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The acceptability of the risk of death in the treatment of respiratory diseases in France

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Abstract

Background The costs associated with respiratory illnesses in the French healthcare budget continue to rise. However, pharmaceutical companies and research centres are continuously developing new treatments. Consequently, accepting these treatments, which necessitates the acceptance of the mortality risk associated with their use, represents a significant economic and public health issue. Our study aims to assess this acceptance.

Methods The data were obtained from an online questionnaire completed by 315 respondents located in France during June and July 2019. The standard gamble method was employed to ascertain the acceptability of risk. This method quantifies the 'disutility' of a health state by evaluating the extent to which an individual is willing to accept a specific mortality risk in exchange for avoiding the state.

Results The study demonstrated that individuals, irrespective of their personal characteristics, were willing to accept a treatment with an average mortality risk of less than 19%. The findings revealed discrepancies between individuals' perceptions of mortality and actual risks.

Conclusions In France, it is incumbent upon public decision-makers and research centres to ensure that treatment-related mortality rates remain below 19% so that patients readily accept treatment, irrespective of their personal characteristics. In addition, they should provide further information on the risks associated with treating respiratory diseases to avoid a discrepancy between the mortality risks perceived by individuals and the actual risks.

Keywords Ambiguity aversion, Mortality risk, Respiratory disease, Risk acceptability, Standard gamble method

JEL Classification: C83, D81, I18.

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Introduction

Chronic respiratory diseases impact the airways and various components of the lungs. Common diseases in this category include asthma, chronic obstructive pulmonary disease, lung cancer, cystic fibrosis, sleep apnoea, and occupational lung diseases. According to the French Society of Pneumology, approximately 10 million people of all ages in France suffer from respiratory diseases. These diseases result in an annual cost of 3.51 billion euros to health insurance[1]. It is imperative to address these diseases as they pose an economic and public health challenge.

Research is contributing to the development of highly effective treatments for respiratory diseases. The latest breakthrough in this field is the discovery of biotherapy, a more personalised approach that minimises the use of corticosteroids. Corticosteroids can lead to weight gain, diabetes, skin complications, mood swings, bone loss, and an increased risk of infection. The emergence of biotherapies is a revolutionary development in the healthcare sector. The French Ministry of Higher Education and Research reports that the pharmaceutical market was worth almost 200 billion euros in 2019, accounting for 24.3% of the global market. It is expected to grow by 8% to 9% annually, reaching 320 billion euros by 2025. However, the National Agency for the Safety of Medicines and Health Products (ANSM) took almost 15 years to approve the treatment. This has led to significant investment in the pharmaceutical industry and public research centres, with no return guarantee. The primary objective of medicines is to provide therapeutic benefits to patients by curing or alleviating symptoms. Therefore, patients need to understand and accept the risks involved in the treatment. Otherwise, an offer without demand can waste time and money. For instance, many people hesitate to take the COVID-19 or lupus vaccines. In this study, we estimated the threshold of acceptability for the risk of death among patients receiving treatment for respiratory diseases in France. We also analysed the individual factors that influence this threshold. Finally, we investigated the preferences of individuals to gain a better understanding of their risk perception.

Our research contributes to the existing literature on risk acceptability assessment. Risk acceptability refers to acknowledging a potential risk without taking steps to reduce it [49]. In the context of health, this risk can lead to death. Economists commonly use the standard gamble (SG) and time trade-off methods to determine health utilities. The standard gamble method measures the 'disutility' of a health state by assessing the extent to which an individual is willing to accept a particular mortality risk in exchange for avoiding the state [43]. However, the time trade-off technique reflects the life expectancy that an individual would sacrifice to avoid a suboptimal health state. This technique is commonly used in health economics to evaluate an individual's quality of life. The individual is presented with a hypothetical scenario: *Imagine you have T years to live. You can choose to live those T years in your current state of health, or you can choose to give up some years of life to live a shorter period in good health. Place a cross on the line to indicate the number of years in good health that you think is equivalent to T years in your current state of health.* Several studies have analysed two health state assessment techniques [4, 33, 34]. This research aims to investigate individual treatment preferences for respiratory diseases by estimating the level of mortality risk acceptability. This study aims to provide objective insights into the maximum degree to which individuals are willing to accept treatment rather than time. We use the SG method to determine risk acceptability, the most appropriate method for our problem. This method has been commonly used in genetic engineering [37, 46] and HIV treatment [18, 31]. However, no research has been conducted on risk acceptance for treating respiratory diseases. As these diseases are prevalent worldwide, there is an urgent need to develop effective treatments. Our estimate of the risk-mortality acceptance threshold is 18.85%. This criterion indicates the need for effective survival outcomes from a treatment. In other words, a treatment is considered acceptable if the survival risk is at least 81.15%. This benchmark can serve as a validation standard for developing and commercialising treatments by research institutions and public decision-makers when selecting funding for health programmes.

This paper also contributes to the literature on individual characteristics and their association with risk acceptance. According to existing literature, personal factors such as age, gender, and education level are crucial in shaping an individual's risk perception [25, 39, 46] . For instance, Jungermann and Slovic's [26] study found that young, poorly educated males were likelier to engage in risky behaviour. Rohrmann [42] and Siegrist et al. [47] investigated factors that affect an individual's level of risk acceptance, including personal beliefs and biases, social norms, cultural values, economic and political conditions, and recent experiences. Our research indicates that the threshold for acceptable mortality risk remains consistent across all individual characteristics, including health status (current health and medical history), personal characteristics (age, gender, income, and occupation), and behavioural characteristics (annual health check, current smoker, risk aversion). Therefore, treatment development can be streamlined as there is no need to tailor treatment to the risk of death.

[1] For more information, please refer to Assurance Maladie [35].

Table 1 The ten-paired lottery-choice decisions under risk and the risk aversion classifications based on lottery choices

Decision	Lottery A				Lottery B			
	Chance to win	Gains	Chance to win	Gains	Chance to win	Gains	Chance to win	Gains
1	10%	7 €	90%	5 €	10%	13 €	90%	0 €
2	20%	7 €	80%	5 €	20%	13 €	80%	0 €
3	30%	7 €	70%	5 €	30%	13 €	70%	0 €
4	40%	7 €	60%	5 €	40%	13 €	60%	0 €
5	50%	7 €	50%	5 €	50%	13 €	50%	0 €
6	60%	7 €	40%	5 €	60%	13 €	40%	0 €
7	70%	7 €	30%	5 €	70%	13 €	30%	0 €
8	80%	7 €	20%	5 €	80%	13 €	20%	0 €
9	90%	7 €	10%	5 €	90%	13 €	10%	0 €
10	100%	7 €	0%	5 €	100%	13 €	0%	0 €

Number of Safe Choices	Range of Relative Risk Aversion for $U(x) = \frac{x^{1-r}}{1-r}$	Risk preference classification
0-1	r < -0.95	*highly risk-loving*
2	-0.95 < r < -0.49	*very risk-loving*
3	-0.49 < r < -0.15	*risk-loving*
4	-0.15 < r < 0.15	*risk-neutral*
5	0.15 < r < 0.41	*slightly risk averse*
6	0.41 < r < 0.68	*risk averse*
7	0.68 < r < 0.97	*very risk averse*
8	0.97 < r < 1.37	*highly risk averse*
9-10	1.37 < r	*stay in bed*

Finally, this study presents evidence of individual preferences when dealing with health risks. Health economists have not agreed on the individual preferences that best align with observed behaviour[2]. Theoretical models, such as Rey and Rochet [41], have concentrated on the relationship between health and wealth in individual utility functions. Previous research has investigated individual preferences, specifically regarding vaccine acceptance [3, 22, 36]. Our findings add to this literature by showing that individuals' preferences do not align with those proposed in the conventional expected utility theory of risk economics, which assumes that individuals consider objective probabilities related to risk. In this study, participants did not solely consider probabilities but instead associated them with weights that varied from the actual values. As a result, the rank-dependent utility theory, which accounts for the subjective transformation of objective probabilities, was confirmed. Therefore, participants' decisions were driven by perceived risk rather than rationality or objective risk. Accounting for this perceptual bias presents a major challenge in the health field. An unintentional distortion of reality in risk perception can seriously affect individual health. It may lead to a reluctance to seek treatment, resulting in a refusal to seek medical attention, and ultimately to disability or, in the worst case, death.

The paper is structured as follows: "Introduction" section describes the standard game method and the survey. "Methodology" section presents the assessment results of acceptable mortality risk in treating respiratory diseases, the impact of individual factors on the threshold of acceptable mortality risk, and the construction of individual preferences when faced with mortality risk. "Results" section discusses the significance and contribution of our results to health programme decisions. The paper concludes in "Discussion" section.

[2] For more information on the health belief model, please refer to Evans [17].

Methodology

Survey instrument

No data is available regarding individual acceptance of the risk of death during respiratory disease treatment. Therefore, we conducted a questionnaire to assess this.

The questionnaire started with questions about personal health, including health history: (1) *Have you ever received a medical diagnosis related to respiratory diseases, such as asthma, chronic cough, chronic bronchitis, or lung cancer? Please answer with a simple Yes or No.* (2) *Do you smoke tobacco? Please answer with a simple Yes or No.* (3) *Do you have an annual check-up with your doctor to monitor your health? Please answer with a simple Yes or No.*

Risk aversion is then evaluated. We used the method described by Holt and Laury [24]. Participants were presented with a choice between Lottery A and Lottery B, as shown in Table 1. Lottery A is less risky than Lottery B because it has less payout variation. The game was repeated ten times. Individuals who chose the less risky option more than four times were considered risk averse.

We then elicited the threshold for risk acceptance. We used the SG method which is described as follows. Respondents are presented with two options: In option A, the individual will undoubtedly experience a particular health condition for the rest of their life. In option B, there is a high-risk treatment with two possible outcomes: life in excellent health with a probability of p or immediate death with a probability of $1-p$. The outcomes are presented as sets (Q, T), where Q represents the state of health, and T represents the duration in years. Q_1 represents full health, Q_2 represents permanent health, and Q_3 represents death. A von Neumann-Morgenstern utility function, $U(Q, T)$, is used to describe the utility perceived by the person of being in a given health state Q from the present and for a given period of T years, followed by death. A common assumption is that $U(Q,T) = H(Q)G(T)$, where H and G are utility functions for health state and duration, respectively.

The aim of using the SG method is to determine the probability of optimal health, p, at which the respondent is unprejudiced between options A and B, i.e. the point at which both options appear equally tempting. Specifically, the standard gamble asks for the probability p that leads to a lack of interest in the outcome (Q_2, T) and the lottery $((Q_1, T), p; (Q_3, 0), 1-p)$, where $(Q_1, T) \succeq (Q_2, T) \succeq (Q_3, 0)$. The equality is expressed mathematically as:

$$\begin{gathered} p \times U(Q_1) + (1-p) \times U(Q_3) = U(Q_2) \\ \Longleftrightarrow \\ p \times H(Q_1)G(T) + (1-p) \times H(Q_3)G(0) = H(Q_2)G(T). \end{gathered} \tag{1}$$

After identifying the indifference point, the health valuation for a specific health question of interest is denoted as p. This conclusion is based on assigning the utility of optimal health to 1 and death to 0, i.e. $H(Q_1) = 1$ and $H(Q_3) = 0$. By using Eq. (1), we can calculate $p = H(Q_2)$, which represents the preference value of living in a health state Q_2 for T years. Therefore, $1 - p$ indicates the threshold for accepting the risk of mortality.

In our study to apply the SG method, we developed a hypothetical scenario based on the work of Bosch et al. [6]: *"You are 60 years old and suffer from a respiratory disease. It causes shortness of breath and swollen legs that make walking around the neighbourhood difficult. Your cough also makes it hard for you to eat and sleep. However, your eyesight, hearing and memory are comparable to other people your age, and you generally feel happy. Suppose there is a treatment that could improve your health to that of a healthy 60-year-old, but it carries the risk of immediate death: You have a τ% chance of dying if you have the treatment, which also means that you have a $(100-\tau)$% chance of living a healthy life because of the treatment. Even if you decide not to have the treatment, your health will remain as initially described."* We defined the probability of mortality and survival to avoid anchoring bias, which occurs when individuals over-rely on pre-existing information or initial data when making decisions. Kahneman and Tversky [27, 28] found that when the outcome of surgery or radiotherapy was presented as a 68% chance of survival, 44% of participants accepted it. However, only 18% accepted the same outcome expressed as a 32% chance of death, which is mathematically equivalent.

Next, we used dichotomous choice contingent valuation methods and open-ended questions to determine the acceptability threshold for mortality risk, allowing participants to understand better and provide more accurate responses. Specifically, we initiated the single-bounded dichotomous choice method[3]: Participants were asked whether they would consent to treatment. For participants who responded in the affirmative, the presumed acceptable mortality risk was equal to or greater than τ%. Conversely, for those who said no, the acceptable risk of death is less than τ%. For those who agreed to treatment, the upper limit is 100%, while for those who refused treatment, the lower limit is 0%. We then asked an open-ended question. Participants were asked to indicate how much risk of death they would be willing to accept for the treatment. If they agreed to the treatment, their acceptable level of mortality risk had to be greater than or equal to τ%, or less than τ% if they did not agree.

To examine the sensitivity of the level of mortality risk, we examined three mortality risk values, namely 10%, 20% and 40%. Thus, $\tau \in \{10, 20, 40\}$ allows us to avoid anchoring bias.

Prior to requesting demographic information from respondents, such as gender, age, income, and occupational groups, we first asked them to confirm their comprehension of the questionnaire. This was done to prevent any bias from uninformed responses due to a lack of understanding of the questions.

Survey implementation and sampling

Panelabs[4], a French company specializing in panels, conducted the online questionnaire. Prior to its digital publication, it was tested on a pilot group. In June and July 2019, 322 French citizens completed the questionnaire. Seven respondents requested assistance understanding the questionnaire. They were excluded from the study. The study then focused on the remaining 315 respondents.

Table 2 presents the socioeconomic characteristics of the panel. To assess the sample's representativeness of the French population, we compared age, gender, income, and occupational groups with the 2016 INSEE data.

A chi-squared test was used to compare the proportions in the two groups. The null hypothesis was that there were no significant differences between the proportions. As all p-values were greater than 5%, Table 2 shows that our data and the INSEE 2016 data were similar. Therefore, our sample can represent the French population regarding gender, age, income, and occupational groups.

Respondents were randomly assigned an initial mortality risk value to test for order and size effects, i.e. $\tau \in \{10, 20, 40\}$. This resulted in three subsamples: Sub-sample 1 at $\tau = 10$ (106 respondents), Sub-sample 2 at $\tau = 20$ (108 respondents) and Sub-sample 3 at $\tau = 40$ (101 respondents).

[3] This technique is increasingly used in health care [8, 9].

[4] For more details see: https://en.panelabs.com/

Table 2 Socioeconomic variables and comparison between the panel and INSEE 2016 data. 315 Respondents

Description	Survey		INSEE 2016		Chi² test (p-value)
	Number of respondents	Percentage of respondents	Number of respondents	Percentage of respondents	
Age					
18-24	92	29.2	95	30	
25-59	147	46.7	141	44.8	0.797
60 or more	76	24.1	79	25.2	
Gender					
Female	168	53.3	163	51.6	0.539
Male	147	46.7	152	48.4	
Income					
Less than 1000€	34	10.8	38	11.9	
1000€-1499€	63	20	64	20.4	
1500€-2499€	62	19.7	64	20.4	0.917
2500€-4499€	104	33	102	32.3	
4500€ and more	52	16.5	47	15	
Professional groups					
Farmer and Craftsman	13	4.1	13	4.2	
Self-employed and executive	84	26.7	81	25.7	0.604
Employee and worker	94	29.8	81	25.6	
Retired person, unemployed person, and homemaker	124	39.4	140	44.5	

Results

Stated mortality risk acceptability

The panel estimate indicates that the mean acceptability threshold for mortality risk in respiratory care in France is 18.85% (median: 10%; standard error: 21.24). Only two studies have assessed the acceptability of the risk of death from respiratory disease. Viscusi et al. [50] found that the average risk acceptance threshold in the United States was approximately 30%. Hammitt and Zhou [21] reported a mortality risk acceptability threshold for pollution-related health hazards in China ranging from 0.3% to 5%. The results of our study fall within this range. We examine individual characteristics that influence this threshold to explore potential reasons for national differences in the acceptability of mortality risk. Table 3 presents our findings.

Table 3 shows that the mean acceptability threshold for mortality risk increases with age. However, there is no significant difference between the three demographic groups (p-values above 0.05). The literature supports the age effect by explaining that aversion to mortality risk increases with age. One possible explanation for the difference in risk-taking behaviour between middle-aged (25-59 years) and older adults is that the former may have more pronounced personal and professional commitments, such as family or work responsibilities. These commitments make them more reluctant to take on additional risks that could interfere with fulfilling these obligations. In contrast, older individuals may be more inclined to attribute health issues to ageing, leading to a reduced sense of mortality risk [1] and a higher threshold for accepting risks. In this study, participants were instructed to imagine themselves as 60 years old and disregarded their actual age when fully engaged in the task. This could account for the absence of an age-related effect.

On average, men and women have no significant difference in their threshold for mortality risk acceptability (with a p-value above 0.05). However, studies on risk perception for diseases have found that women generally perceive risks as greater than men [2, 15]. This finding also applies to various risk categories, including aeroplane accidents, house fires, and car accidents [44], as well as food hazards, violence, crime, floods, and environmental threats, such as radioactive waste, global warming, and technology [16, 29, 38]. The findings indicate that societal norms and expectations surrounding gender, particularly for men, lead to the disappearance of fear of vulnerability and loss of invincibility in the context of respiratory illness.

On average, individuals in the highest income group exhibit a greater tolerance for mortality risk compared to other groups. However, these differences are not statistically significant. The influence of income on risk tolerance is still debated in academic literature. Studies conducted by Ghazy et al. [20] and Schmidt et al. [45] demonstrate that individuals in the highest income bracket tend to have greater risk tolerance. Individuals with lower incomes may be more aware of the financial implications of illness or death in the short and long

Table 3 Median (InterQuartile Range), Mean and standard error according to respondents' characteristics in % and *p*-value of the Mann-Whitney test

		Median (IQR)	Mean	Standard error	p-value (Mann-Whitney Test)
Personal characteristics variables					
Age					
	18-24 (n=92)	10 (2-30)	17.63	19.58	Δ_{12} : 0.988 ; Δ_{13} : 0.345
	25-59 (n=147)	10 (2-30)	18.65	21.56	Δ_{23} : 0.273
	60 or more (n=76)	15 (5-25)	20.73	22.76	
Gender					
	Male (n= 147)	10 (2-30)	20.12	22.59	Δ_{12} : 0.582
	Female (n=168)	10 (2-25)	17.75	20.06	
Income					
	Less than 1000€ (n=34)	10 (2-33.75)	19.50	20.83	Δ_{12} : 0.594 ; Δ_{13} : 0.985 ; Δ_{14} : 0.589 ; Δ_{15} : 0.518
	1000€-1499€ (n=63)	10 (2-20)	16.13	17.88	Δ_{23} : 0.482; Δ_{24} : 0.938 ; Δ_{25} : 0.149
	1500€-2499€ (n=62)	12.5 (3.5-30)	19.29	21.13	Δ_{34} : 0.518 ; Δ_{35} : 0.445
	2500€-4499€ (n=104)	10 (2-30)	18.03	21.40	Δ_{45} : 0.182
	4500€ and more (n=52)	17.5 (2-30.75)	22.86	25.08	
Professional Groups					
	Farmer and Craftsman (n=13)	9 (1-20)	17.60	14.38	Δ_{12} : 0.591 ; Δ_{13} : 0.340 ; Δ_{14} : 0.341
	Self-employed and Executive (n=84)	10 (2-25)	19.71	17.35	Δ_{23} : 0.400 ; Δ_{24} : 0.518
	Employee and Worker (n=94)	11.5 (2-30)	23.20	20.81	Δ_{34} : 0.730
	Retired person. Unemployed person. and Homemaker (n=124)	10 (3-26.25)	21.19	18.85	
Individual Behaviour characteristics variables					
Annual Checkup					
	Yes (n=192)	10 (1-25)	17.92	21.38	Δ_{12} : 0.134
	No (n=123)	10 (4-35)	20.31	21.11	
Current smoker					
	Yes (n=67)	10 (2-32.50)	21.21	24.76	Δ_{12} : 0.858
	No (n=248)	10 (2-30)	18.22	20.23	
Risk averse					
	Yes (n=97)	10 (2-25)	16.78	17.78	Δ_{12}: 0.674
	No (n=218)	10 (2-30)	19.78	22.62	
Individual Health characteristics variables					
Current health					
	Good health (n=280)	10 (2-30)	19.31	21.40	Δ_{12} : 0.330
	Poor health (n=35)	10 (2-20)	15.20	20.10	
Medical history					
	Diagnosed with a health problem which may be linked to respiratory diseases (n=197)	10 (2-30)	18.09	19.41	Δ_{12} : 0.982
	Not diagnosed (n=118)	10 (2-30)	20.13	24.09	
Risk values					
Risk value X					
	X=10 (n=106)	10 (2-20)	18.00	24.33	Δ_{12} : 0.848 ; Δ_{13} : 0.025
	X=20 (n=108)	10 (1.75-25)	15.76	16.90	Δ_{23} : 0.018
	X=40 (n=101)	20 (5-40)	23.06	21.55	

n represents the number of respondents. We test for the significance of the differences with the Mann-Whitney test. The test is as follows: it measures the significance of differences between the class i and the class j of a given variable. The order of a class is by line order. For example, for the variable Age, class 1 corresponds to 18-24, class 2 corresponds to 25-59, and class 3 corresponds to 60 or more. Δ_{12} represents the *p*-value of the test between class 1(18-24) and class 2 (25-59)

term. These implications may include competing financial priorities, such as paying for essentials like food and housing, and lost income due to time off work. As a result, those with lower incomes may be willing to accept a lower level of mortality risk than wealthier individuals. Our study, similar to that of Hammitt and Zhou [21], found no correlation between income and the threshold of acceptable mortality risk. This disconnection between health and wealth may account for the phenomenon. The survival instinct may override the budget constraint.

Individuals in the Farmer and Craftsman classes report the lowest risk acceptance threshold, while those in the Employee and Worker classes report the highest, as found by occupational groups. However, our results indicate that these differences are insignificant, in contrast to Rohrmann [42] and Sjoberg [48], who claim that occupational standards significantly influence risk perception. Therefore, occupational status does not influence the threshold of acceptability of mortality risk in treating respiratory diseases. One reason for this may be that individuals perceive respiratory diseases as causing comparable disability and discomfort regardless of occupation.

Table 3 displays the relationship between individual behaviours and mortality risk acceptance thresholds. Individuals who engage in preventive behaviours, such as having an annual health check-up or not smoking, report a lower level of risk acceptance on average than others. However, these differences are not significant in either case. This contradicts Brewer et al.'s [7] findings but may be justified by the fact that prevention may reduce risk. Uncertainty regarding this reduction may not affect the beliefs of individuals who take preventative measures versus those who make health decisions.

The studies on lung cancer surgery [13] and gene therapy [14] have shown that individuals who are generally risk-averse tend to have a lower threshold for acceptable mortality risk compared to others. However, the difference between the two thresholds is not statistically significant. This phenomenon occurs when individuals make high-risk choices despite their preference for low-risk alternatives because the consequence of their choice is mortality[5].

Table 3 shows that participants with a history of respiratory illness or who report feeling unwell have a lower threshold for accepting the risk of death compared to their counterparts. However, the differences between the thresholds are not statistically significant. Therefore, unlike Kleinhesselink and Rosa's [30] and Ding et al.'s [15] studies, we did not investigate the effect of disease exposure. The research indicates that individuals with greater exposure to the disease have a lower threshold for accepting mortality and experience higher levels of anxiety compared to those with less exposure. Additionally, individuals without exposure to the disease, on average, accept a risk of almost 19%. The study did not find any evidence of cognitive bias related to experience.

Finally, Table 3 shows that individuals who were asked to consider mortality risk values of 10 or 20 per cent reported lower levels of mortality risk acceptability, on average, than those in the 40 per cent group. Statistically significant differences were found (with a *p*-value of less than 0.05). Therefore, these results suggest that initial mortality risk values influence individuals' perceived acceptability of mortality risk.

These findings suggest that socioeconomic, health, and behavioural factors have minimal influence on individuals' acceptance of mortality risk. In other words, despite the diversity of the population studied, there is no significant difference in the reported thresholds of acceptability of mortality risk. Individual preferences for acceptability are relatively homogeneous, even within heterogeneous groups. The adverse effects of respiratory diseases on daily life, such as pain, disability, and loss of social interactions, are widely recognised. This understanding may account for our findings and bring individuals closer to a shared threshold of acceptability regarding the mortality risk associated with treating respiratory diseases. Our analysis suggests that increased homogeneity in medical research and treatment development will aid in identifying the need for non-individualised care. There is no requirement to identify individual profiles within the target population for acceptable levels of mortality risk in the treatment of respiratory diseases.

Individual preferences

We examined how individuals perceived the objective probabilities associated with treatment risk. This investigation enhanced our comprehension of individuals' preferences. Figure 1 displays the acceptability threshold of the stated mortality risk for the three mortality risk values, namely 10% (subgroup 1), 20% (subgroup 2) and 40% (subgroup 3).

Figure 1 shows that people do not value probabilities linearly. They give disproportionate weight to smaller probabilities, resulting in downwardly biased subjective expected utilities (SEUs), while giving less weight to larger probabilities, resulting in upwardly biased SEUs. Probability weighting has a significant impact on SEUs. As a result of feeling threatened, individuals tend to behave more cautiously and take fewer risks, while feeling secure leads to bolder behaviour and greater risk-taking. The expected utility model is the standard for individual decision-making in high-stakes environments [51]. According to this theory, individuals should evaluate objective probabilities, and their risk acceptance threshold should correspond to the objective risk. However, our study's results did not support this. Instead, they suggest that individuals evaluate subjective rather than objective probabilities when treating chronic respiratory disease, contradicting the expected utility theory. Bleichrodt [5] highlights this contradiction. Therefore, individuals may evaluate weight probabilities in a risk context, as proposed in the Rank-Dependent Utility (RDU) theory [40]. In RDU, individuals make decisions based on Eq. (1), using the probability weighting function $w(p)$. The function is defined as follows:

$$\begin{gathered} w(p) \times U(Q_1) + (1 - w(p)) \times U(Q_3) = U(Q_2) \\ \Longleftrightarrow \\ w(p) \times H(Q_1)G(T) + (1 - w(p)) \times H(Q_3)G(0) = H(Q_2)G(T). \end{gathered} \tag{2}$$

As noted in Eq. (1), we assign values of 1 to $H(Q_1)$ and 0 to $H(Q_3)$. This leads us to deduce from Eq. (2) that $w(p) = H(Q_2)$ and the threshold of acceptability of mortality risk is $1 - w(p)$. Therefore, individuals adjust their risk acceptance based on their target level of perceived risk, regardless of their awareness of the surrounding risks.

Discussion

Assessing the acceptability of health risks is a complex process involving evaluating and accepting or rejecting potential health risks. It is a subjective concept that can vary considerably from person to person. Several studies have shown that individual factors influence the acceptability of mortality risk [10–12]. The study indicates that factors such as age, gender, income, occupation, self-prevention, health status, and risk aversion do not significantly impact the acceptability of mortality risk in respiratory disease treatment. It is important to recognise that preferences are homogeneous to prevent research centres, health professionals, and decision-makers from wasting resources on characterising patients to identify their propensity to participate in future treatments.

[5] Risk aversion refers to an individual's tendency to make low-risk choices.

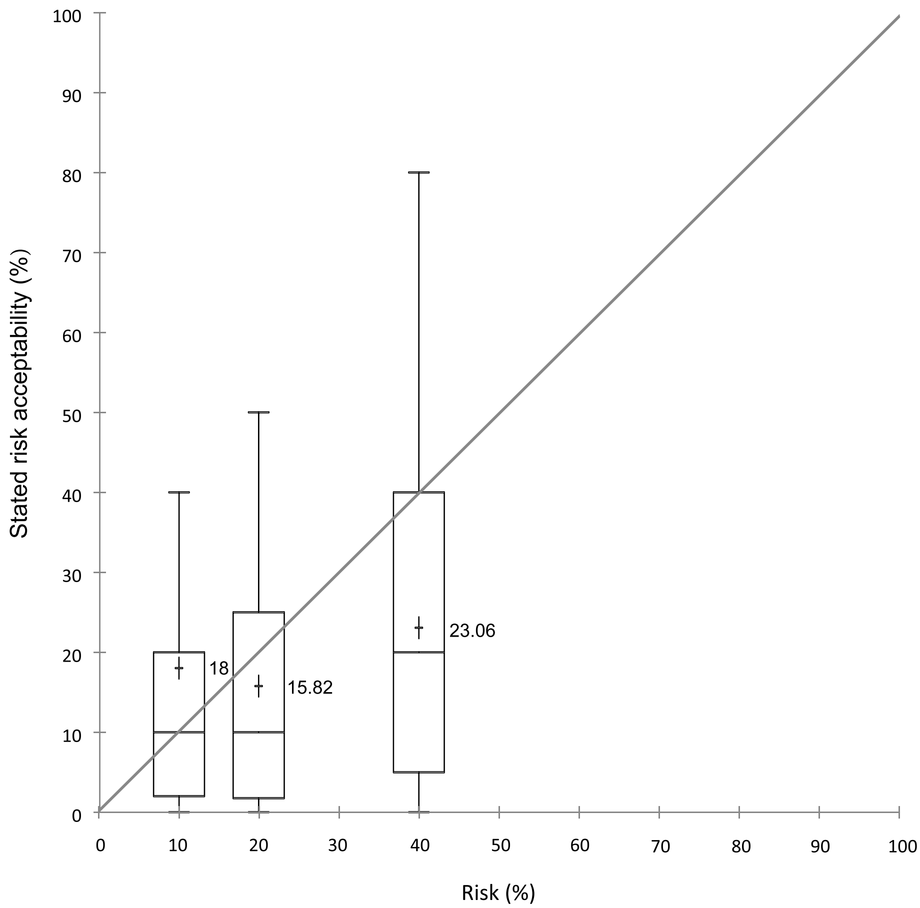

Fig. 1 Stated risk acceptability threshold according to the three risk values

Developing risk acceptability assessments in different contexts is crucial. Firstly, transferring results from one context to another is challenging, as individuals' perceptions of risk often change with the proposed context. Therefore, assessing the threshold of acceptable mortality risk of treatment enables decision-makers and research centres to propose a criterion to help them choose between treatments for respiratory diseases for funding and development. This assessment can be used as a benchmark for measuring therapeutic progress and improving knowledge to meet patients' evolving needs and expectations. Gathering information on a specific disease enriches the literature on health risk perception and focuses on a particular issue. At the outset of medical treatment development, research centres are informed of patients' safety concerns and willingness to accept risks associated with specific health hazards. This information is used to design interventions that are more likely to be accepted and to develop strategies to minimise risks and improve patient outcomes.

Secondly, assessing the acceptability of health risks can help policymakers understand how individuals perceive and respond to such risks. This knowledge can be used to design effective, fair, and responsive policies that address the needs and concerns of the public. Public policy must also consider the cost-effectiveness of treatments that carry risks. Assessing the suitability of these treatments can assist policymakers in determining whether the potential benefits of the treatment outweigh the costs and whether it is a justifiable use of public funds.

The assessment examined individuals' preferences regarding health risks and revealed a discrepancy between actual and perceived risk. Even when individuals are informed about potential hazards, they may modify their decision to accept them based on their desired level of perceived risk. This ambiguity aversion may lead to reluctance to undergo treatments that involve risk. This phenomenon describes a preference for options where the probabilities of outcomes are known rather than uncertain ones. Ambiguity aversion could explain why individuals are reluctant to choose uncertain options. To ensure optimal treatment of respiratory disease and achieve an objectively acceptable level of mortality risk for risk-averse individuals, healthcare providers and authorities should provide explicit and accurate information. The potential benefits of treatment and its impact on improving patients' health and overall quality of life should be highlighted. Additionally, counselling services should be provided to address any fears or concerns that patients may have. Building confidence in the safety and efficacy of the treatment is critical in motivating ambiguity-averse individuals to undergo it. Increasing belief in the treatment could lead to acceptance by considering objective risks rather than subjective ones. Ambiguity aversion may influence decision-making related to health risks.

Conclusion

Despite the severity and prevalence of respiratory diseases, no health risk acceptability assessment has been conducted. This study aims to fill this gap. The results indicate that individuals are willing to accept treatment if the mortality risk does not exceed 18.85%. Furthermore, all individuals agree upon this threshold, with no discernible effect of their characteristics on their decision. When making decisions, individuals may rely on their personal beliefs about the level of risk associated with treatment. However, this can lead to sub-optimal health behaviours, such as refusing treatment even when the risk of death is objectively acceptable. To reduce this bias, the use of information and trust is recommended.

Our study has limitations. Firstly, the data were collected online rather than through face-to-face or telephone interviews, which may affect our data quality. However, according to Fricker et al. [19], Kreuter et al. [32] and Heerwegh and Loosveld [23], the quality of online data collection is equivalent to other means of data collection. Additionally, we collaborated with Createst, a certified data collection company.

Second, when assessing stated preferences, concerns may arise regarding whether they reflect an individual's true attitude or are instead the result of a misunderstanding of probabilities. Our study evaluated each participant's comprehension of mortality risk and survival concepts to address this issue.

Third, the method of preference elicitation known as the standard gamble can be complicated for individuals to respond to due to the use of event probabilities. We employed a closed-ended (single bounded dichotomous choice) and an open-ended method to address this issue. This enabled respondents to express their level of agreement with a reference while still having the freedom to evaluate their choice.

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Authors' contributions

C.O. have contributed to the conception and design, acquisition of data, interpretation of data, analysis of the data, and drafting of the article.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

All participants provided written informed consent prior to their participation. The methods were conducted in compliance with ethical regulations.

Competing interests

The authors declare no competing interests.

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References

1. Abel M, Byker T, Carpenter J. Socially optimal mistakes? Debiasing COVID-19 mortality risk perceptions and prosocial behaviour. J Econ Behav Organ. 2021;183:456–80.
2. Andersson H, Lundborg P. Perception of own death risk: an analysis of road-traffic and overall mortality risks. J Risk Uncertain. 2007;34:67–84.
3. Anli L, Maitland E, Nicholas S, Liu R, Wang J. Individual preferences for COVID-19 vaccination in China. Vaccine. 2021;39(2):247–54.
4. Attema AE, Bleichrodt H, l'Haridon O, Lipmanet SA. A comparison of individual and collective decision making for standard gamble and time trade-off. Eur J Health Econ. 2020;21:465–73.
5. Bleichrodt H. A new explanation for the difference between time trade-off utilities and standard gamble utilities. Health Econ. 2002;11(5):447–56.
6. Bosch JL, Hammitt JK, Weinstein MC, Hunink MGM. Estimating General-Population Utilities Using one Binary Standard-Gamble Question per Respondent. Med Dec Making. 1998;18:381–90.
7. Brewer NT, Weinstein ND, Cuite CL, Herrington JE Jr. Risk perceptions and their relation to risk behaviour. Ann Behav Med. 2004;27:125–30.
8. Cerda AA, García LY. Willingness to pay for a COVID-19 vaccine. Appl Health Econ Health Policy. 2021;19:343–51.
9. Choe Y, Kim H, Choi Y. Willingness to pay for travel insurance as a risk reduction behaviour: health-related risk perception after the outbreak of COVID-19. Serv Bus. 2022;16(3):445–67.
10. Choi AY, Mulvihill MS, Lee H, et al. Transplant Center Variability in Organ Offer Acceptance and Mortality Among US Patients on the Heart Transplant Waitlist. JAMA Cardiol. 2020;5(6):660–8.
11. Coleman NC, Burnett RT, Higbee JD, Lefler JS, Merrill RM, Ezzati M, et al. Cancer mortality risk, fine particulate air pollution, and smoking in a large, representative cohort of US adults. Cancer Causes Control. 2020;31:767–76.
12. Coughlin SS. Social determinants of breast cancer risk, stage, and survival. Breast Cancer Res Treat. 2019;177:537–48.
13. Cykert S. Risk acceptance and risk aversion: patients' perspectives on lung surgery. Thorac Surg Clin. 2004;14(3):287–93.
14. Deakin CT, Alexander IE, Kerridge I. Accepting Risk in Clinical Research: Is the Gene Therapy Field Becoming Too Risk-averse? Mol Ther. 2009;17(11):1842–8.
15. Ding Y, Du X, Li Q, Zhang M, Zhang Q, Tan X, Liu Q. Risk perception of coronavirus disease 2019 (COVID-19) and its related factors among college students in China during quarantine. PloS one. 2020;15(8):e0237626.
16. Dosman DM, Adamowicz WL, Hrudey SE. Socioeconomic determinants of health- and food safety-related risk perceptions. Risk Anal. 2001;21(2):307–17.

17. Evans D. Chapter 25 - Teaching Patients to Manage Their Asthma. In: Castro M, Kraft M, editors. Clinical Asthma. Mosby; 2008. pp. 221–8.
18. Evans D. An Activist's Argument That Participant Values Should Guide Risk-Benefit Ratio Calculations in HIV Cure Research. J Med Ethics. 2017;43(2):100–3.
19. Fricker S, Galesic M, Tourangeau R, Yan T. An Experimental Comparison of Web and Telephone Surveys. Public Opin Q. 2005;69(3):370–92.
20. Ghazy RM, Abdou MS, Awaidy S, Sallam M, Elbarazi I, Youssef N, Fiidow OA, Mehdad S, Hussein MF, Adam MF, Abdullah FSA, Rebai WK, Raad EB, Hussein M, Shehata SF, Ismail II, Salam AA, Samhouri D. Acceptance of COVID-19 vaccine booster doses using the health belief model: a cross-sectional study in low-middle- and high-income countries of the East Mediterranean region. Int J Environ Res Public Health. 2022;19(19):12136.
21. Hammitt JK, Zhou Y. The economic value of air-pollution-related health risks in China: a contingent valuation study. Environ Resour Econ. 2006;33:399–423.
22. Hammitt JK, Geng F, Guo X, et al. Valuing mortality risk in China: comparing stated-preference estimates from 2005 and 2016. J Risk Uncertain. 2019;58:167–86.
23. Heerwegh D, Loosveldt G. Face-to-Face Versus Web Surveying in a High-Internet-Coverage Population: Differences in Response Quality. Public Opin Q - Pub Opin Q. 2008;72:836–46.
24. Holt CA, Laury SK. Risk Aversion and Incentive Effects. Am Econ Rev. 2002;92:1644–55.
25. Jing P, Xu G, Chen Y, Shi Y, Zhan F. The determinants behind the acceptance of autonomous vehicles: a systematic review. Sustainability. 2020;12:1719.
26. Jungermann H, Slovic P. Die Psychologie der Kognition und Evaluation von Risiko. In: Bechmann G, editor. Risiko und Gesellschaft. VS Verlag für Sozialwissenschaften; 1993.
27. Kahneman D, Tversky A. Judgement under uncertainty: heuristics and biases. Science. 1974;185(4157):1124–31.
28. Kahneman D, Tversky A. Prospect theory: an analysis of decision under risk. Econometrica. 1979;47:263–91.
29. Kellens W, Zaalberg R, Neutens T, Vanneuville W, De Maeyer P. An analysis of the public perception of flood risk on the Belgian coast. Risk Anal. 2011;31(7):1055–68.
30. Kleinhesselink RR, Rosa EA. Cognitive representation of risk perceptions: a comparison of Japan and the United States. J Cross-Cult Psychol. 1991;22(1):11–28.
31. Kratka A, Ubel PA, Scherr K, Murray B, Eyal N, Kirby C, Katz MN, Holtzman L, Pollak K, Freedburg K, Blumenthal-Barby J. HIV Cure Research: Risks Patients Expressed Willingness to Accept. Ethics Hum Res. 2019;41(6):23–34.
32. Kreuter F, Presser S, Tourangeau R. Social Desirability Bias in CATI, IVR, and Web Surveys: The Effects of Mode and Question Sensitivity. Public Opin Q. 2008;72(5):847–65.
33. Lipman SA, Brouwer WBF, Attema AE. QALYs without bias? Nonparametric correction of time trade-off and standard gamble weights based on prospect theory. Health Econ. 2019;28(7):843–54.
34. Lipman SA, Brouwer WBF, Attema AE. Living up to expectations: Experimental tests of subjective life expectancy as reference point in time trade-off and standard gamble. J Health Econ. 2020;71:102318.
35. Assurance Maladie. Améliorer la qualité du système de santé et maîtriser les dépenses: les propositions de l'Assurance Maladie pour 2020. Juillet. 2019
36. Michaels-Igbokwe C, MacDonald S, Currie GR. Individual preferences for child and adolescent vaccine attributes: a systematic review of the stated preference literature. Patient. 2017;10:687–700.
37. Muringai V, Fan X, Goddard E. Canadian consumer acceptance of gene edited versus genetically modified potatoes: a choice experiment approach. Can J Agric Econ. 2020;68:47–63.
38. Palmer C. Risk perception: another look at the 'white male' effect. Health Risk Soc. 2003;5(1):71–83.
39. Pigeon C, Alauzet A, Paire-Ficout L. Factors of acceptability, acceptance and usage for non-rail autonomous public transport vehicles: a systematic literature review. Transp Res A Traffic Psychol Behav. 2021;81:251–70.
40. Quiggin J. Risk perception and risk aversion among Australian farmers. Aust J Agric Resour Econ. 1981;25:160–9.
41. Rey B, Rochet JC. Health and Wealth: How do They Affect Individual Preferences? Geneva Risk Insur Rev. 2004;29:43–54.
42. Rohrmann B. Risk Perception Research. In: Renn O, Rohrmann B, editors. Cross-Cultural Risk Perception. Technology, Risk, and Society, vol 13. Boston: Springer; 2000.
43. Salomon JA. Valuing Health States. In: Culyer AJ, editor. Encyclopedia of Health Economics. Elsevier; 2014. pp. 454–8.
44. Savage I. Demographic influences on risk perceptions. Risk Anal. 1993;13(4):413–20.
45. Schmidt U, Neyse L, Aleknonyte M. Income inequality and risk taking: the impact of social comparison information. Theory Decis. 2019;87:283–97.
46. Siegrist M. A causal model explaining the perception and acceptance of gene technology. J Appl Soc Psychol. 1999;29(10):2093–106.
47. Siegrist M, Luchsinger L, Bearth A. The Impact of Trust and Risk Perception on the Acceptance of Measures to Reduce COVID-19 Cases. Risk Anal. 2021;41(5):787–800.
48. Sjöberg L. Explaining risk perception: An empirical evaluation of cultural theory. Risk Management. Routledge. 2020. pp. 127–144.
49. Trimpop RM, Zimolong BM. Risk Acceptance. Encyclopedia of occupational health and safety; 2011.
50. Viscusi WK, Magat WA, Huber J. Pricing environmental health risks: survey assessment of risk-risk and risk-dollar trade-offs for chronic bronchitis. J Environ Econ Manag. 1991;21:32–51.
51. Von Neumann J, Morgenstern O. Theory of games and economic behavior. Princeton University Press; 1944.

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