerenzer, G., Gaissmaier, W., Kurz-Milcke, E., Schwartz, L. M., & Woloshin, S. (2007). (See References). Provides full discussion of studies investigating risk understanding and medical decision making for readers who wish to learn more about transparent information formats.

Lipkus, I., & Hollands, J. G. (1999). The visual communication of risks. *Journal of the National Cancer Institute Monographs*, *25*, 149–163. A historical classic; one of the first papers to raise awareness of the potential benefits of visual aids.

Peters, E. (2012). (See References). A concise and accessible paper about the role of numeracy in judgment and decision making.

Spiegelhalter, D., Pearson, M., & Short, I. (2011). Visualizing uncertainty about the future. *Science*, *333*, 1393–1400. Reviews a collection of studies investigating the influence of visual aids in risk understanding in a wide range of fields (i.e., sport, weather, climate, economics, and politics).

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Notes

1. For major assessments of numeracy, see Kutner, Greenberg, Jin, and Paulsen (2006) and the Organization for Economic Cooperation and Development (2012).
2. For good practices for designing transparent visual aids, see the guidelines of the Human Factors and Ergonomics Society (Gillan, Wickens, Hollands, & Carswell, 1998).
3. For more information, see http://ipdas.ohri.ca/

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