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Effect of Tabular and Icon Fact Box Formats on Comprehension of Benefits and Harms of Prostate Cancer Screening: A Randomized Trial

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Abstract

Background. Fact boxes employ evidence-based guidelines on risk communication to present benefits and harms of health interventions in a balanced and transparent format. However, little is known about their short- and long-term efficacy and whether designing fact boxes to present multiple outcomes with icon arrays would increase their efficacy. **Method.** In study 1, 120 men (30–75 y) completed a lab study. Participants were randomly assigned to 1 of 3 fact box formats on prostate cancer screening: a tabular fact box with numbers, a fact box with numbers and icon array, and a fact box with numbers, separate icon arrays, and text to describe each benefit and harm. Comprehension of information (while materials were present) and short-term knowledge recall were assessed. Study 2 recruited an online sample of 244 German men (40–75 y). Participants were randomly assigned to 1 of the 3 fact box formats or widely distributed health information, and knowledge was assessed at baseline, shortly after presentation, and at 6-mo follow-up, along with comprehension while materials were present. **Results.** In both studies, comprehension and knowledge-recall scores were similar when comparing tabular and icon fact boxes. In the 6-mo follow-up, this positive effect on knowledge recall disappeared. Fact boxes increased knowledge relative to baseline but did not affect decision intentions or perceptions of having complete information to make decisions. **Conclusions.** This study shows that fact boxes with and without icon arrays are equally effective at improving comprehension and knowledge recall over the short-term and are simple formats that can improve on current health information. Specifically, if fact boxes are used at the time or immediately before a decision is made, they promote informed decisions about prostate cancer screening.

Keywords
fact box, risk communication

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Many people have a poor understanding of the benefits and harms of health interventions. For example, most European men and women overestimate the benefits of cancer screening by 10-fold or more.[1] In part, the problem lies in how risk information is communicated to the public. Health information is often not balanced or transparent and uses misleading statistical formats that prevent people from being able to balance benefits against harms.[2,3] For example, communicating benefits in relative (e.g., mammography screening reduces breast

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cancer mortality by 20%) as opposed to absolute (e.g., mammography decreases mortality from 5 in 1000 to 4 in 1000 women) risk reductions decreases understanding and leads to overestimation of benefit.[4–6] In general, transparent formats allow one to understand and compare the magnitude of benefits and harms, improving comprehension and leading to more realistic perceptions of health risks.[4,7]

Health statistics can be communicated transparently in tabular formats[8,9] or represented alongside graphical formats.[10–12] Both formats have been found to promote understanding of health risks,[9,11,13,14] yet the relative efficacy of the formats are mixed,[15–18] and few studies evaluate how well they communicate multiple benefits and harms within the same display. The question of how best to communicate the results in such cases has practical implications as health organizations increasingly seek visually appealing approaches to communicate multiple outcomes (e.g., infographics). Our primary aim is to evaluate the relative efficacy of tabular and graphical formats for communicating multiple benefits and harms on comprehension and knowledge recall (study 1 and 2) and on improving on prior knowledge over the short and longer term (study 2). We also compare the formats to standard health information currently available to the public (study 2).

What Is the Most Effective Fact Box Format for Communicating the Benefits and Harms of Health Interventions?

To facilitate informed decision making, risk communications should adhere to principles of completeness (benefits and harms are presented), balance (equal weight is placed on the presentation of benefits and harms), and transparency (risks are presented in absolute rather than or in addition to relative numbers, and an appropriate reference class is defined).[2,4,19] The fact box, originally proposed by Eddy[8] in the form of a balance sheet, adheres to these criteria by providing a tabular summary of the benefits and harms of intervention options with numerical probabilities for each outcome. Fact boxes have been used to communicate evidence for a variety of health decisions, including cancer screenings and medical treatments.[8,9,16,20–25]

Graphical formats have also been shown to promote risk comprehension relative to formats that include numerical risk information in-text,[9,11–14,17,24] although graphical formats have not been tested within the fact box structure. Of these graphical formats, the icon array is particularly effective at communicating the magnitude of health risks and can overcome potential biases in understanding (e.g., denominator neglect).[26,27] An icon array presents outcomes as proportions of 100 or 1000 icons (e.g., dots, restroom icons), allowing for visual as well as numerical comparisons of quantities.[10,11] A similarity between tabular and icon array formats is that both make the reference class and part-to-whole relationships transparent, enabling people to compare the magnitude of risks within and between options.

The few studies that have examined the relative efficacy of tables and icon arrays for improving knowledge of benefits and harms report mixed results: some show that icon arrays improve comprehension of health risks compared with tabular formats,[16,18] and others show the opposite pattern[15] or report no difference between formats.[17,28] In some cases, individual differences, such as numeracy, account for some of the contradictory findings.[29] However, another potential explanation is the variability in the amount of information provided and the design of the formats. Typically, a single benefit (e.g., pain relief)[30] and 1,[16] 2,[15,18] or up to 3 harms[17] are provided. Integrating evidence for each additional benefit or harm may require greater cognitive demand. There is some evidence to suggest that simple graphical formats (e.g., removing nonfocal information or comparing fewer treatment options) facilitates comprehension of treatment outcomes[31,32] and that presenting treatment options sequentially can improve comprehension of incremental benefit.[33] Presenting benefits and harms within the same icon array[i] can facilitate comparisons of proportions for each outcome across but also within decision options. Presenting benefits and harms in separate icon arrays allows the user to compare proportions for each benefit and harm separately and evaluate the magnitude of each outcome.

Figure 1 shows 3 formats presenting numbers about the benefits and harms of prostate cancer screening drawn from a recent systematic review.[34] In Figure 1A, all information about the benefits and harms is presented numerically in a single fact box that compares outcomes for 2 groups of 1000 men who did or did not participate in screening. In Figure 1B, the information is presented both numerically and in an icon array, in a single box. Finally, in Figure 1C, each benefit and harm is presented in a separate box with accompanying text that draws attention to each outcome and the description for each group. For instance, the biopsy is described as risky and the adverse effects of treatments (impotence and incontinence) are now in the title. The addition of these textual descriptions can have potential implications on outcomes. To our knowledge, there have been no studies that analyze the efficacy of the different formats with multiple benefits and harms.

A

Prostate Cancer Early Detection

by PSA testing and palpation of the prostate gland

Number are for men aged 50 years or older, not participating vs. participating in early detection for 11 years

	1,000 men without early detection	**1,000 men with early detection**
Benefits		
How many men died from prostate cancer?	7	7*
How many men died from any cause?	210	210
Harms		
How many men without cancer experienced a biopsy and a false alarm?	–	160
How many healthy men were diagnosed and treated** for prostate cancer unnecessarily?	–	20

* This means that about 7 out of 1,000 men (50+ years of age) with early detection died from prostate cancer within 11 years.

** E.g. prostate removal or radiation therapy, which can lead to incontinence or impotence.

Source: Ilic et al. (2013) *Cochrane Database of Systematic Reviews,* Art. No.:CD004720.

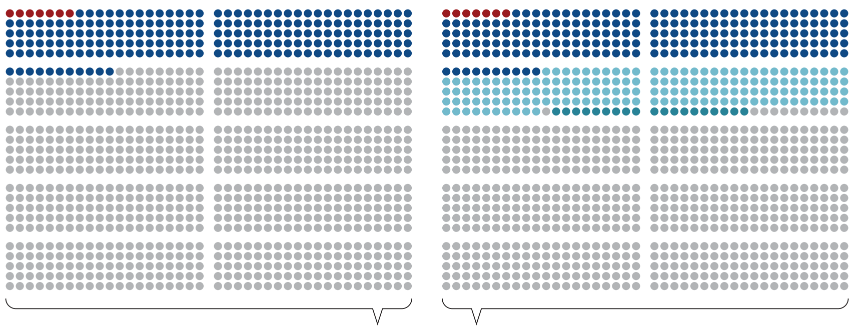
B

Prostate Cancer Early Detection

by PSA testing and palpation of the prostate gland

Number are for men aged 50 years or older, not participating vs. participating in early detection for 11 years

1,000 men without early detection **1,000 men without early detection**



● Men who died from prostate cancer:	7	7
● Men who died from any cause:	210	210
● Men without cancer who experienced a biopsy and a false alarm:	–	160
● Healthy men who were diagnosed and treated for prostate cancer unnecessarily:	–	20
● Other men:	790	610

Source:
Ilic et al. (2013)
Cochrane Database of Systematic Reviews,
Art. No.:CD004720.

Figure 1 (continued)

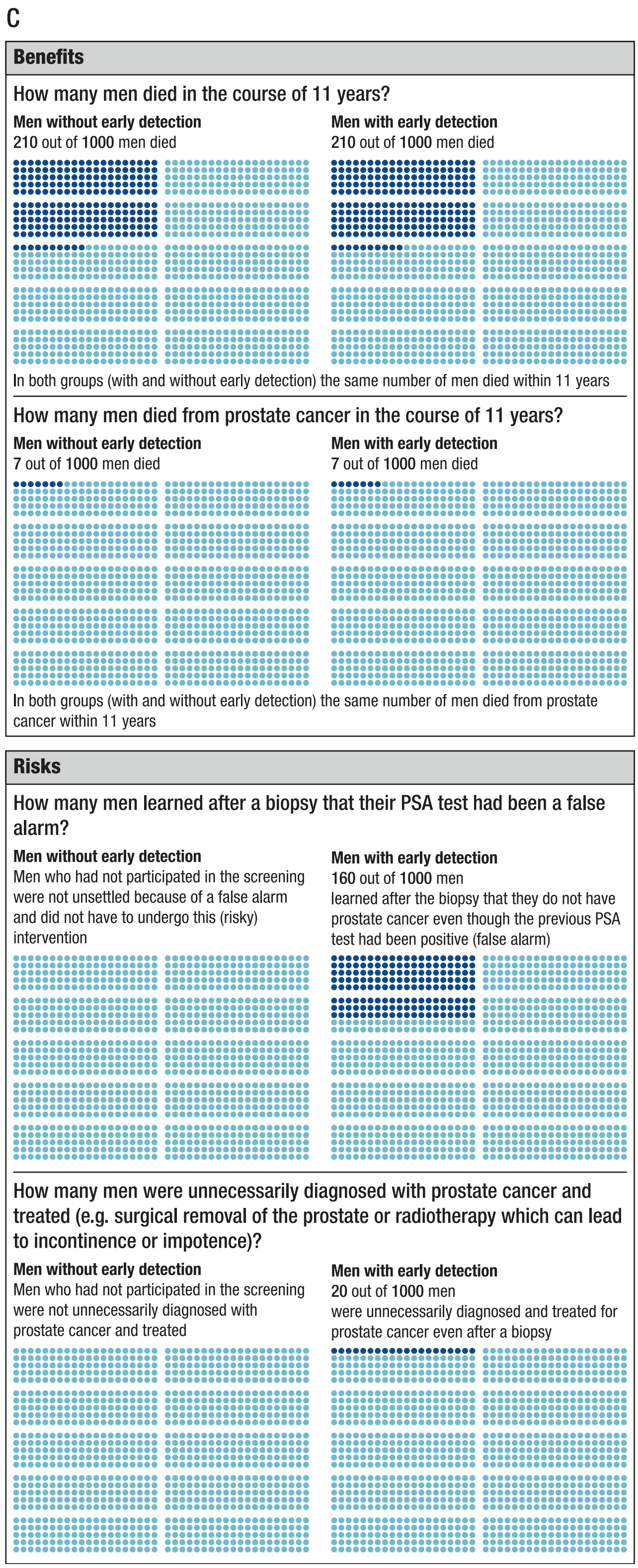


Figure 1 Three fact box formats for presenting 4 outcomes (2 benefits and 2 harms) for prostate cancer screening (studies 1 and 2). (A) Fact box: tabular format. (B) Fact box: single icon array. All outcomes (benefits and harms) are presented within the same icon array pair. (C) Fact box: separate icon arrays. Each outcome (benefit and harm) is presented within a separate icon array pair. Note that all formats stated that the numbers referred to men aged 50 y and older who were/were not screened for a period of 11 y. The text is omitted from Figure 1C to fit the figure on the page and can be found in Appendix A.

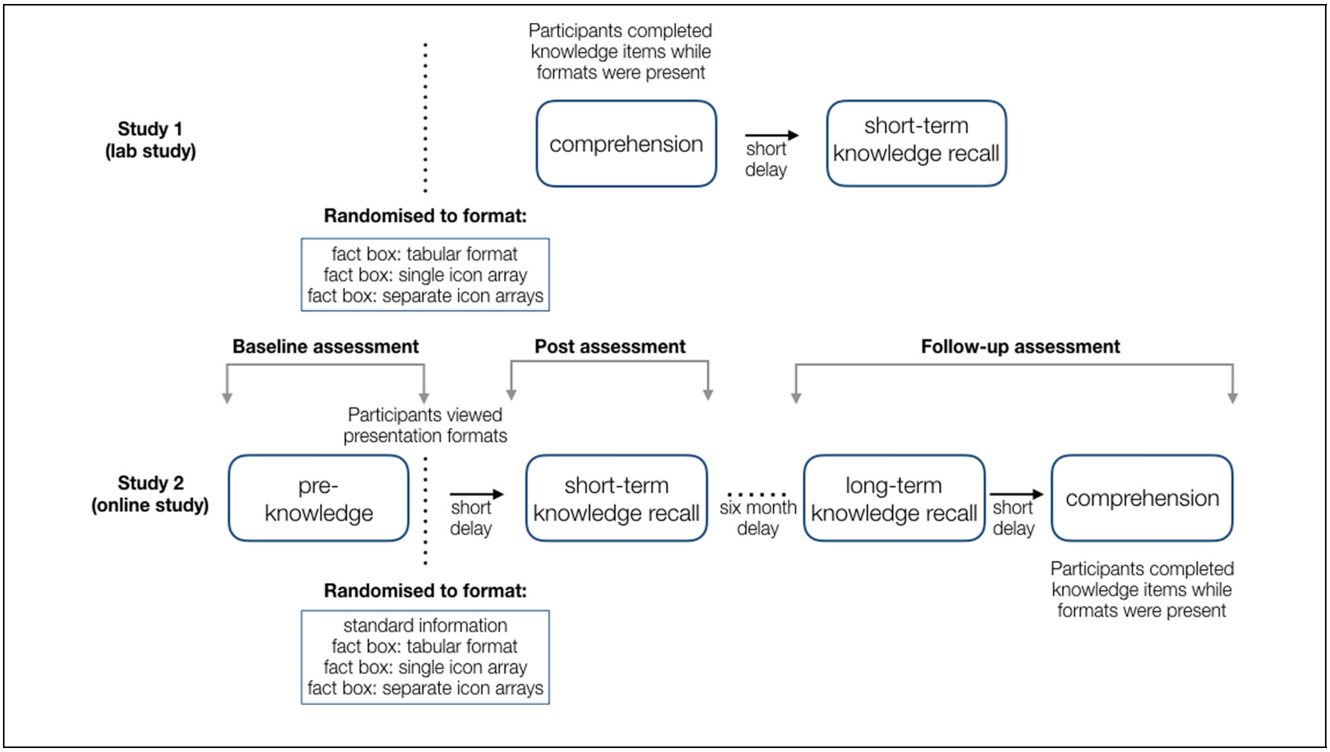


Figure 2 Overview of knowledge, knowledge recall, and comprehension assessments for study 1 and study 2.

Effects of Fact Box Formats on Comprehension, Short- and Long-term Knowledge Recall, and Decision Intentions

The studies addressed 2 additional research questions. First, prior studies have focused on comprehension (e.g., the ability to answer knowledge questions while a fact box is present) rather than on knowledge recall (e.g., the ability to answer questions from memory in the absence of a fact box) or change in knowledge over the short or longer term. Prior studies have compared fact boxes to direct-to-consumer advertisements, or tabular to graphical formats, when materials were provided alongside knowledge questions.[9,15,16,18,24,28] In study 1, we first examine the effects of fact box formats on comprehension and short-term recall. In study 2, we evaluate whether fact boxes improve on prior knowledge and knowledge recall over the short and long term. For example, fact boxes may be most beneficial at the time of presentation and decision making, that is, in comprehension, while knowledge recall may not persist over time.

Study 2 was also designed as an intervention trial, recruiting a more representative sample to explore the effect of fact box formats on decision intentions and behavior in comparison with health information that is currently available from a reputable cancer organization. Many studies comparing different formats often do not establish whether they improve on the information that is currently available to the public, typically because they examine only a few pieces of information in isolation or they study hypothetical scenarios.[15,17,18] We use prostate cancer screening with the prostate-specific antigen (PSA) test because the ratio of benefits to harms is counterintuitive. There is no clear evidence that population-based screening reduces prostate-specific or all-cause mortality, and the harms include the potential for false-positive test results, overdiagnosis, overtreatment, and, as a consequence, incontinence and impotence.[34] Ethical approval for both studies was obtained from the Max Planck Institute for Human Development Ethics Committee. An overview of the studies is shown in Figure 2.

Study 1

The objective of study 1 was to examine which of the fact box formats leads to greater comprehension, better short-term knowledge recall, and more informed decision intentions.

Method

Participants. A total of 120 men were recruited from the Max Planck Institute for Human Development participant pool to complete the study in the lab for a payment of 15 Euros. Men were aged between 30 and 75 y ($\bar{x}$ = 51.7, s = 16.5), 27% had completed middle or secondary school (9–10 y education), 23% had completed high school (12–13 y), and 45% had a bachelor's degree or higher.

Formats. Participants were randomly assigned to receive 1 of 3 formats (1:1 allocation ratio) using a computerized random-number generator: 1) fact box: tabular format (n = 40), 2) fact box: single icon array (n = 39), or 3) fact box: separate icon arrays (n = 41; Figure 1A–C, respectively). Participants were not aware of the alternative formats. The same introductory text was provided for each fact box. All materials were presented in German.

Measures

Comprehension and knowledge. As shown in Table 1, 8 items assessed knowledge about prostate cancer screening as evaluated in medical studies. Three questions examined knowledge of the benefits (e.g., disease-specific mortality reduction), and 5 questions examined knowledge of the harms (e.g., false alarms). Items assessed disease-specific and not total mortality, as reduction in disease-specific mortality is more widely communicated to the public. For the purpose of study 2, Table 1 lists the items in sets of 4 items according to whether or not the information could be found (lower section) or not found (upper section) in the standard information. Numerical estimates were coded as correct within a ±10-point margin of error (e.g., 150–170 out of 1000 men experience a false alarm)[ii] as the focus was on whether or not participants could provide estimates within the right ballpark. To assess comprehension, the knowledge items were presented alongside the formats. To assess knowledge recall, participants completed the knowledge items after a delay completing other study items.

Decision intentions. Participants were asked whether they planned to participate in prostate cancer screening in the next 6 mo and, if not, to indicate the most important reason for their response (see Table 2).

Perceived completeness of information. Participants were asked 2 questions about whether they had all the relevant information 1) about benefits and harms and 2) in general to help them make a decision about screening for prostate cancer. Responses for the 2 items were largely the same and were combined for analysis.

Procedure. Following informed consent, participants were randomized to 1 of the 3 fact box formats and completed the materials on lab computers. Participants completed the comprehension and decision intentions items while viewing the formats, followed by completeness and general evaluation items (e.g., perceived helpfulness, trust in the presented information), demographics, and a numeracy scale.[39] Appendix A presents the results for numeracy and evaluation items. Participants completed the knowledge items again after this short delay (7 min on average; see Figure 2). Comprehension and knowledge recall were the primary outcomes.

Analysis. Repeated-measures analysis of variance was applied to compare the presentation designs[iii] and McNemar tests for comparing dichotomous data for individual presentation designs. Unless otherwise indicated, all effects discussed were $P < 0.001$.

Results and Discussion

Comprehension and short-term knowledge recall. As shown in Figure 3, participants were able to answer an average of 5.8 out of 8 items correctly when the formats were presented alongside knowledge questions. As shown in Table 1, knowledge items that required a numerical response tended to be answered by more participants in the fact box: single icon array, whereas the fact box: separate icon array tended to facilitate answering of nonnumerical items. However, there were no statistical differences between the fact box formats. After a short delay, participants were able to recall on average 5.4 items correctly, indicating a small decrease, $F(1, 117) = 10.47$, $P = 0.002$, $\eta_p^2 = 0.08$, across formats. Further, more than 90% of all participants correctly reported that the same number of men die from prostate cancer in screened and nonscreened groups at both assessment points, irrespective of whether or not the actual numbers were correct.

Decision intensions. When the fact box formats were present, the sample was roughly split amongst the decision intention categories: 33% intended participate in screening, 37% did not intend to screen, and 31% did not state a specific intention (e.g., did not know, had not thought about it). Participants' responses were largely unchanged after the short delay (28%, 37%, and 35%, respectively). There were no differences in decision intentions between formats at any assessment point. Among participants who did not report an intention to screen, "harms outweigh the benefits" was the most stated

Table 1 Percentage of Participants in Study 1 and 2 Answering Each Knowledge Item Correctly when Formats Were Presented Alongside Knowledge Questions (Comprehension) and after a Short Delay (Recall)[a]

		Study 1			Study 2					
Item[b]	Presentation Format	*N*	Comprehension % of *N*	Recall at Post % of *N*	*N*	Baseline % of *N*	Recall at Post % of *N*	*n*	Recall 6 mo % of *n*	Comprehension % of *n*
The following information was missing from the standard information										
Who do you think is more likely to die from prostate cancer? (1) [Men who are screened; Men who are not screened; There is no difference between groups]	Fact box: tabular format	40	70.0	72.5	47	38.3	66.0	30	36.7	63.0
	Fact box: single icon array	39	69.2	71.8	58	32.8	65.5	39	35.9	64.0
	Fact box: separate icon arrays	41	92.7	95.1	56	32.1	83.9	34	50.0	82.0
	Standard information	—	—	—	64	31.3	26.6	40	47.5	38.0
How many men who participate in screening will die from prostate cancer over 10 years? ___ out of 1000 (2) [Correct: 7 out of 1000][b]	Fact box: tabular format	40	77.5	72.5	47	42.6	61.7	30	43.3	80.0
	Fact box: single icon array	39	87.2	76.9	58	37.9	60.3	39	33.3	64.0
	Fact box: separate icon arrays	41	75.6	68.3	56	42.9	42.9	34	32.4	56.0
	Standard information	—	—	—	64	45.3	40.6	40	50.0	35.0
How many men who do not participate in screening will die from prostate cancer over 10 years? ___ out of 1000 (3) [Correct: 7 out of 1000][b]	Fact box: tabular format	40	70.0	65.0	47	34.0	51.1	30	33.3	70.0
	Fact box: single icon array	39	82.1	76.9	58	36.2	53.4	39	33.3	62.0
	Fact box: separate icon arrays	41	73.2	65.9	56	25.0	41.1	34	26.5	56.0
	Standard information	—	—	—	64	37.5	32.8	40	37.5	28.0
How many will undergo unnecessary treatment for a prostate cancer that would not have caused them harm in their lifetime? ___ out of 1000 (7) [Correct: 20 out of 1000][c]	Fact box: tabular format	40	57.5	45.0	47	34.0	42.6	30	36.7	50.0
	Fact box: single icon array	39	59.0	48.7	58	25.9	22.4	39	33.3	59.0
	Fact box: separate icon arrays	41	61.0	39.0	56	21.4	44.6	34	44.1	56.0
	Standard information	—	3	—	64	17.2	29.7	40	22.5	25.0
The following information was included in the standard information										
All men who have a positive screening test have prostate cancer. (4) [True/False]	Fact box: tabular format	40	97.5	95.0	47	91.5	95.7	30	83.3	83.0
	Fact box: single icon array	39	92.3	94.9	58	81.0	89.7	39	94.9	92.0
	Fact box: separate icon arrays	41	90.2	100.0	56	91.1	94.6	34	88.2	97.0
	Standard information	—	—	—	64	78.1	92.2	40	95.0	87.0

(continued)

Table 1 (continued)

Item[b]	Presentation Format	Study 1 *N*	Study 1 Comprehension % of *N*	Study 1 Recall at Post % of *N*	Study 2 *N*	Study 2 Baseline % of *N*	Study 2 Recall at Post % of *N*	Study 2 *n*	Study 2 Recall 6 mo % of *n*	Study 2 Comprehension % of *n*
Who has a greater risk of getting a false diagnosis of prostate cancer? (5) [Man who takes part in screening; Man who does not take part in screening; There is no difference]	Fact box: tabular format	40	67.5	67.5	47	40.4	38.3	30	40.0	43.0
	Fact box: single icon array	39	64.1	64.1	58	39.7	48.3	39	43.6	54.0
	Fact box: separate icon arrays	41	78.0	75.6	56	33.9	46.4	34	44.1	59.0
	Standard information	—	—	—	64	45.3	40.6	40	47.5	47.0
How many will undergo a surgical procedure (a biopsy) to learn that it was a false alarm? ___ out of 1000 (6) [Correct: 160 out of 1000][d]	Fact box: tabular format	40	27.5	22.5	47	2.1	12.8	30	3.3	40.0
	Fact box: single icon array	39	43.6	35.9	58	0.0	13.8	39	0.0	41.0
	Fact box: separate icon arrays	41	39.0	17.1	56	3.6	7.1	34	0.0	26.0
	Standard information	—	—	—	64	1.6	1.6	40	2.5	3.0
What are two severe complications that can result from the unnecessary treatment?[e] (8)	Fact box: tabular format	40	88.8	88.8	47	20.2	26.6	30	23.3	55.0
	Fact box: single icon array	39	84.6	84.6	58	26.7	27.6	39	29.5	21.8
	Fact box: separate icon arrays	41	91.5	90.2	56	25.9	48.2	34	33.8	45.6
	Standard information	—	—	—	64	30.5	31.3	40	30.0	31.3

[a]Numbers beside questions indicate the order in which they were asked.
[b]We note that the pattern of results is the same when only exact verbatim responses to numerical items are scored as correct, although the average number of knowledge items correct drops by 0.7 to 0.8 across conditions and assessment points.
[c]Responses ranging from 1 to 17 out of 1000 were scored as correct.
[d]Responses ranging from 10 to 30 were scored as correct.
[e]Responses ranging from 150 to 170 were scored as correct.
[f]Participants were asked to list 2 severe complications from prostate cancer treatment (participants who reported 2 correct complications received a score of 1.0; those who reported a single correct complication received a score of 0.5). Responses were checked against an evidence-based predetermined list of complications.

Table 2 Percentage of Participants Who Intended to Screen in Study 1 and Study 2, and Main Reasons Reported by Participants Who Did Not Indicate an Intention to Screen at Each Assessment[a]

		Study 1		Study 2			
Format		**While Viewing Format**	**Short Delay**	**Baseline**	**Post**	**6 mo**	**While Viewing Format**
Standard information	Intended to screen:			*n* = 19	*n* = 23	*n* = 15	*n* = 15
				29.7	35.9	37.5	37.5
	Reason for not intending to screen:			*n* = 45	*n* = 41	*n* = 25	*n* = 25
	Harms outweigh benefits			6.7	7.3	24.0	4.0
	Lack of information			33.3	26.8	32.0	40.0
	Alternative strategy			15.6	14.6	0.0	4.0
	Prefer to not know			8.9	14.6	8.0	16.0
Fact box: tabular format	Intended to screen	*n* = 13	*n* = 11	*n* = 11	*n* = 11	*n* = 6	*n* = 5
		32.5	27.5	23.4	23.4	20.0	16.7
	Reason for not intending to screen:	*n* = 27	*n* = 29	*n* = 36	*n* = 36	*n* = 24	*n* = 25
	Harms outweigh benefits[b]	33.3	27.6	5.6	11.1	16.7	16.0
	Lack of information[b]	25.9	31.0	36.1	27.8	33.3	12.0
	Alternative strategy			13.9	11.1	4.2	12.0
	Prefer to not know			11.1	11.1	20.8	24.0
Fact box: single icon array	Intended to screen	*n* = 16	*n* = 14	*n* = 15	*n* = 15	*n* = 6	*n* = 6
		41.0	35.9	25.9	25.9	15.4	15.4
	Reason for not intending to screen:	*n* = 23	*n* = 25	*n* = 43	*n* = 43	*n* = 33	*n* = 33
	Harms outweigh benefits[b]	39.1	36.0	4.7	9.3	12.1	18.2
	Lack of information[b]	17.4	16.0	53.5	39.5	39.4	33.3
	Alternative strategy			9.3	14.0	9.1	9.1
	Prefer to not know			11.6	7.0	9.1	12.1
Fact box: separate icon arrays	Intended to screen	*n* = 10	*n* = 9	*n* = 19	*n* = 13	*n* = 12	*n* = 7
		24.4	22.0	33.9	23.2	35.3	20.6
	Reason for not intending to screen:	*n* = 31	*n* = 32	*n* = 37	*n* = 43	*n* = 22	*n* = 27
	Harms outweigh benefits[b]	25.8	31.3	8.1	30.2	9.1	25.9
	Lack of information[b]	16.1	18.8	45.9	9.3	36.4	25.9
	Alternative strategy			5.4	9.3	4.5	7.4
	Prefer to not know			8.1	16.3	18.2	14.8
Total	Intended to screen	*n* = 39	*n* = 34	*n* = 64	*n* = 62	*n* = 39	*n* = 33
		32.5	28.3	28.4	27.6	27.3	23.1
	Reason for not intending to screen:	*n* = 81	*n* = 86	*n* = 161	*n* = 163	*n* = 104	*n* = 110
	Harms outweigh benefits	32.1	31.4	6.2	14.7	15.4	16.4
	Lack of information	19.8	22.1	42.2	25.8	35.6	28.2
	Alternative strategy			11.2	12.3	4.8	8.2
	Prefer to not know			9.9	12.3	13.5	16.4

[a]As the number of participants who did not indicate an intention to screen changed at each assessment point, the samples contained different participants. Numbers do not add up to 100%; participants who indicated they had other reasons for not intending to participate in prostate cancer screening are not shown.
[b]Only these 2 categories were provided to participants in study 1.

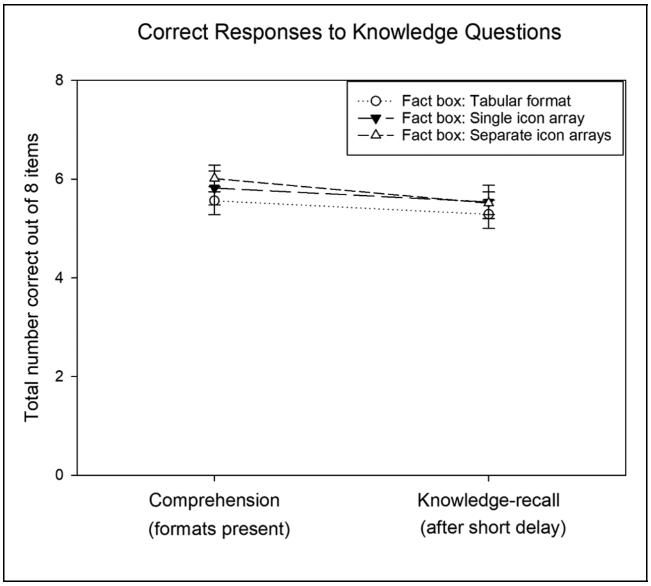


Figure 3 Average number of knowledge items answered correctly during comprehension and knowledge recall for each of the fact box formats (study 1).

reason against screening (Table 2), although most participants indicated that they had other reasons against screening. Additional response categories were provided in study 2 to capture some of the alternative reasons. The reported reasons did not differ between formats.

Perceived completeness of information. On average, 44% of participants perceived that they had complete information about prostate cancer screening to make a decision (Appendix B). There were no differences between formats.

In summary, fact box formats were equally effective at facilitating comprehension and short-term knowledge recall and led to similar decision intentions and perceptions of having complete information about screening to make a decision. The present study did not control for baseline knowledge, and as such, it is unclear whether or not knowledge improved as a result of viewing the formats.

Study 2

Study 2 sought to replicate and extend the findings of study 1 with a more representative sample of men who would reasonably face a decision about prostate cancer screening and to examine effects on decision intentions and behavior. In Germany, men aged 40 y and older were advised to inform themselves of the benefits and harms of screening at the time of the study.[35] Study 2 also sought to examine how fact box formats improved relative to prior knowledge and following a short- or longer-term delay (Figure 2). A 6-mo follow-up period balanced the assessment of knowledge recall against longer-term effects on decision intentions and behavior, without excessive loss to follow-up.

A secondary aim of study 2 was to examine how the fact box formats compared with standard information available to men about screening in the real world. The Deutsche Krebshilfe is a major and reputable independent, nonprofit cancer organization in Germany that disseminated 1.6 million information leaflets on cancer prevention and early detection in 2015.[36] Their standard information leaflet was readily available online and for display in doctors' waiting rooms at the time of the study (see Appendix C for English translation; logos were removed). The standard information did not provide all of the numerical estimates that were necessary to make an informed decision, and participants could feasibly answer 3½ knowledge items correctly (Table 1, lower panel). Unless otherwise specified, the measures and procedure were identical to study 1.

Method

Participants. Participants aged 40 to 75 y were recruited to participate in the randomized trial from a representative pool of German men from an online survey company (see Appendix D for study flowchart and Table 3 for participant characteristics).[iv] Participants were contacted by email with information about the study and a link to the online survey, and they received 1.25 Euro compensation upon completion of the baseline survey and 0.65 Euro upon completion of the follow-up. Two hundred forty-four men completed the baseline and 152 completed the 6-mo follow-up.

Measures. In addition to the measures used in study 1, perceived risk was assessed by asking participants to consider 100 men like themselves and indicate how many they think would die from prostate cancer within the next 10 y. The item was similar to the knowledge question on prostate cancer mortality to allow for comparison against actual mortality but asked specifically about personal cancer risk with a denominator of 100 rather than 1000. In addition, participants who did not indicate an intention to screen were provided with additional answer options to try and categorize "other" reasons against screening. Further, participants who responded

Table 3 Participant Characteristics (Study 2)

	Standard Information (n = 70)	Fact Box: Tabular Format (n = 50)	Fact Box: Single Icon Array (n = 62)	Fact Box: Separate Icon Arrays (n = 62)	Total (N = 244)
Age, $\bar{x}$ (s)	53.4 (8.0)	53.5 (9.3)	53.0 (8.3)	56.1 (9.2)	53.9 (8.7)
Education[a] (%)					
School not completed	0.0	2.0	1.6	0.0	0.8
Hauptschul-/Volksschulabschluss (9 y)	14.3	18.0	14.5	24.2	17.6
Realschulabschluss/mittlere Reife/POS (10 y)	45.7	38.0	25.8	45.2	38.9
Abitur/Hochschulreife/EOS (12/13 y)	15.7	12.0	22.6	8.1	14.8
University degree	20.0	28.0	33.9	19.4	25.0
Promotion[b]	4.3	2.0	1.6	3.2	2.9
Numeracy (%)					
Score = 3	44.3	44.0	38.7	35.5	40.6
Score = 2	22.9	20.0	35.5	30.6	27.5
Score = 1	15.7	22.0	12.9	21.0	17.6
Score = 0	17.1	14.0	12.9	12.9	14.3

[a]The sample was slightly more educated compared with men aged 40 y and older in the German population (69% middle or secondary school education, 27% high school, and 19% bachelor's degree or higher[37]).
[b]PhD or comparable postgraduate degree.

that they did not have complete information to make a decision after viewing the materials were asked to indicate what information was missing. As few participants provided details, and results are presented in Appendix E, along with results for evaluation and numeracy items.

Procedure. Following informed consent, participants were randomly assigned to receive 1 of 3 fact box formats or the standard information (Figure 2).

Baseline survey. Participants were asked about their prior participation in prostate cancer screening and whether they had spoken about screening with their doctor. Participants answered risk perception, knowledge, decision intention, perceived completeness of information, demographics, and numeracy items. Participants were then presented with one of the formats and were asked to read the materials and answer questions on the following pages. After a short delay answering evaluation and risk perception items (average of 5 min), participants again answered knowledge, decision intentions, and perceived completeness items. On average, participants took 30 min to complete the session. The study was conducted between February and March 2015.

6-mo follow-up survey. Participants reported their prostate cancer screening behavior in the 6-mo interval between the baseline and follow-up survey, followed by risk perception, perceived completeness, knowledge, and decision intention items. Comprehension was assessed at the end of the 6-mo survey by presenting participants with the same format they received at baseline alongside knowledge and decision intention questions. On average, participants took 22 min to complete the session. The follow-up was conducted between August and September 2015.

Analysis. Based on prior studies of format effects in risk communication (e.g., ref. 38), assuming a small effect size for knowledge change (η_p^2 = 0.05), we sought to recruit 52 participants per condition to achieve statistical power of 0.90 (within-subjects, 2 correlated assessments with r = 0.50). Prior to any analysis, 19 participants were excluded from the baseline sample as they completed the study in a time frame that was less than 50% of the median duration (i.e., the median duration was around 20 min).[v] Thus, of the 225 participants who were included in the analysis for the baseline survey, 143 (64% retention rate) were included in the follow-up analysis. Sample sizes per format are shown in Appendix E (see also Table 1). The statistical power to detect differences in the effects of the fact box formats over the longer term was 0.76 for a small effect.[vi] In addition to the analysis approach used in study 1, logistic regressions examined the influence of knowledge or knowledge recall on testing intentions and reported testing.

Results and Discussion

Comprehension, short- and long-term knowledge recall. Similar to Study 1, the fact box: separate icon arrays tended to facilitate recall and comprehension of

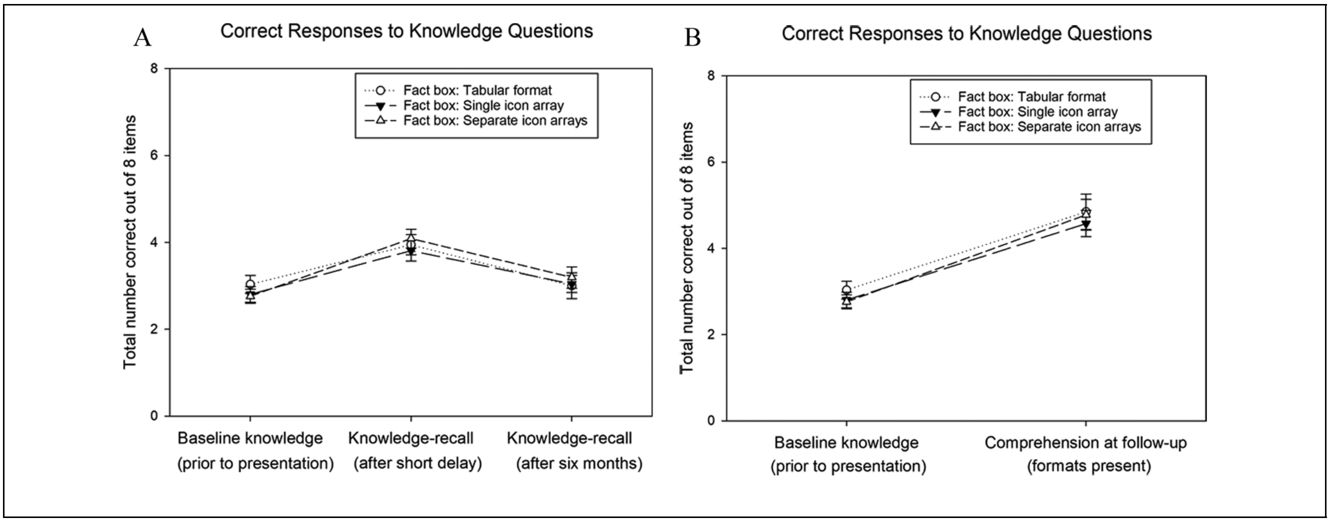


Figure 4 Results for knowledge, knowledge recall, and comprehension in study 2. (A) The total number of items participants answered correctly from baseline to 6-mo follow-up, across the 3 fact box formats. (B) Comprehension scores relative to baseline knowledge at the 6-mo follow-up across each of these formats.

nonnumerical items, whereas fact box: single icon array tended to facilitate answering items requiring a numerical response (see Table 1). Figure 4A displays the average number of knowledge items answered correctly at each assessment point. Six-month knowledge change scores refer to change from baseline. Compared with baseline knowledge, participants showed improvement in knowledge recall when assessed shortly after having been presented with the information for all fact box formats: tabular format, $F(1, 46) = 17.98$, $\eta_p^2 = 0.28$; single icon array, $F(1, 57) = 17.40$, $\eta_p^2 = 0.23$; and separate icon arrays, $F(1, 55) = 39.61$, $\eta_p^2 = 0.42$. There was no difference in improvement across the 3 formats. A general but small long-term effect for improvement in knowledge recall was maintained over 6 mo across all participants and formats, $F(1, 100) = 4.43$, $P = 0.038$, $\eta_p^2 = 0.04$, and did not vary across fact box formats. In addition, participants were more likely to report equal numbers for mortality rates in screened and nonscreened groups after the short delay,[vii] but this effect did not hold at 6 mo. Comprehension of the benefits and harms of screening was greater relative to preknowledge for all fact box formats (Figure 4B). There were no such effects for participants who received the standard information. At each assessment point, participants who received the standard information could answer an average of 3 items correctly and were no better at answering knowledge items that could be found within (versus missing from) the materials (see Table 1).

Screening behavior and decision intentions. At baseline, 88% of participants had previously heard about prostate cancer screening, 40% had talked about screening with their doctor, and 32% reported that they had participated in screening prior to the study. Table 2 shows the percentage of participants who reported that they intended to screen for prostate cancer within the next 6 mo. There was no change in decision intentions across presentation designs at any assessment point. Further, decision intentions were not associated with behavior at 6-mo follow-up. Rather, screening was associated with prior screening behavior: 65% of those who had screened prior to the study (and participated in the follow-up, $n = 34$) reported an intention to screen, and 62% of these did screen during the 6-mo follow-up. Of those who had not previously had a PSA test ($n = 91$), 12% intended to screen at post, and 10% of these reported that they had been screened. At 6-mo follow-up, 22% of participants had spoken with their doctor, and 25% reported having participated in screening in the past 6 mo. When participants answered decision intention items while materials were present, there was a tendency for fewer participants who received fact box formats to intend to screen compared with the standard information.

For participants who indicated that they did not intend to participate in screening, at each time point, the majority tended to report that they lacked sufficient information to make a decision (Table 2). Participants who viewed the fact box: separate icon arrays were less likely to report lacking sufficient information from baseline to postpresentation, $\chi^2(1) = 9.00$ (McNemar test), and more likely to report that harms would outweigh the benefits, $\chi^2(1) = 7.44$, $P = 0.008$ (McNemar test), potentially a consequence of the text describing the harms being more explicit in this condition. However, at 6-mo follow-up, lacking sufficient information was again the main reason reported for not intending to screen. The fact box: tabular format and fact box: single icon arrays did not show any change in reasons for not intending to participate in screening. The reasons for the 3 fact box formats did not differ to those reported for the standard information.

Risk perception. Risk perception remained constant from baseline ($\bar{x} = 10.1$, $s = 14.6$) to postpresentation ($\bar{x} = 10.9$, $s = 14.4$) but increased slightly at 6-mo follow-up ($\bar{x} = 11.3$, $s = 11.6$), $F(1, 138) = 4.16$, $P = 0.043$, $\eta_p^2 = 0.03$. There were no format-specific effects on risk perception. About one-fifth of participants (17.1%) provided responses of "7 out of 100," an estimate that was an order of magnitude higher than the actual risk. It is possible that men gave responses similar to the knowledge item without recognizing the change in denominator. To disentangle whether the apparent overestimation of risk was the result of the change in denominator, a reluctance to provide a number below 1 (e.g., to be consistent with actual risk of 0.7), or a lack of comprehension of the small absolute size of the risk, future studies should employ supplementary risk perception items (e.g., subjective scales) and use consistent denominators.

Perceived completeness of information. After viewing the formats, an additional 10% to 30% of participants perceived that they had complete information about screening to make a decision (Appendix B). Perceptions increased from baseline to postpresentation for the standard information, $\chi^2(1) = 14.60$, $P = 0.008$ (McNemar test), and the fact box: separate icon arrays formats, $\chi^2(1) = 12.26$ (McNemar test). At 6-mo follow-up, completeness perceptions were higher than those reported at baseline for the fact box: tabular format, $\chi^2(1) = 3.44$, $P = 0.006$ (McNemar test) but not for the other formats. Few participants specified the type of information they felt was missing (see Appendix F), and if so, the information requested was often unavailable or not suitable for decision tools (e.g., personalized outcomes, expert opinion). Indeed, participants felt that they had complete information even after receiving the standard information despite no improvements in knowledge recall or comprehension, suggesting that participants are not aware of what constitutes complete patient information about benefits and harms.

In summary, study 2 replicated the general finding from study 1 that tabular and icon fact box designs are equally effective at facilitating comprehension and improving on prior knowledge over the short-term. The improvement in recall disappeared after 6 mo, which suggests that fact boxes are an efficient means to improve comprehension at the time of presentation, as well as short-term recall but not long-term recall. Further, fact boxes improved both knowledge recall and comprehension, whereas there were no improvements when participants received widely available cancer health information.

General Discussion

The results of our 2 studies support prior research showing that tables and graphical formats performed equally well for enhancing comprehension of information about the efficacy of health interventions.[17,28] We extend these findings to demonstrate that tabular and icon fact box formats were comparable for improving comprehension and knowledge recall about multiple benefits and harms over the short term. Consistent with the results of previous studies,[9,24,25] the most beneficial effect of fact boxes occurs during comprehension tasks, in which participants are able to refer to the formats as they consider the knowledge questions. However, we also showed that participants could retain information from the fact box formats even after a short delay, suggesting that the beneficial effects extend beyond information comprehension tasks to improve on actual knowledge. Thus, the best application for fact boxes would be around the time of decision making or during a consultation with a doctor and can be provided to participants to download and bring with them or to take home and have available for reference.

A strength of study 2 is that it included an assessment of baseline knowledge, allowing us to determine how much the formats improved on what the participant already knew. For health issues in which people already hold views about the topic prior to receiving information, fact boxes can build on the knowledge base that people already have. Unfortunately, although knowledge recall at 6-mo follow-up was slightly higher than baseline knowledge across all conditions, we could not demonstrate improvements in knowledge recall for individual formats. Participants appear to have forgotten the information or were exposed to additional information sources (e.g., health websites, friends or family members) that may have influenced their knowledge during the interim, and thus, we cannot yet establish the robustness of the fact box formats over the longer term.

Despite improvements in comprehension and knowledge recall, there were no differences in decision intentions across formats or in comparison to the standard information. Decision intentions did not predict behavior at 6 mo, potentially owing to the short follow-up time frame (e.g., for annual or biannual screening). Of the participants who indicated that they did not intend to screen, the majority reported that they lacked sufficient information to make a decision, and only about half felt that the formats provided complete information about screening to make a decision. In study 2, after receiving the fact box: separate icon arrays, the proportion of participants who reported that they lacked information reduced, and a greater number of participants stated that the harms outweighed the benefits. The fact box: separate icon arrays format displays harms for screened and nonscreened groups separately with accompanying text describing the effects, potentially facilitating understanding that screened groups experienced harms in comparison with the nonscreened group, in which no icons were highlighted. However, our results suggest that although each of the fact boxes increased knowledge recall, many participants still felt that they required additional information before making a decision. As such, the fact box may be useful within the shared decision-making context in a broader medical consultation to facilitate communication of benefits and harms while providing an opportunity for patients to seek additional decision-relevant information. Future work to identify the information perceived to be lacking from decision tools could offer insights into how they may be further improved to facilitate decision making.

Limitations

As a comparison for the fact box formats, the standard information in study 2 was neither complete nor transparent, a typical flaw of public health information.[3] To enable informed decision making, however, health information needs to contain adequate information about the benefits and harms of health interventions in formats that allow people to assess the size of intervention effects, and people need to comprehend this information. Presenting quantitative information about decision outcomes is considered a standard quality criterion for patient decision aids.[4] The studies recruited participants who were within a relevant age range to be informed about prostate cancer screening. However, online participants may have lacked motivation to read the materials or complete the study, and one-third of the participants in study 2 did not complete the 6-mo follow-up, which may have affected the statistical power to detect some longer-term effects.[viii]

Conclusion

Our studies have shown that information about multiple benefits and harms of health interventions can be communicated equally effectively using tabular and icon fact box formats. Further, these formats could easily and simply improve on the present standard for public health information. In fact, recently a number of European health organizations, including the AOK, a major German health insurance company (http://www.aok.de); Helsana, a major Swiss insurance company (https://www.helsana.ch/de); and the Bertelsmann Foundation (http://weisse-liste.de) have taken the initiative to develop tabular and visual web-based fact boxes to inform the public about health interventions. Health organizations have an obligation to provide transparent health information to the public in formats that people understand, and the fact box format should be considered as a viable alternative for improving the public understanding of health risks. Health organizations can adopt either tabular or visual formats to improve the communication of the benefits and harms of health interventions.

Supplementary Material

Supplementary material for this article is available on the *Medical Decision Making* Web site at http://journals.sagepub.com/home/mdm.

Notes

i. It is not always possible to incorporate multiple outcomes in a single icon array, for instance, when outcomes are not mutually exclusive.
ii. For prostate cancer–specific mortality, for which the correct answer is 7 in 1000, the range did not include a 0 response, as this would indicate that the participant incorrectly thought that no men died from prostate cancer. Results for only exact values coded as correct were similar; see the note to Table 1.
iii. Assumptions for mixed analysis of variance (dependent knowledge variables were measured with metric scales, there were no extreme values, the variances of knowledge change was homogeneous) were satisfied, with the exception that for the individual formats, knowledge change was not normally distributed. An additional nonparametric test confirmed that knowledge change from comprehension to recall was not format specific.
iv. German Clinical Trials Register (https://www.drks.de) number: DRKS00014626.

v. The criteria used to remove participants from the sample were decided a priori and are consistent with criteria typically applied by large survey companies as a quality assurance measure to remove inattentive participants from online study samples.

vi. Given the sample size of the 3 fact box conditions (n = 103), the expected effect size ($\eta_p^2 = 0.03$), and the correlation of 2 assessments of knowledge within 6 mo ($r = 0.30$).

vii. Percentage increase from baseline for fact box: separate icon arrays = 52%, $\chi^2(56) = 24.74$; fact box: single icon array = 38%, $\chi^2(58) = 15.61$; and fact box: tabular format = 36%, $\chi^2(47) = 16.20$.

viii. Follow-up analyses suggest that dropout did not account for improvements in knowledge for the standard information, $F(1, 62) = 0.01$, $P = 0.917$; fact box: tabular format, $F(1, 45) = 0.05$, $P = 0.832$; fact box: single icon array, $F(1, 56) = 1.62$, $P = 0.208$; or fact box: separate icon arrays, $F(1, 54) = 0.83$, $P = 0.367$. Furthermore, dropout was not associated with change in intention to screen across formats, $F(1, 223) = 0.02$, $P = 0.895$.

References

1. Gigerenzer G, Mata J, Frank R. Public knowledge of benefits of breast and prostate cancer screening in Europe. *J Natl Cancer Inst*. 2009;101(17):1216–20.
2. Bodemer N, Müller SM, Okan Y, Garcia-Retamero R, Neumeyer-Gromen A. Do the media provide transparent health information? A cross-cultural comparison of public information about the HPV vaccine. *Vaccine*. 2012;30(25): 3747–56.
3. Gigerenzer G. Breast cancer screening pamphlets mislead women. *BMJ*. 2014;348:2636.
4. Trevena L, Zikmund-Fisher B, Edwards A, et al. Presenting quantitative information about decision outcomes: a risk communication primer for patient decision aid developers. *BMC Med Inform Decis Mak*. 2013;13(suppl 2):S7.
5. Akl EA, Oxman AD, Herrin J, et al. Using alternative statistical formats for presenting risks and risk reductions. *Cochrane Database Syst Rev*. 2011;(3):Cd006776.
6. Carling CLL, Kristoffersen DT, Montori VM, et al. The effect of alternative summary statistics for communicating risk reduction on decisions about taking statins: a randomized trial. *PLoS Med*. 2009;6(8):e1000134.
7. Covey J. The effects of absolute risks, relative risks, frequencies, and probabilities on decision quality. *J Health Commun*. 2011;16(7):788–801.
8. Eddy DM. Comparing benefits and harms: the balance sheet. *J Am Med Assoc*. 1990;263(18):2493–505.
9. Schwartz LM, Woloshin S, Welch HG. Using a drug facts box to communicate drug benefits and harms: two randomized trials. *Ann Intern Med*. 2009;150(8):516–27.
10. Ancker JS, Senathirajah Y, Kukafka R, Starren JB. Design features of graphs in health risk communication: a systematic review. *J Am Med Inform Assoc*. 2006;13(6):608–18.
11. Garcia-Retamero R, Okan Y, Cokely ET. Using visual aids to improve communication of risks about health: a review. *Sci World J*. 2012;2012:562637.
12. Garcia-Retamero R, Cokely ET. Communicating health risks with visual aids. *Curr Direct Psychol Sci*. 2013;22(5): 392–9.
13. Waters EA, Weinstein ND, Colditz GA, Emmons KM. Reducing aversion to side effects in preventive medical treatment decisions. *J Exp Psychology Appl*. 2007;13(1): 11–21.
14. Zikmund-Fisher BJ, Ubel PA, Smith DM, et al. Communicating side effect risks in a tamoxifen prophylaxis decision aid: the debiasing influence of pictographs. *Patient Educ Couns*. 2008;73(2):209–14.
15. Hawley ST, Zikmund-Fisher B, Ubel P, Jancovic A, Lucas T, Fagerlin A. The impact of the format of graphical presentation on health-related knowledge and treatment choices. *Patient Educ Couns*. 2008;73(3):448–55.
16. Petrova D, Garcia-Retamero R, Cokely ET. Understanding the harms and benefits of cancer screening: a model of factors that shape informed decision making. *Med Decis Making*. 2015;35(7):847–58.
17. Tait AR, Voepel-Lewis T, Zikmund-Fisher BJ, Fagerlin A. Presenting research risks and benefits to parents: does format matter? *Anesth Analg*. 2010;111(3):718–23 doi: 10.1213/ANE.0b013e3181e8570a.
18. Tait AR, Voepel-Lewis T, Zikmund-Fisher BJ, Fagerlin A. The effect of format on parents' understanding of the risks and benefits of clinical research: a comparison between text, tables, and graphics. *J Health Commun*. 2010;15(5): 487–501.
19. Abhyankar P, Volk R, Blumenthal-Barby J, et al. Balancing the presentation of information and options in patient decision aids: an updated review. *BMC Med Inform Decis Mak*. 2013;13(Suppl 2):S6.
20. Harding Center for Risk Literacy. Health information: fact boxes. 2016. Available from: https://www.harding-center.mpg.de/en/health-information
21. AOK. Faktenboxen: Orientierung für Ihre Gesundheit. 2016. Available from: http://www.aok.de/faktenboxen
22. Bertelsmann Stiftung. Unsere Entscheidungshilfen. 2017. Available from: http://weisse-liste.de/de/entscheidungshilfen/startseite-entscheidungshilfen/
23. McDowell M, Rebitschek FG, Gigerenzer G, Wegwarth O. A simple tool for communicating the benefits and harms of health interventions. *MDM Policy Pract*. 2016;1(1): 2381468316665365.
24. Schwartz LM, Woloshin S, Welch HG. The drug facts box: providing consumers with simple tabular data on drug benefit and harm. *Med Decis Making*. 2007;27(5): 655–62.
25. Sullivan HW, O'Donoghue AC, Aikin KJ. Communicating benefit and risk information in direct-to-consumer print advertisements: a randomized study. *Ther Innovat Regulat Sci*. 2015;49(4):493–502.

26. Galesic M, Garcia-Retamero R, Gigerenzer G. Using icon arrays to communicate medical risks: overcoming low numeracy. *Health Psychol*. 2009;28(2):210–6.
27. Garcia-Retamero R, Galesic M, Gigerenzer G. Do icon arrays help reduce denominator neglect? *Med Decis Making*. 2010;30(6):672–84.
28. Dolan JG, Qian F, Veazie PJ. How well do commonly used data presentation formats support comparative effectiveness evaluations? *Med Decis Making*. 2012;32(6):840–50.
29. Garcia-Retamero R, Galesic M. Who profits from visual aids: overcoming challenges in people's understanding of risks [corrected]. *Soc Sci Med*. 2010;70(7):1019–25.
30. Gaissmaier W, Wegwarth O, Skopec D, Muller AS, Broschinski S, Politi MC. Numbers can be worth a thousand pictures: individual differences in understanding graphical and numerical representations of health-related information. *Health Psychol*. 2012;31(3):286–96.
31. Zikmund-Fisher BJ, Fagerlin A, Ubel PA. Improving understanding of adjuvant therapy options by using simpler risk graphics. *Cancer*. 2008;113(12):3382–90.
32. Zikmund-Fisher BJ, Fagerlin A, Ubel PA. A demonstration of "less can be more" in risk graphics. *Med Decis Making*. 2010;30(6):661–71.
33. Zikmund-Fisher BJ, Angott AM, Ubel PA. The benefits of discussing adjuvant therapies one at a time instead of all at once. *Breast Cancer Res Treat*. 2011;129(1):79–87.
34. Ilic D, Neuberger MM, Djulbegovic M, P D. Screening for prostate cancer. *Cochrane Database Syst Rev*. 2013;(1): CD004720.
35. Stifung Deutsche Krebshilfe. Protstatakrebs erkennen [Detecting prostate cancer] [Pamphlet]. Früherkennungsfaltblatt ed: Stifung Deutsche Krebshilfe; 2014.
36. Deutsche Krebshilfe. Geschäftsbericht 2015. 2015. Available from: https://www.krebshilfe.de/fileadmin/Downloads/PDFs/Geschaeftsbericht/GB-2015_Final.pdf
37. Statistisches Bundesamt. Bildungsstand der Bevölkerung 2014, 26 November. Report No. 210002147004
38. Stacey D, Légaré F, Col NF, et al. Decision aids for people facing health treatment or screening decisions. *Cochrane Database Syst Rev*. 2014;CD001431.
39. Schwartz LM, Woloshin S, BlackWC,Welch HG. The role of numeracy in understanding the benefit of screening mammography. *Ann InternMed*. 1997;127(11):966–72.