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Abstract

Non-adherence to medication leads to reduced health outcomes and increased health care costs. More evidence and analysis is needed to understand the determinants of non-adherence, particularly the impact of the doctor-patient interaction. This relationship is often characterised by conflict during consultations. The aim of this paper is to investigate whether a game theoretic approach can explain the conflict during consultations that lead patients to non-adhere to medical recommendations. The game theoretic models constructed employ the Psychological Expected Utility theory. There is a distinction between information-loving and information-averse patients. Doctors do not always know the type of patient they have and on the basis of limited knowledge, they need to decide how much information to pass on. We relax the assumption of perfect agency and introduce the concept of the doctor's effort. Uncertainty is resolved under various hypotheses of bounded rationality. A complete resolution of the games is offered, and comparative statics results and economic interpretations are given. When a doctor knows with certainty the type of patient she has, she will transfer adequate information and the patient will adhere. If the doctor cannot recognize the patient's need the outcome may be non-adherence to recommendations. Doctors who understand patients' needs improve adherence rates. To enhance adherence, a number of policy recommendations are made. Financial incentives to the doctor do not benefit all types of patients.

Key words: doctor-patient relationship, non-adherence, Psychological Expected Utility, non-cooperative game theory, game tree, bounded rationality, assessment equilibrium.

1. Introduction

Non-adherence to medication is generally defined as 'the extent to which patients take medications as prescribed by their health care providers' (Osterberg and Blaschke, 2005). WHO (2003) describes non-adherence in chronic illnesses as 'a worldwide problem of striking magnitude' as it leads to reduced health outcomes and increased health care costs due to relapses and rehospitalisation. Yet, more evidence and analysis is needed to understand the determinants of non-adherence, particularly the impact of the doctor-patient interaction. This relationship lies at the heart of medical care and is characterised by conflict and tension during consultation. This arises from the fact that the expectations and needs of the two parties do not always coincide.

In general, the existing theoretical models of the doctor-patient relationship do not explain in depth the conflicts of this interaction and the impact it has on a patient's decision to follow recommendations. This is the objective we are pursuing through our game theoretic models in this paper.

The developing field combining Psychology and Economics, commonly called Behavioural Economics, opens new ground to explain behaviours that traditional models fail to capture. Particularly in the case of the doctor-patient relationship Behavioural Economics has made significant progress in the last few years. Models in this field that describe doctor-patient interaction and patients' behaviour have incorporated the notion of beliefs into the patient's utility function and try to explain how these may lead to behaviours, such as avoiding a visit to a doctor (Köszegi, 2003). These models are based on the Psychological Expected Utility theory (henceforth PEU theory) introduced by Caplin and Leahy (2001). The theory is an extension of von Neumann-Morgenstern expected utility theory to situations in which agents experience feelings of anticipation regarding future states. This theory, when applied to health behaviour, allows for the patient's utility function to depend not only on physical outcomes but also on *beliefs* about future physical outcomes. However, all the above attempts to model the doctor-patient relationship are based on the assumption that the doctor is entirely empathetic to the patient and maximises the patient's utility function as if it were his own.

Evidence from the medical literature demonstrates contradictory results. The doctor-patient relationship is often characterised by antagonism and conflict. Both parties have different expectations and agendas that they bring to the consultations, which are often in conflict, and when they are not met they result to undesirable situations such as non-adherence to medical recommendations (Britten et al., 2000). Of course, the consultation is influenced not only by the specific characteristics of the doctor and the patient but also by the context and the setting where the consultation occurs (Weinmann, 1997).

The models we develop in this paper extend previous Behavioural Economic models of doctor-patient interaction to examine how the actions of the two parties change when the notion of effort is incorporated into the model. Also, and most importantly, the models examine whether the introduction of the concept of effort may explain why consultations do not reach their desirable outcomes, i.e. they lead patients to fail to adhere to medical recommendations.

The paper is organized in the following way. The next section summarises some motivating facts from the medical literature that show how conflicting aspects of the doctor-patient relationship influence patients' decisions on whether or not to adhere to recommendations. Particular emphasis is given to the supply of information during the consultation and how this affects communication. The paper then reviews models on doctor behaviour and the doctor-patient relationship from both the fields of Health Psychology and Economics, considering their ability to capture the conflicts that occur during a consultation. The next section then presents our game theoretic model, explaining the doctor-patient interaction and conflict. It also introduces new ideas, such as the notion of effort, as a new variable. Limitations as well as possible directions for future research are then discussed. Finally, the last section discusses the policy implications and concludes.

2. Motivating facts

This section presents the motivating facts that lead to the conceptualisation of the models presented in section 3. It begins with evidence from the medical literature that identifies differences between patient and doctor needs during consultations and how these, when not met, may be linked to non-adherence to recommendations. Particular emphasis is given to issues concerning the supply of information. It then briefly discusses the models of the doctor-patient relationship to identify whether they can capture these conflicts, or whether they can provide useful insights for our models. Finally, the section concludes with a discussion of the elements on which the game theory model will be built.

2.1 Empirical evidence

There is consistent evidence showing that the flow of information exchanged during a consultation is very critical for the formulation of diagnoses and the organisation of treatment (Lambert and Loiselle, 2007). Thus, effective communication is necessary to ensure not only that doctors understand patients' problems and concerns but also that relevant information on diagnosis and treatment is accurately and effectively transferred to maximise benefits from consultation. Input factors that influence the consultation include both aspects of the doctor's and the patient's behaviour but also the context and setting in which this occurs (Weinmann, 1997).

The literature shows that the patient's emotions and beliefs influence his decision on whether or not to adhere (Horne et al., 2001). It is also evident that information regarding patients' health affects their emotions and patients vary in their preferences regarding how much they want to know about their health (Miller and Mangan, 1983). Not all patients want information or benefit from it. For example, a study by Siminoff and Fetting (1991) found that patients who did not accept their physician's treatment recommendations were told in more specific terms what the benefits of the treatment would be. The study therefore suggests that provision of detailed information will not always provide desirable results and, in fact, may lead to therapy decisions that are different to those that the physician might have hoped for.

On the other hand, doctors' communication style can positively influence these beliefs and therefore lead to better adherence to recommendations (Bultman and Svarstad, 2000). However, they are often unable to understand differences in patient preferences regarding information and participation during consultations (Elkin et al., 2007). They often fail to listen to patients and explore their views on their disease and medication. Moreover, the doctor, just as the patient, also experiences feelings during the consultation such as anxiety or anger which have been shown to decrease the overall satisfaction of both parties with the consultation and also patient's adherence to recommendations (Waitzkin, 1984).

In addition, and more importantly for our model, the transmission (supply) of information during the doctor-patient interaction, has been shown in the literature to be related to the clinical setting (Waitzkin, 1984). Busy clinical settings often imply that the doctor may be restricted in the time he can spend with every patient. However, the effect of time on consultation outcomes is controversial. Some studies show that more time does not necessarily lead to better outcomes while other researchers suggest that optimal patient-provider communication requires longer consultations (Brown, 2004). Despite the debate, longer consultations clearly indicate that more information is transferred to the patient.

To sum up the evidence from the medical literature, the supply of information is a very important issue during the consultation. Patients vary in their preferences regarding how much information they want to receive and doctors often fail to recognise these variations. This disconnection with patient's needs may lead to unwanted results, such as decreased patient satisfaction with the consultation and higher rates of non-adherence.

2.2 Review of previous theoretical models

The models reviewed here that describe the doctor-patient relationship and intend to explain the behaviour of the two parties come from two main areas: Health Psychology and Economics.

In Health Psychology three main models are commonly accepted; paternalism, shared decision and informed decision making. Despite their differences, the three models share a common characteristic. The roles of the two parties regarding the supply of information and decision making are clearly defined and do not allow for antagonism between the doctor and the patient. Hence, they do not allow for inconsistency and conflict in decision making and cannot explain how differences between the two parties during the consultation can affect patient's decisions.

In Health Economics the doctor-patient relationship also is of central importance and theories to describe it have been a great challenge for researchers in the area. The perfect-agency model has been very useful in understanding aspects of the doctor-patient relationship. However, it assumes that the doctor and the patient have an identical utility function, and therefore fails to capture conflicts between the two parties. It also seems unrealistic for the perfect agency model to work in actual medical practice as, apart from the patient's needs, the doctor also has other constraints during the consultation which must be taken into consideration, such as administrative constraints, time issues and personal interest.

Departing from the perfect-agency model, there is a extensive literature on how physicians can act beyond only maximising the patient's utility function (McGuire, 2000, Evans, 1974). Scott (Scott, 2000) reviews the model of GP's behaviour and notes that economic models allow doctors' behaviour to be driven not only by altruistic elements but also by other aspects such as workload, income, reputation and other self-interest factors.

Le Grand (2006) in his influential work describes the two different aspects of doctors' behaviour as knightly and knavish and notes that it is 'perfectly possible for someone to be both a knight and a knave: that is, to have altruistic motivations for some of his activities or behaviour and self-interested ones for others'. He also argues that it is not only financial considerations such as income that drive self interested behaviour. Doctors

want not only to improve their economic status but also to have respectful working relationships with their colleagues, limited tort liability, a varied and interesting day's work and the ability to make clinical decisions without undue interference. That said, doctors' failure to be entirely empathetic to patients is not only driven by individualistic elements but also by organisational constraints, such as time pressure and doctors' need to see as many patients as possible.

On the patient's side, the Health Economics literature is more limited in modelling patients' behaviour. The strongly emerging field of Behavioural Economics has resulted in models that offer useful insights into what drives patients' decisions by introducing the notion of beliefs in patients' utility functions. The PEU theory (Caplin and Leahy, 2001) has been used successfully to describe certain aspects of the doctor-patient relationship (Caplin and Leahy, 2004) and patients' behaviour (Köszegi, 2003). However, these models assume a perfect agency relationship between the doctor and the patient, i.e. the doctor maximises the patient's utility as if it were his own.

To sum up, traditional economic models vary in the way they approach the issue of the doctor's utility function but in general they include, apart from the altruistic element, effort, a leisure-income element, as well as reputation and organisational characteristics. Yet, they do not allow for differences in information preferences. On the other hand, Behavioural Economics models using PEU theory capture variations in information preferences; however, they assume a perfect agency relationship between the doctor and the patient.

The choice of Game theory approach

Game theory provides a formal means of explaining optimal strategies under conditions of uncertainty, in which the outcomes depend on the choices of more than one individual. This is the reason why this approach is proposed for the doctor-patient relationship as the final outcomes for both parties depend not only on their individual actions but also on what the other person will do.

The potential use of game theory in describing the doctor-patient interaction has been receiving increasing interest from researchers the last few years. The evidence from empirical studies that agreement is not always reached during a consultation has initiated thoughts on the potential use of game theory to describe this phenomenon (Elliott et al., 2008). Tarrant et al (2004) discuss three main game structures; the Prisoner's Dilemma game, the Assurance game and the Centipede game; however, this is more of a general discussion and exploration of the opportunities and limitations of game theory and not at all the proposal of a formal model. Although discussions on the new perspective that game theory provides for research into the medical

consultations are mainly theoretical debates, they all agree on the potential of this new area of research. Game theory can provide the basis for empirically testable models of the doctor-patient relationship.

2.3 Combining health psychology and economics in our models

Following the discussion above, four aspects of the doctor-patient relationship that affect non-adherence are important for our model. First, information affects patients' beliefs and these have an impact on patients' decision regarding treatment. Secondly, patients vary in their preferences regarding information. Some patients want information, some others feel better when they do not know much about their condition and treatment. Models based on the PEU theory take this into account. Thirdly, doctors do not appear to be consistently able to predict patient preferences. This may be due to organisational constraints that restrict the doctor from spending time with patients or may be due to a lack of adequate training or self-interest. Finally, the doctor's disconnection with the patient's needs may lead to unwanted results such as dissatisfaction with consultation and non-adherence to medical recommendations.

We now combine all these elements to develop our non-cooperative game theoretic models which are a development of previous Behavioural Economic models of doctor-patient interaction. They incorporate the notions of anxiety, effort, etc. and relax the assumption of a perfect agency relationship, in order to explain conflicts that occur during the consultation which may lead to non-adherence to recommendations.

3. The models

3.1 Introduction

The models presented here, with a key number of variables and relations, attempt to capture the salient characteristics of a specific empirical area; their aim is to make predictions.

We present three models of the doctor-patient interaction to describe the supply of information by the doctor during consultation. The models take the form of a game in an extensive form. They are all non-cooperative games between two players; the patient ('he') who has symptoms of an illness and visits the doctor ('she') to obtain a diagnosis. The doctor makes the diagnosis and has to decide how much information to pass on to the patient. However, patients vary in their preferences regarding the level of detail of the information they want to receive and, following the work by Miller et al (1987), are distinguished as either 'blunters', i.e. information-averse patients or 'monitors', i.e. information-loving patients. After receiving information from the doctor, the patient needs to decide whether or not to accept the recommendations and adhere to them.

The first two models are based on the assumption that the doctor knows perfectly the type of the patient she is dealing with. The first assumes that the patient is a blunter while the second assumes that the patient is a monitor. The third model presents a game closer to reality. In this case the doctor cannot tell with certainty whether the patient is a monitor or a blunter. Empirical evidence shows that indeed doctors very often fail to capture the patient's preference for information (Elkin et al., 2007). Model 3 is the most involved game of the three but also the one that explains in the end how a doctor's failure to understand the patient's preference as more detailed information may lead to non-adherence to her recommendations.

The models presented below draw upon the PEU theory (Caplin and Leahy, 2001). The PEU, as mentioned briefly in section 2 above, is an extension of expected utility theory in situations in which agents experience acute feelings of anticipation prior to the resolution of uncertainty. It has been used by Caplin and Leahy to explain supply of information during consultations (Caplin and Leahy, 2004) and by Köszegi to understand patients' behaviour (Köszegi, 2003). Köszegi's confines himself to a model that explains a patient's decision on whether to visit a doctor or not, when anxiety enters his utility function. Caplin and Lealy (2004) present an extensive form game in which the patient signals what type his is, and the doctor, being completely empathetic, decides on how much information to pass on. This model does not allow the patient to play a part himself in deciding whether to accept the information or not.

There are two aspects to the originality of the approach in the models presented in this paper. First, they relax the assumption of perfect agency that the models by Caplin and Leahy (2004) and Köszegi (2003) accept, i.e. that the doctor maximizes the patient's utility as though it were her own. In order to show that the doctor cannot act as a perfect agent the models assume that she needs to put effort into supplying information to the patient. Secondly, they allow for interdependent decisions with an active role both for the doctor, who needs to decide on how much effort to put into the interaction and for the patient who needs to decide whether to accept the doctor's recommendation.

The methodology adopted is that of game theory, which analyses interdependent decisions and their optimality in contrast to a more narrow decision theory approach which only looks at individual decisions. We set up extensive game trees, which explain the order in which players move, their available actions, the information they have regarding the game and their payoffs. In the case of Model 3, the uncertainty regarding the patient's preference for information is resolved under various hypotheses of bounded rationality. This is a well-known approach in economics for modelling problems with uncertainty so that progress in analysis can be made. The models offer, under specific but reasonable assumptions, a complete resolution of the games, i.e. obtain results concerning how much effort the doctor will make and patient's decision to adhere to the

recommendations. They use comparative statistics, give economic interpretations and finally allow for a discussion of the policy implications that emerge. Limitations of the game theoretic approach used here, as well as possible extension, are discussed after the presentation of the models.

3.2 Definitions and preliminaries

We explain here the notation used and, for the sake of completeness, the concepts employed in the models discussed:

- N denotes nature. This is a summary term which is used to denote all factors which determine the type of patient that comes to the doctor.
- There are two types of patients; blunters (B), i.e. information-averse patients, and monitors (M), i.e. information-loving ones. These types were introduced by Miller and Mangan (1983).
- q is the probability with which the doctor believes that nature chooses the patient to be a monitor and $1-q$ to be a blunter. The case were $q=\frac{1}{2}$ corresponds to bounded rationality discussed below. However, more general distributions are considered. q applies only in Model 3 where the doctor does not know with certainty the type of patient.
- s denotes the health state of the patient. It is defined in the interval (s_1, s_2) with probability density function $f(s)$. In other words, s_1 is the lowest level the patient's health can be and s_2 the highest.
- p denotes the probability that the patient will be in state s_1 and $1-p$ that he will be in s_2.
- l is a non-negative constant that denotes a loss in health of the patient if he does not follow the doctor's recommendation. It is assumed to be common for all types of patients, i.e. it is independent of patient's preference regarding information.
- T and NT are the two actions the doctor can take. T denotes that the doctor reveals the whole truth to the patient about his state of health, i.e. she tells the patient that the can be in state s_1 with probability p and in s_2 with $1-p$. NT denotes that the doctor does not reveal the whole picture but simply tells the patient that his expected state of health is $s = p \cdot s_1 + (1-p) \cdot s_2$.
- A and NA are the two actions available to the patient. A denotes that the patient will adhere to what the doctor recommends and NA that he will not.
- u_M and u_B are the utilities of a monitor and a blunter respectively, while u_D is the utility of the doctor.

- ε_1 denotes the effort the doctor needs to make to pass on the information to the blunter and ε_2 the effort she needs to put into the consultation if the patient is a monitor. Both ε_1 and ε_2 are positive constants and are subtracted from the doctor's utility function every time the doctor decides to play T. It is assumed that $\varepsilon_1 < \varepsilon_2$; i.e. more effort is needed to pass on information to a monitor, who is an information-seeking person, than to a blunter, who is information averse.
- a denotes the anger that is created if a monitor realizes that the doctor has not told him the entire truth. It is assumed that a is a positive constant and it is subtracted both from the monitor's and the doctor's utility. We assume that $a > \varepsilon_2$, i.e. the anger created if the doctor does not pass on all the information is greater than the effort the doctor makes to do so.
- w denotes the worry that a monitor experiences if he decides to follow the doctor's advice although he has realized that she has not told him the truth. It is accepted that w is a positive constant and it is subtracted from the monitor's utility.

Non-cooperative games: These describe situations in which each player chooses his strategy independently from the others with the aim of maximising his own payoff. The idea is to find a pair of equilibrium strategies. In contrast, cooperative games allow the players to negotiate before the game starts. The game is then played according to a binding agreement (Binmore, 2007). The games in this paper are all non-cooperative.

Extensive form games: They refer to non-cooperative games. They describe, in a precise way, the role of the players, the moves available to them, the order in which they can move and what information they have every time they have to move, and finally the payoffs received when the game is over (Gibbons, 1992).

A **game tree** is a graphical representation of the extensive form games. On a tree the movement is always downwards and a node is visited only once. Usually all moves made by nature are made at the beginning. These are the random moves.

A **node** denotes the point in the game that, when reached, a decision needs to be made by a player until the terminal node is reached, i.e. the game ends.

A **path** is a unique way of going from the initial node of the tree to a terminal. No two paths can intersect.

An **information set** is a collection of nodes such that the player, whose turn it is to act, cannot distinguish among them. In other words, if an information set includes more than one node the player does not know exactly at which of those nodes he is located.

Games of perfect and imperfect information: A game is said to be of perfect information if every information set of the game contains only a single node, or in other words, no player will then ever have doubts about what has happened in the game so far (Binmore, 1991).

Complete information requires all players to know everything about the structure of the game as well as the strategies and the payoffs available to other players.

Games of perfect recall: In games of perfect recall none of the player ever forgets what he once knew about the game (Glycopantis and Muir, 1996).

Pure strategies: A pure strategy of a player in an extensive form game is a function that assigns an action to each information set of the players (Binmore, 1991, Osborne and Rubinstein, 1994, Glycopantis and Muir, 1996).

Mixed strategies: A mixed strategy in an extensive form game is a probability distribution over the pure strategies (Glycopantis and Muir, 1996).

Behavioural strategies: A behavioural strategy assigns independently to each of the players' information sets a probability distribution over the actions available at that set (Glycopantis and Muir, 1996).

Backward induction: Backward induction is a method used to solve a game. The method requires starting from the end of the game and then working backwards to its beginning. Suppose there are two players. The last player chooses first what the best option for him is, knowing what the other player(s) has played. He will select whichever of the actions gives him the highest utility. The tree then folds up showing the options left for the first player. Similarly, he will now select the action that gives him the highest utility. This will eventually give the predicted solution for the game.

Bounded rationality: It describes how a rational choice should be made when the agent is constrained by the amount of information available and by his computational abilities (Simon, 1957). Given this limited information the players take optimal decisions by maximising (expected) payoffs.

The principle of insufficient reason is based on the notion of bounded rationality. The rationale is that if there is no sufficient reason for a player to assume that his opponent will be of a particular type, then he treats all alternative types as equally probable (Glycopantis and Muir, 1994, Luce and Raiffa, 1957).

Optimal path: An optimal path describes a series of optimal decisions by the players and occurs with the probability of the initial move. The payoffs of the players are attached at every terminal node. In our models they refer to the utilities of the doctor and the patient and will be discussed extensively below. Optimal decisions are reached in terms of expected utilities.

Nash equilibria (NE): A pair of strategies in a game of two players is a Nash equilibrium if each player's strategy is the best response to the other player's strategy (Binmore, 1991). The Nash equilibrium, or Cournot-Nash equilibrium, is a confirmation of the beliefs of the agents concerning each other strategies.

Subgame: This consists of an information set which is a singleton, i.e. a node, and the rest of the tree which stems from that node (Gibbons, 1992, Binmore, 1991).

Subgame perfect equilibria: it is a Nash equilibrium for every subgame. It is a refinement of a Nash equilibrium. It safeguards the agents against possible mistakes or the irrational behaviour of their opponents.

Assessment equilibrium: This solution concept defines an equilibrium not only in terms of what the players do but also in terms of what they believe. It consists of a pair of behavioural strategies and beliefs for which two properties hold: a) the players, given their beliefs, always choose an optimal action and b) the beliefs are updated using other beliefs and actions taken, by applying Bayes' rule wherever possible (Binmore, 1991).

Perfect Bayesian Equilibrium (PBE): A PBE consists of a set of optimal behavioural strategies and a set of players' beliefs which attach a probability distribution to the nodes of information sets. The strategies must be optimal given beliefs. The beliefs are formed by updating, using the available information, and must support the optimal strategies. This concept must really be used when genuine Bayesian updating takes place (Glycopantis et al., 2003).

3.3 The utility functions

The patient's utility function is basically of the nature proposed by Köszegi (2003). It is a version of the PEU which is defined not only over physical outcomes but also over beliefs about future physical outcomes. It is assumed there are Periods 1, the present, and 2, the future. The game is played in Period 1 when the payoffs are also calculated. The patient needs to decide whether to follow the doctor's advice according to what he believes his health will be in period 2. His von Neumann-Morgenstern type utility function depends ultimately on his health state s, the action he decides to take, and is conditional upon his attitude to information. It takes the form:

$$u(E[s-l \,|\, \text{patient's information preference}]) \,. \tag{1}$$

There are two types of patients; monitors, i.e. information-loving and blunters, i.e. information-averse ones. For monitors, the flow of high levels of information from the doctor to the patient lowers the anxiety level regarding future health, while it raises it for blunters.

We first consider the case of an information-averse patient. Similar to a risk-averse individual, who comparing utility to expected utility does not take a fair gamble (Kreps, 1990) , an information averse patient prefers to know the expected state his health can be rather than knowing the probabilities with which he will be in worse or better state. Or as Köszegi (2003) puts it he "dislikes bad news more than he likes good news". Consequently, the utility function for the information-averse patient is (strictly) concave and differentiable (Figure 1 (a)).

Knowing his expected health $E[s]$ gives him greater utility, $u_B(E[s])$, than the utility he would get if he expects to be in state s_1 with probability p and in state s_2 with probability $1-p$, which reduces his utility to $E[u_B(s)]$. Concavity means that this holds for any s, s_1' and s_2', where $s \in [s_1', s_2']$).

For the information-loving monitor, the picture is reverse. He prefers to know the probabilities with which his state of health will be better or worse than knowing the expected state. His utility function is convex throughout and differentiable (Figure 1 (b)). Knowing the probabilities with which he could be in states s_1 and s_2 gives him a utility of $E[u_M(s)]$ while knowing the expected state of health reduces his utility to $u_M(E[s])$. A (strictly) convex utility function implies that this holds for any s, s_1' and s_2', where $s \in [s_1', s_2']$.

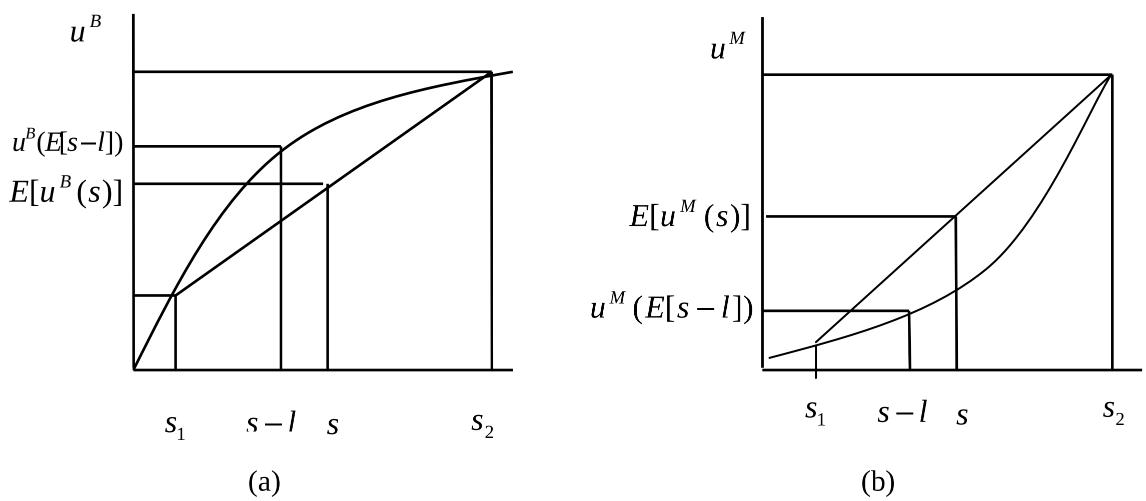


Figure 1: Utility function for a blunter (a) and a monitor (b).

For the doctor's utility function we make two assumptions. First, her utility increases as the patient's health does, but she is information neutral to his prospects of health, i.e. her utility, u_D, is linear. Second, she takes into account the effort she needs to make every time she transfers information, as well as the negative atmosphere, i.e. anger a, and the worry w that are created if she does not pass on the full information to a monitor. Effort, anger and worry are all measured in (dis)utility terms.

The calculations of the payoffs of the doctor and the patient are conducted by taking into account their preferences about information, the strategies chosen by both players, the effort expended and the probable anger and worry caused. Doctor and patient consider the effect of their own actions, taking into account the choice of their opponent, with a view of maximizing their individual utilities. Therefore, the games we present are non-cooperative.

We now consider the three models in more details.

3.4 Model 1: The patient is a blunter

In this game of perfect information and perfect recall the doctor knows she is dealing with an information-averse patient. A blunter is a patient whose anxiety increases with more information about his possible state of health.

The extensive form of the game is illustrated through the tree in Figure 2. Although it is not necessary, it includes, for later comparisons, Nature, N, which has chosen in the beginning of the game the patient to be a blunter. The doctor, Player 1, moves first and the patient, Player 2, can find himself at a node where the doctor has played T, i.e. she has spent time and passed on all the information, or NT, i.e. she has withheld part of the information. The patient can then choose whether to play A (adhere), or NA (not adhere).

The strategies of the doctor are therefore {NT, T}. The pure strategies of the patient are {(A, NA), (A, A), (NA, NA), (NA, A)}, where, for example, (A, NA) means that if he finds himself at node 2 he will play A and if at 2' he will play NA. Of course the players can also choose to mix their pure strategies.

The payoffs of each player depend on the strategies chosen by both players and are given by the vectors in the terminal nodes. The first element refers to Player 1 and the second is the payoff of Player 2.

If the doctor plays T, i.e. gives all the information to the patient, and the patient plays A, i.e. adheres, then the doctor has a payoff of $E[u_D(s)]-\varepsilon_1$, where ε_1 is the effort she puts into supplying the information. The patient's payoff is $E[u_B(s)]$. If the doctor plays T, but the player plays NA, i.e. he does not adhere, then the health outcome will be reduced by l given that the patient has not followed the doctor's recommendations. The payoffs for the doctor will be $u_D(E[s]-l)-\varepsilon_1$ and for the patient $u_B(E[s]-l)$.

If the doctor plays NT and the patient plays A they have payoffs $u_D(E[s])$ and $u_B(E[s])$ respectively. However, if the doctor plays NT and the patient plays NA then their respective payoffs are $u_D(E[s]-l)$ and $u_B(E[s]-l)$. That is, both the patient and the doctor lose utility because the patient's health outcome is reduced as he has not followed the doctor's recommendations.

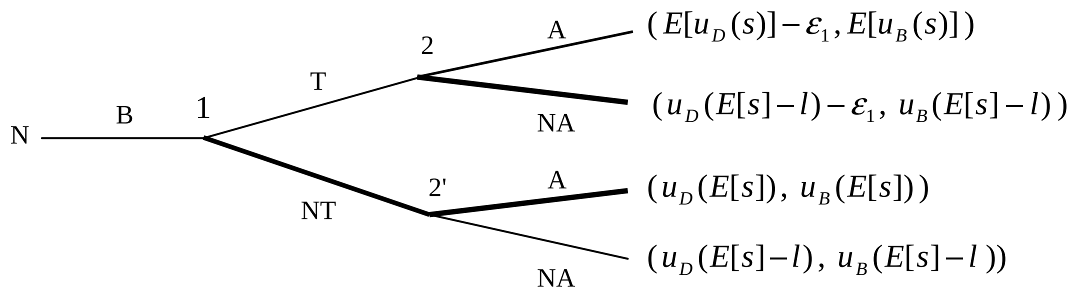


Figure 2. The doctor-patient game indicating the optimal path (Model 1).

Backward induction is used to solve the game. The method requires starting from the end of the game and then working backwards, through the optimal decisions of the players, to the initial node. In our model it suffices to reach singleton 1 as Nature is not optimizing a payoff.

In the tree, the patient moves last having observed the action of the doctor. In the backward induction his decision are considered first. Given that he is a blunter, if the doctor plays T, then he will play NA, i.e. he will decide not to follow her advice because $u_B(E[s-l]) > E[u_B(s)]$. On the other hand, if the doctor has played NT, i.e. she has not spent much time and has not given all the information, then the patient will decide to play A because $u_B(E[s]) > u_B(E[s]-l)$. Hence, the patient will adhere to the doctor's recommendations.

Following the optimal decisions of the patient, the tree folds up into the one presented in Figure 3. This now indicates the possibilities available to the doctor. Comparing her payoffs in the two alternative moves, she will decide to play NT and therefore not spend time with the patient.

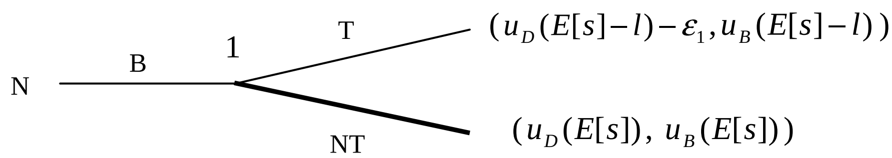


Figure 3: Backward induction (Model 1).

The first game theoretic solution concept available is that of Nash Equilibrium. It is defined here as a pair of strategies such that given the strategy of one player the other cannot change and do better. There are two pure strategies Nash equilibria in Model 1: { NT ;(A , NA)} and { NT ; (A , A)}. Indeed, if the doctor plays NT the patient cannot play any other strategy because that will result in him reducing his outcomes. Likewise, if the patient plays (A , NA) or (A , A) and the doctor changes her strategy from NT to T she will only be worse off because $E[u_D(s)]-\varepsilon_1 < u_D(E[s])$.

The stronger solution concept of a subgame perfect equilibrium (SPE) is the outcome of the backward induction. It requires a Nash equilibrium at every subgame. It safeguards the patient against the possibility that the doctor chooses her action by mistake or without observing the rationality principle of optimal decisions. In this game the SPE is { NT ; (A , NA)}.

Model 1 shows that when the doctor knows with certainty that the patient prefers not to be aware of many details about his condition and treatment, as this increases his anxiety, it is optimal for her not to spend much time and effort to provide all the possible information. This seems to be quite an obvious observation but will be crucial for an understanding of the general model discussed below. Also, the patient having observed that the doctor has not given him a lot of information, he decides that it is optimal for him to play strategy (A , NA). Therefore, the optimal path of the game is NT - A shown in Figure 2. In other words, the doctor will expend no effort and the patient will adhere. It is precisely the fact that the patient is information averse which implies that he will follow, on the optimal path, the doctor's instruction. He finds it reassuring that she has not spent much time and effort to explain his health conditions.

3.5 Model 2: The patient is a monitor

We now examine what happens when the patient has been chosen by nature to be a monitor, i.e. a person who likes information. Again, the structure and the payoffs of the game are common knowledge to the players.

The extensive form of the game is illustrated in Figure 4. As in Model 1, the doctor moves first by deciding whether to spend time in providing information to the patient (T) or not (NT). Armed with the privilege of knowing what the doctor has played, the patient then decides whether to adhere (A) or not (NA). As in Model 1, the pure strategies for the two players of the game are {NT, T} for the doctor and {(A, NA), (A, A), (NA, NA), (NA, A)} for the patient, where for example (A, NA) means that if he finds himself at node 2 he will play A and if at 2' he will play NA. Of course the players can choose to mix their pure strategies. Again, the payoffs of each player depend on the strategies chosen by both players and are given by the vectors in the terminal nodes. The first element refers to Player 1 and the second is the payoff of Player 2.

If the doctor plays T, i.e. gives all the information to the patient, and the patient plays A, i.e. adheres, then the doctor has a payoff of $E[u_D(s)]-\varepsilon_2$, given that supplying all the information requires effort. The patient's payoff is $E[u_M(s)]$. If the doctor plays T, and the patient plays NA, i.e. he does not adhere, then the health outcome will be reduced by l and the respective payoffs for the doctor will be $u_D(E[s]-l)-\varepsilon_2$ and for the patient $u_M(E[s]-l)$. That is, both the doctor and the patient are worse off given that the patient has not followed the doctor's recommendations and as a consequence his health has been reduced.

If the doctor plays NT and the patient plays A, they have a payoff of $u_D(E[s])-a$ and $u_M(E[s])-a-w$ respectively. This is due to the fact that the anger created because the patient does not receive all the information reduces the utility of both players. In addition, the patient's worry reduces his payoff even further. On the other hand, if the doctor plays NT and the patient plays NA then their payoffs are $u_D(E[s]-l)-a$ and $u_M(E[s]-l)-a$ respectively.

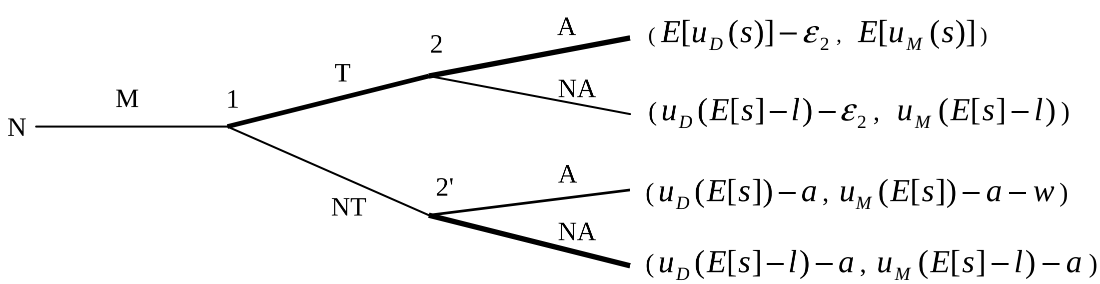


Figure 4: The doctor-patient game indicating the optimal path (Model 2).

Again, backward induction gives the solution to the game. In the tree the patient moves last having observed the action of the doctor. In the backward induction his actions are considered first. Given he is a monitor (M),

if the doctor plays T then he will play A; ie. he will follow her advice because $E[u_M(s)] > u_M(E[s]-l)$. On the other hand, if the doctor has played NT then the patient will play NA, because $u_M(E[s]-l) - a > u_M(E[s]) - a - w$. Hence, the patient will not adhere to the doctor's recommendations.

Following the optimal decisions of the patient, the tree in Figure 4 folds up into the one presented in Figure 5. This now indicates the possibilities available to the doctor. Since $E[u_D(s)] - \varepsilon_2 > u_D(E[s-l]) - a$ the doctor will decide to play T.

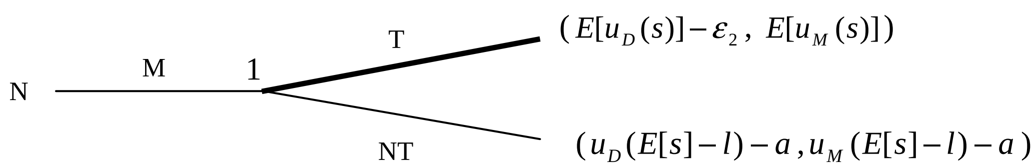


Figure 5: Backward induction (Model 2).

There are two pure strategies Nash equilibria for this game; $\{T;(A, NA)\}$ and $\{T;(A, A)\}$. Indeed, none of the players can change his/her strategies given the strategy that the other has chosen and do any better. The subgame perfect equilibrium is $\{T;(A, NA)\}$. It safeguards the patient against the possibility that the doctor is irrational or chooses her action by mistake.

Model 2 shows that when the doctor knows with certainty that the patient is an individual for whom more information reduces anxiety, it is best for her to put in the effort to explain in detail the prospects for his health. Again, this appears to be an obvious conclusion. However it will be crucial for the understanding of the later model. Therefore, the optimal path of the game is T - A shown in Figure 4. In other words, the doctor will need to put in the effort and the patient will adhere. It is precisely the fact that the patient is information loving that implies that he will follow, on the optimal path, the doctor's instruction. He finds reassuring the fact that she has put in much time and effort to explain the conditions of his health.

3.6 Model 3: The doctor does not know the type of patient

Let us discuss the third game which is the most realistic representation of the doctor-patient interaction. In this model the doctor does not know with certainty the type of patient she is dealing with. The extensive-form of the game is presented through the tree in Figure 6.

Nature (N) moves first, at time 0, and selects the type of the patient. The doctor does not know the type of the patient she is dealing with. This is represented in the game tree by the information set I shown by the dotted closed curve which contains the two nodes. If the doctor finds herself in I and wishes to play a pure strategy then it must be the same from both nodes. This is the significance of the information set I . The game described is of complete but imperfect information and perfect recall.

In order for the doctor to be able to take an action, and thus for the optimal paths to be calculated, she attaches a probability q that the patient is a monitor and a probability $1-q$ that he is a blunter. As will be shown below she can apply the principle of insufficient reason, an idea based on bounded rationality and apply an equal probability to the two events or a more general distribution expressing her information and beliefs.

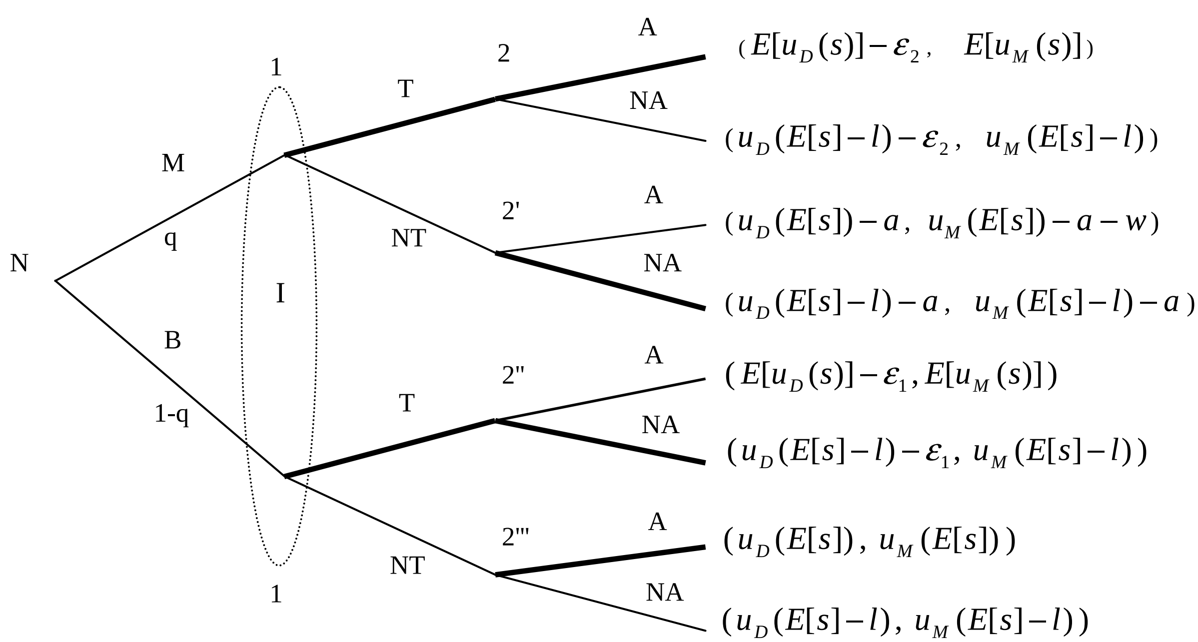


Figure 6: Extensive form of doctor-patient game indicating the optimal paths if doctor plays T (Model 3).

The doctor's pure strategies are { NT , T }. Each pure strategy is played from both nodes in information set I. The information sets of the patient are singleton. His pure strategies are: {(A, NA, NA, NA), (A, A, NA, NA), (A, NA, A, NA), (A, NA, NA, A), (A, A, A, A), (A, NA, A, A), (A, A, NA, A), (A, A, A, NA), (NA, A, A, A), (NA, NA, A, A), (NA, A, NA, A), (NA, A, A, NA), (NA, NA, NA, NA), (NA, A, NA, NA), (NA, NA, A, NA), (NA, NA, NA, A)}, where for example (A, NA, NA, NA) means that the patient plays A from node 2 and 2''' and NA from nodes 2' and 2''.

As in the previous models, the payoffs of each player depend on the strategies chosen by both players and are given by the vectors at the terminal nodes, with the first element referring to Player 1 and the second to Player 2.

Of course, the information set I implies that the doctor has to take the same action from both nodes. However, going down a particular path from the initial node to a terminal one we have the same payoffs for the doctor and the patient as going down the corresponding path in Figure 2 if the patient is a blunter or Figure 4 if the patient is a monitor. Thus we obtain the payoffs and the terminal nodes of Figure 6.

Again, backward induction is used to obtain the optimal paths of the game. The patient knows exactly the path which has been followed up to a node when it is his turn to decide. In particular he knows whether he is a blunter and the choice of the doctor.

If the patient is a monitor (M) and the doctor has given him the information he wants, i.e. she has played T , then the patient will play A since $E[u_T^M(s) > u_T^M(E[s]-l)$ as shown in Figure 1 (b). So, in this case the patient will adhere. However, if the doctor plays NT , i.e. she does not pass on all the information, and the player is a monitor, then he will get angry and will express his anger in his payoff. This reduces both the utility of the patient and the doctor by a . In addition to this, the constant w is used to express the patient's worry if he accepts the treatment while he knows that the doctor has not given him all the information he wanted. This brings the patient's utility down further, in a way that it is assumed to imply: $u_N^M(E[s]-l)-a > u_N^M(E[s])-a-w$. In this case therefore, the patient will play NA, i.e. he will not adhere to the doctor's recommendations.

Let us now consider the case of a blunter (B). If the doctor plays T then as shown in Figure 1(a) the patient will play NA, i.e. he will not adhere, because: $u_T^B(E[s]-l) > E[u_T^B(s)]$. On the other hand, if the doctor has

played NT , i.e. she does not give all the information, then the patient will decide to play A because $u_N^B(E[s]) > u_N^B(E[s]-l)$.

Following the optimal decisions of the patient, the tree in Figure 6 folds up to the one in Figure 7. This shows the moves available for the doctor, along with the payoffs for every move for both the doctor and the patient.

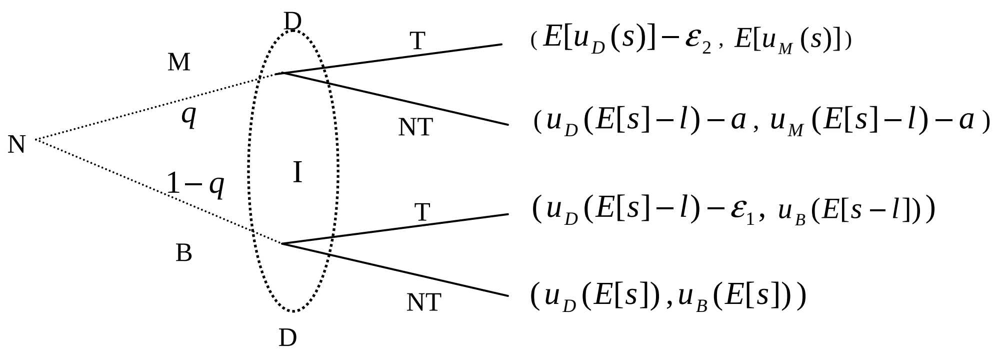


Figure 7: Backward induction (Model 3).

As said above, the dotted closed curve shows that the doctor does not know which node she is under following choice M or B. She will attach probabilities, expressing her beliefs, q that the patient is a monitor and $1-q$ that the patient is a blunter. Furthermore, the fact that the doctor's utility is linear implies that $u_D(E[s]) = E[u_D(s)]$.

The solution of the game can be obtained by applying the principle of insufficient reasons (Luce and Raiffa, 1957) which is based on the notion of bounded rationality (Simon, 1957, Glycopantis and Muir, 1994). As we shall see below, the doctor can apply the principle of insufficient reason and give an equal probability to the two events of Nature choosing either a monitor or blunter or a more general distribution expressing her information and beliefs. If there is really no sufficient reason to suppose that the patient is of either type the doctor will assign equal probabilities for the patient to be a monitor or a blunter. We shall also consider the implications of the doctor believing, probably on the basis of information collected, that the patient is more probably of a particular type.

We now examine for which q , let us call it $q*$, the doctor is indifferent between playing T or NT . If the doctor plays NT her payoff will be:

$$U_1 = q \cdot [u_D(E[s]-l)-a] + (1-q) \cdot u_D(E[s]) . \qquad (2)$$

If the doctor decides to play T her payoff will be:

$$U_2 = q \cdot (E[u_D(s)] - \varepsilon_2) + (1-q) \cdot [u_D(E[s]-l) - \varepsilon_1]. \tag{3}$$

For the doctor to be indifferent between NT and T, payoffs of the two actions must be equal, or in other words: $U_1 = U_2$. Replacing U_1 and U_2 with their equivalents from (2) and (3) this is:

$$q \cdot [u_D(E[s]-l) - a] + (1-q) \cdot u_D(E[s]) = q \cdot (E[u_D(s)] - \varepsilon_2) + (1-q) \cdot [u_D(E[s]-l) - \varepsilon_1]. \tag{4}$$

The solution to the above equation, called $q*$ is given below[1]:

$$q* = \frac{u_D(E[s]) - u_D(E[s]-l) + \varepsilon_1}{2u_D(E[s]) - 2u_D(E[s]-l) + a + \varepsilon_1 - \varepsilon_2}. \tag{5}$$

We bring equation (5) to a more manageable form:

$$q* = \frac{u_D(E[s]) - u_D(E[s]-l) + \varepsilon_1}{u_D(E[s]) - u_D(E[s]-l) + \varepsilon_1 + u_D(E[s]) - u_D(E[s]-l) + a - \varepsilon_2} = \frac{X}{X+Y} \tag{6}$$

where:

$X = u_D(E[s]) - u_D(E[s]-l) + \varepsilon_1 > 0$ and

$Y = u_D(E[s]) - u_D(E[s]-l) + a - \varepsilon_2 > 0$.

We now want to examine what the doctor will do under bounded rationality. As mentioned above, under bounded rationality the doctor does not hold any information regarding the patient's preferences and therefore applies equal probability to the patient being a monitor or a blunter. In mathematical terms, $q = \frac{1}{2}$.

Under bounded rationality, the doctor is indifferent between playing T or NT when $q* = \frac{1}{2}$. Equivalently, we have:

$$\frac{X}{X+Y} = \frac{1}{2} \Leftrightarrow -\varepsilon_1 = -a + \varepsilon_2 \Leftrightarrow \varepsilon_1 + \varepsilon_2 = a. \tag{7}$$

[1] Calculations are omitted for the purpose of clarity of the results. Detailed solution to the equation is given in Appendix A.1.

We rewrite the above condition (7) in order to interpret the above conclusions:

$$\frac{1}{2}\cdot(\varepsilon_1+\varepsilon_2)=\frac{1}{2}\cdot(0+a)\,. \tag{8}$$

For $q^*=\frac{1}{2}$ the left-hand side of the above equation (8) is the average disutility of effort if the doctor plays T and the right-hand side is her average disutility if she plays NT. When this holds, the doctor is indifferent between U_1 and U_2 and therefore she is indifferent on whether to play T or NT.

We now examine under which conditions the doctor will play T or NT. Under bounded rationality, in the case of insufficient reason, i.e. when $q=\frac{1}{2}$, the doctor will play NT if $U_1>U_2$ which is equivalent to $\varepsilon_1+\varepsilon_2>a$.[2] This implies $q^*>\frac{1}{2}$. Following the interpretation used above, this means that the doctor will not pass on all the information to the patient if the average disutility of effort of providing the information is greater than her average disutility if she does not. The patient will then play A, i.e. will adhere, if he is a blunter or NA, i.e. will not adhere, if he is a monitor. This is an assessment equilibrium as it is defined not only in terms of what the players do but also in terms of what they believe.

On the other hand, under bounded rationality, the doctor will play T if $U_1<U_2$ which is equivalent to $\varepsilon_1+\varepsilon_2<a$.[3] This implies $q^*<\frac{1}{2}$. That means that the doctor will pass on all the information to the patient if the average disutility of effort of doing so is lower than her average disutility if she does not. The patient will then play A, i.e. will adhere, if he is a monitor or NA, i.e. will not adhere, if he is a blunter. Again this is an assessment equilibrium.

To sum up, under bounded rationality, i.e. when the doctor attaches probability $\frac{1}{2}$ that the patient is a monitor or a blunter, the following three cases are possible:

- The doctor will be indifferent as whether to play T or NT when $\varepsilon_1+\varepsilon_2=a$,
- The doctor will play NT when $\varepsilon_1+\varepsilon_2>a$,

[2] Calculations are omitted for the purpose of clarity of the results. Detailed solution to the equation is given in Appendix A.2.
[3] Again, calculations are omitted. Detailed solution to the equation is given in Appendix A.3.

- The doctor will play T when $\varepsilon_1 + \varepsilon_2 < a$.

We note that given the beliefs of the doctor, the optimal paths can be considered to be describing a Nash equilibrium, since nobody can improve his payoff given the strategies of the other. However, since decisions are taken under the doctor's beliefs concerning the nodes in I it is more appropriate to use the concept of assessment equilibrium which takes into account the initial beliefs of the doctor. We cannot really talk about a Perfect Bayesian Equilibrium because no updating of beliefs takes place based on Bayes rule.

For the case $q^* < \frac{1}{2}$ the optimal paths are shown in Figure 6 through the black lines from the nodes in the information set to two terminal nodes.

From the above conclusions we derive that as ε_1 and ε_2 go up, i.e. the effort the doctor needs to make to pass on information increases, she will be willing to play NT. On the contrary, when ε_1 and ε_2 decrease then the doctor will play T.

On the other hand, when a increases, i.e. the anger created when the patient is a monitor and the doctor does not pass on all the information to him, then the former is willing to play T. However, when a decreases then the doctor will play NT.

These comparative statics results provide useful insights to understanding policy implications derived from the models. These will be discussed later on this paper.

4. Limitations and directions for future research

This section discusses the limitations as well as possible extensions of the model presented above. To begin with, effort is rather a general concept that is used in the model as a way of demonstrating that the doctor cannot be expected to act as a perfect agent for the patient and maximise the patient's utility function. Apart from having her own utility function, she is often constrained by her strength and desire to serve a number of patients and by organisational factors. Effort has been used here as a proxy for a set of factors, and in future research their particular effect could be the object of analysis. For example, one could consider separately the effect of the length of time than can be allocated to a patient, the working hours of a doctor or the administrative support available to screen the patient.

Model 3 presented a realistic situation in which the doctor cannot tell the type of patient she is examining. On the other hand, the patient knows exactly his own type and the doctor's choice of action. An extension could be to analyse a model in which the patient will, of course, know his type but will not be able to tell with certainty what the doctor has played. In other words, in the extended model the patient will not be able to identify whether the doctor has told him the whole truth or not. For example, the length of consultation time will only be indicative but not decisive.

That would lead to a more involved game. It would create an extra two information sets with two nodes in each. Beliefs per type of patient would have to be attached to these nodes, pure strategies would be per information set, and there would be no subgames. The appropriate equilibrium concept would be that of perfect Bayesian equilibrium. The beliefs of the patient would be updated using Bayes rule. The analysis could reveal further aspects of the doctor-patient relationship.

An interesting point of conflict of interests between the two parties is the different way they value present and future outcomes. Doctors are more future-oriented and want to maximize patients' health outcomes in the future and are less interested in patients' anticipatory feelings in the present. Their goal is to improve patients' health in the future rather than making a patient happier now.

On the other hand, patients are more oriented towards the present and tend to discount the future. They put more weight on leading an easier life now rather than thinking of the consequences of their future health status. This is particularly true for life-style behaviours such as smoking. In order to model this conflict one could build again on Caplin and Leahy's Psychological Expected Utility theory (Caplin and Leahy, 2001). There would be two periods - the present (1) and the future (2). The total utility is the sum of the utilities per period. The conflict of time-preferences could be modelled by allowing the doctor to put more weight on health outcomes in the future, while the patient would give a higher weight to the present.

We assumed in our models that every agent has one type of utility function that is concave, convex or linear. Of course, one could also consider more general utility functions such as a Friedman-Savage function to describe different attitudes to information concerning bad and good news. Our approach was designed to give an explanation of features and findings of experimental studies.

Of course, more empirical testing of the models presented could be the object of future research. An ongoing effort to collect more data and information concerning the doctor-patient relationship could produce further findings which could be analysed by an adjustment and adaptation of the theoretical model analysed here.

5. Discussion of findings and policy implications

The models developed here give concrete insights to doctors and policy makers to understand first how patients' information preferences and beliefs affect their decisions and also how specific interventions may improve the doctor-patient relationship and help to achieve adherence to recommendation. The policy implications derived from the models will be discussed with respect to the doctor, the patient and the health system.

The models presented in this paper capture the fact that patients vary in their preferences regarding how much information they need. Patients do not always want to know everything regarding their condition and future state (Morgan et al., 1998). Too much information increases the anxiety of blunters and, if provided, results in non-adherence to recommendations. In contrast, information decreases the anxiety for monitors and helps them adhere to what the doctor suggests.

Therefore, interventions aiming to educate patients and help them adhere to recommendations should be tailored to the patient's specific needs. Providing all the information will not always give desirable results and in fact, may lead to therapy decisions that are different to those that the physician might have hoped for (Siminoff and Fetting, 1991). Indeed, the literature on tailored care has shown that interventions focusing on the patient's individual needs increase satisfaction with care and improve adherence rates (Kreuter et al., 2000). Leaflets and information material should be given to those who seek information but not necessarily to those who do not.

The models also provide interesting and specific results regarding the doctor's role and how it can be influenced to improve adherence. We consider financial incentives first by assuming that doctors can be rewarded for their effort in supplying information to the patient. We start at $q^* = \frac{1}{2}$ in which the doctor is indifferent to playing T or NT. Financial incentives to reward effort imply that ε_1 and ε_2 are reduced as part of them has been bought out through a money reward.

Model 3 showed that as ε_1 and ε_2 decrease the doctor tends to play T, i.e. she will tend to pass on to the patient all the information. In other words, financial incentives that reward the doctor for her effort would have the result that she puts more effort into the consultation. This would increase adherence rates among monitors, i.e. information loving patients. However, if the patients are blunters this has the opposite effect.

Therefore, the policy implication is that financial incentives to compensate doctors for their effort are an effective method of improving adherence only when patients are information loving.

It is interesting to see how doctors would behave under a different payment method system. Under Payment by Results schemes, doctors are paid not only on the basis of the number of patients they see but also by taking into account improvements they achieve in a patient's health outcomes. Assuming that adherence improves health outcomes it is interesting to see what the model predicts regarding doctors' behaviour. In our model a constant P would be added to the payoff of the doctor when the patient plays A. The model implies that in terms of expectations, a payment in itself will not change directly the decision of the doctor. However, indirectly, it might reduce the doctor's disutility from the effort resulting in a reduction of ε_1 and ε_2, in which case we get the same results as with financial incentives. In terms of policy implications the models do not seem to confirm a direct effect of the Payment by Results scheme in improving adherence. It can only have an indirect effect if it is seen as an alternative way of rewarding effort.

Model 3 also shows that a doctor's decision to put effort into a consultation also depends on a, i.e. the negative atmosphere created when a monitor realises that the doctor does not pass on all the information. The constant a can be perceived as the lack of trust developed during the consultation. If a decreases, i.e. an atmosphere of trust is created, the Model shows that the patient reaches the same decision. However, the doctor can move from the indifferent point to the possible $\varepsilon_1 + \varepsilon_2 > a$. In this case the doctor will play NT. In other words, in situations where the consultation is characterised by trust the doctor can put in less effort, i.e. can spend less time with the patient. As the model shows this benefits the blunter.

In addition, the doctor's training could show significant improvements in adherence rates. Doctors should be educated to understand patients' different needs and be better able to detect them. Knowing the type of patient she is diagnosing gives the doctor the privilege to be able to play a game of complete information. In this case the implication of our analysis is that the doctor passes on to the patient the right amount of information and therefore, as shown in Models 1 and 2, he will adhere to the recommendations.

Health system related interventions could also provide very helpful insights in terms of improving adherence. The models imply, as shown above, that if the doctor knows the patient's preferences then she plays the game with perfect information, thereby improving adherence rates. This is achieved through better trained administrative support able to screen the patient before the consultation. The patient could be asked to

complete a straightforward but appropriately designed questionnaire while waiting to see their doctor, with the aim of staff being able to identify information preferences.

For this purpose, a number of instruments has been validated and repeatedly been used to identify ‘monitoring’ and ‘bluntering’ preferences. The Miller Behavioral Style Scale (MBSS) is one of the most well known and frequently used instruments developed by Miller, who introduced the concept of ‘monitors’ and ‘blunters’ (Miller, 1987). Completing this scale enables doctors, especially when seeing patients for the first time, to obtain information regarding the type of patient they are about to meet and therefore can pass on an adequate level of information. Ideally, using the model’s terminology, the completion of the questionnaire would enable the doctor to play the game as predicted by Model 1 or 2, depending on the type of patient.

This simple intervention would lead to a situation where patients’ needs for information are more likely to be understood by the doctor and this would increase satisfaction with the consultation and also a patient’s intention to follow recommendations. This is shown clearly by our Models.

To sum up, a combination of institutional interventions and instruments to help the doctor and the patient, such as incentive schemes and tailored care, are appropriate for improving adherence rates among patients and this is predicted by our models.

6. Concluding remarks

The aim of this paper has been to investigate whether a game theoretic approach that captures patients’ preferences for information about their health and doctors’ possible inability, for various reasons, to understand these preferences, may explain why patients fail to adherence to medical recommendations. The review of the literature identified a gap in this area as previous theoretical models failed to explain these conflicts in the doctor-patient relationship.

The game theoretic approach used here offers an interdependent decision analysis which explains the optimal decision for both players. In particular, it explains why the doctor may decide not to provide all the information to the patient and the patient may decide not to adhere to recommendations.

More specifically, the paper presented an extensive form approach, expressed through game trees, that models the supply of information by a doctor to a patient when anxiety enters the latter’s utility function and the former needs to put effort into supplying information. The models drew upon the Psychological Expected Utility introduced by Caplin and Leahy (2001).

The present models contribute to the literature in that the doctor takes into account not only the patient's utility but also the effort required, as a proxy of a number of constraints, to supply information. Moreover, in our models the patient is given an active role and can make decisions, based on his payoff function, whether to accept the recommendation or not. In the first two models, the doctor knows the type of patient she is dealing with. In Model 3, which is more realistic, the doctor does not know with certainty the type of patient and she acts under various hypotheses of bounded rationality to resolve the issue of uncertainty (Simon, 1957).

The models were built under specific but reasonable assumptions and offer a complete resolution of the games, using comparative statistics analysis and giving economic interpretations. Their predictions are also reasonable. Models 1 and 2 show that when the doctor knows with certainty the type of patient she will transfer the adequate information and the patient will adhere. In Model 3 the situation is more complicated. The doctor does not know the type of the patient and needs to decide how much information to pass on. She has to consider not only the patient's utility but also the effort she needs to put into supplying information.

Our analysis shows that, in deciding whether to fully inform the patient or not, the doctor will compare her average disutility of putting in effort to the average disutility of not doing so. The latter will stem from the anger of a monitor patient who realises that he has not been told the truth. This is an important marginal condition of the type that is encountered throughout economic theory.

Another result is that the patient will accept the doctor's recommendation if she has successfully supplied the information he wants regarding his state of health. A monitor will be satisfied with full information and a blunter with a less detailed explanation of his health prospects.

Model 3 successfully predicts that consultations where the doctor does not recognise the patient's need and fails to pass on to the patient the right information may result to non-adherence to her recommendations. The analysis here is appropriate in situations where the patient visits the doctor for the first time to obtain a diagnosis, and there is no prior information regarding the type of patient. This is often the case in acute care, where an urgent consultation is needed for a diagnosis and prescription. It can also refer to a first consultation for the treatment of a chronic condition. In this case the patient at some point will visit the doctor again, possibly due to relapse or for continuing treatment.

It might then be possible for the doctor to deduce the patient's type based on the information imparting effort that she put in previously and on the patient's subsequent state of health. Our analysis covers this case as well. Either Model 1 or Model 2 will now be appropriate to apply for subsequent consultations. This may partially explain why visits to the doctor for longer periods may improve adherence among patients.

In summary, a measure of success has been achieved in constructing models with realistic assumptions and reasonable predictions. A number of policy implications to increase adherence rates can be made. The models were developed to capture the basic features of existing empirical evidence. Of course, there is a need to continuously update empirical investigations. The present paper is part of the cumulative theoretical knowledge in the area.

APPENDIX
(Calculations for Model 3)

A.1 The indifference point, $q*$.

The doctor will be indifferent in playing NT or T when $U_1 = U_2$. Replacing the payoffs this is equivalent to the following equations:

$$q \cdot [u_D(E[s]-l)-a]+(1-q)\cdot u_D(E[s]) = q\cdot (E[u_D(s)]-\varepsilon_2)+(1-q)\cdot [u_D(E[s]-l)-\varepsilon_1],$$

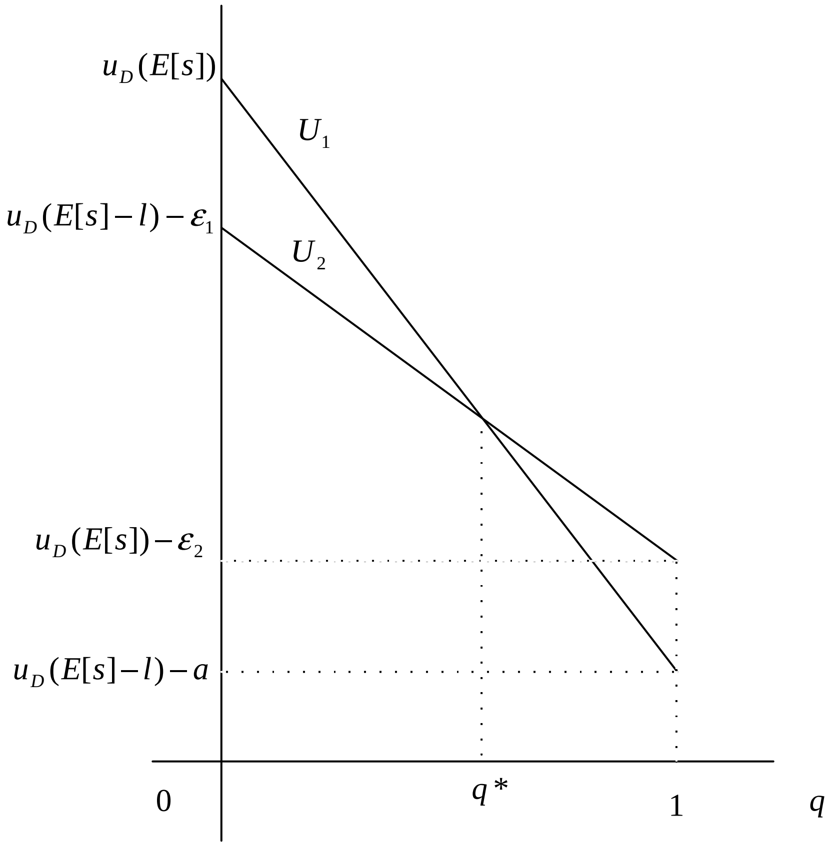
$$q\cdot u_D(E[s]-l)-q\cdot a+u_D(E[s])-q\cdot u_D(E[s]) = q\cdot E[u_D(s)]-q\cdot \varepsilon_2+u_D(E[s]-l)-\varepsilon_1-q\cdot u_D(E[s]-l)+q\cdot \varepsilon_1,$$

$$q\cdot [u_D(E[s]-l)-a-u_D(E[s])-E[u_D(s)]+\varepsilon_2+u_D(E[s]-l)-\varepsilon_1] = u_D(E[s]-l)-u_D(E[s]-l)-\varepsilon_1.$$

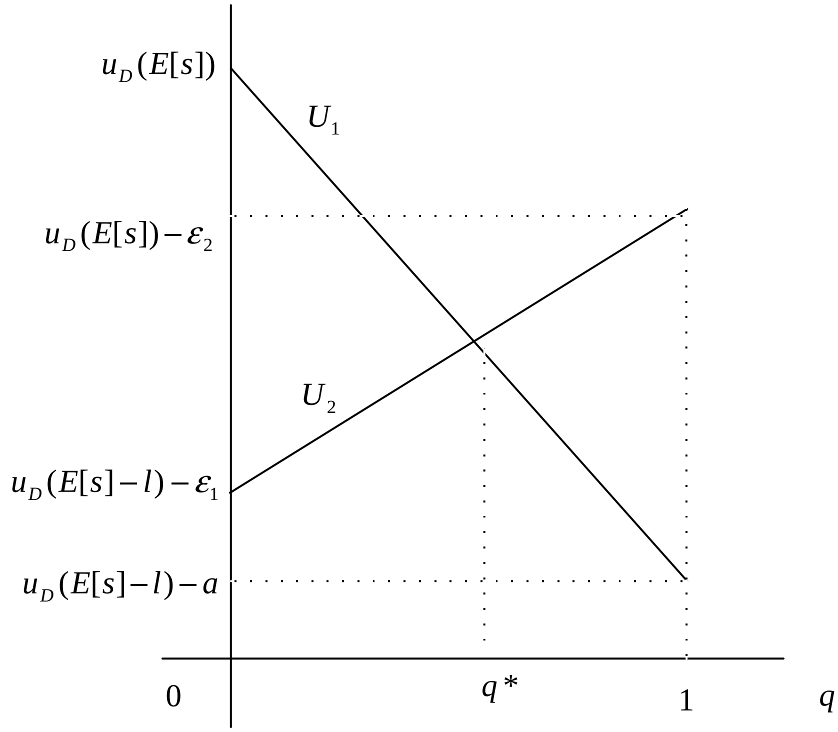
Recall that the doctor's utility function is linear therefore $E[u_D(s)] = u_D(E[s])$. This results to:

$$q* = \frac{u_D(E[s])-u_D(E[s]-l)+\varepsilon_1}{2u_D(E[s])-2u_D(E[s]-l)+a+\varepsilon_1-\varepsilon_2}.$$

A.2 The functions U_1 and U_2.



(a) Case 1: $u_D(E[s]-l)-\varepsilon_1 > u_D(E[s])-\varepsilon_2$ or $\varepsilon_2 > \varepsilon_1 + l$.



(b) Case 2: $u_D(E[s]-l)-\varepsilon_1 < u_D(E[s])-\varepsilon_2$ or $\varepsilon_2 < \varepsilon_1 + l$.

A.3 Case 1: The doctor will play NT when $U_1 > U_2$.

Replacing the payoffs this is equivalent to the following equations:

$$q\cdot[u_D(E[s]-l)-a]+(1-q)\cdot u_D(E[s]) > q\cdot(E[u_D(s)]-\varepsilon_2)+(1-q)\cdot[u_D(E[s]-l)-\varepsilon_1],$$

$$q\cdot u_D(E[s]-l)-q\cdot a+u_D(E[s])-q\cdot u_D(E[s]) > q\cdot E[u_D(s)]-q\cdot\varepsilon_2+u_D(E[s]-l)-\varepsilon_1-q\cdot u_D(E[s]-l)+q\cdot\varepsilon_1,$$

$$q\cdot[u_D(E[s]-l)-a-u_D(E[s])-E[u_D(s)]+\varepsilon_2+u_D(E[s]-l)-\varepsilon_1] > u_D(E[s]-l)-u_D(E[s]-l)-\varepsilon_1,$$

$$q\cdot[u_D(E[s]-l)-a-u_D(E[s])-E[u_D(s)]+\varepsilon_2+u_D(E[s]-l)-\varepsilon_1] > u_D(E[s]-l)-u_D(E[s]-l)-\varepsilon_1.$$

Recall that the doctor's utility function is linear, therefore $E[u_D(s)] = u_D(E[s])$. This results in:

$$q < \frac{u_D(E[s])-u_D(E[s]-l)+\varepsilon_1}{2u_D(E[s])-2u_D(E[s]-l)+a+\varepsilon_1-\varepsilon_2}.$$

Or:

$q < \frac{X}{X+Y}$, where:

$X = u_D(E[s]) - u_D(E[s]-l) + \varepsilon_1 > 0$ and

$Y = u_D(E[s]) - u_D(E[s]-l) + a - \varepsilon_2 > 0$.

Under bounded rationality $q = \frac{1}{2}$ therefore:

$$\frac{1}{2} < \frac{X}{X+Y} \quad \Leftrightarrow \quad X+Y < 2X \quad \Leftrightarrow \quad X > Y \quad \Leftrightarrow \quad \varepsilon_1 > a - \varepsilon_2 \quad \Leftrightarrow \quad \frac{1}{2}(\varepsilon_1 + \varepsilon_2) > \frac{1}{2}(a+0) .$$

A.4 Case 2: The doctor will play T when $U_1 < U_2$.

Replacing the payoffs, this is equivalent to the following equations:

$$q \cdot [u_D(E[s]-l) - a] + (1-q) \cdot u_D(E[s]) < q \cdot (E[u_D(s)] - \varepsilon_2) + (1-q) \cdot [u_D(E[s]-l) - \varepsilon_1],$$

$$q \cdot u_D(E[s]-l) - q \cdot a + u_D(E[s]) - q \cdot u_D(E[s]) < q \cdot E[u_D(s)] - q \cdot \varepsilon_2 + u_D(E[s]-l) - \varepsilon_1 - q \cdot u_D(E[s]-l) + q \cdot \varepsilon_1,$$

$$q \cdot [u_D(E[s]-l) - a - u_D(E[s]) - E[u_D(s)] + \varepsilon_2 + u_D(E[s]-l) - \varepsilon_1] < u_D(E[s]-l) - u_D(E[s]-l) - \varepsilon_1,$$

$$q \cdot [u_D(E[s]-l) - a - u_D(E[s]) - E[u_D(s)] + \varepsilon_2 + u_D(E[s]-l) - \varepsilon_1] < u_D(E[s]-l) - u_D(E[s]-l) - \varepsilon_1 .$$

Recall that the doctor's utility function is linear, therefore $E[u_D(s)] = u_D(E[s])$. This results in:

$$q > \frac{u_D(E[s]) - u_D(E[s]-l) + \varepsilon_1}{2u_D(E[s]) - 2u_D(E[s]-l) + a + \varepsilon_1 - \varepsilon_2} .$$

Or:

$q > \frac{X}{X+Y}$, where:

$X = u_D(E[s]) - u_D(E[s]-l) + \varepsilon_1 > 0$ and

$Y = u_D(E[s]) - u_D(E[s]-l) + a - \varepsilon_2 > 0$.

Under bounded rationality $q = \frac{1}{2}$ therefore:

$$\frac{1}{2} < \frac{X}{X+Y} \quad \Leftrightarrow \quad X + Y < 2X \quad \Leftrightarrow \quad X > Y \quad \Leftrightarrow \quad \varepsilon_1 > a - \varepsilon_2 \quad \Leftrightarrow \quad \frac{1}{2}(\varepsilon_1 + \varepsilon_2) > \frac{1}{2}(a + 0)\,.$$

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