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Health-Related Basic Numerical Literacy

Carina Ferreira[1], Teresa Abreu[1], Ricardo Gonçalves[1], José M. Pereira[2], Mário Basto[1]
[1]*Higher School of Technology, Polytechnic Institute of Cávado and Ave, Barcelos, Portugal*
[2]*CICF - Research Center on Accounting and Taxation, Polytechnic Institute of Cávado and Ave, Barcelos, Portugal*

Abstract: *The purpose of this study is to evaluate the very basic numerical skills of health professionals and the general public, to correctly understand the health information that comes to them routinely. The importance of mathematical and statistical literacy cannot be overstated so that informed consent can take place and adequate joint decision-making between doctor and patient can happen. The goal is todecrease the number of interventions and increase the quality of the services provided, reducing healthcare spending as a result. The competences measured in this study encompasses basic but fundamental concepts related to risk, such as the comparison of risks for its correct assessment, the estimation of the reduction of unwanted effects in a group from the reduction in the number of unwanted effects in another group of a different size (absolute risk reduction), the recognition that the bases are necessary to be able to compare absolute frequencies between two groups, and the knowledge and perception that lowering all-cause mortality provides better evidence of benefit than lowering single-cause mortality. The results indicate a need to strengthen the numerical and statistical education of the general community, specifically physicians and nurses.*

Keywords: Numerical literacy,Statistical literacy, Absolute risk, Relative risk, All-cause mortality, Single-cause mortality

I. INTRODUCTION

It is impossible to separate mathematics and statistics from daily living in a culture characterized by information and knowledge. This science is not only assiduously present in the media, but is also instinctively employed in activities of daily life, like insports, weather, economy, stock market, engineering or medicine. It is typically applied to support thesis or give legitimacy to marketing materials, claims, or ideas.In this context, it is crucial to examine why almost all citizens can read and write, but so few comprehend statistical data, and why basic distinctions, such as the one between absolute and relative risk, is not better understood. Health risksand benefits communicated to physicians, nurses and patients frequently misleads them. This happens, for example, when presenting the benefits using the relative risk reduction (often a large figure) and the harms using the absolute risk increase (usually a small figure). As a result, advantages are viewed as significantly greater than harms [1][2].Any procedure's risks must be carefully assessed using the absolute risk, since the relative risk,to be fully interpretable, depends on the baseline risk.

According to a number of publications [1][2][3][4][5], a substantial portion of the general population, and in particular a considerable number of physicians and nurses, do not accurately perceive a variety of numerical and statistical concepts. This issue is exacerbated by the opaque manner in which information is frequently communicated to health professionals and patients.

A correct understanding of the harms and benefits of any medical intervention is crucial, regardless of whether one is a medical practitioner or a patient. All treatments carry risks, which must be weighed against their benefits [1]. Unfortunately, nearly the entirety of the population suffers from a misunderstanding of numbers [1]. This lack of literacy can lead to erroneous perceptions on the part of physicians and patients, which can have serious implications for the decision and consent intended to be informed by those concerned. This issue will not only affect the medical judgment and informed consent between doctor and patient, but it will also have a significant financial burden on health care systems.

According to Gigerenzer et al. [1] patients frequently have misconceptions that prevent them from providing informed consent. These misconceptions include the idea that tests or treatments are infallible, the overestimation of the benefits of screening while underestimating the harm, the confusion between early detection and prevention, and a lack of understanding of basic health statistics.Patients must accurately comprehend the numbers and statistics they are presented with, what they actually mean, in order to ask pertinent questions and engage in meaningful discussions with

health professionals about the risks and benefits of the interventions being suggested to them, so that they can decide wisely in cooperation with their doctors.

Numerous people are unable to solve simple problems involving numbers, such as fractions, proportions, or probabilities, which are essential for the correct understanding of the communication of health-related risks, resulting in a diminished perception of risks, an inability to make informed medical decisions, and consequently, poorer medical outcomes [5].

Gigerenzer et al. [1] highlight the importance of early education in statistical reasoning with clear communication of results. Statistical thinking should be taught at all educational levels, especially in health programs. Only in this manner can numbers be appropriately interpreted and correct decisions made.

II. Methods

A questionnaire was created using questions adapted from previous research [3][4][6]. The questionnaire was taken to be as concise as possible while still maintaining its objectivity, and its length was kept to a minimum. Everyone who took part in the study was assured complete anonymity, and in order to make the respondents feel as at ease as possible, every question, with the exception of the one in which they were asked to identify their professional group, was made optional. The majority of the questions are copies of those that were already asked and validated in the studies that were cited. After the questionnaire has been finished, it was put through a preliminary test with several different professionals. All of them evaluated the clarity of the questions, the order in which they were presented, the length of the questionnaire, and any and all features that they thought were important, and at the end of the process, they pointed out the questions' problems and gave suggestions for how they could be improved. The small deficiencies detected were incorporated in the final questionnaire.

Through the social media sites, the questionnaire was made available. People were asked to respond, and then asked to share the questions on their own social media profiles, so that the number of responses could expand. The objective was to communicate with as many people as possible in as little time as possible. It was decided not to set a minimum sample size because the purpose of the study is exploratory and the statistical tests that were run were solely for gathering information and not to infer. The statistical evaluation was carried out with the assistance of the software IBM SPSS 25 [7] and Tableau Desktop 2018 [8]. In light of the fact that the sample was not chosen at random, any attempt to generalize the results must be approached carefully.

The general population as well as health professionals in particular were polled in this research to determine how well-versed they are in the basics of numerical literacy as it relates to health. Four questions were used to assess four different goals. Specifically, to determine if the general public and health professionals (physicians and nurses): know how to compare fractions and figure out which one is the biggest, and how to use this knowledge correctly in risk assessment (question 1); to be able to calculate the reduction in undesirable effects in a group of a specific size based on the reduction in undesirable effects in a group of a different size (absolute risk reduction) (question 2); realize that the knowledge of the bases is required to compare absolute frequencies in two groups (question 3); understand that there is stronger evidence of benefits from reducing all-cause mortality than from reducing single-cause mortality (question 4).

III. Results

In the year 2019 and for three months and ten days, the questionnaire was accessible online.The final sample consisted of 485 individuals, including 154 physicians, 142 nurses, and 189 people from other professions.

The first question considered attempts to determine whether or not healthcare workers (such as physicians and nurses), and members of the general public are able to compare fractions, determine which is the largest, and apply this information appropriately in risk assessment. This purpose was addressed by asking the following question:

Question nº 1:Mrs. Manuela is informed that her chances of dying of cancer are one in 296 and that she has a one in 407 chance of passing away from a cerebrovascular accident (CVA). Which is greater, the probability that Ms. Manuela die of cancer or die of CVA?

A) Cancer

B) CVA

C) The probabilities are equal

This is a very basic numerical literacy question involving elementary arithmetic, and it is believed that all health professionals and the vast majority of the general population will respond appropriately. However (Figure 1), 17 healthcare professionals (4 physicians and 13 nurses) and 21 others failed to respond, indicating the CVA response,

while 1 physician, 6 nurses, and 14 others from the general public stated that the probability were equal, a seemingly meaningless response.

The differences in the responses of physicians, nurses, and the general population were statistically significant ($\chi^2(4) = 19.539, p = 0.001$) with physicians providing the highest rate of accurate responses (96.8%), followed by nurses (86.6%), and then the general population (81.5%).

	Profession			
Answer	Physician	Nurse	Other	Grand Total
Cancer	149	123	154	426
CVA	4	13	21	38
Equal probabilities	1	6	14	21

	Profession			
Answer	Physician	Nurse	Other	Grand Total
Cancer	96.8%	86.6%	81.5%	87.8%
CVA	2.6%	9.2%	11.1%	7.8%
Equal probabilities	0.6%	4.2%	7.4%	4.3%

Figure 1. Distribution of responses to the first question by profession (correct answers appear in green).

The second question looked at the ability of healthcare professionals (physicians and nurses) and members of the general public to compute the decrease in unfavorable effects in a group of a certain size based on the decrease in unfavorable effects in a group of a different size (absolute risk reduction). The following question was made in order to achieve this goal:

Question n° 2:Let's say that screening for a specific condition causes the death rate to drop from 4 to 3 per 100 individuals. Imagine that 1000 persons are regularly screened. What is the most accurate prediction of how many of these 1000 people will no longer pass away from this illness?

A) 3
B) 10
C) 30
D) 40

Similar to the prior question, this one's straightforward arithmetic calls for a high number of accurate responses, mainly from health professionals. A reduction of 10 fatalities per 1000 people screened is predicted if there is a drop of one death for every 100 people screened. The absolute risk reduction is 1 percentage point. The results, however, were fairly disappointing, with just 75.3% of physicians answering correctly. The results for nurses were even more shocking, with only 52.8% properly answering, somewhat less than the 53.4% of the general population (Fig.2). Almost all of the other responses focused on the estimation that 30 fewer people will die, which suggests that despite the information being sent in a totally open manner, it was likely incorrectlyinterpreted.

The differences between the two response options '10' and '30', by physicians, nurses and the general population, proved to be statistically significant ($\chi^2(2) = 17.701, p < 0.001$).

	Profession			
Answer	Physician	Nurse	Other	Grand Total
Did not reply			2	2
3		1	5	6
10	116	75	101	292
30	37	63	76	176
40	1	3	5	9

	Profession			
Answer	Physician	Nurse	Other	Grand Total
Did not reply			1.1%	0.4%
3		0.7%	2.6%	1.2%
10	75.3%	52.8%	53.4%	60.2%
30	24.0%	44.4%	40.2%	36.3%
40	0.6%	2.1%	2.6%	1.9%

Figure 2. Distribution of responses to the second question by profession (correct answers appear in green).

The third question examined the ability of healthcare professionals (physicians and nurses) and the general public to recognize that the knowledge of the bases is necessary to compare absolute frequencies between two groups. To attain this objective, the following question was asked:

Question nº 3: According to a new study, 30 people who regularly consume broccoli have died, compared to 100 people who do not consume broccoli. According to this study, which conclusion best explains the association between broccoli consumption and mortality?

A) Lowers the risk of death
B) It does not change the risk of death
C) Increases the risk of death
D) I don't have data to answer

It is not possible to draw conclusions from the information provided because the quantity of broccoli eaters and broccoli non-eaters is unknown. The responses were practically distributed between the correct response 'I don't have data to answer' and the response 'lowers the risk of death'.Physicians had the highest hit rate at 55.8%, followed by nurses at 47.2% and the general public at 40.2%(Fig. 3). Nearly half of respondents agreed that the best conclusion is that eating broccoli reduces the chance of mortality, as more people died in the group that did not consume broccoli. This interpretation may indicate a lack of numerical literacy, but it most likely indicates that many health professionals and members of the general public are misled by the way the results are presented, most likely because they did not expect the information to be transmitted in a biased manner, whether intentionally or unintentionally.

There were statistically significant differences between the correct answer and the other responses from physicians, nurses, and the general population ($\chi^2(2) = 8.321, p = 0.016$).

	Profession			
Answer	Physician	Nurse	Other	Grand Total
Did not reply			1	1
Lowers the risk of death	64	70	97	231
It does not change the risk of death	2	3	11	16
Increases the risk of death	2	2	4	8
I have no data to answer	86	67	76	229

	Profession			
Answer	Physician	Nurse	Other	Grand Total
Did not reply			0.5%	0.2%
Lowers the risk of death	41.6%	49.3%	51.3%	47.6%
It does not change the risk of death	1.3%	2.1%	5.8%	3.3%
Increases the risk of death	1.3%	1.4%	2.1%	1.6%
I have no data to answer	55.8%	47.2%	40.2%	47.2%

Figure 3. Distribution of responses to the third question by profession (correct answers appear in green).

The fourth and final question assessed healthcare professionals' (physicians and nurses) and the general public's ability to recognize that there is stronger evidence of benefits from reducing all-cause mortality than from reducing single-cause mortality. To achieve this goal, the following question was posed:

Question nº 4: Consider a new drug called 'MediBom' that has been launched on the market for people over 60. It can be read: 'MediBom reduces the risk of death by heart attack by 25%'. However, like all medicines, this one also has side effects. The only serious side effect is liver failure. The other side effects are extremely mild and rare.What additional information constitutes better evidence that 'MediBom' helps people?

A) A lower percentage of individuals died from any cause in the 'MediBom'group compared to the placebo (control) group
B) 'MediBom'lowers cholesterol levels
C) Many doctors prescribe 'MediBom'
D) A lower percentage of individuals died fromheart attack in the 'MediBom'group compared to the placebo (control) group

The results are displayed in Fig. 4. Physicians are the most aware of the fact that lowering all-cause mortality gives stronger evidence of benefit than lowering single-cause mortality, despite the fact that only roughly a third of physicians selected the correct answer. Only 12.0% of nurses and 14.3% of the general population also selected the correct response. The most given answer was: 'A lower percentage of people died from heart attack in the 'MediBom' group compared to the placebo (control) group'.

Answer	Profession			
	Physician	Nurse	Other	Grand Total
Did not reply	1	1	8	10
Lower percentage of individuals died from any cause in the 'MediBom' group	51	17	27	95
'MediBom' lowers cholesterol levels		5	12	17
Many doctors prescribe 'MediBom'		3	7	10
Lower percentage of individuals died from heart attack in the 'MediBom' group	102	116	135	353

Answer	Profession			
	Physician	Nurse	Other	Grand Total
Did not reply	0.6%	0.7%	4.2%	2.1%
Lower percentage of individuals died from any cause in the 'MediBom' group	33.1%	12.0%	14.3%	19.6%
'MediBom' lowers cholesterol levels		3.5%	6.3%	3.5%
Many doctors prescribe 'MediBom'		2.1%	3.7%	2.1%
Lower percentage of individuals died from heart attack in the 'MediBom' group	66.2%	81.7%	71.4%	72.8%

Figure 4. Distribution of responses to the fourth question by profession (correct answers appear in green).

The differences between the two most given response options (lower all-cause mortality versus lower single-cause mortality) among physicians, nurses and the general population were statistically significant ($\chi^2(2) = 21.114, p < 0.001$).

IV. Conclusion

The risk of acquiring an illness is merely a probability, which is frequently expressed as a fraction.Using very basic arithmetic skills, the first question in the present study, which involved comparing fractions and determining which provided the biggest risk, should be simply and easily addressed.Comparing risks often involves comparing fractions. Only 87.8 percent of respondents (whether they were physicians, nurses, or others) properly compared the fractions, which was somewhat disappointing. This can be related to the population's arithmetic illiteracy and the need for improvement in very basic arithmetic skills. There can be no informed or conscious decisions without this.

Based on knowledge of the absolute risk reduction for a given medical procedure, the ability of the respondents to estimate the number of individuals in a given group of known size who were likely to benefit from that procedure, was very unsatisfactory.Only 75.3% of physicians did the math correctly. The results for nurses and general population were even more shocking, with only about half properly answering. In addition to a lack of numerical literacy, there may be some confusion in this situation. However, in the real world, information is presented in numerous formats, and there is no opportunity for misunderstanding when health decisions must be made.

Risk is not an integer. It is a probability. A probability ranges from zero to one, or from zero to one hundred when expressed as a percentage. Absolute values can only be turned into fractions, that is, into probabilities or risks, if the bases are known.Only after that, can comparisons be conducted.In the third question (which assesses this), it is noted that just slightly more than half of the physicians, slightly less than half of the nurses, and 40.2% of the general population appear to comprehend this. These findings are concerning because they suggest that people are easily deceived and susceptible to making poor choices.

Lastly, although not directly related to the mathematics of risks, the last question tackles a recurring issue, namely, recognizing that there is more evidence of benefits from reducing all-cause mortality than from reducing single-cause mortality. Only roughly one-fifth of respondents provided appropriate answers, which was a very depressing result. This line of thought may be the result of medicine's increasing specialization, in which participants appear to have lost sight of the big picture.

These results cannot be generalized to all the population, because the sample was not random, but they serve as a warning flag for long-recognized issues that do not appear to have been sufficiently addressed or resolved. The transmission and reinforcement of numerical and statistical education, particularly as it pertains to health, must be expanded to all persons, and particularly to all health professionals, so that decisions about medical procedures can be made consciously and with wisdom.Only when medical professionals and patients are fully educated about the extent of the benefits and potential issues of a particular medical procedure can proper informed consent take place. Due to the widespread dissemination of risk-based misunderstandings, this information is frequently not properly comprehended.

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