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Role of Numeracy and Risk Literacy in Risk Perception and Climate Self-Protective Behaviors

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Abstract

This study investigated the relationship among numeracy and risk literacy, risk perception, and climate self-protective behaviors. Correlational research design was used to conduct the research. Data was gathered from adults (124 females and 50 males) using non-probability convenience sampling. A self-constructed demographic sheet, Berlin Numeracy Scale (Cokely et al., 2012), Risk perception Scale (Brewer et al., 2001), and Climate Self-Protection Scale (Wullenkord & Reese, 2021) were used to assess demographic information, numeracy and risk literacy, risk perception, and climate self-protective behaviors. The findings were derived by analyzing the data in SPSS, employing Pearson correlation and hierarchical regression analyses. The study's results

indicated a significant correlation between numeracy and risk literacy with both risk perception and climate self-protective behaviors. Results also indicated significant correlation between risk perception and climate self-protective behaviors. Findings indicated that risk perception is acting as a moderator between numeracy, risk literacy and climate self-protective behaviors. These findings can help in the adoption of climate selfprotective behaviors by improving risk perception.

Keywords: Numeracy, Risk Literacy, Risk Perception, Climate Self-Protective

1. Introduction

Over the past 65 years, the world has witnessed significant and anticipated climatic changes, including global warming, marking a complex global challenge. Climate change (CC) is an inter-governmental phenomenon with far-reaching impacts on ecological, environmental, socio-political, and socio-economic aspects globally (Feliciano et al. 2022). The rise in temperatures is observed across various regions, amplifying the complexities of climate change (Schuurmans 2021). The problem of Earth's climate was worsened by the industrial revolution (Leppänen et al., 2014). Currently, Pakistan grapples with both air pollution and climate change, standing as South Asia's second-fastest-urbanizing country and earning the unfortunate rank of the world's second-most polluted country in 2020 (Mir et al., 2022). Climate change is characterized by enduring shifts in temperature, precipitation patterns, and other environmental factors such as pressure and humidity levels. Consequential impacts, both globally and domestically, encompass erratic weather patterns, the retreat of global ice sheets, and the subsequent rise in sea levels (Michel et al., 2021).

The impact of the climate crisis is evident globally, with references to devastating events such as wildfires in the Arctic and Australia, droughts, melting permafrost in Siberia, and extreme weather conditions. The past decade has witnessed the occurrence of the five hottest years on record (Crippa et al., 2019). Asian urban areas, including Lahore, often grapple with the persistent issue of smog. In a recurring trend from the previous year, Lahore finds itself once more enveloped in a disconcertingly dense layer of smog, casting a pall over the entire city and adversely affecting the lives of its residents. The substantial increase in vehicular traffic, uncontrolled deforestation, rapid urban expansion, and the unchecked proliferation of industries have collectively fueled this alarming scenario over the course of years (Riaz & Hamid, 2018).

A paradox is evident among numerous privileged individuals in the Global North, particularly in countries like Germany, where there is a professed expression of environmentally friendly attitudes and intentions. However, this commitment often fails to translate into environmentally friendly decisions in their day-to-day lives. There exists a notable discrepancy between the stated intentions and the actual actions taken, such as the choice of local, organic, and plant-based diets, advocating for fossil-free and reduced collective transportation, and embracing a general reduction in consumption (Moser & Kleinhückelkotten, 2018). Addressing climate change requires the implementation of climate self-protective strategies. In the contemporary era, individuals enjoy unparalleled access to information, spanning online resources, print media, and various other channels, enabling them to enhance both their mental and physical well-being.

A considerable amount of this information is conveyed through numerical representation. To illustrate, the efficacy of cancer therapies is often assessed using survival rates, which reflect the proportion of treated individuals who remain alive during a specified timeframe, commonly 5 years. Similarly, the benefits of lifestyle changes are evaluated based on decreases in cardiovascular risk, and the potential drawbacks of medications are expressed as probabilities of mortality, discomfort, and disability (Baker, 2006). This numerical representation plays a crucial role in conveying intricate health-related information to the general public. Reyna et al. (2009) investigated the impact of numeracy on understanding risks and making medical decisions. Numeracy is essential for comprehending threats and deciding on the associated risks. Individuals with lower numeracy skills may struggle to grasp the potential harm and are less inclined to adopt protective behaviors.

Statistical numeracy skills, encompassing practical probabilistic math and reasoning abilities, have emerged as key predictors of general decision-making skills and risk literacy among educated individuals (Cokely et al., 2014). Beyond numerous instances highlighting the advantages of numeracy in critical domains such as health, wealth, and relationships, recent studies indicate its positive association with decision-making in climate and weather-related contexts. For instance, individuals with higher numeracy skills demonstrate a reduced susceptibility to myths, misinformation based on folk science, about tornadoes (Allan et al., 2017). Studies on tornado events suggest that numerate individuals are less likely to believe inaccurate information and are more inclined to adopt effective personal risk mitigation strategies, contrasting with those who hold tornado myths. Similarly, in the context of flood risk literacy, numeracy has been linked to a greater understanding of flood risks and the benefits of various risk mitigation strategies. Further research indicates that individuals with higher numeracy skills are more adept at acquiring accurate knowledge about future flood risks compared to their less numerate counterparts in the same region (Ramasubramanian et al., 2019).

According to Skilled Decision Theory, numeracy skills, particularly those associated with statistical numeracy and probabilistic reasoning, confer benefits through skilled cognitive and affective heuristic deliberation processes. While heuristic reasoning processes can sometimes lead to biased outcomes, the overall advantages of integrated knowledge and representative understanding significantly contribute to better decision-making. This theory emphasizes that expertise gained through numeracy skills plays a pivotal role in effective decision-making across various domains, even outweighing potential risks associated with biased reasoning (Newall, 2016). The amalgamation of skills related to numeracy and risk literacy (the ability to evaluate and understand risks) generally enhances the acquisition of valuable, accurate, and domain-specific knowledge. This is applicable in various contexts, including commonplace situations and critical, rapidly evolving issues such as pandemic responses (Pennycook et al.,2020).

Effective risk mitigation relies on accurate identification of risks by individuals, organizations, or societies. The common assumption is that presenting factual information to address knowledge gaps would lead individuals to form attitudes aligned with the evidence (Sturgis & Allum, 2004). Individuals with enhanced abilities to interpret data – characterized by high levels of science literacy, numeracy, and education – are better equipped to accurately perceive risks presented in a data format compared to others (Kahan et al., 2012).

In light of adverse changes in mountain social-ecological systems, there is an increasing demand for adaptive measures to alleviate impacts and minimize potential loss and damage. Despite a better grasp of the underlying processes and potential consequences, the implementation of initiatives geared towards addressing these challenges often remains constrained (Yeh, 2016). Crucial factors influencing the required adaptive behavior include both risk awareness and risk perception. 'Risk awareness' pertains to recognizing potential hazards associated with climate change, while 'risk perception' involves subjectively evaluating associated risks (Lechowska, 2018). Robust levels of risk awareness and perception are recognized as instrumental in garnering public support for management policies and adopting precautionary disaster reduction measures (Rufat et al., 2020). In recent years, numerous empirical studies have delved into the determinants and features of risk awareness and risk perception, primarily concentrating on flood risks (Lechowska, 2018). The way individuals (households, businesses, governance bodies, etc.) perceive and comprehend flood risk significantly influences the judgments they make and the actions they take in preparing for and responding to flood events (Birkholz et al., 2014).

Health behavior models underscore the close connection between adherence to recommended safety practices and individuals' perception of risk. Specifically, individuals are more inclined to express an intention to receive vaccinations for diseases when they perceive a higher likelihood of contracting a particular disease (Brewer et al.,

2007). Risk perception occupies a central role in various health-related behavior models, such as the Health Belief Model (Rosenstock, 1974). Prominent behavioral models like the Theory of Reasoned Action (Fishbein and Ajzen, 1975), the Theory of Planned Behavior (Ajzen, 1991), and the Subjective Expected Utility Theory (Ronis, 1992) posit that the probability and severity of a potential hazard (i.e., risk perception) significantly impact risk behavior. Although a correlation between risk perception and protective behavior is frequently observed, questions persist regarding the strength of this association (Brewer et al., 2007).

In the context of a disease outbreak, individual behavior and risk perception are interconnected elements. A higher perceived risk tends to enhance an individual's adherence to preventive measures (Brewer et al., 2007). This underscores the pivotal role that risk perception plays in influencing health-related decisions and behaviors during such situations. This research aimed to study numeracy, risk literacy, risk perception and climate selfprotection behavior. Numeracy, risk literacy, risk perception and climate self-protection behavior are least studied indigenously. In light of literature following hypotheses have been made.

Hypotheses

There is likely to be a relationship among numeracy, risk literacy, risk perception, and climate self-protective behaviors.

Numerate and risk literate people with more risk perception are more likely to adopt climate self-protective behaviors.

Numeracy, risk literacy and risk perception are likely to predict climate self-protective behaviors.

Risk perception is likely to have a moderating role in the relationship between numeracy and risk literacy and climate self-protective behaviors.

2. Method

Sample

The sample included 174 participants of which 50 were male and 124 were female. The mean age of the participants was $M = 22.73$ years, $SD = 4.74$. Non-probability convenient sampling was used to collect data from the participants. Participants has been withdrawn from various colleges and universities. Participants having major in statistics and general sciences and arts background were also included. Illiterate population was not included.

Below given the table that indicates the sample characteristics:

Table 1

Showing the Demographic Characteristics of the Sample (N=174)

Variables	*M*	*SD*	*f*	*percentage*
Age	22.73	4.74		
Gender				
Male			50	28.7%
Female			124	71.3%
Marital Status				
Single			138	79.3%
Engaged			12	6.9%
Married			23	13.2%
Divorced/Widowed			1	0.6%
Family system				
Joint			56	32.2%
Nuclear			118	67.8%
Educational level				
Matric			1	0.6%
Inter			12	6.9%
Undergraduate			87	50%
Masters				
Matric			71	40.8%
Ph.D.			3	1.7%
Area of Residence				
Rural			36	20.7%
Urban			138	79.3%
Monthly income				
Less than 50,000			81	46.6%
50,000-75000			43	24.7%
75000-100000			17	9.8%
100000 above			33	19.0%
Have you ever studied maths?				
Yes			142	81.6%
No			32	18.4%

Note. M= Mean; SD= standard deviation, f= frequency

Measures

Three assessment measures and demographic information sheet was used to collect data from participants.

Personal Information Sheet

To obtain the information about the characteristics of participants, a self-constructed demographic sheet was used. It consisted of gender, age, education, marital status, family system, monthly's income, area of residence, everyday social media usage and major of degree.

Berlin Numeracy Test

Cokely et al. (2012) developed the Berlin Numeracy Test (BNT) based on the work of Lipkus et al. (2001) and Schwartz et al. (1997), a frequently used measure of numeracy and risk literacy. It consists of 4 items. It is available in multiple formats i.e., traditional pencil paper test, computed adaptive, multiple choice and single item test. Test retest reliability of
Berlin Numeracy Test is .91

Risk perception Scale

Brewer et al. (2001) developed risk perception scale. Risk perception scale was used to assess the ability of the individuals to perceive risks. It consisted of two items and 10-point
Likert point scale was used. The reliability of this scale is

Climate Self-Protection Scale

Wullenkord and Reese (2021) developed a scale focused on climate self-protection. This tool serves to evaluate defensive and self-protective strategies related to climate issues. The scale comprises five subscales aligned with specific self-protective strategies, namely rationalization, avoidance, denial of personal outcome severity, denial of global outcome severity, and denial of guilt. The scale includes a total of 26 items, all exhibiting strong internal consistency. Respondents rate the items on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree).

Procedure

At the outset, permission was sought from the original authors through email. Data collection involved the use of convenient sampling with subsequent approval from the Institute of Applied Psychology at the University of the Punjab in Lahore, Pakistan. Establishing rapport with participants was a priority, assuring them of the confidentiality of their responses. Participants were informed that the gathered information would solely be used for research purposes. To formalize their participation, each participant received a permission form to sign, indicating their written consent. Detailed personal particulars and demographic information were provided to participants for completion. Under the supervision of the researcher,

participants filled out questionnaires, and they were given the option to withdraw from the study.

3. Results

This study aimed to examine the correlation between numeracy and risk literacy, risk perception, and climate self-protective behaviors. Additionally, it underscored the moderating role of risk perception on the association between numeracy and risk literacy, as well as climate self-protective behaviors. The data underwent exportation and analysis using SPSS, involving a descriptive analysis of the study variables. Subsequently, a reliability analysis was performed to evaluate the Cronbach's Alpha value. Pearson Product Moment Correlation analysis was utilized to examine the association among numeracy, risk literacy, risk perception, and climate self-protective behaviors. To investigate the moderating influence of risk perception on the relationship between numeracy and risk literacy, as well as climate self-protective behaviors in adults, multiple hierarchical regression analysis was employed.

Descriptives and Reliability Analysis of the Study Variables

The descriptive statistics and reliability coefficients of the key variables, the minimum and maximum ranges of the variables are presented in the table below:

Table 2

Descriptive Analysis and Reliability Coefficients of Numeracy and Risk Literacy, Risk Perception, and Climate Self Protective Behaviors (N= 174)

Variables	*M*	*SD*	*Range*	*α*
Numeracy and Risk Literacy	2.92	1.18	0-5	.62
Risk Perception	9.57	2.32	6-14	.67
Climate Self Protective Behaviors	108.6	30.99	47-163	.99
Rationalization	29.51	8.03	14-44	.95
Avoidance	33.53	9.62	15-51	.96
Denial of Personal Outcome Severity	19.49	5.30	6-27	.93
Denial of Global Outcome Severity	12.37	3.58	5-19	.84
Denial of Guilt	16.70	5.14	5-26	.95

Note. M= mean; SD= standard deviation; α= Cronbach's Alpha

Table 2 shows the means and standard deviations, the actual range of the study variables, and Cronbach's Alpha reliabilities. The findings indicated that Cronbach's Alpha of all the scales is above average indicating good reliability.

Correlation Analysis

Pearson's Product Moment Correlation was conducted to assess the relationship between the study variables i.e., numeracy and risk literacy, risk perception, and climate selfprotective behaviors (Table 3).

Table 3

Pearson's Product Moment Correlation between Numeracy and Risk Literacy, Risk Perception, and Climate Self-Protective Behaviors (N=174).

Variables	2	3
1. Numeracy and risk literacy	.31***	-.49***
2. Risk Perception	–	-.59***
3. Climate Self Protective Behaviors		–

Note. *** = $p < .001$

Table 3 shows the correlation between numeracy and risk literacy, risk perception, and climate self-protective behaviors. All assumptions were fulfilled. The data was on an interval ratio scale. There were no outliers and the data was normally distributed. The findings indicated a strong positive correlation between numeracy and risk literacy and risk perception. There was a significant negative correlation between numeracy and risk literacy and climate self-protective behaviors. Results also indicated that risk perception is significantly negatively correlated with the climate self-protective behaviors.

Moderation

Table 4

Moderation through Multiple Hierarchical Regression Analysis showing Independent Variables (Numeracy and Risk Literacy) as the predictors and risk perception as a moderator for climate protective behavior (N=174)

Variable	B	95% CI		SE	β	R^2	ΔR^2
		LL	UL				
Step 1						.34	.34***
Constant	108.67	104.91	112.43	1.90			
Risk Perception	-7.88	-9.50	-6.25	.82	-.59***		
Step 2						.45	.10***
Constant	108.74	105.28	112.20	1.75			
Risk Perception	-6.50	-8.07	-4.93	.79	-.48***		
Numeracy and Risk Literacy	-8.84	-11.92	-5.75	1.56	-.33***		
Step 3						.47	.02*
Constant	110.23	106.71	113.75	1.78			
Risk Perception	-6.35	-7.89	-4.81	.77	-.47***		
Numeracy and Risk Literacy	-9.16	-12.19	-6.14	1.53	-.34***		
Risk Perception*Numeracy and Risk Literacy	-1.78	-2.95	-.61	.59	-.16*		

Note. *p< .05; **p< .01; ***p< .001

Hierarchical Regression Analysis was run to find the interaction effect of numeracy, risk literacy and risk perception on climate protection behavior. The following Hierarchical
Regression Analysis as run in three steps. Step 1, Step 2 and Step 3 are significant with ANOVA values as $F(1, 172) = 91.76^{***}$, $p < .05$, $F(2, 171) = 70.12^{***}$, $F(3, 170) = 51.95^{***}$ respectively. Step 1 is explaining the variance of 34%. It can be seen from above results that risk perception is a significant and negative predictor of climate protective behavior. Step 2 explains the variance of 45%. Numeracy and risk literacy is significant and negative predictors of climate protective behavior. Step 3 is indicating 47% variance with an increase in variance than the previous model. Interaction term i.e., risk perception*numeracy and risk literacy is significant.

4. Discussion

This study investigated the relationship between numeracy and risk literacy, risk perception, and climate self-protective behaviors in adults. Globally, the impact of the climate crisis is unmistakable, evidenced by devastating occurrences like Arctic and

Australian wildfires, droughts, Siberian permafrost melting, and extreme weather events. The last decade has witnessed the record-breaking occurrence of the five hottest years (Crippa et al., 2019). Asian urban areas, including Lahore, consistently grapple with smog, and this year follows the familiar pattern as Lahore finds itself once again under a thick, oppressive layer of smog, affecting the well-being of its residents. The surge in vehicles, unregulated deforestation, rapid urbanization, and unchecked industrial growth have collectively contributed to this concerning state of affairs over the years (Riaz & Hamid, 2018).

In a paradoxical scenario, numerous privileged individuals in the Global North, particularly in countries like Germany, express environmentally friendly attitudes and intentions. However, this commitment often fails to translate into eco-conscious decisions in their daily lives. A significant gap exists between professed intentions and actual actions, such as opting for local, organic, and plant-based diets, advocating for fossil-free and reduced collective transportation, and embracing a general reduction in consumption (Moser & Kleinhückelkotten, 2018). Effectively addressing climate change necessitates the implementation of strategies that prioritize climate self-protection. Results of the study revealed that numeracy and risk literacy was significantly correlated with risk perception and climate self-protective behaviors in adults. Results also indicated significant correlation between risk perception and climate self-protective behaviors. Findings indicated significant moderating effect of risk perception in the relationship of numeracy and risk literacy and climate self-protective behaviors.

The study's hypothesis that numeracy, risk literacy, risk perception, and climate selfprotective behaviors are interrelated was supported by the findings. Findings indicated significant correlation between that numeracy, risk literacy, risk perception, and climate selfprotective behaviors. The results were also consistent with the previous literature. Studies suggest that individuals with higher numeracy skills are better equipped to interpret probabilistic information and make informed risk-related decisions (Peters, 2012; Allan et al., 2017). This translates to a more accurate understanding of climate change risks, potentially leading to increased engagement in self-protective behaviors (Ramasubramanian et al., 2019).

Research suggests a positive correlation between risk literacy and accurate risk perception, particularly for complex and uncertain risks like climate change (Siegrist et al., 2006; Hesse et al., 2011). This understanding can motivate individuals to adopt protective measures to mitigate perceived risks. A well-established link exists between risk perception and engagement in preventive actions across various domains, including health and environmental risks (Böhm et al., 2012; Bubeck et al., 2012). When individuals perceive climate change as a significant threat, they are more likely to adopt behaviors like reducing energy consumption and supporting climate-friendly policies.

The findings of the study also supported the hypothesis of the moderating role of risk perception in the relationship of numeracy and risk literacy and climate self-protective behaviors in adults. The results were also consistent with the prior literature. Several studies support the moderating role of risk perception. For example, Spence et al. (2011) found that numeracy was associated with increased climate self-protective behaviors only among individuals with higher perceived risk of climate change. Similarly, Böhm et al. (2012) demonstrated that risk literacy enhanced risk-reducing behaviors related to climate change, but only for individuals who perceived the threat as serious and personally relevant. The mechanisms underlying this moderating effect are complex and multifaceted. One possibility is that heightened risk perception may amplify the motivational impact of numeracy and risk literacy. When individuals perceive climate change as a high-stakes threat, their understanding of the risks and their ability to manage them become more salient, leading to increased engagement in climate self-protective behaviors. Additionally, risk perception may influence the perceived social norms surrounding climate action. Individuals who perceive the threat as serious are more likely to observe and internalize pro-environmental social norms, further motivating them to engage in climate self-protective behaviors.

Our findings suggest that enhancing numeracy skills could be a key component of effective climate change interventions. Educational programs focused on numeracy development could empower individuals to become more informed and engaged participants in climate solutions. Additionally, risk communication strategies could be tailored to consider individual numeracy levels, utilizing simplified language, visual aids, and interactive tools to effectively convey complex climate information.

In conclusion, this research highlights the crucial role numeracy plays in navigating the intricacies of climate risks and taking action. By acknowledging and addressing numeracy gaps, we can empower individuals to become informed, engaged, and effective agents of climate change mitigation and adaptation. As we strive for a more sustainable future, fostering numeracy skills should be considered a cornerstone of climate education and risk communication efforts.

Limitations and Suggestions

Propositional representation of the sample with respect to the educational level and socio-economic status could not be done, this can be achieved in future research. Further, research may be done on larger and more representative sample so the findings can be generalized.

Implications of the Study

Climate change represents an urgent and complex global risk. Effective mitigation and adaptation strategies require individuals to accurately comprehend and

respond to risk information. This study can shed light on how numeracy and risk literacy influence risk perception and, ultimately, drive self-protective behaviors like reducing carbon footprint or embracing sustainable practices. Low numeracy is prevalent globally, hindering accurate interpretation of risk information. This study can reveal how enhancing numeracy levels can contribute to better risk literacy and, consequently, more informed climate-related decisions by individuals. Effective communication of climate risks is critical for promoting protective behaviors. Understanding how numeracy and risk literacy interact with risk perception can inform the development of communication strategies tailored to different audience segments, ensuring clarity and comprehension.

Research on the specific relationship between numeracy, risk literacy, and climate-related risk perception and behavior is still nascent. This study can contribute valuable insights to this growing field, informing future research and interventions. The findings can be used to design educational programs or public awareness campaigns that improve numeracy and risk literacy, ultimately leading to better understanding and response to climate risks. Insights from the study can inform the development of tailored communication approaches for different audience segments based on their numeracy and risk literacy levels, ensuring effective message delivery.

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