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Framing the Clinical Encounter: Shared Decision-Making, Mammography Screening, and Decision Satisfaction

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The study examines whether physicians' framing of clinical interactions is related to patient shared decision-making (SDM) satisfaction when using a clinical decision support tool (CDST) concerning mammographic screening. To answer this question, we combined (a) system log data from a CDST, (b) content coding of the physicians' message framing while using the CDST, and (c) a post-visit patient survey to assess SDM satisfaction concerning screening mammography. Results suggest that two types of message frames — consequence frames and numerical frames — moderated the relationship of the CDST on SDM satisfaction. When the CDST displayed low risk of breast cancer for a patient, physicians were able to improve the cognitive aspects of SDM satisfaction by framing the consequences of mammography screening in positive terms. However, when the physician delivered the numerical information in relative, rather than absolute terms, the patient's SDM satisfaction was reduced. Our study advances previous message framing effect research in health communication from experimental settings to clinical encounters. It also discusses the importance of delivering risk-congruent frames in clinical settings.

Screening mammography for women aged 40–49 remains controversial as organizations that issue guidelines provide differing recommendations for initiation and frequency of screening (Ernster, 1997). The U.S. Preventive Services Task Force (USPSTF) recommends that women below 50 take personal values into account in deciding when and how frequently to initiate mammography. In contrast, the American Cancer Society (ACS) advises that screening begins at age 45 and the American College of Radiology (ACR) suggests annual screening (Schrager & Burnside, 2019). This creates confusion among patients and physicians, generating anxiety when considering screening options (Squiers et al., 2011).

Clinical decision support tools (CDST) can help physicians address the inconsistencies of screening guidelines and facilitate patients' choice-making by integrating evidence-based information into clinical conversations, reducing patient anxiety, and encouraging shared decision-making (SDM) (Eden et al., 2015; Rimer et al., 2001). The CDST examined in this article estimates individualized risk based on patient characteristics and presents a graphical representation to regulate a patient's negative emotions aroused by lack of literacy in quantified, numeral information (Schapira et al., 2008; Silk & Parrott, 2014; Yamashita et al., 2019).

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However, a patient's perception can be impacted not only by a CDST's assistive effects but also by how the physician presents the information provided by the CDST. Few studies have investigated the impact of a physician's clinical style when using CDST, despite considerable value of message framing as a theoretical approach to understanding how message presentation shapes patient satisfaction (e.g., Covey, 2011; Lipkus et al., 2019; Lueck, 2017). We argue that, within the context of breast cancer screening discussions, two major message frames become salient; one is the consequence frame, regarding potential harms and benefits, while the other is the framing of numerical information in "relative" versus "absolute" terms. The two framing approaches may moderate a CDST's assistive effect on SDM satisfaction.

Literature Review

The CDST Assistive Effect on Shared Decision-Making Satisfaction

Shared decision-making (SDM) is defined as "a process in which patients are involved as active partners with the physician in clarifying acceptable medical options and in choosing a preferred course of clinical care" (Sheridan, Harris, & Woolf, 2004, p. 56). The decisional conflict scale (Janis & Mann, 1977) and the three-step "choice-option-decision" talk (Elwyn et al., 2017; 2012) are two popular frameworks used to assess the clinical SDM process. The former focuses on the assessment of a patient's uncertainties and decision-making conflicts, particularly when confronted with tradeoffs in selecting a course of action (Griffey & Shah, 2016; Janis & Mann, 1977). The latter centers on an observer's evaluation of the physician-patient deliberation and provides guidance in routine clinical practice (Elwyn et al., 2012).

To improve patient SDM satisfaction when considering mammographic screening, clinical decision support tools (CDST) are designed to assist physicians and patients in navigating screening guideline discrepancies. Such CDST are applied in patient-centered communication to explain the morbidity and mortality outcomes of the disease, the risks and benefits of different screening options, and the meaning of medical treatments (e.g., Eden et al., 2015; Hersch, Jansen, & McCaffery, 2018; Mathieu et al., 2010; Singh et al., 2019). One major function of CDST is to ameliorate the difficulties of communicating medical information in quantitative format. Patients' poor numeral literacy can arouse math anxiety and negative emotions when processing health risk information, potentially impeding their understanding (Schapira et al., 2008; Silk & Parrott, 2014). As numeracy deficits include lack of skills in interpretation, probability, and statistical inference involving quantitative information (Goggins et al., 2014; Yamashita et al., 2019), most CDSTs develop visual formats to clarify quantitative information because graphs are effective in revealing numeric relations (Cleveland & McGill, 1984; Singh et al., 2019; Trevena et al., 2013).

In our study, the physician entered information relating to patient risk factors (i.e. age, race, family history), into the *Breast Cancer Risk Estimator-Decision Aid (BCARE-DA)*, a CDST that can present a risk visualization of breast cancer likelihood in the next 10 years. This calculator uses mammographic breast density levels recorded in the electronic medical record[1] and other personal information to determine personalized risk of breast cancer and its mortality likelihood with regards to annual/biennial screening (BCSC, 2018). The individualized estimates are graphically displayed on a computer with explanations of over-diagnosis, false positives, and mortality rates based on different guidelines. Figure 1 presents CDST screenshots in a sequential order.

While an information display about the benefits and harms of annual/biennial mammograms improves SDM, the physician's message framing styles may moderate the assistive effect. It is important to recognize that information provided by CDST is not neutral. Indeed, patients with higher risk estimates, as presented on the CDST, may react differently to a particular framing of the clinical encounter than patients with a lower risk estimate. It is reasonable to assume that results shown on the CDST screen will prime a patient's risk perception, and interact with the physicians' framing of the information presented, jointly shaping SDM satisfaction.

Consequence and Numerical Framing Effects

Patient perceptions when considering healthcare recommendations are influenced by physician message-framing (Bernstein, Kupperman, Kandel, & Ahn, 2016; Nan, Daily, & Qin, 2018). Framing effects are understood as the outcomes of message resonance on an individual's preexisting cognitive schemas (McLeod & Shah, 2014), and highlight the way in which particular strategic message designs activate or suppress individual judgments (Meyerowitz & Chaiken, 1987; Nan et al., 2018). Numerous studies reveal that gain-framed appeals (i.e., the benefits of taking actions) and loss-framed appeals (i.e., the costs of inaction) function differently in prevention and promotion scenarios in the context of health communication (e.g., Cho, Chun, & Lee, 2018; Robbins & Niederdeppe, 2019; Rothman et al., 2006).

We argue that, within the context of breast cancer screening discussions, two major message frames become salient; one is the consequence frame regarding potential harms and benefits, while the other is a numerical verbalization frame, whether in "relative" versus "absolute" terms. For the consequence frames, SDM concerning screening mammography requires that the physician communicates both the potential harms (e.g., false positives) and benefits (e.g., early cancer detection) to help patients make educated screening decisions (Mandelblatt et al., 2006). Both the beneficial consequences of undergoing mammography, such as early detection and improved survival rate of breast cancer, and the harms of screening, like false positives, can drive patient-physician discussions.

The benefits and harms of mammography screening are actually the first layer of gain- and loss- frames, which creates what is known as "desirable vs. undesirable outcomes" by focusing on the "message's explicit linguistic representation of the kernel state of the consequence under discussion" (O'Keefe & Jensen, 2006, p. 5). A complete gain/loss frame contains both the kernel state of the consequence sequence, as well as descriptions of compliance/noncompliance with the health behaviors (e.g. advocating physical exercise because it is beneficial for health).

The second layer of gain- and loss-frames, compliance versus noncompliance, is lost in clinical encounters, as physicians are asked to consider patients' values in decision making, rather than opining particular behaviors. In other words, physicians are not inclined to be compliance-focused or noncompliance-focused about mammographic screening in certain age ranges, especially when guidelines conflict.

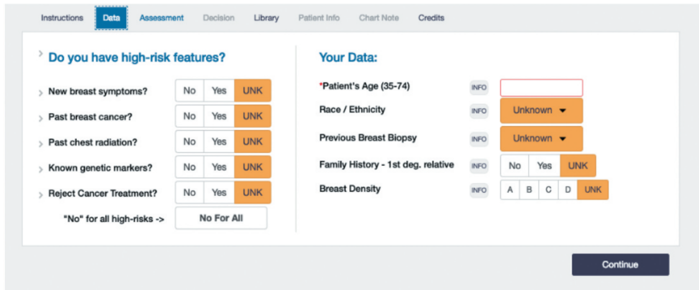
Apart from consequence framing, quantified information is the other important element to consider within the mammography screening discussion. Previous studies have highlighted the necessity of understandable and accurate numerical communication within the clinical encounter (Hanoch, 2004; Trevena et al., 2013). The difficulties of explaining statistical information to patients can be diminished by presenting frequency frames in the following ways: natural rather than probabilistic (Hanoch, 2004), and relative rather than absolute (Koo et al., 2017). Therefore, the current study proposes that two styles of message frames, consequence and numerical, moderate CDST beneficial effects on patient's perception toward SDM satisfaction.

Theoretical Framework and Hypotheses

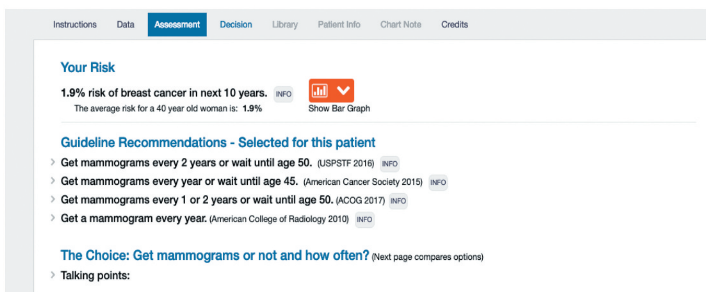
We expect an interaction effect of the CDST's use with physicians' message framing styles when communicating with

[1]The level of breast density is confirmed to be an independent factor that influences risk of breast cancer (Schrager & Burnside, 2019).

Step 1 Input the patient's personalized information to estimate breast cancer risk. Some factors, such as previous breast biopsy and density, are imported from the electronic health records (EHRs) loaded on the doctor's computer.



Step 2 Generate estimated risk and display the screening recommendations from different national guidelines.



Step 3 Visualization of the benefits and harms recommended by different guidelines.

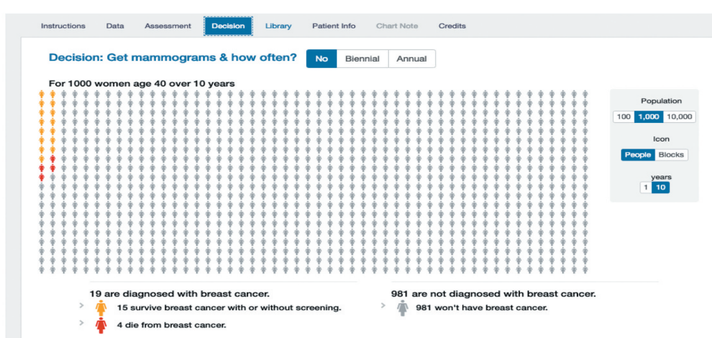


Figure 1. Screenshot of the B-CARE tool.[55]Readers can access to the tool without EHR built-in at https://www.healthdecision.org/tool#/tool/mammo *Step 1* Input the patient's personalized information to estimate breast cancer risk. Some factors, such as previous breast biopsy and density, are imported from the electronic health records (EHRs) loaded on the doctor's computer.*Step 2* Generate estimated risk and display the screening recommendations from different national guidelines.*Step 3* Visualization of the benefits and harms recommended by different guidelines.

patients. The CDST in the present study not only displays screening information, but also primes the patient's risk perception through the *Breast Cancer Risk Estimator*. Previous studies have discovered that if message frames are consistent with an individual's perceived goals, their attitude will be strengthened after the information exposure (Sengupta & Johar, 2002). Thus, patients with low estimated breast cancer risk may prefer message delivery framed in a low-risk appeal, considering the mechanism of psychological resonance (Wan, 2008).

It is reasonable to hypothesize that, if individuals are presented with estimates of below-average risk of breast cancer, the use of positive consequence and non-absolute number frames may lead to an increase in SDM satisfaction. Previous research shows that attributes of positive outcomes increased satisfaction from gain-framed appeals (Rothman & Salovey, 1997). Though recognized that absolute versus relative number frames can influence individual decision-making (e.g., Baron, 1997; Bonner & Newell, 2008), few researchers have shown a correlation between numerical format and risk condition matching. Based on current information, we can only deduce that patients who are estimated to be below average risk will expect low-risk relevant message delivery from the physician.

H1: For patients who are evaluated as below average risk for breast cancer, the use of positive consequence frames will increase SDM satisfaction.

H2: For patients who are estimated as below average risk for breast cancer, the use of relative number frames will increase SDM satisfaction.

In contrast, patients estimated as having a higher likelihood of breast cancer may expect more negative consequence and absolute frames to match their risk status.

H3: For patients estimated as above average risk for breast cancer, the use of negative consequence frames will increase SDM satisfaction.

H4: For patients estimated as above average risk for breast cancer, the use of absolute numerical frames will increase SDM satisfaction.

Method

Study Procedure and Sample

The study was approved by the University of Wisconsin-Madison Institutional Review Board. Study recruitment was conducted from May 2017 through May 2018. The inclusion criteria required English-speaking women aged 40–49, not having received mammography screening in the nine months before, and not having a history of dementia or breast cancer. Patients scheduled for a primary care appointment, during which a discussion of mammography screening would be appropriate, were invited to participate in the study. Audio recordings of clinical conversations between physicians and patients related to mammography screening while using a CDST were transcribed for content analysis. Surveys were mailed one week after the visit, with a reminder postcard sent four days later; if no response was received within three weeks, an additional copy of the survey packet was mailed.

Measurement

This study combines (a) system log data from a CDST, (b) content coding of the physicians' message framing while using the CDST, and (c) a post-visit patient survey to assess SDM satisfaction concerning screening mammography.

CDST Estimated Risk (Patients' Perception)

Personalized risk assessment was presented by the CDST, providing an estimation of the patient's likelihood of breast cancer development within a 10-year period, based on individual risk factors. This data was drawn from system logs. Risk factors consisted of information relating to breast health ("Do you have new breast symptoms/past breast cancer/past chest radiation/known genetic markers/reject cancer treatment?"), age, and race. Additional information was also collected regarding the patient's biopsy record, first degree relative with breast cancer history, and breast density (if a prior mammogram had been recorded). If any individual information was absent, such as family history, the appropriate value estimated from the Breast Cancer Surveillance Consortium (BCSC) calculator was imputed.[2] This data was used to distinguish patients estimated as below average risk for breast cancer from those above average risk for breast cancer. The calculation from BCSC displayed both the patient's 10-year incidence of breast cancer and the average incidence for U.S. women of the same age. We then categorized patients into high versus low-risk groups, in which those estimated above the average incidence for U.S. women of the same age as high-risk and those below the average incidence for U.S. women of the same age as low-risk.

Coding of Clinical Conversations

Two trained judges coded the transcribed audio recordings of clinical conversations between patients and physicians while using the CDST during clinical encounters for frames. Paragraphs were treated as single coding units, and the summation score of each framing category per conversation was calculated as the unit of analysis.[3] Both coders reached an average Cohen's Kappa of 0.78 reliability for the five coded frame categories:

Positive Consequence Frame

A positive framing category includes positive valence/terminology that triggers beneficial feelings about mammography screening or cancer detection (e.g. " … that would have been 63 out of 1000 that have a biopsy that ends up being completely fine." " … there is one life saved … ").

Negative Consequence Frame

A negative framing category includes negative valence/terminology that triggers feelings of fear, anxiety, harm, and loss regarding mammography or cancer detection (e.g. "If we say, our decision is no mammogram, three out of those 1000 women would die from breast cancer," or " … if we do a mammogram every other year – there are harms on this side.").

[5]Readers can access to the tool without EHR built-in at https://www.healthdecision.org/tool#/tool/mammo

[2]More information about the mechanism of tailored evaluation could be retrieved from https://www.healthdecision.org/tool#/tool/mammo. The estimated prediction from the tool is based on a competing risk model using the 2000 to 2010 SEER data for breast cancer incidence and 2010 vital statistics for competing mortality risk (refer to Tice et al., 2015).

[3]The coding frame formula can be summarized as *Category Score* = $\sum_{i \in R_j} X_{ij}$.X is the frame category, i is the paragraph order number in *jth* transcript.

Relative Numerical Frame
For each utterance, mentions of referential lines regarding numeric messages were scored with a value of 1 (e.g. "One out of four, or 25% will be diagnosed with breast cancer," "Out of these 21, 17 are going to survive and four are going to die from breast cancer.").

Absolute Numerical Frame
For each utterance, mentions of absolute, pure numbers, based on the physician's presentation, were graded as positive one (e.g. "Four women are expected to die of breast cancer within 10 years," "124 are going to actually have biopsies that are going to end up being normal.").

Temporal Frame
In addition to the hypothesized frames, the framing of outcomes within a temporal span by the physician was also coded (e.g. "So, your 10-year risk of getting breast cancer is two percent. The average for somebody your age is 3.2 percent."). The results from the CDST should be contextualized and discussed within a "10-year" window, so these variables were included in analysis for control purposes.

Post-Visit Patient Survey of SDM Satisfaction
For the outcome, SDM satisfaction, we used the Decisional-Conflict Scale, due to its validation in empirical testing and acceptance by the North American Nursing Diagnosis Association (Boland et al., 2017; Janis & Mann, 1977; Myers et al., 2018; O'Connor, 1995). The question format covers five dimensions of SDM: informed perception, value clarity, supportive perception, certainty, and efficiency.[4] In total, 15 items covering these dimensions were assessed. Items were summed, divided by 15, and multiplied by 25 to calculate an overall SDM satisfaction score (Cronbach α = 0.90). Higher scores indicate greater SDM satisfaction.

Analytical Strategies

The multilevel mixed effect model, conducted in STATA 15, was employed for data analysis. The multilevel mixed effect model was selected due to its modeling strength with differentiating variances further explained by multiple groups and individuals synchronously (Gutierrez & StataCorp, 2006). In our case, we controlled physicians' differences at the group level.

Results

Eleven primary care physicians agreed to participate in the study and provided informed consent. A total of 100 women met the eligibility criteria and were invited to participate in the study. Forty-six women were excluded due to refusal to be recorded, and/or unfinished survey responses. The resulting enrollment included 63 patient subjects who provided informed consent and who utilized the CDST when discussing screening mammography with their physicians. Twelve patient subjects were subsequently eliminated from study records due to missing data points (audio/transcription, tool use data, patient survey).

The final data set includes 54 observations. Data from clinical transcriptions, CDST tool use, and survey responses were merged based on subject ID. The resulting sample has a mean age of 43.9 (SD = 2.81) and includes 94.44% White, 3.7% African-Americans, 3.7% Asian, 3.7% Hispanic/Latino, and 1.85% Native American or Alaska Native. All subjects were covered by health insurance, and 83.02% had an annual household income above 55,000 USD before tax. More than half held at least some college education. As seven subjects had the same risk ratio as the average population, 47 observations were included for data analysis. Table 1 displays the descriptive statistics for each numerical variable.

Patients with Low Risk of Breast Cancer (H1 & H2)

For SDM satisfaction, the interaction effect of positive consequence frames with low-risk estimation is significant for informed perception and value clarity. This suggests that, for patients estimated as below the average breast cancer incidence for U.S. women, the increased use of positive consequence frames gives rise to informed SDM and improved value clarity. For the other three dimensions of SDM satisfaction (supportive perception, clarity, and efficiency perception), the influence of positive consequence frames remains positive (see model estimation results in Table 2).

The overall satisfaction score (Column 1 in Table 2) is improved with use of positive consequence frames for low-risk patients at p value less than 0.1. Figure 2 displays the two types of predicted interaction effects with the confidence interval at 95%. The trajectory of the pattern shows a strengthening effect of positive consequence frames on low-risk estimation for SDM satisfaction.

However, when we observe the interaction effect between the low-risk patient group and relative numerical frames, there is no apparent strengthening effect. Overall satisfaction, value clarity, and supportive perception decline as a result of an increase in relative numerical frames for low-risk patients. Figure 3 shows the predicted pattern of the three dimensions for SDM satisfaction.

It is important to note the weakening effect of relative numerical frames for low-risk breast cancer patients. Our hypotheses (H2) indicate that we expected relative numbers would lead to decreased risk perception, thus matching low-risk expectations. However, the results suggest that for low-risk patients, frequent use of relative numbers does not ease negative cognition triggered by the information displayed on the screen. These results override the assumption that patients viewed the visual presentation of risk information as neutral.

Patients with High Risk of Breast Cancer (H3 & H4)

There is no significant interaction effect of tool-estimated risk and negative consequence frames, or absolute numerical frames

[4] The questionnaire for the five dimensions of SDM satisfaction is presented in Appendix.

Table 1. Zero-order correlations and descriptive statistics (N = 47)

	1	2	3	4	5	6	7	8	9	10	11
1.Overall satisfaction	1.0										
2.Informed perception	.82**	1.0									
3.Value clarity	.85**	.80**	1.0								
4.Supportive perception	.89**	.70**	.70**	1.0							
5.Certainty	.90**	.62**	.65**	.75**	1.0						
6.Efficiency perception	.83**	.50**	.55**	.76**	.80**	1.0					
7.Negative consequence frame	.17	.30**	.14	.12	.11	.10	1.0				
8.Positive consequence frame	−.09	−.21	−.17	−.03	−.04	.03	.18	1.0			
9.Relative numerical frame	.12	.18	.17	.12	.07	−.01	.21	.08	1.0		
10.Absolute numerical frame	−.08	−.09	.08	−.14	−.01	−.18	−.30*	−.28**	.09	1.0	
11.Temporal frame	.13	.17	.19	.03	.21	−.07	−.20	.05	−.03	.15	1.0
Mean	44.70	40.60	51.33	45.57	61.88	37.23	1.32	0.98	1.36	2.40	1.72
SD	12.14	13.98	18.47	10.11	18.88	11.65	1.40	1.10	1.17	2.31	0.71

*p < .05. **p < .01.

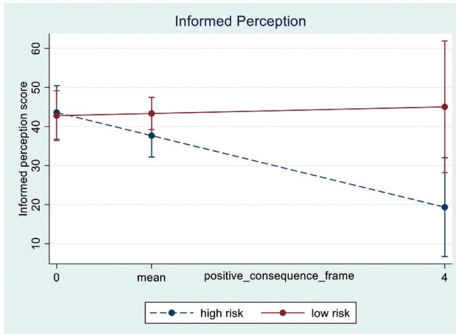
Table 2. Multilevel mixed effect model of estimated risk and frames (positive consequence & relative numerical).

	Overall Satisfaction	Informed Perception	Value Clarity	Supportive Perception	Certainty	Efficiency Perception
Interaction Effect						
Risk (low) X Positive Consequence Frame	4.30⁺ (3.10)	6.62* (3.29)	10.54* (4.11)	1.66 (2.72)	4.62 (5.33)	1.19 (3.21)
Risk (low) X Relative Numerical Frame	−7.01* (3.23)	−5.14⁺ (3.43)	−12.71** (3.92)	−6.69* (2.84)	−6.98 (5.57)	−5.80⁺ (3.35)
Main Effect						
Risk (low)	9.27⁺ (5.72)	6.23 (3.29)	13.14⁺ (7.59)	10.79* (5.01)	6.76 (9.84)	10.36⁺ (5.93)
Negative Consequence Frame	.64 (1.21)	1.94⁺ (1.28)	.61 (1.61)	−.16 (1.06)	1.31 (2.08)	−.28 (1.26)
Positive Consequence Frame	−2.96⁺ (1.87)	−6.06** (1.98)	−6.63* (2.48)	−1.17 (1.64)	−2.96 (3.22)	.12 (1.94)
Relative Numerical Frame	6.34* (2.96)	5.54⁺ (3.14)	11.88** (3.93)	6.22* (2.59)	6.21 (5.09)	4.31⁺ (3.06)
Absolute Numerical Frame	−.91 (.74)	−1.05 (.79)	.08 (.99)	−1.04⁺ (.65)	−.77 (1.28)	−1.27⁺ (.77)
Temporal Frame	.93 (2.18)	2.79 (2.31)	2.08 (2.89)	−.68 (1.91)	4.65 (3.75)	−2.49 (2.26)
Log Likelihood	−170.39	−173.09	−183.41	−164.33	−195.35	−172.06
Wald Chi2 (10)	23.35	35.78	45.54	17.07	10.10	13.71
Random-effects Parameters						
Physicians: Identity Var (_cons)	1.63e-17 (9.02e-14)	4.81e-17 (6.09e-16)	2.39e-20 (2.89e-19)	1.61e-18 (2.33e-17)	2.76e-09 (9.23e-06)	.41 (13.59)
Var (residual)	96.60 (20.14)	108.63 (22.65)	170.09 (35.47)	74.22 (15.48)	285.91 (59.83)	103.44 (25.39)

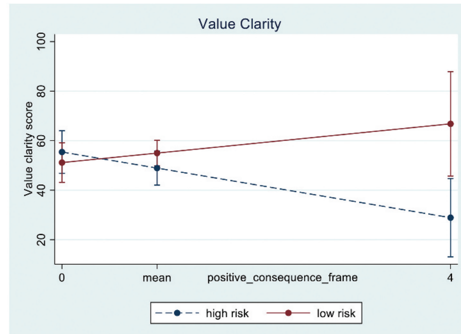
⁺*p* < .1. * *p* < .05. ***p* < .01.

for patients with high risk (Table 3). This may be a result of the small sample size (N = 47), as it is easier to induce Type II errors. However, when compared to the low-risk group of patients, several main effects are worth mentioning.

First, high risk as estimated by the CDST is a significant factor in reducing overall SDM satisfaction, informed perception, and value clarity. If the *p* value at the 0.1 threshold is considered, we find a strengthening effect of the negative consequence frame on value clarity and a weakening effect of absolute numerical frames on certainty. However, contrary to the low-risk group of patients, the strengthening/weakening effect from the two types of frames across the five dimensions

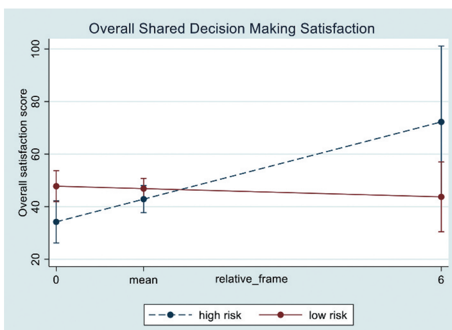


Informed Perception

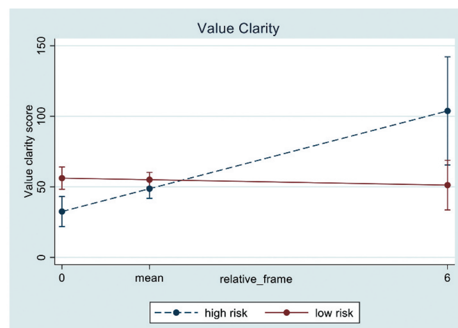


Value Clarity

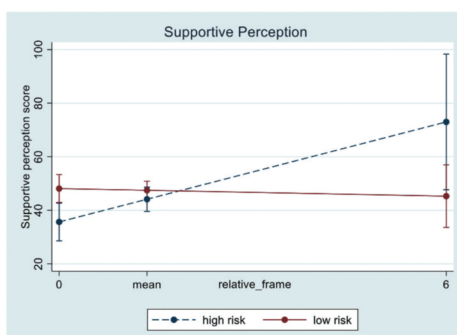
Figure 2. Interaction effect of estimated risk and positive consequence frames.



Overall Satisfaction



Informed Perception



Supportive Perception

Figure 3. Interaction effect of estimated risk and relative numerical frames.

and overall SDM satisfaction is not consistent. The negative consequence frames increase informed perception, value clarity, and supportive perception, while decreasing the certainty of mammographic options and efficiency of personal choice.

Conclusion and Discussion

This analysis demonstrates the importance of physicians' framing strategies while delivering medical information aided by a CDST. Observational data from clinical encounters expand the scope of the message framing effect to situational contexts, and advance a pragmatic approach to framing effects research. Statistical tests support H1, suggesting that for patients presented with low-risk information, positive consequence frames can increase the patient's SDM satisfaction in regard to informed perception and value clarity. However, with respect to numerical frames, the physician's relative frames did not improve SDM satisfaction. The findings imply that varying elements of SDM satisfaction may be easily influenced by the intersection of CDST information assessment and the physician's numerical message framing.

For patients with high risk, informed perception, value clarity, and supportive perception were improved through the use of negative consequence frames, while certainty and

Table 3. Multilevel mixed effect model of estimated risk and frames (negative consequence & absolute numerical).

	Overall Satisfaction	Informed Perception	Value Clarity	Supportive Perception	Certainty	Efficiency Perception
Interaction Effect						
Risk (high) X Negative Consequence Frame	.80	4.63	6.34^{+}	1.17	−3.09	−2.26
	(3.28)	(3.38)	(4.58)	(2.86)	(5.31)	(3.24)
Risk (high) X Absolute Numerical Frame	−.04	2.24	2.18	−.03	-4.05^{+}	.18
	(2.39)	(1.82)	(2.47)	(1.54)	(2.86)	(1.76)
Main Effect						
Risk (high)	−5.76	−16.36*	−19.77*	−5.7	9.5	−2.65
	(7.33)	(3.38)	(10.24)	(6.39)	(11.87)	(7.28)
Negative Consequence Frame	.83	1.67	.38	−.13	1.95	.09
	(1.40)	(1.41)	(1.91)	(1.19)	(2.22)	(1.39)
Positive Consequence Frame	−1.36	−3.65*	−2.75	−.48	−1.41	.48
	(1.64)	(1.69)	(2.29)	(1.43)	(2.66)	(1.62)
Relative Numerical Frame	.69	1.31	1.53	.76	.81	−.39
	(1.43)	(1.47)	(1.99)	(1.24)	(2.31)	(1.43)
Absolute Numerical Frame	−.87	-1.60^{+}	−.34	−.91	.26	-1.37^{+}
	(.92)	(.95)	(1.29)	(.80)	(1.49)	(.93)
Temporal Frame	1.68	3.62^{+}	3.86	.02	5.77	−2.76
	(2.39)	(2.47)	(3.33)	(2.08)	(3.89)	(2.39)
Log Likelihood	−173.26	−174.68	−188.61	−166.94	−195.43	−173.21
Wald Chi2 (10)	15.23	30.33	27.01	10.31	9.9	10.83
Random-effects Parameters						
Physicians: Identity	1.78e-16	6.89–15	3.68e-19	9.43–20	6.96e-20	5.42
Var (_cons)	(2.462–15)	(1.06e-13)	(4.70e-15)	(1.14e-18)	(8.85e-19)	(15.44)
Var (residual)	109.41	116.40	213.28	83.13	286.9	104.23
	(22.81)	(24.27)	(44.47)	(17.33)	(59.82)	(25.23)

$^{+}p < .1$. * $p < .05$. ** $p < .01$.

efficiency were diminished by the same frames. Such frames did not consistently improve satisfaction with SDM for patients estimated to be high risk. The findings imply that individuals estimated to have low risk had more coherent cognitive and emotional responses to SDM satisfaction. We suspect that self-defense motivation may be higher in patients with higher breast cancer risk. If individuals are motivated by self-defense, they are more likely to induce psychological reluctance and reduce cognitive systematic processing (Nan et al., 2018). Future research would advance the understanding of integrating information processing models into this moderation effect to obtain a more comprehensive understanding.

Our study advances previous research on CDST and SDM by incorporating a message framing approach. The present study also broadens framing research by focusing on the actual use of frames by clinicians, advancing a pragmatic approach. Extracting frames in clinical conversations allows insight into how health information is presented in a clinical encounter, especially when it is based on scientific evidence, but differs in framing depending on the physician's emphasis. Data obtained from real conversations may increase external validity by accounting for contextualized facts. We found that consequence and numerical frames had particular power in SDM satisfaction. Previous studies about message framing effects in health domains mainly focused on the persuasiveness of gain- vs. loss-framed messages (Nan et al., 2018; O'Keefe & Jensen, 2006) without attending to relative vs absolute frames during the clinical encounter. This study also expands the understanding of message framing and its relationship to an integrative perceptual outcome (i.e. SDM satisfaction), which can provide greater insight into physicians' message delivery strategies during a clinical encounter surrounding mammographic screening.

The major limitation of the current study is the lack of numeracy or graph literacy controlled in the model and the imprecise assumption that patients hold the same level of health literacy. Previous studies found that understanding numbers and graphs are critical components of health literacy in primary care and have effects on trust in physicians and SDM (LaVallie et al., 2012; Rodríguez et al., 2013; Schapira et al., 2008). However, as socioeconomic status influenced numeral literacy significantly (Smith, Wolf, & Wagner, 2010), our pool of women aged 40–49 from primary care settings may overcome the omitted variable bias to some extent. Future research can consider including a health literacy scale (e.g., Nguyen et al., 2015) to evaluate a three-way interaction effect on SDM satisfaction. Another two limitations of the present study are the small sample size and the generalizability to other medical decision scenarios. The limitation of sample size could be addressed through the use of mixed effect models and the systematic bias from the patients.

There are several implications for clinical practice that can be derived from our study. First, it suggests that physicians should attend to the particular patient risk status when delivering numerical and consequence information about health risks. Previous studies on health information communication technologies (ICTs) focus greatly on the facilitation of the tool's applications with little attention to the physician's moderating role during this process (e.g., Singh et al., 2019). The present research overrides the assumption that patients and physicians treat information from the decision aid tool in a neutral way. The findings should also encourage CDST developers to consider not only presenting graphic features but supplementing these with verbal aids tailored to the target population's risk and literacy levels. The risk-congruence verbal guidance is essential for clinical encounters based on quantified estimates from the CDST. Second, when the CDST is applied to other clinical settings such as colorectal cancer screening discussion, patients may come from heterogeneous demographics with different graph literacy. Verbal instructions matching with individual risks can guide physicians' framing strategies in an explicit way. Furthermore, as risk-based screening is found to benefit short-term mammography outcomes (Burnside et al., 2019), risk-congruent frames will be in great demand to improve SDM satisfaction. Healthcare practitioners may take the results of this study a step further by setting conversational guidelines based on the patient's personal values and preferences aided by a CDST.

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Appendix

The questionnaire for the five dimensions of SDM satisfaction measurement (Janis & Mann, 1977; Myers et al., 2018)

Items are given on a Likert Scale: 0 = 'strongly agree'; 1 = 'agree'; 2 = 'neither agree nor disagree'; 3 = 'disagree'; 4 = "strongly disagree". The scale was reversed from the original base for model interpretation. For example, 0 = 'strongly agree' was changed to 4 = 'strongly agree'.

Dimensions	Definition	Type of Aspects	Measured Items
Informed Perception	The delivery of information concerning options, benefits, risks and side effects that make patients feel more informed.	Cognitive	I know which options are available to me. I know the benefits of each option. I know the risks and side effects of each option.
Value Clarity	There are detailed description of outcomes that allows patients to better judge their value.	Cognitive	I am clear about which benefits matter most to me. I am clear about which risks and side effects matter most. I am clear about which is more important to me.
Supportive Perception	Patients are guided or coached through deliberation and shared decision making.	Cognitive	I have enough support from others to make a choice. I am choosing without pressure from others. I have received enough advice to make a choice.
Certainty	Patients feel less uncertainty and anxiety as a result of patient-doctor conversation.	Affective	I am clear about the best choice from me. I feel sure about what to choose. I feel sure about what to choose.
Efficiency	A patient believes or feels their preferred course of action will be implemented.	Affective	I feel sure about what to choose. My decision reflects what is important to me. I expect to follow through with my decision. I am satisfied with my decision.