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The impact of the format of graphical presentation on health-related knowledge and treatment choices

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ABSTRACT

Objective: To evaluate the ability of six graph formats to impart knowledge about treatment risks/benefits to low and high numeracy individuals.
Methods: Participants were randomized to receive numerical information about the risks and benefits of a hypothetical medical treatment in one of six graph formats. Each described the benefits of taking one of two drugs, as well as the risks of experiencing side effects. Main outcome variables were verbatim (specific numerical) and gist (general impression) knowledge. Participants were also asked to rate their perceptions of the graphical format and to choose a treatment.
Results: 2412 participants completed the survey. Viewing a pictograph was associated with adequate levels of both types of knowledge, especially for lower numeracy individuals. Viewing tables was associated with a higher likelihood of having adequate verbatim knowledge vs. other formats ($p < 0.001$) but lower likelihood of having adequate gist knowledge ($p < 0.05$). All formats were positively received, but pictograph was trusted by both high and low numeracy respondents. Verbatim and gist knowledge were significantly ($p < 0.01$) associated with making a medically superior treatment choice.
Conclusion: Pictographs are the best format for communicating probabilistic information to patients in shared decision making environments, particularly among lower numeracy individuals.
Practice Implications: Providers can consider using pictographs to communicate risk and benefit information to patients of different numeracy levels.

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1. Introduction

Improving informed medical decision making has been identified as a priority in the U.S. healthcare system [1–3]. Ensuring medical decisions are informed that patients have an accurate understanding of the risks and benefits associated with their treatment options [3–5]. Although such risk and benefit information are often presented numerically, research has shown that many Americans have difficulty in understanding and processing numbers [6–8]. The Adult Literacy and Lifeskills survey conducted in 2003 found that U.S. adults had lower numeracy scores than those from four other countries (Switzerland, Norway, Bermuda, and Canada) [9]. Moreover, even for those with high numeracy, the stress of a new diagnosis can make it difficult to process new and complex numerical information [10].

However, tools designed to improve informed medical decision making often fail to include visual aids, such as graphs or tables, to help convey complex risk and benefit information [11,12]. Although inclusion of graphical information in decision aids is strongly recommended by the International Patient Decision Aids Standards Committee [13], there is little consensus regarding which methods for conveying information to patients are most likely to achieve the necessary level of understanding about treatment risks and benefits. There is also evidence that some formats in which numerical information is presented may bias patients and/or have unanticipated effects on their understanding of the information [12,14].

The best method for presenting numerical information may differ based on the numeracy of the reader. A recent review article discussed the fact that different risk communication methods may be needed for individuals with low vs. high levels of numeracy [10]. Although there are some studies of how to present numerical

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information effectively [12,15–20] virtually none have had sufficient numbers of low and high numeracy subjects to evaluate whether formats may be more or less effective in these different groups [7,10]. There is also a lack of research to describe how patients perceive different types of graphs (e.g., whether a particular type of graph is trustworthy or not) [15].

The main objective of this analysis was to evaluate the ability of six types of numerical communication formats (pie chart, bar graph, pictograph, modified pictograph or "sparkplug," modified pie graph or "clock," and table—see Figs. 1–6 for examples), to impart knowledge about treatment risks/benefits in a hypothetical medical decision making scenario among low and high numeracy individuals. Secondary objectives were to assess participants' perceptions of the graphs, and to assess with the association between knowledge and making the optimal treatment choice.

2. Methods

An online hypothetical medical decision making scenario was developed by our research team. Participants were randomized to view treatment risk and benefit information in one of the six numerical communication formats (from now on referred to as "graph formats") and to answer a series of questions. Study participants were drawn from a panel of Internet users administered by Survey Sampling International (SSI) who voluntarily agreed to receive invitations to fill out questionnaires, as we have done in prior research [21–23]. The final SSI subject pool approximates the U.S. Census on education level, race and income. To ensure demographic diversity and offset large expected variations in response rates (especially for African Americans and Hispanic-Americans), we established target response levels for each racial/ethnic group. We also drew three distinct age samples within each race (18–39, 40–59 and 60 and older) to offset differential response rates by age. We point out that the goal of this study was not to achieve representative sampling, but rather to compare the impact of graphical formats across experimental groups. The number of email invitations in each demographic sub-group was dynamically adjusted until all quotas were achieved. Individuals completing our web-based survey were entered into a drawing to win cash prizes.

2.1. Procedures

After logging into the website, participants were provided a brief description of the goal of the survey. Participants were then asked to imagine the following scenario: "Imagine that you are visiting your doctor for your annual physical exam. Your doctor just finished running some tests, which show that the arteries in your heart are partially clogged. If your arteries remain clogged you will need to have bypass surgery. This operation would involve opening up your chest and performing surgery on your heart to bypass the blocked artery. Most people receiving bypass surgery remain in the hospital for close to one week and take up to three months to recover."

Participants were told that there were two pills they could take to unclog their arteries and possibly avoid needing bypass surgery (called Pill A and Pill B). However, each pill had a risk of mild headaches and severe nausea. Participants were then randomized to receive risk/benefit information (i.e., likelihood of needing bypass surgery and experiencing each side effect) f (1) bar graph; (2) pictograph; (3) modified pictograph ("sparkplug"); (4) pie chart; or (5) modified pie graph ("clock graph"); and (6) table (see Figs. 1–6).

2.2. Outcome assessments

The primary outcome of this analysis consisted of two different types of knowledge, verbatim and gist knowledge, defined below. Secondary outcomes included respondents' perceptions of the trustworthiness, "scientificness," and effectiveness of the graph format they viewed as well as the respondents' treatment choice.

2.2.1. Verbatim knowledge (i.e., the ability to correctly read numbers from graphs)

Four questions were used to measure respondents' verbatim knowledge; two related to the number of patients affected by a treatment and two asking them to calculate numerical differences between treatments. These questions were as follows: (1) If 100 people took Pill B, approximately how many would need bypass surgery? (2) If 100 people took Pill B, approximately how many would get severe nausea? (3) Compared to people who did not take a pill, approximately how many fewer people would need bypass surgery if they took Pill B? and (4) Compared to people who did not take a pill, approximately how many more people would get mild headaches if they took Pill B?. Correct answers were initially determined by assessing the proportion of respondents who provided the correct numerical answer. We then expanded the definition of "correct" to include answers within two points above or below the actual correct number. We used this definition to determine the number of correct answers out of the four questions (0–4). For this analysis, we defined adequate verbatim knowledge as answering three or four questions correctly (coded 1) vs. answering two or fewer questions correctly (coded 0).

2.2.2. Gist knowledge (i.e., the ability to identify the essential point of the information presented)

Gist knowledge was assessed with two questions that asked participants to distinguish which treatment yielded the best (or worst) outcome. These questions were: (1) Who is less likely to need bypass surgery: a person who took Pill A or a person who took Pill B? (2) Who is more likely to experience nausea: a person who took Pill A or a person who took Pill B?. Correct answers were determined by the proportion of respondents who answered both gist questions correctly. The final measure of gist was defined as answering both questions correctly (coded 1) vs. answering 0 or 1 question correctly (coded 0).

2.2.3. Respondent perceptions of graph formats

Respondents rated how trustworthy and scientific they perceived the graphical format to be in presenting information, and how effective in conveying the risk and benefit information. All questions used a 0–6 scale with 0 being the lowest and 6 being the most favorable rating.

2.2.4. Treatment choice

After viewing the information provided by the specific graph type, respondents were also asked, "Given everything you know about this medical condition, would you choose to take no pill, Pill A, or Pill B?". Because Pill B reduced the risk of needing bypass surgery and only slightly increased the likelihood of side effects, it was deemed the medically superior treatment option.

2.3. Independent variables

The primary independent variable in this analysis was type of graph viewed, categorized into six groups: table, pictograph, pie, bar, sparkplug or clock. The remaining independent variables included respondent age, race/ethnicity, gender and numeracy level. Per the original sampling design, we categorized the sample into three groups based on self-reported age: (1) less than 40 years of age; (2) age 40–59; and (3) 60 years of age or older. Educational attainment was categorized into having a high school education or less, some college or trade school, or having a bachelor's degree or higher. Race/ethnicity was categorized into white or non-white, although 18% of respondents were of non-white racial/ethnic groups, we did not have sufficient numbers within each group to evaluate the groups separately. Numeracy was evaluated using the Subjective Numeracy Scale (SNS) [24] which has been validated against objective measures of numeracy and shown to relate to the ability to comprehend risk communications [25]. For this analysis, we divided the sample using a median split to classify respondents as having higher or lower numeracy skills.

2.4. Analysis

First, we generated descriptive statistics for dependent and independent variables. Comparisons of adequate verbatim and gist knowledge by independent variables were made using *t*-tests for continuous and Chi-square tests for categorical variables. We then evaluated the mean number of answers correct for both verbatim (range: 0–4 questions) and gist (range: 0–2 questions) according to the type of graph viewed overall and stratified by low and high numeracy. We compared the mean number of answers correct for each graph type between low and high numeracy respondents using *t*-tests. We conducted logistic regression of the dichotomous measure of both verbatim and gist knowledge stratified by numeracy, controlling for graph type and other individual characteristics (gender, age, race, and education). For the regressions, the table graph format served as the reference category.

We evaluated perceptions of different graph formats by evaluating the mean responses to the questions relating to the graph's trustworthiness, "scientificness," and effectiveness (each on a scale of 0–6). We assessed the overall mean score by graph and compared associations between perceptions for each characteristic (trustworthy, scientific and effective) by numeracy using *t*-tests. Differences in perceptions across graph types were assessed using ANOVA.

Finally, we regressed the dichotomous measure of treatment choice (medically superior choice vs. other choice) on verbatim and gist knowledge, controlling for independent variables. We conducted this regression in a forward stepwise fashion: (1) regressing medically superior treatment choice on participant demographics and numeracy and (2) including the six graph formats as independent variables in order to evaluate whether the type of graph format was independently associated with making the medically superior treatment choice.

3. Results

3.1. Description of the sample

A total of 3153 participants logged onto the website and began the survey. Of these, 2412 participants (76.5%) answered all questions and were included in the analyses. The final sample was 52% women, 82% self-identified white, and had an average age of 49 years (range:18–90). Eighteen percent had a high school education or less, 44% had some college or trade school, and 38% held a bachelor's degree or more. Fifty percent of participants were classified as lower numeracy. Of note is the finding that 33% of those with a bachelor's degree or more were classified as low numeracy vs. 55% of those with some college and 69% of those with a high school or less education.

3.2. Description of outcomes

Using the dichotomous definitions described earlier, half (50%) of the sample had adequate verbatim knowledge, 62% had adequate gist knowledge and 37% had both types of knowledge. Respondents' perceptions of the graph types were generally favorable, though we found some differences across constructs and numeracy levels. Approximately three-quarters of the sample (73%) indicated that they would choose Pill B, the medically superior treatment choice.

3.3. Associations between individual characteristics and knowledge

Table 1 describes the associations between individual characteristics (gender, age, race, education and numeracy) and adequate verbatim and/or gist knowledge. Those who were male, white, younger than age 40, had higher educational attainment and higher numeracy more often had adequate verbatim and gist knowledge (Chi-squares ranged from 4.82 to 46.97; $p < 0.05$).

3.4. Associations between type of graph and knowledge

Table 1 also reports the bivariate associations between type of graph and verbatim and gist knowledge. Respondents who saw the table were most likely to have adequate verbatim knowledge (67% for table vs. 18–62% for other formats, $p < 0.001$), while those that viewed pie more often had adequate gist knowledge (68% for pie vs. 57–65% for other formats, $p < 0.05$). Fifty eight percent of those who saw a pictograph had adequate verbatim knowledge, compared with 18% of those who saw pie, 49% of those who saw sparkplug and 46% of those who saw clock ($p < 0.001$). Slightly more who saw bar had adequate verbatim knowledge (62%) than pictograph (58%). Pictograph was also good at conveying gist knowledge, with 65 % of those who saw pictograph having adequate gist knowledge, compared with 59% of those who saw bar, 61% of those who saw sparkplug, 64% of those who saw clock and 57% of those who saw table ($p < 0.05$).

Table 2 provides the mean number of questions answered correctly for each graph format using the original values of verbatim and gist knowledge, overall and stratified by numeracy. Overall, individuals who viewed the table format answered the

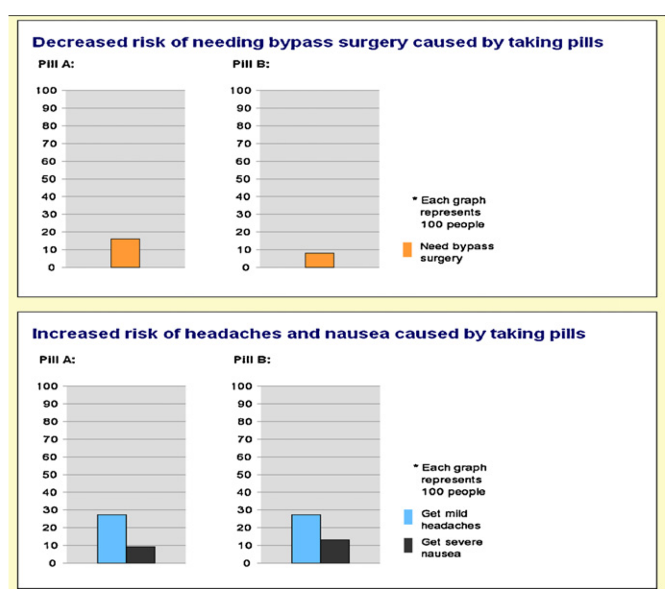

Fig. 1. Example of bar graphs.

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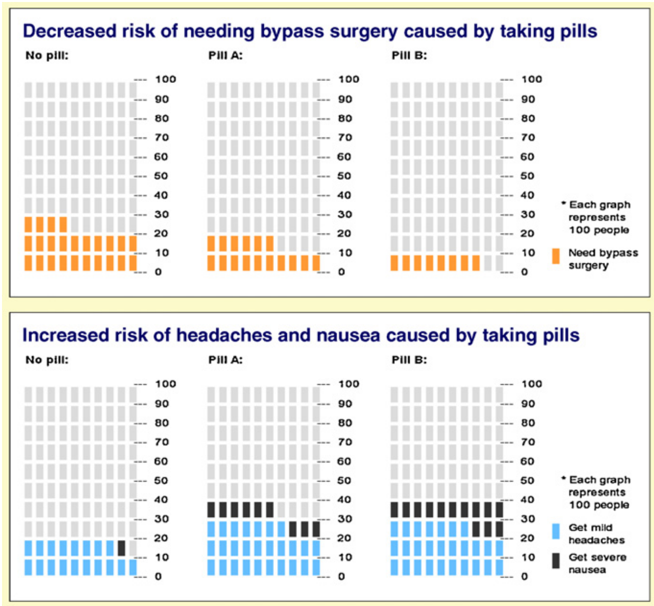


Fig. 2. Example of pictographs.

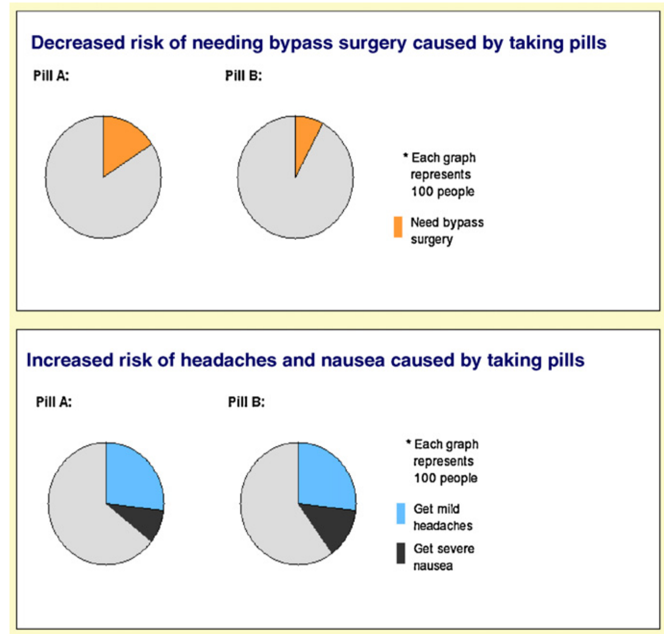


Fig. 4. Example of pie graph.

most questions correctly for verbatim knowledge ($F = 51.20$, $p < 0.0001$), while those who viewed a pie graph answered most questions correctly for gist knowledge ($F = 4.09$, $p = 0.0011$). The pictograph followed table and pie for producing the most correct answers for verbatim and gist knowledge. Respondents with higher numeracy answered significantly more of the questions correctly for both verbatim and gist knowledge regardless of graph type. Among those with lower numeracy, table and pie continued to produce the most correct answers for verbatim and gist knowledge, followed by pictograph in both cases.

3.5. Factors associated with having adequate verbatim and gist knowledge

Table 3 provides the logistic regression results for having adequate verbatim and gist knowledge stratified by low and high numeracy. For both lower numeracy respondents, pictograph and bar were not significantly different from table in conferring verbatim knowledge, while all other formats did significantly worse than table for imparting verbatim knowledge. For higher numeracy respondents, all formats except bar did significantly worse for imparting verbatim knowledge ($p < 0.05$). Conversely, all graph formats were more likely than table to be associated with adequate gist knowledge, though not all associations were statistically significant. Among lower numeracy respondents, those who viewed a pie graph were significantly more likely than those who viewed table to have adequate gist knowledge (OR: 2.03, 95% CI: 1.34–3.08), as were those who viewed a pictograph (OR: 1.11, 95% CI: 1.11–2.56). Among higher numeracy respondents, none of the graph formats was significantly better than table for generating gist knowledge, although both pie and pictograph

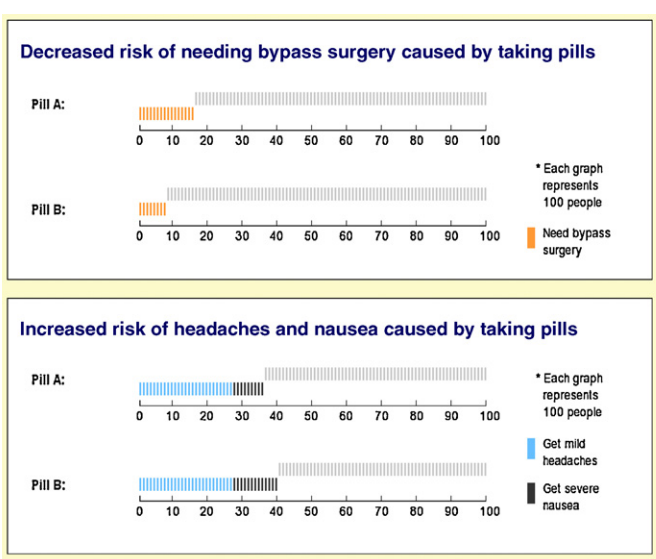


Fig. 3. Example of sparkplug.

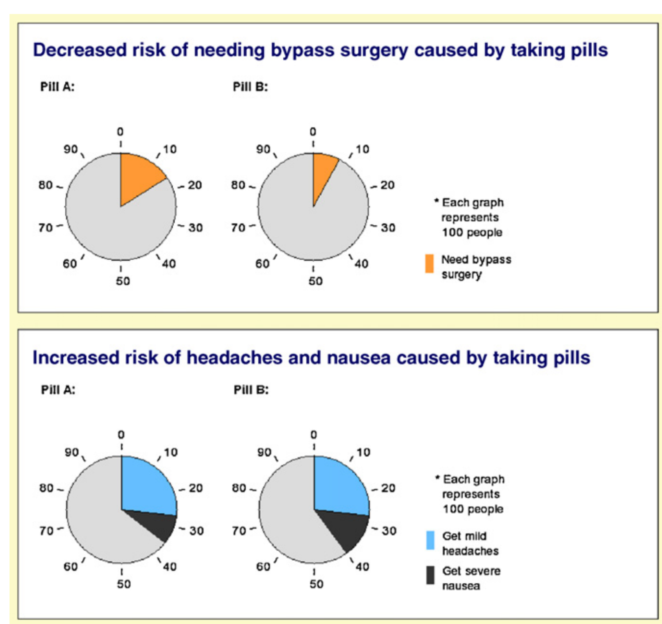
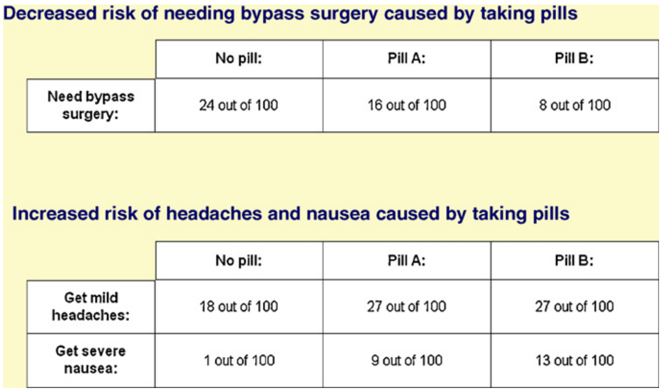


Fig. 5. Example of "clock" graph (modified pie).


Decreased risk of needing bypass surgery caused by taking pills

	No pill:	Pill A:	Pill B:
Need bypass surgery:	24 out of 100	16 out of 100	8 out of 100

Increased risk of headaches and nausea caused by taking pills

	No pill:	Pill A:	Pill B:
Get mild headaches:	18 out of 100	27 out of 100	27 out of 100
Get severe nausea:	1 out of 100	9 out of 100	13 out of 100

Fig. 6. Example of table.

were borderline significant ($p = 0.091$ and $p = 0.098$ for pie and pictograph, respectively).

3.6. Respondents' perceptions of graph formats

Respondents rated table as the most effective, trustworthy and scientific compared to the other formats across low and high numeracy respondents. For every type of graph, across all three constructs, higher numeracy individuals rated each type graph significantly higher than did low numeracy respondents ($p < 0.05$). The pictograph – which did well at conveying both verbatim and gist knowledge – was favorably rated all constructs (results not shown).

3.7. Factors associated with making the medically superior treatment choice

Table 4 provides the results for the logistic regression of making the medically superior treatment choice vs. another choice. Model 1 provides the results where the medically superior choice was regressed on verbatim and gist knowledge and individual characteristics. Model 1 shows that both verbatim and gist knowledge are significantly associated with making the medically superior treatment choice (OR: 1.85, 95% CI: 1.50–2.29 and OR: 2.98, 95% CI: 2.43–3.67 for verbatim and gist knowledge, respectively). The odds ratio for gist knowledge is considerably higher than that for verbatim knowledge, suggesting that having adequate gist knowledge is associated with a greater likelihood of making a medically superior treatment choice though both are positively associated with the outcome. Those with higher numeracy were significantly more likely to make a correct treatment choice (OR: 1.31, 95% CI: 1.05–1.62). Model 2 shows that including the type of graph in the model does not significantly affect the impact of either verbatim or gist knowledge on the medically superior treatment choice, nor does graph type influence any of the other associations in the model. None of the graph types were significantly associated with making a correct treatment choice.

Table 1
Associations between respondents' verbatim and gist knowledge, independent variables and type of graph

	Verbatim knowledge % (N)	Gist knowledge % (N)
Age (years)		
<40	58 (448)	68 (525)
41–59	51 (408)	61 (489)
60 or older	41 (344)*	59 (485)*
Gender		
Male	47 (586)	65 (744)
Female	53 (610)*	60 (751)^
Education		
High school or less	39 (163)	54 (226)
Some college or trade school	48 (501)	60 (638)
Bachelor's degree or more	58 (535)*	68 (631)*
Race		
White	53 (1031)	64 (1262)
Non-white	39 (169)*	55 (237)*
Numeracy		
Low	38 (446)	54 (612)
High	62 (728)*	71 (842)*
Type of graph		
Table	67 (267)*	57 (226)^
Pictograph	58 (213)	59 (243)
Pie	18 (72)	68 (267)
Bar	62 (255))	65 (238)
Sparkplug	49 (198)	61 (253)
Clock	46 (195)	64 (272)

*$p < 0.001$; ^$p < 0.05$ for Chi-square tests of differences between groups.

4. Discussion and conclusion

4.1. Discussion

Our results are consistent with others who have shown that the presentation of risk and benefit information in different formats will have different effects on how viewers evaluate the information [12,15–17]. Schapira et al. recently showed that patients perceived lifetime breast cancer risk to be lower when risk information was communicated with a bar graph compared with a pictorial display of risk (either using human forms or rectangular forms) [15]. Our results are also in line with those of Feldman-Stewart et al. who found that the format is most useful in estimation of precise numerical assessment – likened to verbatim knowledge in our study – was the presentation of numbers, such as we found with the table format [16]. Taken together, these results suggest that clinicians and decision aid developers need to pay close attention to the format in which risk and benefit information is conveyed. Moreover, the choice of format may need to be dependent on the goal of the communication. If the goal is to impart more general knowledge about which treatment is better or worse, our results would suggest that a pie format is a good choice. Conversely, if the goal is for patients to understand a specific numeric risk or benefit (e.g., the exact number of patients likely to experience a side effect), a table may have the desired impact. In many medical situations, however, both types of numerical information are important for ensuring that patients of varying numeracy levels can make optimal decisions. Our results suggest that the pictograph may be a particularly attractive option since it was consistently associated with achieving adequate levels of both verbatim and gist knowledge across numeracy levels. A recent study by Price et al. [20] similarly recommended pictographs as being the optimal format in which to display quantitative risk and benefit information.

As emphasized by Peters et al. and others, the presentation of medical risk and benefit information may be particularly problematic for those with low numeracy [7,10,26,27]. A review on this topic emphasized that more effort is needed to understand how to improve the ability of low numeracy individuals to make informed decisions [10]. Consistent with this review, we found that all graph formats did better among those of higher numeracy, although even those with high numeracy did not always have adequate verbatim or gist knowledge. We found that the pictograph was the format that

Table 2
Mean number of correct questions for verbatim and gist knowledge overall and by numeracy level

	Verbatim knowledge: mean number correct (range: 0–4)				Gist knowledge: mean number correct (range: 0–2)			
	Overall	Low numeracy	High numeracy	*t*-Test low vs. high	Overall	Low numeracy	High numeracy	*t*-Test low vs. high
Table	2.94	2.57	3.33	−5.97, $p = 0.000$	1.41	1.25	1.56	−4.22, $p = 0.000$
Pictograph	2.46	2.16	2.77	−4.02, $p = 0.0001$	1.56	1.46	1.68	−3.28, $p = 0.0011$
Pie	1.27	1.01	1.59	−4.9, $p = 0.000$	1.59	1.50	1.68	−2.67, $p = 0.0079$
Bar	2.55	2.09	3.01	−6.44, $p = 0.000$	1.45	1.27	1.60	−4.50, $p = 0.000$
Sparkplug	2.25	1.84	2.59	−5.44, $p = 0.000$	1.50	1.32	1.65	−4.92, $p = 0.000$
Clock	2.20	1.81	2.63	−6.38, $p = 0.000$	1.55	1.42	1.67	−3.93, $p = 0.0001$

generally produced adequate levels of both types of knowledge across numeracy levels. Our finding that pictograph did significantly worse for imparting verbatim knowledge among high numeracy respondents who could suggest that when asked to provide a specific numerical estimate, those of higher numeracy are most comfortable with the format that shows the actual number. Given that those of higher numeracy tend to be better able to interpret and process the presentation of risk and benefit information across different graphical formats, focusing on the format that does better among lower numeracy individuals is most likely to improve informed decision making for this vulnerable population [7,26].

Schapira et al. [15] have pointed out that the degree to which patients trust the format in which information is delivered is likely to have an influence on the uptake of that information and whether it is used in their medical decisions. Others have shown that individuals tend to prefer the simplest formats for receiving health-related information [28,29]. Ours is one of the first studies to evaluate the perceptions of the viewers regarding graphs along several constructs, including trustworthiness, in a large sample of respondents with varying degrees of numeracy. We found the pie graph being perceived as least trustworthy and scientific and the table format perceived as being the most trustworthy and scientific. This result is particularly interesting given that these are probably the most commonly used formats in public sources of health information (e.g., magazines and newspapers). Importantly, both low and high numeracy respondents rated the pictograph favorably on all three constructs suggesting that this format would be well-accepted by patients making medical decisions. This finding, together with the result that the pictograph did best at imparting both types of knowledge, would make it as the recommended format for effective delivery of risk and benefit information.

Little research has evaluated the impact of graphical formats on actual treatment choices. We found that type of graph format was not associated with making a medically superior treatment choice, but that having adequate levels of both verbatim and gist knowledge was positively associated. These results suggest that the impact of the format in which information is delivered may influence actual medical decisions by first affecting the type and amount of knowledge gained by patients.

Our study should be interpreted in the context of some limitations. First, we used an Internet sample as we have done in prior research [21–23]. Although large and demographically diverse, this sample was not representative of those without Internet access. As well, those who responded were likely interested in the topic. However, the goal of this study was not to achieve representative sampling, but rather to compare the impact of graphical formats across experimental groups. Our design therefore supports internal validity by randomly distributing sample characteristics evenly across the formats, thus controlling for any response bias [21,22]. We point out that our study underscores the importance of the format of information delivery, since even among Internet users we found significant proportions did not have adequate verbatim or gist knowledge. Second, we queried respondents about a hypothetical medical

Table 3
Logistic regression of verbatim and gist knowledge stratified by numeracy

	Verbatim knowledge OR (95% CI)		Gist knowledge OR (95% CI)	
	Low numeracy ($N = 1123$)	High numeracy ($N = 1175$)	Low numeracy	High numeracy
Gender (female vs. male)	1.03 (0.79, 1.35)	1.13 (0.86, 1.48))	0.89 (0.69, 1.14)	1.14 (0.88, 1.49)
Age (years)				
<40	Referent	Referent	Referent	Referent
41–59	0.72 (0.52, 0.98)^	0.63 (0.46, 0.89)*	0.76 (0.56, 1.02)	0.65 (0.47, 0.89)*
60 or older	0.46 (0.33, 0.63)**	0.37 (0.27, 0.52)**	0.60 (0.45, 0.80)**	0.56 (0.41, 0.79)**
Race (non-white vs. white)	2.36 (1.67, 3.34)*	1.98 (1.39, 2.82)**	1.51 (1.12, 2.05)*	1.43 (1.01, 2.02)^
Education				
≤High school	Referent	Referent	Referent	Referent
Some college	1.04 (0.76, 1.44)	1.63 (1.05, 2.54)^	0.99 (0.74, 1.33)	2.11 (1.38, 3.21)**
≥Bachelor's degree	1.59 (1.11, 2.27)^	1.80 (1.17, 2.77)*	1.29 (0.92, 1.81)	2.39 (1.58, 3.60)**
Type of graph				
Table	Referent	Referent	Referent	Referent
Pictograph	0.93 (0.61, 1.43)	0.55 (0.34, 0.88)*	1.69 (1.11, 2.56)*	1.45 (0.92, 2.27)
Pie graph	0.11 (0.07, 0.19)**	0.09 (0.05, 0.15)**	2.03 (1.34, 3.08)*	1.48 (0.94, 2.32)
Bar	0.78 (0.52, 1.19)	0.83 (0.52, 1.33)	1.08 (0.72, 1.63)	1.06 (0.70, 1.61)
Sparkplug	0.51 (0.33, 0.78)**	0.37 (0.24, 0.58)**	1.13 (0.74, 1.71)	1.33 (0.87, 2.03)
Clock graph	0.42 (0/28, 0.64)**	0.38 (0.25, 0.60)**	1.48 (0.98, 2.22)	1.41 (0.91, 2.16)

^$p \leq 0.05$; *$p \leq 0.01$; **$p \leq 0.001$.

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Table 4
The impact of verbatim and gist knowledge and graph format on making the medically superior treatment choice

	Model 1	Model 2[a]
Knowledge		
Verbatim (incorrect vs. correct)	1.87 (1.46–2.39)*	1.80 (1.38–2.33)*
Gist (incorrect vs. correct)	3.11 (2.53–3.81)*	3.16 (2.57–3.88)*
Demographics		
Age		
≤40	Referent	Referent
41–59	0.96 (0.75–1.23)	0.96 (0.75–1.22)
60 or older	1.11 (0.88–1.43)	1.11 (0.87–1.43)
Race (non-white vs. white)	1.42 (1.11–1.82)^	1.41 (1.10–1.81)
Education		
≤High school	Referent	
Some college or trade school	0.79 (0.60–1.05)	0.78 (0.59–1.03)
Bachelor's degree or more	0.92 (0.68–1.23)	0.90 (0.67–1.22)
Numeracy (low vs. high)	1.38 (1.11–1.70)^	1.39 (1.12–1.71)^
Type of graph		
Pie		Referent
Bar		1.00 (0.70–1.43)
Pictograph		0.93 (0.65–1.33)
Sparkplug		0.84 (0.59–1.18)
Clock		1.05 (0.75–1.48)
Table		1.22 (0.84–1.77)

*$p \le 0.001$; ^$p \le 0.005$.
[a] Controlling for all variables in Model 1.

decision making scenario; our findings need to be confirmed among patients making actual treatment decisions with their providers. As well, our study did not evaluate the impact of having providers who deliver medical information to patients via different graph formats; results may be different from those obtained from Internet delivery. Our results underscore the importance of further investigation of the impact of graph formats in actual clinical settings and decision scenarios.

4.2. Conclusion

Having an accurate understanding of the risks and benefits of treatment options is a key element of an informed decision [30]. Including graphical formats in decision aids is recommended as a method for conveying risks and benefits and helping with decision making [13]. Our findings indicate that tailoring the graph format to the type of information needed for a particular medical decision would likely produce the most informed patient. Since this approach is likely not realistic in many medical decision making situations, the pictograph would be the recommended format as it most effectively conveyed both types of knowledge across numeracy levels and was perceived favorably by different types of respondents.

4.3. Practice implications

Providers and decision tool developers need to be aware of the differential effects on patient's knowledge that may be generated through the use of different graph formats. Further work to evaluate the impact of delivering medical information to patients in different graphical formats by providers themselves is needed. Lower numeracy individuals may be vulnerable to poor medical decisions if material is not conveyed in understandable and preferred formats. The pictograph may be the best format in situations where tailoring graph format to the type of knowledge required by patients of different numeracy levels is not possible.

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