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Statistical Metrics in Healthcare

José M. Pereira[1], Teresa Abreu[2], Ricardo Gonçalves[2], Mário Basto[2]

[1]CICF - Research Center on Accounting and Taxation, Polytechnic Institute of Cávado and Ave, Barcelos, Portugal

[2]Higher School of Technology, Polytechnic Institute of Cávado and Ave, Barcelos, Portugal

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Abstract: **The relevance of health statistics in improving individual and public health cannot be overstated. Health statistics hold information on diseases, relative and absolute risks, effects of medical treatments, survival and mortality rates, among others. Understanding these figures is crucial for making informed decisions in several medical areas and in health policy. To make sense of health statistics, however, a certain amount of statistical knowledge is required. If not, statistics can be misinterpreted, leading to incorrect conclusions and decisions. The purpose of this study is to establish, with the use of three questions, if healthcare professionals and patients comprehend the often misunderstood concepts of survival, mortality, and lethality rates. An online questionnaire was available from October 30, 2022 to February 4, 2023. The final sample comprised 129 replies, with 37 health professionals and 92 individuals from other professions. Despite the limited sample size, the results indicate that both health professionals and the general population need to improve their statistical knowledge on survival, mortality, and lethality rates. By improving statistics health literacy many positive benefits can be expected to be achieved, such as better health and less overtreatment and healthcare expenses, due to better decision-making and fewer interventions and treatments.**

Keywords: **survival rate, mortality rate, fatality rate, lethality rate, screening.**

I. INTRODUCTION

Health mathematics and statistics are hard to separate from daily life in a culture dominated by information and data. Generally, they are employed to support an argument or provide credibility to marketing materials, statements, or ideas. However, the risks and benefits of health procedures are frequently misunderstood. It is usual for health professionals and patients, to misinterpret numbers and statistics [1], [2], [3], [4], [5], [6], [7], [8], [9]. Incorrect comprehension of numbers impacts practically the whole population, including journalists, politicians, attorneys, physicians, and nurses, among others [1]. This issue is typically the result of the intentional or unintentional use of confusing information. The purposeful nontransparent dissemination of information is to influence individuals by exaggerating the benefits and trivializing the risks [1]. This problem will not only alter how physicians think critically and how patients give informed consent, but it will also have a big effect on patients' health and the costs of the healthcare system. From this point of view, it is important to know why so few citizens understand statistical and numerical data well. The appropriate informed consent may only be granted when both the physician and the patient are fully aware of the benefits and risks of a medical intervention. When making decisions and drawing conclusions, physicians and patients must also take into account the strength and quality of the data from conducted and published studies, the existence of conflicts of interest, and all available medical information.

Health care professionals and patients are constantly confronted with a variety of health questions to which they can only respond if they have an accurate understanding of what the health figures actually represent. Numerous individuals are unaware of the statistics, do not comprehend them, and place blind faith in diagnoses and therapies. The incorrect interpretation of health information by patients frequently results from a lack of basic statistical and numerical knowledge, but it also results from the emotional nature of the doctor-patient relationship (doctor-patient relationship based on paternalism, on the trust of patients in health professionals who represent knowledge and the illusion of certainty) and the

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existence of conflicts of interest within the healthcare system [1]. A significant portion of the information a patient relies on and receives originates from health professionals. Consequently, the inability of these professionals to comprehend the information assumes greater significance, as they may inadvertently transmit inaccurate information to patients. Nevertheless, in order to make educated judgments, patients must also comprehend health concepts and statistics, as trusting others may not be enough [1]. Every treatment includes inherent risks which must be weighed against its benefits. Gigerenzer et al. [1] also describe several common misconceptions that prevent patients from giving informed consent, such as the illusion of infallibility of tests or treatments, the overestimation of the benefits of screening while harms are usually unknown, the confusion of early detection with prevention, and the lack of understanding of basic health statistics. Even highly educated individuals exhibit health illiteracy, exhibiting difficulties with very simple math queries [10], [11].

Also, for managers in the health care industry, knowledge of health statistics is a vital ability. The understanding of the meaning of health related statistics, allows inform decision making and prevents overdiagnosis and overtreatment, hence decreasing health expenses. Decisions made by managers in the health care sector have a big impact on how patients are treated, how resources are allocated, and how much money is spent. Data and statistics can be used to base decisions on evidence and facts.

Various statistics, such as the mortality rate, lethality rate, and survival rate, are employed to figure out the impact of a specific disease or treatment on the population or an individual. To accurately estimate this impact, it is necessary to comprehend what these concepts actually represent and how they differ. In order to improve the health of the population, it is crucial that health professionals, researchers, and policymakers comprehend and correctly apply these notions. Understanding these figures is also important for the general population, since it enables individuals to appropriately assess the risks associated with certain diseases and the efficacy of particular treatments. The accurate comprehension will assist health professionals in identifying the most effective prevention and treatment approaches, as well as assisting patients in making informed decisions, and health authorities in implementing suitable public policies. Incorrect comprehension, on the other hand, can lead to improper decision-making by both health professionals and individuals. In the end, it is essential to comprehend clearly these concepts, so that the transfer of information becomes more transparent.

In particular, understanding the differences between mortality and lethality rates is important, since they may dictate different public health actions or different treatments for patients by health professionals. The survival rate for a given time period, on the other hand, is not a transparent metric due to a number of biases. Knowing these biases allows more informed and rational decision making. To improve the transparency of the survival rate for a given time period, it is crucial that health professionals and the general population recognize and understand the features that can influence this metric, so that people can better comprehend what it really indicates and make more informed health decisions.

This paper addresses only these terms among the many statistical concepts in health. Understanding their meaning and limitations is essential for making informed decisions. To achieve this purpose, a three-question online survey was distributed. The objective was to assess people's knowledge and perception on this topic.

This paper has the following structure: section two describes the concepts of mortality, lethality, and survival rates, followed by sections describing the methods, the results obtained, and ultimately, the conclusions.

II. HEALTH STATISTICS

Mortality and lethality rates

The mortality rate is the ratio of the number of fatalities attributable to a certain illness over a given time frame to the total population during the same period. Consequently, the mortality rate of an illness is the ratio of fatalities attributed to that pathology, including both healthy and sick individuals. The mortality rate indicates how many people a disease kills in a given population over a given period. Hence, those illnesses with the greatest mortality rate will be ones that cause the most deaths.

The case fatality rate (CFR) or lethality rate of a disease represents the rate of persons who die as a result of that disease in relation to the total population diagnosed with it (only sick individuals diagnosed are taken into consideration). The infection fatality rate (IFR) considers all the population with the disease (diagnosed or not). This one is a better measure but more difficult to estimate. In both cases, the sick population is a critical aspect that might be difficult to obtain accurately, a difficulty that is exacerbated for diseases that present asymptomatic cases, i.e., patients who do not exhibit symptoms despite having the illness.

As with rare diseases, both a high lethality rate and a low mortality rate are possible. Likewise, a low lethality rate might coexist with a high mortality rate. This is the case of diseases that spread quickly over a population. It is crucial to correctly understand and use these concepts. The mortality rate provides more accurate information regarding the number of fatalities from a particular disease that occur in a given population during a given period of time.

Survival rate

Any time period can be used for the survival rate. The most used survival metric for cancer is 5-year survival, although five years are not particularly noteworthy. The 5-year survival rate is calculated by dividing the number of cancer patients who are still alive five years after their first diagnosis by the total number of diagnosed cancer patients. Since cancer is chronic, employing a temporal frame to record a patient's survival renders the measure misleading.

For instance, the mortality rates and 5-year cancer survival rates obtained from some studies, appear to be at odds with one another. Consider the example given by Marcus et al. [12]. This example was used to create the first question of the implemented survey. In a randomized controlled study of lung cancer screening in smoking men, the intervention group got routine chest radiography and sputum cytology. Participants who underwent screening had a 5-year lung cancer survival rate of 35% compared to 19% for those who did not undergo screening. Mortality rates for the intervention group were 4.4 deaths per 1000 person-years and 3.9 deaths per 1000 person-years for the control group. In other words, screening enhanced the survival rate while concurrently increasing the mortality rate. An explanation for this apparent paradox lies in the definition of survival rate which allows several biases to emerge.

Politicians are also affected by the difficulties of appropriately interpreting statistical concepts such as survival rate [1]. A scenario provided by Gigerenzer et al. [1] effectively illustrates this issue. During a 2007 campaign, former New York mayor Rudy Giuliani claimed to have had prostate cancer five or six years prior, applauding the 82 percent survival rate in the United States compared to the 44 percent survival rate in the United Kingdom, which had socialized medicine. The likelihood of surviving prostate cancer appeared to be around twice as high in the United States, but once one understands what these numbers actually represent, one might draw radically different conclusions. In the United States, the majority of prostate cancers were detected using PSA screening, whereas in the United Kingdom, the majority were diagnosed based on symptoms. The timing of the diagnosis was distinct, and hence, it might have a substantial impact on the survival rate. In this example, two biases are obvious.

The first bias, referred to as leading time bias, stems from the fact that screening promotes early cancer detection, i.e., more malignancies are detected early. Leading time is the interval between the detection of a disease and the appearance of its clinical symptoms. The apparent increase in survival time is attributable to the fact that earlier diagnosis correlates to an artificially extended survival time. This probably happened in the United States, where the search for the PSA marker in men meant that more cancers were found at an earlier stage.

The second bias is called overdiagnosis bias, in which the survival rate is artificially inflated by the inclusion of non-progressive cancers or false positives [13], [14], [15]. To make matters worse, overdiagnosis leads to overtreatment, which, in the case of cancers, is extremely harmful to the patient due to the harsh nature of the treatments. In the United States, screening with PSA marker research in men, very likely overdiagnosed cancers that would not have emerged as such, if screening had not been undertaken, or whose growth would have been so sluggish that the individual would have died from another cause. Lesions of low clinical importance may have been identified by the screening process which may explain the improved survival rate observed.

Sone et al. [16], after three years of a CT lung cancer screening program, identified virtually as many cancers in non-smokers as in smokers, which is another example of overdiagnosis bias. However, smokers are approximately 15 times more likely to die from lung cancer than non-smokers, which indicates to the discovery of non-progressive tumours in non-smokers, i.e. overdiagnosis of lung cancers, which would not have occurred if CT scans were not performed. This example was used to create the second question of the implemented online survey.

Other biases can emerge, such as the healthy volunteer bias, in which participants who volunteer for screening are more likely to be from higher socioeconomic groups, have better health care, or have a healthier diet, as they may be more in line with the recommendations of health professionals [17]. This bias can distort the survival rate even further in favor of screening.

Additionally, it is also recognized that the most quickly fatal cancers, which grow and spread quickly, have a shorter preclinical phase than cancers that develop slowly. As a result, screening procedures have a tendency to pick up on tumors that progress more slowly, which will also benefit those picked up during screening in terms of survival time (length time bias). This bias has different forms, one of which is the overdiagnosis bias.

All these biases result in an elevated survival rate, giving the impression that screening is more helpful than it actually is.

As a statistic for evaluating the success of a screening process, the 5-year survival rate has additional limitations. For instance, an individual's life span may appear to have been prolonged by a treatment for an early-screened cancer, by a medication so toxic that shortens rather than lengthens life, provided that the loss in life span is less than the lead time.

The capacity to differentiate and comprehend the differences between the survival and the mortality rate, as well as their limitations, is essential for physicians and patients to make an informed decision. Using the mortality rate should facilitate the clear transmission of information, since the survival rate is not a transparent indicator of information [1].

III. METHODS

From October 30, 2022, through February 4, 2023, a three-question survey was accessible online. The confidentiality of each participant was guaranteed. No monetary compensation or other incentive was offered in exchange for participation in the study. The questionnaire was subjected to a first evaluation and the small deficiencies noted were addressed in the final survey. The three questions asked are as follows:

Question 1: Consider a published randomized controlled study of male lung cancer screening. The 5-year lung cancer survival rate for participants who were screened was 35%, compared to 19% for those who were not screened. The mortality rate for the screened group was 4.4 deaths per 1000 person-years, while the mortality rate for the unscreened group was 3.9 deaths per 1000 person-years. In other words, screening enhanced survival while simultaneously increasing mortality. How can you best explain this apparent contradiction?

A) Something in the data has to be wrong.

B) The information conveyed by the mortality rate is more often misleading than that conveyed by the survival rate.

C) The information conveyed by the survival rate is more often misleading than that conveyed by the mortality rate.

D) This type of apparent paradox is common and in these cases the data should be ignored.

Question 2: In a study published after three years of a CT lung cancer screening program, virtually as many cancers were identified in non-smokers as in smokers. Given that smokers have a higher risk of dying from lung cancer, how can this seemingly surprising outcome be best explained?

A) Detection of non-progressive cancers in non-smokers (overdiagnosis).

B) Tobacco does not cause lung cancer.

C) There is no logical explanation for these findings.

D) The paper is wrong.

Question 3: A new drug designed to prevent death from 'Navis' disease is intended to be launched on the market. The drug is taken as a preventative measure prior to contracting the disease. The results of the randomized, controlled, and double-blind clinical trial involving 2000 participants in each of the experimental and control groups are as follows:

- 500 individuals in the experimental group contracted 'Navis' disease. Of these individuals, 10% succumbed to the disease, or the lethality rate was 10%.

- 100 individuals in the control group contracted 'Navis' disease. Of these individuals, 20% succumbed to the disease, or the lethality rate was 20%.

In terms of public health, it can be concluded that:

A) The value of greatest interest in this trial is not the mortality rate in each group, but rather the lethality rate in each group and the results of the trial support its approval.

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B) The value of greatest interest in this trial is not the lethality rate in each group, but rather the mortality rate in each group and the results of the trial support its approval.

C) The value of greatest interest in this trial is not the mortality rate in each group, but rather the lethality rate in each group, and the results of the trial do not support its approval.

D) The value of greatest interest in this trial is not the lethality rate in each group, but rather the mortality rate in each group, and the results of the trial do not support its approval.

IV. RESULTS

The first question is based on the findings of Marcus et al. [12]. Screened participants had a better 5-year lung cancer survival rate and a concurrently higher mortality rate. The meaning of the survival rate explains this apparent inconsistency. According to Gigerenzer et al. [1], this is a nontransparent measure, and the survival rate should be substituted by the mortality rate. Option C) is the best response. The obtained responses are listed in Table 1. There were no statistically significant differences between the responses of health professionals and the general population ($\chi^2(3) = 0.658, p = 0.883$). For both health professionals and the general population, the option with the most responses was the one that stated that the mortality rate is usually more misleading than the survival rate. This suggests that a significant portion of the population, including health professionals, does not comprehend or understand well these concepts.

TABLE 1: Answers to the first question.

Answer	Health professionals		General population		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
A)	4	10.8%	14	15.2%	18	14.0%
B)	16	43.2%	34	37.0%	50	38.8%
C)	**9**	**24.3%**	**23**	**25.0%**	**32**	**24.8%**
D)	8	21.6%	21	22.8%	29	22.5%
Total	37	100.0%	92	100.0%	129	100.0%

Sone et al. [16], after three years of a CT lung cancer screening program, identified virtually as many cancers in non-smokers as in smokers. The best explanation for this observation points to an overdiagnosis of lung cancers in non-smokers, given that smokers are around 15 times more likely to die from lung cancer than non-smokers. The second question is based on these results. This question does not address any of the three rates discussed previously, either survival, lethality, or mortality rate. However, it does so indirectly by addressing the issue of screening, which can result in an inflated survival rate due to overdiagnosis.

The option that best explains the apparent contradiction is A), as it is quite probable that non-smokers are overdiagnosed with cancer when employing an active lung cancer screening program. The vast majority of health care professionals selected the most adequate response. It was also the response provided by the majority of the general population. The second most given response was option C) that there is no logical explanation for what occurred. The differences in the proportions of correct responses between health professionals and the general population were statistically significant ($\chi^2(1) = 8.548, p = 0.003$). It should be emphasized that three respondents of the general population cited option B), that smoking does not cause lung cancer (Table 2).

Table 2: Answers to the second question.

Answer	Health professionals		General population		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
A)	**31**	**83.8%**	**52**	**56.5%**	**83**	**64.3%**
B)	0	0.0%	3	3.3%	3	2.3%
C)	5	13.5%	24	26.1%	29	22.5%
D)	1	2.7%	13	14.1%	14	10.9%
Total	37	100.0%	92	100.0%	129	100.0%

The purpose of the third question is to determine whether respondents have an accurate understanding of the meaning and use of lethality rate and mortality rate in a public health context. The question itself suggests the meaning of the lethality rate.

In this question it is said that the lethality rate in the experimental group was 10%. Given that 500 individuals in the experimental group contracted the disease, the mortality rate was 50 in 2000, or 2.5%. In the control group, the lethality rate was higher, at 20%, but because only 100 people contracted the illness in 2000, only 20 died, resulting in a 1% mortality rate. Despite the fact that the control group had a greater lethality rate, as the disease incidence was smaller, ultimately fewer individuals died. In terms of public health, the drug decreased lethality but raised morbidity, resulting in an overall rise in mortality, which is the most crucial concept, because it affects the entire population. As the drug increased mortality, the findings do not support its approval. The correct answer should be option D).

Table 3 has the answers. Option D) was selected by 43.2% of the health professionals surveyed. Regarding the general population, the most common answer was option A), with only 17.4% selecting the correct response, D). The general populacion placed a greater emphasis on the letalithy rate than the mortality rate, most likely due to a misunderstanding of the distinction between these concepts. The differences in the responses between health professionals and the general population were statistically significant ($\chi^2(3) = 9.984, p = 0.019$).

Table 3: Answers to the third question.

	Health professionals		General population		Total	
Answer	Frequency	Percent	Frequency	Percent	Frequency	Percent
A)	11	29.7%	43	46.7%	54	41.9%
B)	7	18.9%	19	20.7%	26	20.2%
C)	3	8.1%	14	15.2%	17	13.2%
D)	**16**	**43.2%**	**16**	**17.4%**	**32**	**24.8%**
Total	37	100.0%	92	100.0%	129	100.0%

V. CONCLUSION

Not understanding the limitations of the survival rate can lead to errors and poor decision-making. Commonly, it is inferred that if the 5-year survival rate for a particular cancer is, for example, 90% if diagnosed early, but declines to 20% if detected later, this demonstrates the importance of early diagnosis and screening programs. This is not correct. Screening enables early diagnosis, which artificially increases the percentage of cancer patients who live beyond five years. Additionally, it causes overdiagnosis by identifying cancers that will not progress.

Also, the differences between lethality and mortality rates, as well as their utility in various scenarios, are not always fully understood.

The purpose of the first question is to assess people's comprehension of the survival and mortality rate concepts. Both health professionals and the general population overestimated the survival rate in comparison to the mortality rate.

The second question addresses the issue of screening, which can result in an inflated survival rate due to overdiagnosis. The correct answer was the most frequently cited by both health professionals and the general population, but with a high rate of correct answers by health professionals, indicating that the community, with a special emphasis on health professionals, appears to understand the problem of overdiagnosis.

The third question suggests that there is likely some confusion between the notions of lethality rate and mortality rate, with health professionals demonstrating the most comprehension.

In order for informed consent and decision-making to be carried out appropriately, it is necessary to reinforce and keep on educating patients, as well as health professionals, on crucial statistical literacy in health topics.

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