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Research Paper

The impact of framing, communication format, and numeracy on risk perception, emotion, and medication intentions

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ABSTRACT

Introduction: Medication adherence is influenced by both psychological and medical factors, including risk communication and numeracy skills. The way side-effect information is presented – whether in a positive or negative frame, and whether numerical data is conveyed in frequencies or percentages – can impact adherence. These effects may be more pronounced for individuals with lower numeracy.

Aim: This study examines how framing and number formats affect risk perception, moderated by numeracy skills, while exploring emotional responses to medication side effects and intentions to use the medication.

Material and methods: Participants (N = 332) were asked to read a medication description with varying side-effect information based on experimental conditions. They were randomly assigned to a 3 (frame: positive, negative, combined) × 2 (numerical format: percentages, frequencies) between-subjects design. The study assessed risk perception, medication intention, and emotional responses while considering participants' numeracy levels. Materials and data are available at: https://osf.io/83ura.

Results and discussion: Framing and numerical format significantly influenced risk perception and medication intention. Negative framing and frequency-based formats resulted in higher risk perception and lower medication intention. Moreover, numeracy interacted with the numerical format: individuals with lower numeracy showed higher medication intention in the percentage format and reported more negative emotions in the frequency format.

Conclusions: The way information is framed and presented numerically plays a significant role in shaping risk perception and medication intention. Negative framing and frequency formats tend to increase perceived risk and decrease medication intention. Tailoring communication based on numeracy levels could improve medication adherence.

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1. INTRODUCTION

Medication adherence is a critical issue with significant implications for both desired health outcomes and the management of potential side effects. While medical factors are often the primary focus, psychological elements also play a crucial role in adherence. These include the communication of treatment plans, the framing of risks and benefits, and individual differences among patients.

A 2017 National Institute on Drug Abuse NIDA[1] report found that 2,000,000 Americans misused pain relievers annually, with 5,480 new cases daily. Similarly, a 2019 European study[2] reported that 47.9% of individuals used prescribed medications, while 32.5% relied on non-prescribed ones. These figures highlight the widespread use of medications and the challenges of proper adherence. Effective health communication often relies on numerical data – such as percentages related to side effects, dosages, and timing – which require numeracy skills for accurate interpretation. Statistical numeracy – the ability to understand and apply probabilistic and statistical concepts – is a key predictor of better decision making across various domains.[3–6] For example, individuals with higher numeracy demonstrate better comprehension of medical risks[7,8] and, in cases such as diabetes management, achieve improved blood sugar regulation.[9] Despite its importance, numeracy skills vary widely. An OECD report[10] on adult numeracy proficiency revealed that 19% of participants scored below Level 1, indicating difficulty with basic numerical concepts, including medical statistics.

This study aims to replicate and extend an experiment by Peters et al.,[11] which examined how framing and numerical formats influence risk perception in medical contexts. Framing refers to how information is presented, such as emphasizing the proportion of individuals experiencing side effects versus those who do not. Number format pertains to how data is displayed, for example, as percentages or frequencies. Their findings indicated that participants with higher numeracy maintained consistent risk perceptions regardless of number format, while those with lower numeracy exhibited significant variability. However, their research focused solely on risk perception, excluding related constructs such as emotions and medication intentions. Our study aims to fill this important gap.

The role of emotions in health-related decision making has been increasingly recognized. For instance, research[12] has shown that risk perception and emotional factors, such as worry, are significant predictors of intentions toward COVID-19 preventive behaviors. The importance of both emotional and cognitive factors (e.g., risk perception) is well-recognized in the literature on judgment and decision-making, such as in the seminal theoretical model of the risk-as-feelings hypothesis.[13] Similarly, the interplay of emotional and cognitive factors is acknowledged in health behavior research and health communication.[14–17]

For example, Petrova et al.[15] demonstrated the impact of both positive (i.e., assurance, hope, and relief) and negative emotions (i.e., anxiety, fear, and worry) on perceived risks, benefits, and behavioral intentions in health contexts. Their work includes studies on cancer screening (e.g., prostate and breast cancers) and the 2014 Ebola pandemic, illustrating how emotions shape risk perception and health-related intentions.

2. AIM

This study aimed to replicate the work of Peters et al.[11] with a Polish sample. Based on their findings, we formulated two confirmatory hypotheses:

(1) H1: The framing of side-effect information will influence the perceived risk of the medication.
(2) H2: Individuals with lower numeracy will be more influenced by the numerical format (frequency vs. percentage) than those with higher numeracy when evaluating the risk of a drug.

Additionally, we sought to extend the original research by examining emotional responses to medication side effects and assessing participants' intentions to take the medication. We explored whether both framing and numerical format would not only affect risk perception but also shape emotional responses and medication intentions.

3. MATERIAL AND METHODS

Participants (N = 332) were students (M_{age} = 25.7; SD_{age} = 8; 85% females). In the online experiment, participants were randomly assigned to one of six groups following a 3 × 2 factorial design, manipulating framing (negative, positive, combined) and numerical format (frequency, percentage). All participants were instructed to imagine experiencing severe headaches that occasionally caused them to miss work. They were then provided with the following medication information, adapted from Peters et al[11]: 'In a recent large study, the medication significantly reduced the number of headaches experienced by patients. Instead of getting headaches every few months, most people in the study (65% of participants) experienced headaches only once or twice a year. When they did get a headache, it was much milder. The medication comes in the form of a pill taken daily and costs $5 per month. Overall, the medication is very well tolerated.'

Additionally, they were provided with a description of side effects varying depending on the condition (Table 1). After reading this information, participants rated how risky they perceived the medication to be on a 5-point scale (1 – not risky, 5 – extremely risky), their intention to take the medication ('How willing would you be to take this medication in this situation?'; 1 – definitely not, 5 – definitely yes), and the emotions they felt while reading the information using a standardised tool,[15] which includes 6 adjectives representing positive (assured, hopeful, relieved) and negative (anxious, afraid, worried) emotions. Each emotion was rated on a 7-point scale (1 – not at all, 7 – extremely).

Finally, participants completed items measuring individual differences in numeracy[18,19] as well as demographic and control questions.

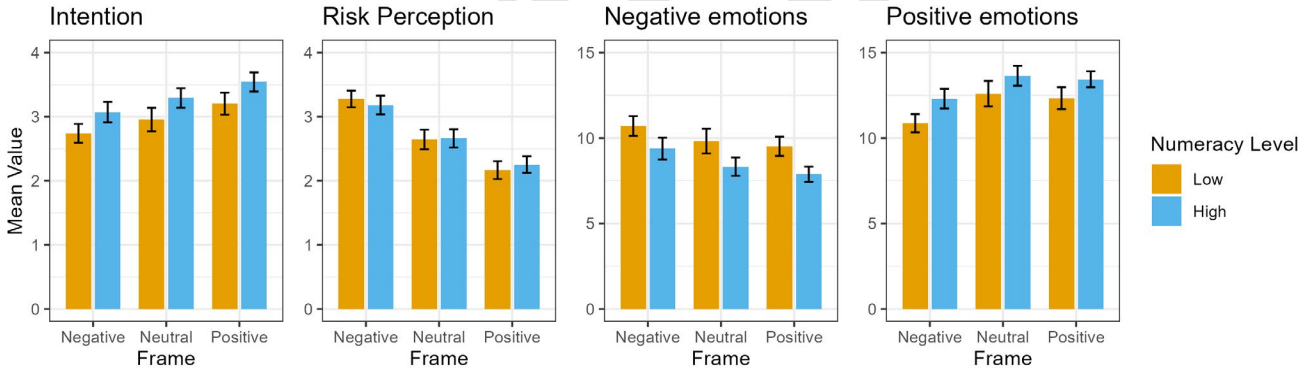
Table 1. The description of side effects in six between-subjects conditions (based on Peters et al.[11]).

Number format	Frequency	Percentage
Percentage	Positive	90% of patients do ***not*** get a bad blistering rash
Percentage	Negative	10% of patients get a bad blistering rash
Percentage	Combined	10% of patients get a bad blistering rash. This means that, of all the patients taking this medication, 10% of patients get the rash and 90% do not
Frequency	Positive	90 out of every 100 patients do ***not*** get a bad blistering rash
Frequency	Negative	10 out of every 100 patients get a bad blistering rash
Frequency	Combined	10 out of every 100 patients get a bad blistering rash. This means that, of 100 patients taking this medication, 10 patients get the rash, and 90 do not

Table 2. The summary of results from the 3 (Frame) × 2 (Format) × 2 (Numeracy) ANOVAs for the 4 dependent variables.

DV	Frame	Format	Numeracy	Frame × Format	Frame × Numeracy	Format × Numeracy	Frame × Format × Numeracy
Risk perception	**F = 26.717; P < 0.001**	**F = 13.097; P < 0.001**	F < .001; P = 0.994	F = 0.451; P = 0.637	F = 0.478; P = 0.621	F = 0.174; P = 0.677	F = 0.359; P = 0.698
Medication intention	**F = 4.805; P = 0.009**	**F = 6.956; P = 0.009**	**F = 6.721; P = 0.010**	F = 1.656; P = 0.193	F = 0.027; P = 0.973	**F = 4.074; P = 0.044**	F = 0.679; P = 0.508
Negative emotions	**F = 3.211; P = 0.042**	F = 1.978; P = 0.161	**F = 9.986; P = 0.002**	F = 0.065; P = 0.937	F = 0.016; P = 0.985	**F = 4.632; P = 0.032**	F = 1.478; P = 0.230
Positive emotions	**F = 4.196; P = 0.016**	F = 0.033; P = 0.856	**F = 6.499; P = 0.011**	F = 0.514; P = 0.599	F = 0.076; P = 0.927	F = 2.630; P = 0.106	F = 0.050; P = 0.951

Figure 1. The effects of frame (negative, combined, positive) and numeracy (low vs. high) were examined across 4 dependent variables: medication intention, risk perception, negative emotions, positive emotions.



4. RESULTS

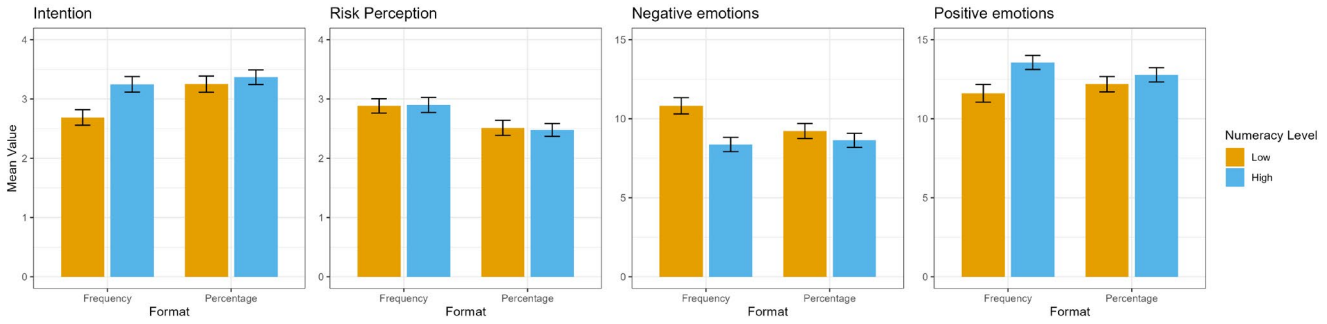
Main analyses were conducted using a 3 (frame: positive, negative, and combined) × 2 (number format: percentages, frequencies) × 2 (numeracy: high numeracy ≥ 7 vs. low numeracy < 7) between-subjects design for the dependent variables: risk perception, medication intention, and emotions (positive and negative). The results are summarized in Table 2, Figures 1 and 2, and supplementary Table S1.

We observed main effects of format and frame on risk perception and medication intention. Information presented in the frequency format (compared to percentages) was perceived as riskier, and participants reported a lower intention to take the medication. Similarly, in the negative frame, the medication was perceived as riskier compared to the combined and positive frames, with a significant difference also observed between the positive and combined frames. However, significant differences in medication intention were only found between the negative and positive frames.

Regarding emotions, significant differences were observed between the negative and neutral frames for positive emotions and between the negative and positive frames for negative emotions.

Significant effects of numeracy were found only in the interaction between numeracy and format on medication intention and negative emotions. For individuals with higher numeracy, the format did not influence responses. However, those with lower numeracy experienced more negative emotions when side-effect information was presented in frequencies rather than percentages, making them less inclined to take the medication. Moreover, in-

Figure 2. The effects of format (percentage vs. frequency) and numeracy (low vs. high) were examined across four dependent variables: medication intention, risk perception, negative emotions, positive emotions.



dividuals with higher numeracy generally reported more positive emotions, fewer negative emotions, and a greater willingness to take the medication.

5. DISCUSSION

This study highlights the significant impact of how medical risk information is framed and formatted on emotional responses and medication decisions. We replicated the effect of framing and formatting on medication risk perception, as seen in previous research by Peters et al.[11] However, we found no support for the interaction between numeracy and format on risk perception. Nevertheless, individuals with lower numeracy experienced heightened negative emotions and reduced medication intentions when exposed to frequency-based side-effect descriptions. This highlights a key target for improving public health communication. Evidence suggests that visual aids can bridge comprehension gaps for those with lower numeracy.[20] Incorporating such tools into standard medical communication could reduce emotional distress and promote more informed health decisions.

Finally, if the goal is to increase medication acceptance, particularly for treatments associated with anxiety-inducing side effects, healthcare providers should avoid negative framing. Presenting risk information in a combined or positive frame may mitigate fear responses while preserving informed consent, and balancing emotional and cognitive aspects of medical decision making.

This study has several limitations. It was conducted online using a student sample and relied on self-reports rather than real patients and their actual behaviors. Future research should replicate these findings using more advanced designs. Despite these limitations, we believe that our results provide valuable insights that may inspire the development of more effective risk communication strategies.

5. CONCLUSIONS

(1) Information presented in frequency format and negative framing increases perceived risk and lowers medication intention.

(2) Individuals with lower numeracy are more emotionally affected by frequency-based information, reducing their willingness to take medication.

Conflict of interest

None declared.

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Ethics

The study received ethical approval from the Ethics Committee at the Faculty of Psychology in Wroclaw, SWPS University (08/P/03/2024).

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ChatGPT was utilized to enhance the manuscript's readability and language.

Data availability

All materials, datasets, and supplementary files are available at https://osf.io/83ura/.

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