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G rard Mondello

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BUILDING BELIEF SYSTEMS AND MEDICAL ETHICS: THE COVID-19 CONTROVERSIES

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GÉRARD MONDELLO

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Building Belief Systems and Medical Ethics: The Covid-19 Controversies

G rard Mondello*

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Abstract: *The Covid-19 pandemic upset both the economies of most countries, but also the field of medical science. As never, public opinion has interfered in the choice of therapeutic trials as evidenced by the controversies surrounding protocols using hydroxychloroquine. The public's choice for these treatments is explained as the application of a kind of individual "Pascal's wager". This article analyses the formation of the belief system of individuals by applying ambiguity theory's insights and information entropy. It shows that the public's choices are the result of efficient communication strategies chosen by these treatments' promoters.*

Keywords: Uncertainty Theory, Ambiguity, Pharmacy, Medicine

JEL : I1, I18, I19, D81 , L65

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* Universit  C te d'Azur, GREDEG, UMR 7321, CNRS.
250, rue Albert Einstein
06560 Valbonne, Sophia Antipolis. France
Tel.: + 33-4-93954327-fax:+ 33-4-93653798,
gerard.mondello@gredeg.cnrs.fr

0. Introduction

In December 2019, in Wuhan, China, a new coronavirus (SARS-CoV-2) emerged and caused numerous severe pneumonia cases (Lai et al, 2020)¹. More than seven months later, the epidemic became pandemic and in July 2020, Covid-19, this disease's name, reached more than 13 million people around the World and killed more than 600,000 people. By now (July 2020), neither proven pharmacological treatment nor vaccine exist.

Covid-19 has turned the world economy upside down. Many countries decided to confine their populations leading to a generalized contraction of GDP. This has brought passengers transport to a halt, making essential sectors such as tourism, catering and many industries (automotive, aeronautics, etc.) more precarious. Beyond these material factors, the pandemic has also undermined the scientific research field by casting doubt in the public's minds about the usual methodology's assessment for drugs and treatment protocols. This doubt has been fueled by two main events:

- First, a highly prestigious French biologist, professor Didier Raoult, claimed that the protocol he applies in his institute in Marseille (France) is effective. This protocol combines an antiviral drug used against malaria, hydroxychloroquine, and a macrolide antibiotic, azithromycin, (later CHQ+AZI Protocol (or still E Protocol for theoretical developments))². On the grounds of the lack of proven treatments, and the disease's rapid progression, he favors an emergency or, still, a 'battlefield' medicine, freeing himself from the standard methodologies advocated by medical and pharmaceutical academies. This concerns mainly phase II and III of standard trials (double-blind or randomized studies). He regards them too cumbersome or even unethical when patients' vital risk is involved (some would benefit from the treatment and the placebo test-group would not). For other clinicians and pharmacologists and for many States, whatever the urgency, the long-term safety of patients must prevail because they admit no deviation from standard drug development processes.

- The second comes from the failure of a scientific article in the most prestigious medical journals, the "Lancet" (Merah et ali (2020 a, b). This paper was an observational study

¹ The latter has been referred to as Coronavirus 2 (Severe Acute Respiratory Syndrome (SARS-CoV-2) by the International Committee on Virus Taxonomy (ICTV), and the disease has been officially named Coronavirus Disease-2019 (COVID-19) by the World Health Organization (WHO), which on 12 March 2020 declared it a pandemic and became a public health emergency of international concern (WHO (2020)).

² More precisely, initially in China, some trials showed that in vivo HCQ could be efficient and Pr. Raoult added the macrolide azithromycin.

concerning hospitalized patients retrospectively recorded (more than 96,000 patients and more than 650 hospitals on several continents) (Merah et al (2020 a)). According it, hydroxychloroquine had no curative effect and, moreover, the mortality rate was higher in the groups that received the molecule than in the groups without it. Numerous unknowns about the data source and structural inconsistencies led three out of four authors to resign and to the paper's withdrawal (Merah et al (2020b)). This journal's prestige is so high that it conducted World Health Organization (WHO), first, to stop trials using hydroxychloroquine and second, after the paper's removal, to resume them (WHO definitively dropped them in mid-June following the results of randomized trials).

Both factors combined to prompt public opinion doubting from the standard and well-accepted evaluation methodologies and governments' prevention policies. Consequently, a lot of people consider that patients should retain their free will and be able to choose the CHQ+AZI if they so wish as opposed to the standard one (let us call it S) that hospital spontaneously apply while awaiting the discovery of more effective treatment.

In some countries (notably France), CHQ+AZI Protocol enjoys strong support in public opinion. This support expresses through the press (TV, newspapers), social networks, and even mass petitions³. Several factors add to explain this mistrust in official medicine: populism of some State's leaders (USA, Brazil), opposition to the government rooted in long months of protests (France, Belgium), etc. Furthermore, this support is fueled by constant pro-active communication by the CHQ+AZI Protocol's promoters. The result is a constant tension between the government's decisions and a part of public opinion that many doctors support. On this basis, they challenge the government's decision and considers that from their free will patients, should be able to choose their treatment on the grounds of a kind of individual Pascal's wager.

This constant pressure from public opinion is not without cost. It contributes to HCQ-based therapeutic trials proliferate. This is done at the expense of other trials and to the disorganization of the research system and therapy assessment systems. It follows that the research treatment and vaccines processes may be threatened by a constant opposition that inflicts the means devoted to scientific research. For instance, on June 30, 2020, around 232 active or planned clinical trials are testing the ability of hydroxychloroquine or chloroquine to

³ For example, on the social network FaceBook you can count nearly 90 direct support sites for Professor Raoult.: https://www.facebook.com/search/groups/?q=didier%20raoult&epa=SERP_TAB, See also the newspaper "le Monde" du 07/03/20 William Audureau et Assma Maad "Une exploration de la « Raoultosphere » sur Facebook", https://www.lemonde.fr/les-decodeurs/article/2020/07/03/une-exploration-de-la-raoultosphere-sur-facebook_6045017_4355770.html

treat or prevent COVID-19⁴. This state of matter prevents testing other promising treatments by exhausting financial and physical means. Indeed, one in six has been devoted to testing the effects of chloroquine and its derivatives, while other sources have been neglected.

The public's influence is considerable, even inducing both the nature and quantity of clinical trials and even the drugs to be administered. The aim of this article is therefore to try to understand how public opinion reacts to an unknown situation. Indeed, through this pandemic, people are evolving in a world of radical uncertainty that makes them psychologically vulnerable. This uncertainty is non-probabilistic in Knight's (1921) sense. Building a belief system based on available information is for them a means of reducing the negative consequences this uncertainty. This one may lead to some cognitive dissonances that cast doubt on the scientific trials results. The study of motivations belongs to the sociology field: mistrust towards the authorities, economic conditions, level of education, etc. However, concerning economic analysis, we focus on the study of belief systems formation. Thus, the article aims at understanding how the agents may be led to choose unproven, and even inefficient, treatments compared to any others recommended by the Authorities.

This approach will be underpinned by an application of ambiguity theory derived from Ellsberg's paradox. The latter has led to experiments to test attitudes towards ambiguity (Camerer (1995)) and has inspired various generalizations of expected utility theory to account for ambiguity (Camerer and Weber (1992), see also Baillon and Larridon (2016)). Schmeidler (1989) opened a fruitful avenue by introducing Choquet's capacities into expected utility theory, i.e. the possibility for subjective probabilities not to sum to 1. This non-additivity property allows for different attitudes to ambiguity. In particular, a concave (superadditive) capacity reflects optimism, while a convex (subadditive) capacity reflects pessimism (see Schmeidler (1989), Wakker (2001)).

We use a special type of Choquet's capacity called neoadditive capacity as Chateauneuf, Eichberger, and Grant (2007) conceptualized it. This one applies well to our problem where individuals may feel optimistic or pessimistic to ambiguity. Thus, agents make their choice with incomplete confidence in the specified probability distribution. They choose an act among the set of available acts (here treatments) that maximizes a weighted sum that comprises the minimum utility, the maximum utility, and expected utility relative to this probability distribution. The agents' ambiguity degree can be measured by the model's parameters. This

⁴ In ClinicalTrials.gov, <https://clinicaltrials.gov/> (July 1, 2020).

degree is the complement of the degree of confidence and the degrees of optimism and pessimism, which determine the weights assigned to the maximum utility and the minimum utility.

This article constantly challenges both institutional and scientific news and their consequences in terms of the agents' choices. It aims at understanding how the patients constitute their belief system through both the different protocols stakeholder's communication. To analyze this question, beyond ambiguity theory we refer also to information entropy. We highlight that the promoters of Protocol E develop a permanent doubt about institutional decisions. This doubt leads to reinforcing patients' opinions as opposed to government decisions to choose this protocol independently of any contrary scientific communication. We highlight that it reinforces the preference for the ambiguity of patients in favor of protocol E

In the first section, we settle the nature of uncertainty under which the agents make their beliefs, in the second one, we show how a belief system may be built under radical uncertainty while section three analyzes how competitive information channels compete to impose a protocol. The last section concludes.

1. Uncertainty, ambiguity and patients' choice

Some patients consider that facing the radical uncertainty triggered by covid-19, they find themselves in Pascal's wager situation. In other words, refusing the Authorities' standard treatment, they ask for access to Protocol E. They argue that their healing probability is higher than with S. However, should this treatment fail, they state that their healing chances are identical to these of being cured by Protocol S. This paragraph will study this proposal by distinguishing between the Paschalian wager' terms and its transposition to the choice of a therapeutic protocol.

1.1 Stylized facts and the HCQ+AZI protocol's choice

Herper and Riglin (2020) show from STAT and Applied XL reports that, since January 2020, research centers and hospitals have conducted 1,200 clinical trials to test treatment and prevention strategies against Covid-19. Moreover, these tests were performed in a disorderly and haphazard way contributed to waste huge amounts of financial and human resources. Furthermore, one out of six trials was designed to study hydroxychloroquine or chloroquine, which have been shown to have no beneficial effect on hospitalized patients⁵. This hype for

⁵ Trials are costly. Moore et al, (2020) starting from a sample of 138 pivotal clinical for the FDA corresponding to 59 new therapeutic agents from 2015 to 2016, estimated median unitary cost to \$19.0 million (interquartile

CHQ, in top of that of its promoters, comes from the strong support of States' leaders as Trump (USA) or Bolsonaro (Brazil). Thus, in the United States, Shehab, Lovegrove, and Budnitz (2020) show that after President Trump's support for HCQ's treatments, their sales soared significantly: "From February 2020 to March 2020, the estimated number of patients receiving dispensed hydroxychloroquine prescriptions increased 86.2% (from 367 346 to 683 999) and the number receiving dispensed chloroquine prescriptions increased 158.6%(from 2346 to 6066). Of the patients receiving dispensed hydroxychloroquine prescriptions, the estimated number receiving both hydroxychloroquine and azithromycin increased 1044% (from 8885 to 101 681)". These factors influence public decision-making and patients' choice. This craze has been particularly strong in France, where numerous controversies over the dispensation of the HCQ+AZI protocol fueled public debate. These controversies explain why a large number of patients and doctors required the HCQ+AZI protocol to be administered and why a large public favors it. These clarifications explain the demand for free access to this treatment under the Pascal's wager terms. It is this point that we will now deal with.

1.2 Blaise Pascal's wager and patients' freedom of choice

"Pascal's wager" matches Blaise Pascal's "Wager on the Problem of Eternity": whether God exists or not, we might as well believe in him in order to be sure of earning our place in bliss, if it exists⁶. Pascal's wager has been the subject of a large literature in the field of economic decision-making⁷. Here, we restrict the analysis to its simplest probabilistic expression. Then, the following elementary events describe the possibilities of access or not to beatitude and in God's belief: B : « Access to Bliss», C : « Believing in God», D : « God's existence». For the believer, the existence of God is beyond doubt. If $pr(D)$ represents God existence probability, then for him/her, $pr(D) = 1$. Pascal asks the non-believer to believe in God in the spirit of a game. Thus, for Pascal's gambler, God revelation will or will not be on death, he must attribute a certain probability to the existence of God: $1 \geq pr(D) > 0$. Before going further, let us examine the following question: what is the probability of attaining bliss conditionally to our trust in God? This is apparently a conditional probability that expresses as:

$$pr(B|C) = \frac{pr(B \cap C)}{pr(C)}$$

range, \$12.2 million-\$33.1 million). However, costs differ according the number of patients, the nature of drugs, etc. Comparative trials with placebo reach the highest cost (\$35.1 million (95% CI, \$25.4 million-\$44.8 million).

⁶ Blaise Pascal, *Pensées*, fragment 397.

⁷ See Hájek's for an exhaustive review (2018).

May this probability be less than 1? This means that believing does not imply accessing to beatitude, and if this is the case, it goes against Pascal's wager: « *Let us weigh the gain and the loss in wagering that God is. Let us estimate these two chances. If you gain, you gain all; if you lose, you lose nothing. Wager, then, without hesitation that He is* ». This proposition links beatitude to belief God with $pr(B|C) = 1$, it follows that $pr(B \cap C) = pr(C)$. Let's go a step further and ask ourselves if $pr(B \cap C)$ can be less than 1? This would mean that "to believe and attain bliss" would not be guaranteed, which is the same contradiction as above because $pr(B|C) = 1$ would then depend on $pr(C)$ being equal to $pr(B \cap C) < 1$, but there is no reason to believe that this equality is verified for another value than 1, thus, $pr(B \cap C) = pr(C) = 1$. These events are independent of God's existence characterized by $1 \geq pr(D) > 0$. Indeed, it is at our journey's end (our death) that we will know whether or not God exists. This is independent of the God's belief. The question is then knowing what the conditional probability is of reaching bliss when one believes (i.e. the link between belief and bliss), this conditionally to God's existence:

$$pr(B \cap C|D)$$

In fact, these two events are independent⁸ :

$$pr(B \cap C|D) = pr(B \cap C)P(D) = 1 \cdot pr(D) = p > 0$$

Then, access to beatitude is all the more plausible the more one attaches a certain probability to God's existence. If God exists and I do believe (i.e. if I conform to his law in deeds and heart in Pascal's sense) then, my Salvation is insured with a probability of p . However, if God exists, but if I don't believe, I am denied access to bliss with certainty. Obviously, there, the probabilities are totally subjective. Asserting that God exists with a given probability is not based on any prior experimentation or statistical data, for the believer $p = 1$. However, that is not the one Pascal is targeting. but the free thinker. He makes him admit that as a rational man he cannot consider that $p = 0$. Thus, the latter can only estimate God's existence as probable: $0 < p \leq 1$. Therefore, if he believes, his salvation is assured.

1.3 Transposing the Pascal's wager

Can we transpose the Pascal's wager terms to the therapeutic choice which consists of choosing the empirical protocol E rather than the standard treatment, given that the patient who chooses E, is also subjected to basic or standard treatment S? The Pascal's wager patient could

⁸ Proof in appendix 1.

say: « *I put myself in the conditions of the Pascal's rational man and I admits that protocol E can heal me with a probability of $pr(E) = e > 0, e \leq 1$. Knowing that experimental protocol U will only be available in the very distant future and as I wholeheartedly believe in in protocol E, I ask that it be administered to me.* ».

As before, we will distinguish three elementary events and compare them, qualitatively to Pascal's bet, the three event proposals:

G : « The recovery »; K: « The belief that protocol E cures» and E: « Protocol E does cure ».

Thus, to put the patient in the Pascal's wager condition, we must pattern the relations between G, K and E, on the ones between B, C, D. Then, let us first consider the probability of healing $pr(E)$ which could be assimilated to the probability of God's existence $pr(D)$. We admit that the patient is somehow "to be convinced" and that he or she supposes that, $1 \geq pr(E) > 0$, as for Pascal's "libertine". In general, however, the patient is already convinced in such a way that he or she is THE believer with $pr(E) = 1$. To be on the safe side of the wager, we discard this conception to assume that $1 \geq pr(E) = e > 0$. It is worth noting, however, that this value can be both subjective (what the patient believes) and objective, which is revealed by the tests or trials on the day the patient makes his or her decision. For now, admit that this probability corresponds to the patient's assessment. Then, the question is what is the probability of achieving a cure if one believes in treatment E? That is, in terms of conditional probabilities:

$$pr(G|C) = \frac{pr(G \cap C)}{pr(C)}$$

In Pascal's wager, the promise of paradise is linked to the following proposition: "It is because I believe in God that I win bliss". It corresponds to the active attitude of the person who begins to believe, and it depends on his or her will or faith alone. Can the analogy be continued here? It is obvious that the patient's action is limited to believing, but that this belief is in no way constitutive of his healing, which depends on the effectiveness of the treatment.

Can we then put $pr(G|K) = 1$ or, in other words, "the probability of recovery conditional on my belief in the virtues of treatment K is certain"? Obviously, healing is not linked to belief, they are in fact two independent events.

$$pr(G|K) = pr(G) \text{ and } pr(K|G) = pr(K),$$

And, therefore :

$$pr(G|K) = pr(G).pr(K)$$

I can posit, as a good believer in E, that $pr(K) = 1$ and thus:

$$pr(G|K) = pr(G).1 = pr(G)$$

Where $pr(G)$ is the recovery probability. The first snag in Pascal's wager is the impossibility of trusting that the fact of believing in the treatment virtues guarantees the patient's healing, while the libertine's belief in God guarantees him eternal life. Whereas for the first $pr(B|C) = 1$, for the second one:

$$pr(G|K) = pr(G) < 1$$

We can then ask the question of healing conditional on the fact that Protocol E heals. In other words, we now consider:

$$pr(G|E) = \frac{pr(G \cap E)}{pr(E)}$$

The two events are not independent. If Protocol E is applied at the patient's request, the patient's recovery is related to the Protocol E likelihood of success. Objectively, no protocol may guarantee that $pr(G \cap E) = 1$. In other words, there is no protocol that 100% cures the patients. Negative side effects may not cure a patient (that also may die), so not only do $pr(G \cap E) < 1$, but also $pr(G \cap E) < pr(E)$. Indeed, in the absurd reverse case ($pr(G \cap E) > pr(E)$) and consequently, $pr(G|E)$ could be higher than 1. Condition for having $pr(G|E) = 1$, obviously would be that $pr(G \cap E) = pr(E)$ which would be a contradiction in terms because if $pr(G \cap E) < 1$ and $pr(E) < 1$ (with clearly $pr(G \cap E) < pr(E) < 1$) then , $pr(G|E)$ cannot be greater than these two values by being equal to 1. Hence, the only possibility would be that $pr(G \cap E) = pr(E) = 1$, it is a rejected proposal. Consequently, if $pr(G \cap E) = f < e$ then

$$pr(G|E) = \frac{pr(G \cap E)}{pr(E)} = \frac{f}{e} = e'$$

$$\text{with } e' < e$$

Reaching this stage, finally, despite its differences with Pascal's wager, this calculation could be likened to it insofar as the probability of recovery is e' and that access to bliss depends on the likelihood of being placed in God's existence. This is what we are now discussing.

1.4 Discussion

In fact, appearances are deceptive. Indeed, $pr(G|E)$ depends on essentially objective factors and not subjective. Indeed, in Pascal's wager, it is enough to pose a positive probability, however small, to make belief attractive. Action depends only on oneself and one's free will to accept Pascal's proposals. Concerning Protocol E, things are different. Indeed, $pr(E)$ and $pr(G \cap E)$ can only influence the patient if these probabilities are known and accepted by the patient. Thus, if the scientific community agrees to give value to $pr(G \cap E) = \hat{f}$ et à $pr(E) = \hat{e}$, in such a way that $pr(G|E)$ corresponds to the objective recovery conditional probability if Protocol E is adopted, then this probability is expressed as:

$$pr(G|E) = \frac{\hat{f}}{\hat{e}} = \hat{e}'$$

If the standard protocol S, is such that its conditional probability of success is: $pr(G|S) = \hat{s}'$ and that $\hat{s}' < \hat{e}'$ then, very objectively, the patient is justified in requesting protocol E. However, if there is no such objective assessment of \hat{e}' , this means that $pr(G \cap E)$ and $pr(E)$ are based on the subjective assumptions of the patient. The latter by requesting the application of protocol E implicitly evaluates two functions or two probabilities. The first is the probability of success of protocol E, and the second is the conditional probability of recovery using E.

We find ourselves in one of the (simplest) configurations of the Ellsberg's Paradox. Indeed, "Protocol E"'s supporters consider the authorities' word to be less credible than that of "Protocol S"'s supporters. In so doing, they show a preference for ambiguity because their approach is similar to a situation of radical uncertainty described in the so-called Ellsberg Paradox, (Ellsberg (1961)). Ellsberg's paradox shows that, in uncertainty, the decision-maker determines his choice by the probabilities and the consequences associated with these probabilities but also by the degree of confidence he attributes to his own judgement concerning the probabilities. The latter term refers to ambiguity in Ellsberg's sense and reflects his attitude towards uncertainty.⁹

⁹ The highlighting of this paradox supposes that an individual must choose an urn among two in which there are equal numbers of black and red balls in both. Drawing a black ball will provide him with a gain of \$100. In urn 1, the proportions of the balls are known, in urn 2, the proportions are unknown (uncertainty). Following various possible choices, if it turns out that the individual chooses combinations that favor urn 2, this means that he considers that the probability of drawing a black ball (and therefore of winning) is greater than that of urn 1, thus showing a preference for ambiguity (the uncertain situation). Other individuals may show an aversion to ambiguity

The rationale for a protocol's choice was based on information received from contradictory sources. In spite of the multiplicity of means (radio, television, internet newspaper information, social networks), two main channels can be distinguished. Thus, a patient i , implicitly (or explicitly) when he receives information can estimate his probability of being cured conditionally to a protocol $v \in \{E, S\}$ following the conditional probability:

$$pr(G_i|v) = pr(G_i \cap v)/pr(v) = \frac{prv_i}{pr(v)} = pr(v_i')$$

However, this information relates to the protocol v effectiveness, (i.e. $pr(v) \geq 0$), but also to the individualized evaluation $pr(G_i \cap v)$. Thus, playing on two parameters, the third is deduced. The information transmitted can be "personalized" and lead the patient to estimate his or her own survival level as soon as he or she has information on the success probability of the protocol. This specific information may take the form of $pr(G_i \cap v)$ ou $pr(v_i')$. The issue of patients' choice of protocols is a matter of communication strategies between the proponents of Protocol E and the government that implement Protocol S.

2. Building a belief system: science vs. Persuasion

We model the attitude of a representative agent facing uncertainty. To do this, we use the neo-additive preferences notion of Chateauneuf, Eichberger, and Grant (2007). This is a special case of Choquet's expected utility (CEU) developed by Schmeidler (1989). Ambiguity induces the agents to overweight the best and worst outcomes of a given action compared to the standard Expected Utility Theory. This model is particularly suitable for studying a patient's behavior. Indeed, considering a disease, two focal outcomes exist that roughly correspond to the best situations (recovery) and the worst (not healing or even dying). Hence, we analyze the behavior of a representative patient who does not trust official medicine and prefers to follow the experimental protocol E. This patient may feel either preference or aversion to ambiguity about the protocol efficiency. This depends on the level and source of received information.

2.1. Neo-capacity and choice in radical uncertainty

With Chateauneuf et al (2007)'s, the so-called neo-additive preferences make it possible to formalize both preferences and aversion for ambiguity. The set of all states of nature is represented by $\sigma \in \Omega$ and the overall results by X . An act is a function $b: \Omega \rightarrow X$ which assigns

by choosing urn1. In general, individuals direct their choices to the ballot box for which the probabilities are known.

a result to the entire space of act. Neo-additive preferences can be represented by the following function defined on the acts' space:

$$V(b) = \delta\alpha A + \delta(1 - \alpha)B + (1 - \delta)\mathbb{E}_\pi u(b(s)) \quad (1)$$

Where: $\mathbb{E}_\pi u(b(s))$ represents the expected gains usefulness or associated with the events (where $u(\cdot)$ is the utility index associated with the gain $b(s)$ for the state s). This compares with the conventional probability distribution π over all states of nature.

- $A = \max_{b(s) \in X} u(b(s))$ the maximum value of expected earnings, and
- $B = \min_{b(s) \in X} u(b(s))$, their minimum value.

The decision-maker's preferences may be influenced by the weight he or she assigns to extreme values A et B . This weighting modifies the probability distribution, which may be objective or subjective. Weight δ represents the measure of ambiguity, i.e. the over- or under-valuation of extreme values with $1 \geq \delta \geq 0$. Note that δ applies to these values and to expectation $\mathbb{E}_\pi u(\cdot)$. Consequently, the individual compares the latter (the occurrence of average values to extremes). The more he or she contests the mean value, the more weight is given to A and B with a high δ and a weak $1 - \delta$. Following Wakker (2001), to these values, the authors add, the optimistic or pessimistic behaviour of the decision-maker. Thus, the decision-maker may consider that he is more likely to obtain a high value for his decision (A) than the smallest (B). In this case he (or she) is optimistic α is close to 1, whereas if he's a pessimist, $1 - \alpha$ will be close to 1 with, $1 \geq \alpha \geq 0$. Thus, the decision-maker maximizes a convex combination $V(b)$ representing the maximum gain, minimum gain and average gain weighted by its optimistic or pessimistic nature and its level of aversion to ambiguity.

2.2. Favoring protocol E

We now consider a patient i which has the choice between protocol E and protocol S. He estimates his chances of recovery based on the protocol in question. $v \in \{E, S\}$ following the conditional probability:

$$pr(G_i|v) = pr(G_i \cap v)/pr(v) = \frac{pr(v_i)}{pr(v)} = pr(v_i') \quad (2)$$

(with $e'_i = \{e'_i, s'_i\}$)

If he estimates as A the healing gain and $(-B)$ the loss of no healing, (with $A > -B$), the number of events related to the states of nature is only two: (Healing, not healing). Then, if $u((G_i|v))$ is the gain of healing by following the protocol v alors $Max\{u((G_i|v))\} = A$ and

the one not to heal is $Min\{u(\overline{G}_i|v)\} = -B$, it follows that the expected gain using treatment $v, v \in \{E, S\}$ is:

$$\mathbb{E}_\pi u(\check{G}_i|v) = pr(v_i')A - (1 - pr(v_i'))B$$

So, for Protocol E :

$$\mathbb{E}_\pi u(\check{G}_i|E) = e'_i A - (1 - e'_i)B$$

And for Protocol S :

$$\mathbb{E}_\pi u(\check{G}_i|S) = s'_i A - (1 - s'_i)B$$

Note that π and π' refer to different probability distributions. Thus, if the patient receives no conflicting information about treatment E and is willing to believe in its effectiveness, then he or she will adhere to it. This means that if we consider its expected utility function of Choquet, it will be expressed as:

$$V(E) = \mu \alpha A - \mu(1 - \alpha)B + (1 - \mu)\mathbb{E}_\pi u(\check{G}_i|E)$$

Where μ represents the aversion to ambiguity and as before, α corresponds to his level of optimism about his recovery, ($1 \geq \mu \geq 0, 1 \geq \alpha \geq 0$). In this situation it is assumed that for him $\mathbb{E}_\pi u(\check{G}_i|E) > \mathbb{E}_{\pi'} u(\check{G}_i|S)$ with $e'_i > s'_i$.

a) In the first situation ((Appendix 2) “Absolute confidence in the probability distribution” π), the patient has no information about the Protocol E’s recovery likelihood from the government’s side. The only available information comes from Protocol E’s promoters, who claim a higher healing rate than with standard treatment. Consequently, patients have two choices. The first is to inform themselves about the scientific literature on the available treatments, or not. Many reasons explain why they do not get informed: insufficient scientific education, people under pressure because as he/she is ill, he/she enough time to choose, etc. In any case, if the individual opts for treatment E, then he/she take into consideration the healing conditional probability corresponding to his or her situation as advanced by the promoters of E to be acceptable. Following Ellsberg's paradox, the individual who accepts a probability of cure as reliable ($e'_i = pr(G_i|E)$), expresses an aversion to ambiguity.

b) We assume now that the authorities must decide about Protocol E validity (cases (b) and (c) in Appendix 2). In case (b)), they state that protocol E is not conclusive and does not cure better than S. In case c, the government considers that the negative side effects reduce the benefit without curing better than S. Therefore, we highlight that the conditions for the patient to continue to choose E in spite of his stated and verified deficiencies are that he feels doubts about the probability ratio between both therapies: $\mathbb{E}_\pi u\left(\left(\check{G}_i|E\right)\right) = \mathbb{E}_\pi u\left(\left(\check{G}_i|S\right)\right)$ with $e'_i = s'_i$. As a result, he/she prefers ambiguity. $\mu > 0$, but this condition is not sufficient, also he/she needs to be more optimistic than the healing probability with treatment S, i.e. $\alpha > s'_i$.

The results are more severe when authorities point out that the expected benefits of Protocol E are lower than those of the standard protocol when the former produces serious and undesirable side effects. This means that the condition for not surrendering to the authorities' arguments is a degree of preference for ambiguity μ greater than:

$$1 \geq \mu > \frac{(s'_i - e'_i)}{(\alpha - e'_i)}$$

This result is true with the condition that $\alpha > e'_i$ (a higher degree of optimism of cure with treatment E higher probability of cure with treatment S, such that $\alpha > s'_i$). Then, it is legitimate to ask how the E promoters' words may find greater resonance in some patients?

3. Illustration: belief system's and the HCQ+AZI protocol dispute

Confidence and mistrust combine about the available treatments range (even if the latter is limited). Patients "build" their belief system that confidently makes them accept a given protocol. However, it would be wrong believing that they are irrational; their choices are based on the degree of trust they place in the received information.

3.1 Public authorities and uncertainty reduction: information entropy.

In this sub-paragraph we examine the factual elements relating to the authorities' attitude about both protocols, and we analyze the process by which the agents reduce their uncertainty level and choose a protocol, despite the government's information and decisions.

3.1.1 Information and institutional decisions

Pro-protocol HCQ-AZI patients and doctors are asking the government both for its generalization and immediate accessibility. This, for the former in the name of their freedom of choice and, for the latter, for their freedom to prescribe¹⁰. To simplify matters, before March 2020 the prescription of a pharmaceutical specialty had to conform with its Marketing Authorization (MA) or Temporary Use Authorization (TUA). Following the pandemic progression in France, the French Parliament added a chapter to the Public Health Code entitled "State of Health Emergency". The administration of the HCQ+AZI protocol in Marseille hospitals led to changes in the conditions for administering medicines outside of the MA. Indeed, the government considered that this protocol's therapeutic advances were poorly known and required new trials. The High Council of Public Health prohibited this extra use¹¹ due to the lack of "data acquired from science" on the day the decree was issued.

By highlighting the methodological CHQ+AZI protocol's flaws, the government considers that, according to its knowledge, its recovery's probability is not conclusive. It follows that this protocol should not be applied outside the standard trials. Moreover, its massive and uncontrolled use among the public may produce or increase undesirable side effects on patients. In doing so, the authorities blindly apply the precautionary principle which easily extends from the environment to Public Health. Medical authorities are all the more reluctant to authorize free prescriptions as they are guided by the medical equivalent precautionary principle, i.e. the "Primum non (or nil) nocere" that stems from Hippocrates' Treaty on Epidemics. Following several reports and the subsequent WHO¹² decision, the National Agency for the Safety of Medicines (ANSM) reports (ANSM(2020 a and b), and reports from regional pharmacovigilance centers concerning HCQ-AZI combination's side effects, and based on its own estimates, on 26 May 2020, on a collegial formation, the High Council of Public Health concluded that there was no sufficiently robust clinical study demonstrating the efficacy of hydroxychloroquine in Covid-19 regardless of the severity of the infection.¹³.

¹⁰ In French law, article R.4127- 8 of the French Public Health Code.

¹¹ Article L. 3131-5 of the Public Health Code and recommendations of the High Council of Public Health.

¹² WHO, tweet on 25/05/2020: "The Executive Group has implemented a temporary pause of the hydroxychloroquine arm within the Solidarity Trial while the data is reviewed by the Data Safety Monitoring Board"-

¹³ Thus, the HCSP recommends:

-Hydroxychloroquine (alone or in combination with a macrolide) should not be used in the treatment of Covid-19...

- Assess the benefit/risk of the use of hydroxychloroquine in therapeutic trials.

- Strengthen national and international regulation of the various tests evaluating hydroxychloroquine in Covid-19.

3.1.2 Public information and reduction of information entropy

Governments must respect the precautionary principle. Consequently, without certainty about a given treatment effectiveness and safety, the latter must either closely administer the risky protocol or prohibit it following the scientific information at its disposal. By its cautious attitude, the government does not contribute to reducing the uncertainty the agents face. This uncertainty may be assessed by the Shannon (1948)'s information entropy. This notion measures uncertainty degree i.e. the degree of information. The higher the uncertainty, the higher the informational entropy. Then to simplify, consider the following conditional probability distributions of success and failure for the E and S protocols:

- $pr(G_i|s) = pr(G_i \cap s)/pr(s) = \frac{pr(s_i)}{pr(s)} = pr(s'_i) = s'_i$ where s'_i expresses the standard protocol's success and \bar{s}'_i the failure conditional probability, i.e. $S'_i = \{s'_i, \bar{s}'_i\}$ and let the symmetric distribution be:
- $E'_i = \{e'_i, \bar{e}'_i\}$ for protocol E.

In the absence of information on both protocols' efficiency, the entropy level for each is maximal. Indeed, we can consider that: $s'_i = \bar{s}'_i = e'_i = \bar{e}'_i = \frac{1}{2}$. Thus, formally, as an information system entropy is the sum of the products of the probabilities of the different states by the logarithms of these probabilities taken with the inverse sign. It follows that if $H_i^S(S)$ and $H_i^E(E)$ measure the respective expected entropy of the two protocols then:

$$H_i^S(S) = -\left(s'_i \text{Log}_2(s'_i) + \bar{s}'_i \text{Log}_2(\bar{s}'_i)\right) = \frac{1}{2} \left(-\text{Log}_2\left(\frac{1}{2}\right)\right) = 1$$

And $H_i^S(S) = H_i^E(E) =$ which is the maximum entropy value. Thus, in the absence of information the entropy is maximum. Suppose that with more information X, on the X protocol, is $H_i^S(S|X)$ et $H_i^E(E|X)$, où par exemple $s'_i = 3/4$ et $e'_i = 7/8$. Then, it appears that $I_i^S(S) = H_i^S(S) - H_i^{S'}(S)$ and $I_i^E(E) = H_i^E(E) - H_i^E(E|X)$ expresses the amount of entropy destroyed by the arrival of new information.

$$I_i^S(S) = 1 - \left(\frac{3}{4} \text{Log}_2\left(\frac{3}{4}\right) + \frac{1}{4} \text{Log}_2\left(\frac{1}{4}\right)\right) = 1 - 0.8113 = 0,1887$$

These expressions make it possible to assess the influence of communications on the protocol's effectiveness level. Thus, what can be the impact of information on the efficiency of

one of them (here protocol E) that could lead to its prohibition? By this decision, the authorities mean that this protocol is ineffective. Thus, theoretically: $e'_i = 0$ et $\bar{e}'_i = 1$, at this level, $H(E/\bar{E})$ refers to protocol E entropy from the Government's view (\bar{E} the government information that E is ineffective). Then, as its ineffectiveness probability is 1, $H(E/\bar{E}) = -(0 + 1 \log_2 1) = 0$. A null entropy means that the information is complete and describe a certain fact. The a priori belief in the protocol E's efficiency by agent i involves that $H_i^E(E) < H_i^S(S)$, i.e., $e'_i > s'_i = 1/2$ by assumption. Note as both protocols are independent, having information on protocol E does not preclude that protocol S's uncertainties decrease. Despite government intervention on Protocol E (or more specifically the CHQ+AZI protocol), a large part of the public is not convinced of its ineffectiveness. It is this point that we will now examine.

3.2 Pro-active communication strategy of the CHQ+AZI protocol's proponents

The public's preference for the CHQ+AZI protocol essentially explains by its promoters' strong pro-active strategy about its efficiency. People uses simultaneously, press, audiovisual media, auto-published non-randomized trials, critics of trials' standard methodology. Acting this way, they maintain the ambiguity phenomenon by claiming that their protocol is efficient. This claim lies on to main pillars.

- The first one is the questioning of standard pharmaceutical industry trials based on the codification of "Evidence Based Medicine" (EBM).
- The second one is an aggressive communication strategy (press, official reports, non-randomized trials).

3.2.1 Challenges to Phase III Clinical Trials

Professor Rouault strongly put into question the "Evidence Based Medicine" methodology (EBM). EBM spread in the 1980s and, initially, its aimed rationalizing the patients' diagnosis and treatment by giving clinicians access to the most effective knowledge.

“Inexpensive electronic data bases and widespread computer literacy now give doctors access to enormous amounts of data. Evidence based medicine is about asking questions, finding and appraising there levant data, and harnessing that information for every day clinical practice”. Rosenberg W, Donald, A., (1995). p.1122.

In theory, the practitioner should have access to any information source, and no-surprisingly this methodology developed in symbiosis with internet expansion that gave access to huge databases. Thus, according of one of its main promoters David Sackett:

“Finally, in terms of study designs, evidence- based medicine is not restricted to randomized trials and meta-analyses. It involves tracking down the best external evidence with which to answer our clinical questions.”

In its most ideal version, the "EBM" intended to provide an incomparable tool for therapeutic decision-making. This idyllic vision is increasingly challenged by practitioners and researchers who denounce the major pharmaceutical companies' stranglehold on the EBM systematization and its growing submission to financial interests. Since the eighties of the last century, academic contributions show how the pharmaceutical industry has invested the field of therapy by focusing the validation of protocols on a reduced vision of EBM: randomized clinical trials. Indeed, these trials are fundamental for bringing the products tested to the market. Thus, pharmaceutical industry funding of clinical trials is strongly associated with favorable results for the latter. The literature highlights several biases ranging from trial design, publications, access to databases (clinical efficacy, toxicity, drug costs, etc.). The authors show a statistically significant association between funding sources and study outcome. Consequently, the industry selects drugs that are likely to prove effective and the issues are flawed due to too small samples size. Furthermore, the researchers fear that funding will be interrupted if the studies do not yield favorable results (see Sismondo (2008), Bero and Rennie (1996), Davidson (1986), Chren and Landefeld (1992), Bowman M.A., (1986), Bowman, Pearle (1988)).

Proponents of the HCQ-AZI protocol rely on these recurrent criticisms about pharmaceutical groups dominance on EBM to justify their therapeutic choice. Besides, they bring two other therapeutic considerations.

- The first concerns the randomized trials supposed irrelevance: This includes rejecting the rationale for EBM as a basis for Phase III therapeutic trials. This comparative study tests the efficacy of a new treatment against the best reference treatment. It is a prerequisite for marketing authorization (MA). Professor Didier Raoult fully endorses its refusal to set up a control group that does not receive treatment by ethical reasons: *"It cannot be said that in order to save patients, randomized trials are necessary, because they are carried out in a very recent way for extremely precise areas for which their contribution to the world's overall health has*

yet to be demonstrated"¹⁴ or still in the Echos of 08 April 2020: "*What the history of infectious diseases shows us is that, in the vast majority of cases (perhaps 99% of known diseases), there have never been multicentric, randomized, double-blind studies to respond to a situation of this nature*".

- The second one concerns the necessity to immediately healing patients rather than experimenting. For example, in a randomized trial, patients that receive a placebo would not benefit from treatments that would guarantee them heal given the disease rapid evolution. The "*primum non nocere*" would not apply here. The choice of care rather than experimenting is called "equipoise". Hence, when real uncertainty prevails within the specialized medical community about the usefulness of a treatment and when a randomized trial is set up, if it turns out that before the study's end the new treatment is beneficial and that the study puts those at risk then all participants should benefit from it.

3.2.2 Systematic and Orchestrated Criticism of Studies Contrary to CHQ-AZI Protocol and Government Advice.

a) Scientific critics of the CHQ-AZI protocol

The ClinicalTrials.gov database lists 232 clinical trials testing chloroquine or hydroxychloroquine either for the treatment of SARS-CoV-2 infection (in and outpatients) or for its prevention¹⁵. To date (June 2020), most of the recently published clinical trials have not demonstrated the efficacy of HCQ (with or without azithromycin) respectively on hospital mortality.

Based on both factors, the sponsors of the CHQ-AZI protocol applied it for therapeutic purposes while attempting to scientifically legitimize their approach by conducting non-randomized trials. Thus, IHU Méditerranée Infection produced three studies corresponding to three therapeutic trials (Gautret 2020 a and b) Million et ali (2020). Several authors (Machiels,J.D., et ali (2020), Dahly, Gate and Morris (2020), Bik (2020)) highlighted flaws of these studies: lack of randomization, co-variables (age, sex, state of progress, of the disease...), small sample size (26 for the first and 80 for the second), the inclusion of patients who did not want the treatment, and the exclusion of patients which considerably improved their results. Their reinstatement leads to similar results that would have been obtained in the absence of treatment, the lack of information concerning the choices that led to the choice of the antibiotic

¹⁴ In « Quotidien du Médecin » on April, 2nd, 2020

¹⁵ <https://clinicaltrials.gov/ct2/results?cond=covid&term=Hydroxychloroquine&cntry=&state=&city=&dist=>

azithromycin. Furthermore, in the second study (Gautret et al. (2020 b)) compares a French sample and a Chinese control group older and more severely affected than the French group (Zhou et al. (2020)). A third non-randomized study (Million M, 2020) followed 1061 patients treated with the same combination for at least 3 days. As pointed out by Samer, Curtin, Ing-Lorenzini, Vetter, (2020) "*this study is a low-intake study because the patients are young and poorly affected, i.e. their "national early warnings score" (NEWS) of 0 to 4 (on a scale of 7 and above) represents 97.4% of the total number of patients. An unfavorable outcome should be noted in 50% of patients with a NEWS score >5*". It should be noted that the good results concern an even younger population (42.4 years and 17.4 standard deviation).

More generally, criticisms of the HQC+AZI protocol show, at best, that its results do not differ significantly from standard treatments and even, given the potential hydroxychloroquine's serious side effects, some patients' health may deteriorate to death (due to the observation of numerous cardiac arrhythmias (Q-T prolongation phenomena)). As regards studies and reviews indicating the impossibility of achieving significant results, the randomized Recovery study (Recovery (2020) under the direction of Peter Horby and Martin Landra) shows neither a significant difference in the primary endpoint of mortality at 28 days (25.7% for patients treated with hydroxychloroquine versus 23.5% for usual care) nor evidence of beneficial effects on the hospital stay of patients (see also Rosenberg, Dufort, Udo et al. (2020), Geleris et al. (2020), Tang et al. (2020). Divya, Dulal, (2020), Jing, Yu, and Li, (2020), Rawaf, Al-Saffar et al (2020), Osborne et al (2020). (2020). For negative side effects see Lu Ren, et al, (2020), and a published study, Mahévas et al, (2020), Mercurio, Yen, Shim, (2020), Silva Borba et al, (2020), Cipriani et al, (2020).

b) *Discrediting any scientific challenge to the CHQ-AZI protocol*

Even if the CHQ-AZI protocol's flaw is known, practitioners continuously call for administrating it without legal bounds¹⁶. In addition, social networks openly favorable to the CHQ-AZI treatment also reaffirm their support and challenge the government's decisions before courts. Furthermore, constantly through reports or interviews, the protocol's promoters, try to disavow contradictory studies (Senate report (Raoult (2020 c), interviews in front of the main news channels, tweets, etc.). The proponents continuously assert to the public's direction its efficiency.

¹⁶ For example, the petition: « Laissons les médecins prescrire » (in French) : <https://stopcovid19.today/>

This is all the truer as the scientific methodology, with the publication and withdrawal of a study considered as major by the Lancet (Mehra, Desai, Ruschitzka, Patel (2020a,b)) has been widely questioned. Scientists have appreciated this failure to its true dimension, i.e. a massive fraud on the nature of the data collected by a firm created by one of the study's contributors. However, the public that favors the HCQ+AZI protocol interpreted it as a manifestation of the empirical approach victory.

3.2.3 Analytical interpretation of these controversies

Government's Protocol HCQ+AZI ban did not reduce the public's faith about its effectiveness. The Public Authorities failed showing that healing probability is null, i.e. $e'_i = 0$ and $\bar{e}'_i = 1$ ($i = 1, \dots, I$, where I represents the set of people favorable to the protocol). Then, if for the government, $H(E/\bar{E}) = 0$, (\bar{E} government information on E) in the opposite, for many people $H_i^E(E) \rightarrow 0$, (where $H_i^E(E)$ is the protocol E entropy for the agent i), this value is reached for $e'_i \rightarrow 1$ and $\bar{e}'_i \rightarrow 0$. What are the reasons for this government failure?

An agent i receives at least two kinds of contradictory information. The first originate from the official authorities (State, WHO, academia), these are to be noted T , the second comes from the protocol's proponents and are totally in contradiction with the government's ones, they are noted V . Both are supposed to reduce his uncertainty. Let $T \cap V$ be the information received by agent i , these restrict his/her information set related to protocol E. Let $Pr_i(E|T \cap V)$ be the probability to heal with protocol E after receiving information T and V . If it occurs that: $Pr_i(E|T \cap V) = Pr_i(E|V)$, then T and V are conditionally independent from E. This means that information A coming from the authorities does not affect the agent's beliefs. In terms of informational entropy, this translates into:

$$H_i^E(E|V) = H_i^E(E|T \cap V) < H_i^E(E)^{17}$$

With: $H_i^E(E|T) = H_i^E(E)$ (recalling that $H_i^E(E) < H_i^S(S)$)

In other words, for ($i = 1, \dots, I$), the information transmitted through the authorities does not change the beliefs in Protocol E healing that are reinforced by any new communication.

4. Conclusion

¹⁷ The demonstration is classic for conditional independence and will not be reported here.

This paper aims at showing that radical uncertainty into which covid-19 has plunged Humanity is a source of cognitive dissonance about treatment and vaccine choices. Choosing a controversial protocol belongs to the ambiguity theory's field. This choice is a matter of belief and mistrust and may correspond to a preference for ambiguity as set out in Ellsberg's paradox. The mistrust concerns the governments' announcements and proposals concerning recommended medication in response to the pandemic. Belief applies to the supposedly positive effects of a treatment that neither the academic nor the public authorities validate, apart from the treatment's promoters. At a deeper level, this gap between a part of public opinion and the various scientific and medical authorities reflects a growing mistrust of the former in the face of official discourse.

This mistrust may induce particularly harmful consequences. It puts pressure on the public authorities, who are "summoned" to find remedies for a situation that is partly beyond their control. The excessive media coverage of uncertain results contributes to increasing irrational behavior. Irrational here must be taken in the sense of refusal or inability to understand scientific discourse. Of course, it is not a question of each individual becoming a specialist in science, which requires decades of learning but of being able to hear several discourses and to make the right balance from the available information. In short, in the context of the scientific uncertainties surrounding the Covid-19 pandemic, this mistrust leads to a controversial protocol being given a higher probability of cure than it should be. Under the public opinion pressure, the priority given to the latter leads to the diversion of substantial financial and human resources that might have been used for other tests. Randomized trials need not only funding but also patients. Some have had to be stopped following the refusal of patients to be treated by protocols other than the "star" protocols. The purpose of this article has been to show through which informational mechanisms these beliefs arise. We have emphasized the proactive informational strategies of the promoters of these protocols. The latter create their own informational channels that reduce informational entropy to their benefit. Patients confronted with new and contradictory information do not remain in uncertainty as soon as they choose the most appropriate information source that best meets their expectations. Training people in scientific methodology and a review of the scientific procedures for drug evaluation seem to be of the utmost importance.

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APPENDIX 1

Study of $pr(B \cap C|D) = P(D) = p$

Note that $B \cap C$ et D are two independent events, so the assumption that D is achieved does not change the probability of the formation of $B \cap C$. Indeed, $(B \cap C)$ To "enter into bliss and believe" is independent of the "existence of God", and vice versa. The two events are independent. As we have shown that $pr(B \cap C) = 1$, It follows that:

$$pr(B \cap C|D) = pr(B \cap C)P(D) = 1.P(D) = p$$

APPENDIX 2

We consider the patient's Choquet expected Utility:

$$V(E) = \mu \alpha A - \mu(1 - \alpha)B + (1 - \mu)\mathbb{E}_\pi u\left(\left(\check{G}_i|E\right)\right) \quad (6)$$

Where μ represents aversion to ambiguity and as before, α corresponds to his level of optimism about his recovery. ($1 \geq \mu \geq 0, 1 \geq \alpha \geq 0$). In this situation it is assumed that for him :

$\mathbb{E}_\pi u\left(\left(\check{G}_i|E\right)\right) > \mathbb{E}_{\pi'} u\left(\left(\check{G}_i|S\right)\right)$ with $e'_i > s'_i$. We consider three cases:

a) a) Absolute confidence in the probability distribution π :

Then, if patient i considers that this probability is plausible and effective, his aversion for ambiguity will be strong and he will put his confidence to the expected payoff. Indeed, he has no reason to doubt of $e'_i = pr(G_i|E)$. Thus, in the extreme case where this aversion turns out to be absolute (i.e., he has absolute confidence in his chances of recovery with Protocol E, $\mu = 0$ and, naturally:

$$V(E) = 0 \alpha A - 0(1 - \alpha)B + \mathbb{E}_\pi u\left(\left(\check{G}_i|E\right)\right) = \mathbb{E}_\pi u\left(\left(\check{G}_i|E\right)\right) = e'_i A - (1 - e'_i)B \quad (7)$$

b) (b) Announcement by the authorities that treatment E provides no more gain than S

This situation means that for the authorities $\mathbb{E}_\pi u\left(\left(\check{G}_i|E\right)\right) = \mathbb{E}_{\pi'} u\left(\left(\check{G}_i|S\right)\right)$. The question then is not why the individual will prefer treatment E to S, but what are the reasons that will lead him to choose E. He will make this choice if :

$$V(E) > \mathbb{E}_{\pi'} u\left(\left(\check{G}_i|S\right)\right) = s'_i A - (1 - s'_i)B \quad (8)$$

In other words, if :

$$\mu \alpha A - \mu(1 - \alpha)B + (1 - \mu)\mathbb{E}_\pi u\left(\left(\check{G}_i|E\right)\right) > \mathbb{E}_{\pi'} u\left(\left(\check{G}_i|S\right)\right) \quad (9)$$

Now, the individual assesses the confidence he or she can place in the official assessment of his or her recovery with Protocol E, i.e.

$$\mathbb{E}_{\pi}u\left(\left(\check{G}_i|E\right)\right) = \mathbb{E}_{\pi'}u\left(\left(\check{G}_i|S\right)\right) = s'_iA - (1 - s'_i)B \quad (10)$$

By replacing this value in (9), and expanding, we get:

The condition for having: $V(E) > \mathbb{E}_{\pi'}u\left(\left(\check{G}_i|S\right)\right)$ is that he has an aversion to ambiguity that should not be nil, i.e. $\mu > 0$ and that his level of optimism $\alpha > s'_i$, i. e. the conditional probability of recovery with treatment S.

c) Announcement by the authorities that treatment E provides less effective than S.

This situation may arise if, for example, the authorities show that Protocol E may cause strong, potentially life-threatening side effects without a higher probability of cure than with treatment S. In such cases, it is considered that : $\mathbb{E}_{\pi}u\left(\left(\check{G}_i|E\right)\right) < \mathbb{E}_{\pi'}u\left(\left(\check{G}_i|S\right)\right)$, or, as before:

$$\mu \alpha A - \mu(1 - \alpha)B + (1 - \mu)\mathbb{E}_{\pi}u\left(\left(\check{G}_i|E\right)\right) > \mathbb{E}_{\pi'}u\left(\left(\check{G}_i|S\right)\right)$$

But now, we can no longer substitute the two expectations and consequently :

$$\mu \alpha A - \mu(1 - \alpha)B + (1 - \mu)(e'_iA - (1 - e'_i)B) > s'_iA - (1 - s'_i)B$$

Developing:

$$\mu ((\alpha - e'_i)(A + B) > (s'_i - e'_i)(A + B), \text{ i.e. :}$$

$$\mu ((\alpha - e'_i) > (s'_i - e'_i),$$

Thus, two conditions are identified for $V(E) > \mathbb{E}_{\pi'}u\left(\left(\check{G}_i|S\right)\right)$ when $\mathbb{E}_{\pi'}u\left(\left(\check{G}_i|S\right)\right) > \mathbb{E}_{\pi}u\left(\left(\check{G}_i|E\right)\right)$ and $(s'_i > e'_i$:

i)

$$\mu > \frac{(s'_i - e'_i)}{(\alpha - e'_i)}$$

ii) For $\alpha > e'_i$ and it should be noted that the condition for condition 1 to be met as $\mu < 1$ is

$$\frac{(s'_i - e'_i)}{(\alpha - e'_i)} < 1 \text{ et } \alpha > s'_i$$

We find the same condition as in the second case: the degree of optimism in healing must be greater than the probability of healing with the standard S protocol.

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