DOCUMENTO DE TRABAJO. E2009/ 07

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Centro de Estudios Andaluces
CONSEJERÍA DE LA PRESIDENCIA

E2007/06

New Perspectives in the Design of Pharmaceutical Copayments[1]

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ABSTRACT:

In this paper we propose a new approach for the design of pharmaceutical copayments. We departure from the standard efficiency argument that advocates for copayments that are decreasing in the health benefits of the patients in order to discipline consumption. Under our approach, copayments are justified by the difficulties for the provider to fully fund their health services.

We use results from the literature on axiomatic bargaining with claims to incorporate criteria of distributive justice into the design of copayments. We find that equity arguments might lead to a relation between copayments and clinical status that diverges from those proposals based on efficiency arguments. In particular, we show that equity-based copayments should be *increasing* rather than decreasing in the health benefits that the treatments provide the patients. The reason is that a low health benefit implies the patient has an important permanent health loss that cannot be avoided with the medication. Equity-based copayments, thus, try to avoid a double jeopardy where on top of the health loss, the patients also face a substantial monetary cost.

Keywords: **Pharmaceutical copayments, equity, axiomatic bargaining, claims.**

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[1]We are deeply indebted to José Luis Pinto for his help and support in developing this project. We also would like to thank the audience at the 29 *th* Meeting of the Spanish Association for Health Economics (AES) in Málaga and at the 7 *th* European Conference on Health Economics in Rome, for their valuable comments. Financial support from Fundación Centro de Estudios Andaluces is gratefully acknowledged. All the remaining errors are our sole responsibility.

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1 Introduction

There have been proposals to incorporate the clinical effect of a treatment in the design of copayments. The idea is to link copayments with clinical benefit. The more clinical benefit for the patient, the lower that patient's cost share would be. In other words, more cost-effective treatments should have lower copayments. Linking copayments with the cost-effectiveness of medical services has been named Value-Base Insurance Design (VBID).[1] Similar proposals have been put forward for public health systems.[2] Newhouse (2006) has also suggested that based on the findings of behavioral economics, it may not be sufficient to provide enough information to patients to make them take good decisions. For this reason, he suggests that cost-sharing should be much more specific in the sense that it should focus more on medical goods or services that reduce future medical costs and/or improve health.

One of the main arguments behind this proposal lies in the limited capacity of people to take the right decisions in the health care market. This argument dates back to the debate on the interpretation of the demand curve held in the Journal of Health Economics some time ago. Rice (1992) argued that in presence of copayments patients reduce both high and low value treatments, that is, they reduce consumption of medical services that have marginal costs both above and below marginal benefits. Rice argues that *patients do not always have sufficient information and experience to make the right choices for themselves*. In this spirit, Fendrick et al (2001) argue that *for many medical conditions the decisions are complex and the responsibility for decision making might best involve the clinician or the provider of the prescription drug benefit* (p. 862). The consequence of this is that copayments reduce consumption of both high-value and low-value services (see Chernew (2008) and Chernew and Fendrick (2008) for a summary of the evidence). For this reason, supporters of VBID suggest that copayments have to be based on the expected clinical benefit. In this way, patients would only reduce consumption of those medicines that produce the smaller health benefit. The main objective of this approach is then to maximize health, that is, efficiency. The interesting point here is that this way of structuring copayments is not based on the assumption that patients have enough information in order to choose the best treatments, rather the opposite. copayments are related to health benefits precisely because patients lack enough information to reduce only consumption of low-value services. It is then assumed that the "architect" of copayments has this information.

In this paper we want to show that the theoretical arguments behind VBID could be in conflict with equity principles. This problem is especially important if we assume that

[1] See Fendrick and Chernew (2006).

[2] See Walley (1998).

in most cases the patient follows the medical treatment that the doctor considers it is the best. Why should the patient be "penalized" because he has been *unlucky* with the medical treatment that the doctor thinks it is the best? A patient can be unlucky for two reasons. The first is that the treatment is expensive. The second is that the treatment is not very efficient. Why should he face higher copayments if the best available treatment is not very efficient? Raising copayments for low-benefit treatments is even more problematic when patients are severely ill. Assume a patient with a severe condition that is unlucky and the best available treatment for his condition is not very efficient. Should we then penalize this patient with a higher copayment because he has been unlucky? Or should we do rather the opposite? In short, the questions we want to address in this paper are the following: i) which should be the relation between copayments and health benefits if copayments are based on equity (not on efficiency) principles? ii) Would it change under different equity principles? iii) Would it be different from efficiency based copayment schemes?

In order to clarify our point we will start assuming (with Fendrick) that the responsibility of the choice of treatment rests in the doctor or in the provider. Assume we have two patients (or group of patients) with two different health problems that need medical treatment. The patients are advised by their doctors on the medicine that it is best for them. We could also assume that in both cases benefits outweigh costs so as Pauly and Blavin (2008) have pointed out there is no moral hazard and we would not need cost sharing. These treatments should be provided at zero cost since they are treatments that would be purchased by consumers even if they had to pay full cost. This would be the logical conclusion of the VBID approach. However, assume that the provider cannot raise enough money in premiums or taxes in order to cover the full cost of these treatments. That is, copayments are needed because the provider has problems in funding their health services and not because governments think that copayments are a good instrument to reduce inefficient consumption.[3,4] Under these circumstances, which rules should we follow

[3]We refer to governments since we are more familiar with the role of copayments in public health systems. To the extent that private insurance companies are under some sort of pressure that makes easier for them to raise funds using copayments instead of raising premiums, our arguments can be applied to private settings as well.

[4]Probably, in an ideal world, this situation would never happen. If a government thinks that a health treatment produces more benefits than costs but it needs more money to fund the treatment, it can raise taxes. In practice, this may not happen for several reasons related to public choice problems. For example, taxpayers may not believe that the government is going to use this money for this purpose, they may think that the government can reduce inefficient consumption in other areas. These reasons can make the government reluctant to raise taxes. At the same time, the government can be under pressure to provide a new medical treatment. Overall, the government can think that some kind of copayment is an easier way of collecting the funds in order to provide this treatment. Also, in some low income

in order to design copayments? Apparently, the VBID approach would suggest that we should use lower copayments for patient(s) whose medicine is more efficient. We will show that if we design copayments using equity principles, the result could be quite different.

We will then move to a different situation. We will assume that the two patients can choose between two different medicines. The doctor suggests to each patient several potential medicines and the patient can choose between them. How would equity-based copayments work? Would they produce good incentives to patients? As it will become clear in the paper, the answer depends on the precise criterion we use in designing the copayments.

The theoretical framework that we propose in order to answer this research question is the so-called "axiomatic bargaining" literature. This literature interprets the budget allocation problem as a bargaining process between agents and advocates for sharing solutions that fulfill a series of a priori desirable properties (axioms). We will use this framework because it is a theory specifically designed to incorporate fairness considerations (through the axioms imposed) and, in this paper, we contemplate copayments as a purely equity issue.

The use of an axiomatic bargaining framework to solve a resource allocation problem in health care was first suggested by Clark (1995), who compared the health care budget allocation between two patients under four alternative rules. More recently, Cuadras-Morató et al. (2001) have enriched Clark's original setting by allowing for the possibility that agents have "claims" about the resources they would like to receive.[5]

There are different possible interpretations of the claims in the context of the allocation of health care resources. In this paper we will consider two alternative definitions that, as it will become clear in what follows, will crucially determine the outcome of the resource allocation problem. First, we can define the claim of an agent as the point up to which the marginal productivity of resources is positive. This interpretation coincides with the definition of need 'as capacity to benefit' suggested by Williams (1974). Under this approach, the claim of an agent is "constrained" by the capacity of the medical technology to provide a health benefit. An alternative is to consider the claim as an "unconstrained"

countries the tax system may not be very well developed. Maybe, this argument is less relevant in a private health care market since an insurance company can raise insurance premiums to fund treatments that produce more benefits than costs and consumers can accept this increase in premiums since they can link this increase in premiums to access of better medical treatments. However, it can also be the case that for private insurers it is easier to justify in front of their customers the use of copayments than a raise in premiums, even for medical treatments that produce more benefits than costs. If this is the case, our argument can be also applied to private insurers. If this is not the case, our paper would be less relevant in private settings.

[5] This analysis is based on the literature on axiomatic bargaining with claims pioneered by Chun and Thomson (1992).

right of the agent. In this case, as in Cuadras-Morató et al. (2001), the claim can be seen 'as an exogenously determined amount of health to which everyone is entitled because there is a socio-political agreement about it. For instance, the claim could be fixed at 70 QALYs, if this is the (at birth) life expectancy adjusted for quality of the population'.

We build on a setting similar to that in Cuadras-Morató et al. (2001) and we study the properties that copayments would have under two classic resource-allocation rules: The proportional and the equal-loss solution. The proportional solution allocates utilities across agents in a way that is proportional to their unsatisfied claims.[6] The equal-loss solution equalizes across agents the losses in utility relative to their claim point, with the restriction that no agent ends up being worse off than at his initial allocation.[7]

The two allocation rules differ in the set of copayments they give rise to. Nevertheless, they share some basic features. First, when we consider the 'constrained' version of the claims, the two rules yield copayments that are based only on the costs of the treatment with no influence at all of the health benefits. The proportional criterion suggests that copayments should be a fixed percentage of the cost of the treatment (in line with the current system of copayments in countries such as France or Spain). The equal-loss criterion advocates for copayments of a fixed magnitude (as it is the case in the UK).

When the claims of the agents are 'unconstrained', a link between health benefits and copayments emerges. In this case, however, the standard efficiency argument that the more clinical benefit for the patient, the lower that patient's cost-share should be, is completely turned on its head: Under the two solutions, the lower the health benefit that the treatment can provide to the patient, the lower the copayment he should face. The reason is that a low health benefit implies the patient has an important permanent health loss that cannot be avoided with the medication. Thus, equity-based copayments try to avoid a double jeopardy where on top of the health loss, the patients also face a substantial monetary cost. As a result, the agent who has a worse health-recovery possibility is favoured through a larger subsidization.[8]

We finally assess the properties of the equity-based copayments in terms of incentives, by allowing patients to choose from a set of possible treatments. In this respect, we find that only the proportional copayments have good efficiency properties as, contrary to the equal-loss copayments, they induce the patient to choose the most cost-effective treatment.

The remainder of the paper is organized as follows. Section 2 lays out the model and presents the solutions we will use in the resource allocation problem. Sections 3

[6] Historically, this has been advocated as a reasonable criteria of justice since the works of Aristotele. For a formal analysis of this solution see Chun and Thomson (1992)

[7] See Chun (1988) for a detailed analysis of this rule.

[8] Note that this reasoning is in line with the fair-innings argument. See, for instance Williams (1997).

and 4 compute the copayment structures with constrained and unconstrained claims, respectively. Section 5 studies the incentives that the equity-based copayments provide to patients. Section 6 introduces income considerations in the model. Section 7 provides a generalization of the basic set-up for n different treatments. Finally, Section 8 concludes.

2 The Model

2.1 The Basic Framework

There are two patients (or patient groups), $N = \{1, 2\}$, who are in need of a pharmaceutical treatment to recover from a certain health loss.[9] Each patient has an initial health status s_i. This health status is measured by a monetary transformation of the QALYs left of life expectancy. Thus, both the quality and length of life may be taken into consideration.

Patients have access to drugs that can improve their health status. Each patient has been prescribed a particular drug and, hence, it is not at patients' discretion to choose their preferred pharmaceutical. For patient i, the consumption of drug i can provide him with an extra h_i QALYs. Hence, h_i is a measure of the effectiveness of the treatment for illness i. With this, we can define by $H_i(h_i|s_i)$ the monetary value of the h_i additional QALYs given by drug i, conditional on an initial level of health s_i.

The treatment needed by patient i has a total cost p_i and the patient faces a copayment rate of $c_i \in [0, 1]$.[10] Thus, we can define the utility of agent i (in monetary terms) as:

$$U_i = s_i + H_i(h_i|s_i) - c_i p_i \tag{1}$$

For simplicity, we abstract from any income effect, i.e., we do not include the income of the patients as a determinant of the copayment levels they will face. Moreover, we assume that all treatments have a positive net benefit (i.e., that $\beta_i \equiv H_i(h_i|s_i) - p_i > 0$, for every i).[11]

Finally, each patient has a claim, or expectation, ε_i about the health status he would like to reach. As stated in the Introduction, this claim admits two interpretations. First, it can be interpreted as an exogenously determined amount of health (a life expectancy

[9] We restrict ourselves to the case with only two groups of patients to simplify the exposition. The analysis of the general case is presented in Section 7.

[10] Note that p_i does not measure the cost of a single dose of the drug, but that of the whole duration of the treatment. Therefore, copayments are defined over the total expenditures that the patient makes during the treatment.

[11] The abstraction from income effects is inessential for our main insights. See Section 6 for a version of the model that incorporates this feature.

measure) that each patient thinks he deserves (denote it by e_i). This vector might represent, for instance, a socioeconomic agreement of the quality-adjusted life expectancy that each agent should be entitled to. Given this claim and the treatment possibilities, we can define $\lambda_i \equiv e_i - (s_i + H_i(h_i|s_i)) \geq 0$ as the value of the unrecoverable health (the value of the loss in health that the treatment cannot bring back the patient, relative to his ideal health state). Alternative, the claim can be constrained to be the utility in the absence of copayments, i.e., $\varepsilon_i = s_i + H_i(h_i|s_i)$. This alternative leaves aside the idea that each person has the "right" to enjoy an exogenously determined amount of health. Instead, it determines the ideal point through the health improvements that the treatment can provide to the patients. This assumption, therefore, links the right of the patients to request a higher utility in the final sharing to their possibilities of recovery.

The health authority (HA) is responsible for paying all the costs of the treatments not levied through the copayments. The total budget to be allocated to drug financing is B. Thus, the budget constraint faced by the HA is given by:

$$\sum_{i\in\{1,2\}} (1-c_i)\, p_i \leq B. \tag{2}$$

To make the analysis non-trivial, we assume that it is impossible to simultaneously fully subsidize both patients. Formally:

$$p_1 + p_2 > B. \tag{3}$$

2.2 The Resource Allocation Problem

The impossibility to fully subsidize both patients generates a resource allocation problem with claims. The feasibility set is determined by the vectors of copayments rates that are simultaneously "affordable" for the HA. As in any other allocation problem in the presence of scarcity, there are three key elements that need to be identified: The utility possibility frontier, the disagreement point and the resource allocation rule to be used.

The utility possibility frontier of the allocation problem relates the utilities that can be awarded to each patient with the amount of resources available to distribute. From (1) we get:

$$c_i p_i = s_i + H_i(h_i|s_i) - U_i.$$

Substituting the equation above into (2), rearranging terms and binding the budget constraint we get

$$\sum_{i\in\{1,2\}} U_i = B + \sum_{i\in\{1,2\}} (s_i + H_i(h_i|s_i) - p_i)\,. \tag{4}$$

We also need to define the "disagreement" or reference point of the problem. Formally, this is the vector of utility levels that the agents would obtain in case they did not reach an agreement about the distribution of the resources. In our setting it corresponds to the value of the agents' utility in the absence of any subsidization of the drugs $(s_i + H_i (h_i|s_i) - p_i)$.

In this paper we compute those copayments that satisfy a series of "desirable" distributive axioms.[12] We will use two solution concepts that satisfy some basic properties: (i) *Pareto optimality*: There is no feasible alternative solution that is preferred by all agents; (ii) *Symmetry*: Agents with equal characteristics should be treated equally; (iii) *Monotonicity:* If the feasible set (i.e., the budget to be shared) expands, other things being equal, all agents should be better off.

The first solution concept we use is the Proportional Solution. This solution corresponds to the maximal point inside the feasible set in the segment connecting the disagreement point with the claims point. Formally, the proportional solution (U_1^{pr}, U_2^{pr}) is given by the utility levels that simultaneously satisfy:

$$U_1^{pr} + U_2^{pr} = B + (s_1 + H_1 (h_1|s_1) - p_1) + (s_2 + H_2 (h_2|s_2) - p_2)$$

$$\frac{U_1^{pr} - (s_1 + H_1 (h_1|s_1) - p_1)}{\varepsilon_1 - (s_1 + H_1 (h_1|s_1) - p_1)} = \frac{U_2^{pr} - (s_2 + H_2 (h_2|s_2) - p_2)}{\varepsilon_2 - (s_2 + H_2 (h_2|s_2) - p_2)}.$$

We also consider the equal loss solution that allocates utilities in such a way that the agents end up at the same "distance" from their ideal point. If the claims of the patients are equal, then this solution equalizes the health states across patients. Formally, the equal-loss solution $\left(U_1^{el}, U_2^{el}\right)$ is given by the utility levels $\left(\tilde{U}_1^{el}, \tilde{U}_2^{el}\right)$ that simultaneously satisfy:

$$\tilde{U}_1^{el} + \tilde{U}_2^{el} = B + (s_1 + H_1 (h_1|s_1) - p_1) + (s_2 + H_2 (h_2|s_2) - p_2)$$

$$\varepsilon_1 - \tilde{U}_1^{el} = \varepsilon_2 - \tilde{U}_2^{el},$$

provided they fulfill the restriction that copayments have to be smaller or equal than 1. Formally, for every $i \in \{1, 2\}$

$$\tilde{U}_i^{el} \geq s_i + H_i (h_i|s_i) - p_i \tag{5}$$

Notice that these two solutions differ in the role they give to the value of the utility of the agents in the absence of any subsidization. In the proportional solution, this utility level is relevant, as the final allocation will be proportional to the difference between

[12] See Clarke (1995) for a first application of axiomatic bargaining to prority setting in health care.

the claim of the patient and his disagreement point. In the equal-loss solution, on the contrary, the disagreement point only sets a minimum reservation utility that is secured for all patients but, other than that, it plays no role on the allocation of resources.

The following sections compute the copayments for each of these solution concepts.[13]

3 Copayments with Constrained Claims

As stated in the Introduction, the notion of claims admits several interpretations. Consider, first, that these ideal points are the maximal utilities the agents can obtain *constrained by their initial health state and the treatment possibilities available.* Formally, this corresponds to a setting where the claims of the patients are $\varepsilon_i = s_i + H_i\left(h_i|s_i\right).$

In what follows, we compute the optimal copayments in this scenario.

3.1 The Proportional Copayments

As we said, the proportional criterion allocates the resources available to share (B) among the individuals in such a way that their resulting utilities are proportional to their unsatisfied claims. Formally, the proportional solution (U_1^{pr}, U_2^{pr}) is given by the utility levels $\left(\tilde{U}_1^{pr}, \tilde{U}_2^{pr}\right)$ that simultaneously satisfy:

$$U_1^{pr} + U_2^{pr} = B + \left(s_1 + H_1\left(h_1|s_1\right) - p_1\right) + \left(s_2 + H_2\left(h_2|s_2\right) - p_2\right)$$

$$\frac{U_1^{pr} - \left(s_1 + H_1\left(h_1|s_1\right) - p_1\right)}{p_1} = \frac{U_2^{pr} - \left(s_2 + H_2\left(h_2|s_2\right) - p_2\right)}{p_2},$$

provided they fulfill the restriction that copayments have to be smaller or equal than 1. Formally, for every $i \in \{1, 2\}$

$$\tilde{U}_i^{pr} \geq s_i + H_i\left(h_i|s_i\right) - p_i \tag{6}$$

In case (6) is violated for one patient, then the proportional solution (U_1^{pr}, U_2^{pr}) is obtained by binding the restriction for this patient and allocating the remaining budget to the other. From here it is straightforward to find that:

[13] To ease the exposition, we will consider a simplified environment where the budget constraint is so tight that it prevents from fully subsidizing any patient. Formally, this amounts to assuming that $B < \min\{p_1 + p_2\}$.

Lemma 1 *The utilities awarded to each patient under the* ***proportional criterion with constrained claims*** *are given by:*

$$U_1^{pr\_c} = s_1 + H_1\left(h_1|s_1\right) - p_1 + \frac{p_1}{p_1+p_2}B$$

$$U_2^{pr\_c} = s_2 + H_2\left(h_2|s_2\right) - p_2 + \frac{p_2}{p_1+p_2}B.$$

Once the utilities are computed, and using the fact that, from (1) we have that

$$c_i^{pr\_c} = \frac{s_i + H_i\left(h_i|s_i\right) - U_i^{pr\_c}}{p_i}$$

it is straightforward to obtain that:

Proposition 1 *The copayments charged to each patient ($i = \{1,2\}$)* ***under the proportional criterion with constrained claims*** *are given by:*

$$c_i^{pr\_c} = 1 - \frac{B}{p_1+p_2}.$$

Note first that, since $B < p_1 + p_2$ it always holds that $c_i^{pr\_c} > 0$, so both patients have to pay part of their treatment. Moreover, under the proportional criterion, patients are never charged the whole price of the drug (i.e., $c_i^{pr\_c} < 1$ for every i) and, hence, both patients are always subsidized. Thus, even if the proportional criterion gives priority to one patient over the other, this prioritization is never absolute.

The interpretation of $c_i^{pr\_c}$ is very simple. It is a copayment that depends only on the overall shortage of resources. The copayment rate does not differ across patients depending on the relative costs of their drugs. It is an homogeneous system in which all patients pay the same percentage of the cost of the drug.[14]

In addition to this, the copayment charged to patient i is increasing in the cost of drug i. The reason is that an increase in the cost of a drug means a reduction in the subsidizing possibilities for the health authority. Given a fixed budget B, an increase in p_i implies that a larger share of the cost has to be charged to the patients. This, indeed, causes that not only the copayment charged to patient i, but also the copayments charged to the patient who use the other treatment, will increase if drug i becomes more costly. In this sense, the proportional criterion implies that the cost of a given drug is not the sole responsibility of its user, instead, these costs are "socialized" across all patients.

[14] The copayment systems in several European countries such as Belgium, France, Greece, Luxembourg, Portugal or Spain are based (though with some specific features on each country) on this idea of charging the patients a fixed proportion of the price of the drug.

3.2 The Equal-loss Copayments

As already defined, the equal-loss criterion allocates resources in such a way that the distance between the patients' utility and their ideal (claim) point is equalized. Formally, the equal-loss solution with constrained claims $\left(U_1^{el}, U_2^{el}\right)$ is given by the utility levels $\left(\tilde{U}_1^{el}, \tilde{U}_2^{el}\right)$ that simultaneously satisfy:

$$\tilde{U}_1^{el} + \tilde{U}_2^{el} = B + \left(s_1 + H_1\left(h_1|s_1\right) - p_1\right) + \left(s_2 + H_2\left(h_2|s_2\right) - p_2\right)$$

$$s_1 + H_1\left(h_1|s_1\right) - \tilde{U}_1^{el} = s_2 + H_2\left(h_2|s_2\right) - \tilde{U}_2^{el},$$

provided they fulfill the restriction that copayments have to be smaller or equal than 1. Formally, for every $i \in \{1, 2\}$

$$\tilde{U}_i^{el} \geq s_i + H_i\left(h_i|s_i\right) - p_i \tag{7}$$

In case (7) is violated for one patient, then the equal-loss solution $\left(U_1^{el}, U_2^{el}\right)$ is obtained by binding the restriction for this patient and allocating the remaining budget to the other.

Assume, without loss of generality, that patient 1 faces a cheaper drug than those of type 2 (i.e., that $p_1 < p_2$). It is straightforward to obtain that:

Lemma 2 *The utilities awarded to each patient under the* ***equal-loss criterion with constrained claims*** *are given by:*

- *If* $p_1 \geq p_2 - B$, *then:*

$$\begin{aligned} U_1^{el\_c} &= s_1 + H_1\left(h_1|s_1\right) - \frac{\left(p_1 + p_2 - B\right)}{2} \\ U_2^{el\_c} &= s_2 + H_2\left(h_2|s_2\right) - \frac{\left(p_1 + p_2 - B\right)}{2}. \end{aligned}$$

- *If* $p_1 < p_2 - B$, *then:*

$$\begin{aligned} U_1^{el\_c} &= s_1 + H_1\left(h_1|s_1\right) - p_1 \\ U_2^{el\_c} &= s_2 + H_2\left(h_2|s_2\right) - p_2 + B. \end{aligned}$$

This solution is divided in two different regions depending on whether when equalizing across patients the losses in utility relative to their claim point, patient 1 ends up being worse off than at his initial (unsubsidized) utility, or not. If this happens, the solution leaves this patient fully unsubsidized and allocates the whole budget on the other patient.

Once the utilities are computed, it is straightforward to obtain that:

Proposition 2 *The copayments charged to each patient* ($i = 1, 2$) ***under the proportional criterion with constrained claims*** *are given by:*

- *If* $p_1 \geq p_2 - B$, *then:*
$$c_i^{el\_c} = \frac{(p_1 + p_2 - B)}{2p_i}$$

- *If* $p_1 < p_2 - B$, *then:*
$$\begin{aligned} c_1^{el\_c} &= 1 \\ c_2^{el\_c} &= 1 - \frac{B}{p_2} \end{aligned}$$

From the above proposition, we see the first important distributional difference between the proportional and the equal-loss prioritizations. Under the equal-loss criterion it can be the case that one patient has to bear the full cost of the drug, feature that never occurred in the proportional case (where c_i was always smaller than one). Hence, when the prioritization is based on an equal-loss argument, it may give an absolute priority to finance one illness and, hence, lead to the exclusion of the other.[15] This occurs if one treatment is very cheap relative to the other one. Both treatments are subsidized when the costs of the two drugs are relatively similar. The copayment system, in such a case, only depends on the cost of the treatment, being inversely related to it: If drug i is more costly than drug j, the percentage of the cost paid by patient i is smaller than the one paid by patient j, in such a way that the total expenditures made on the drugs ($c_i p_i$) are equal for the two patients. Formally,

$$c_i^{el\_c} p_i = \frac{p_1 + p_2 - B}{2}.$$

This, in fact, can be seen as a copayment system where all drugs face a constant total copayment.[16] Since the copayment is fixed on absolute terms, it can be reinterpreted as being a decreasing proportion of the total cost of the drug.

This difference with the proportional case is driven by the way the solution compensates the differences in costs. Under the proportional solution an increase in the cost of one drug implied an increase in the copayment rates for all drugs. Under the equal-loss approach, on the contrary, the more costly drug i is, the smaller the copayment charged to patient i. Even if a higher cost for drug i implies, on the overall, a reduction in the subsidizing possibilities for the HA, the effect that dominates is that the higher the cost

[15] Note that, in this case, the copayment for the drug that is subsidized is increasing in its costs. This is an artificial feature generated by the fact that now all the budget is allocated to a single drug.

[16] This system is used in some European countries such as Austria, Germany or Great Britain (where there is a fixed payment of 9.76€ per prescription).

of one patient's drug, the less utility he will have relative to his ideal point and, therefore, the larger subsidization he should receive in order to compensate. This increased egalitarianism of the equal-loss rule, relative to the proportional one, causes that, as a result of the increase in the price of drug i, it is patient j, whose drug's price has not changed, the one who is charged with a higher copayment rate .

4 Copayments with Unconstrained Claims

The purpose of this section is to illustrate how the main characteristics of the copayments change when we move to a setting with unconstrained claims.

4.1 The Proportional Copayments

Using the fact that, now $\varepsilon_i = e_i$ and proceeding analogously as in Section 3, we have that the proportional solution (U_1^{pr}, U_2^{pr}) is given by the utility levels $\left(\tilde{U}_1^{pr}, \tilde{U}_2^{pr}\right)$ that simultaneously satisfy:

$$\tilde{U}_1^{pr} + \tilde{U}_2^{pr} = B + (s_1 + H_1(h_1|s_1) - p_1) + (s_2 + H_2(h_2|s_2) - p_2).$$

$$\frac{\tilde{U}_1^{pr} - (s_1 + H_1(h_1|s_1) - p_1)}{\lambda_1 + p_1} = \frac{\tilde{U}_2^{pr} - (s_2 + H_2(h_2|s_2) - p_2)}{\lambda_2 + p_2},$$

provided they fulfill the restriction that copayments have to be smaller or equal than 1. Formally, for every $i \in \{1, 2\}$

$$\tilde{U}_i^{pr} \geq s_i + H_i(h_i|s_i) - p_i \tag{8}$$

In case (8) is violated for one patient, then the proportional solution (U_1^{pr}, U_2^{pr}) is obtained by binding the restriction for this patient and allocating the remaining budget to the other one.

From here it is straightforward to find that:

Lemma 3 *The utilities awarded to each patient under the* ***proportional criterion with unconstrained claims*** *are given by:*

$$U_1^{pr\_u} = s_1 + H_1(h_1|s_1) - p_1 + \frac{\lambda_1 + p_1}{\lambda_1 + p_1 + \lambda_2 + p_2} B$$

$$U_2^{pr\_u} = s_2 + H_2(h_2|s_2) - p_2 + \frac{\lambda_2 + p_2}{\lambda_1 + p_1 + \lambda_2 + p_2} B.$$

Once the utilities are computed, and using the fact that, from (1) we have that

$$c_i^{pr} = \frac{s_i + H_i(h_i|s_i) - U_i^{pr}}{p_i}$$

it is straightforward to obtain that:

Proposition 3 *The copayments charged to each patient* ($i = 1, 2$) ***by the proportional criterion with unconstrained claims*** *are given by:*

$$c_i^{pr\_u} = 1 - \frac{\lambda_i + p_i}{p_i(\lambda_1 + p_1 + \lambda_2 + p_2)}B$$

Analogously as in the constrained scenario, under the proportional solution, patients are never charged the whole price of the drug (i.e., $c_i^{pr\_u} < 1$ for every i) and, hence, the prioritization among patients is never absolute. Also again, an increase in the cost of a drug increases all copayments charged, not only that of the patient whose drug has become more expensive.

Interestingly, with unconstrained claims a new effect appears that links copayments with health benefits through the unrecoverable health of patients. In particular, we find that the copayment for patient i is decreasing in his unrecoverable health (λ_i). This is a *fair innings* effect: If the patient has a permanent health loss that cannot be avoided with the medication, at least, he should not pay a high proportion of the treatment costs. This way the copayments try to avoid a *double jeopardy* situation, by favoring the patient that has a worse health-recovery possibility through a larger subsidization.

It is interesting to deepen a bit more on the distributional properties of the copayments derived. First, we can identify when the copayment charged to one patient will exceed that of the other. Straightforward algebra leads to:

$$c_1^{pr\_u} > c_2^{pr\_u} \Longleftrightarrow \frac{\lambda_1}{p_1} < \frac{\lambda_2}{p_2}.$$

From here we get two insights: (i) As already said, the larger the value of the unrecoverable health of each patient, the lower the copayment and, hence, ceteris paribus the agent with a lower value of λ will pay more. (ii) Other things being equal, the higher the cost of a drug, the higher the copayment the patient will face. Note that, at a first sight, this may seem counterintuitive and against the ideas of distributive justice we are putting forward in this analysis. To clarify this, consider now the overall amount of resources allocated to each patient from the health authority (i.e., the total subsidy: $Sub_i = (1 - c_i)p_i$). It is straightforward to find that,

$$Sub_1^{pr\_u} < Sub_2^{pr\_u} \Longleftrightarrow \lambda_1 + p_1 < \lambda_2 + p_2.$$

When we consider the overall subsidy, therefore, the apparent contradiction disappears as, other things being equal, the patient buying a more costly drug always receives a larger share of the total budget. Nevertheless, as allocating more resources from one patient can only be done at the expense of diverting resources from the other, these extra resources given to the more costly drug do not fully compensate the increase in costs, in such a way that a more costly drug will face a higher copayment.

4.2 The Equal-loss Copayments

The equal-loss criterion allocates resources in such a way that the distance between the patients' utility and their ideal (claim) point is equalized. Formally, the equal-loss solution $\left(U_1^{el}, U_2^{el}\right)$ is given by the utility levels $\left(\tilde{U}_1^{el}, \tilde{U}_2^{el}\right)$ that simultaneously satisfy:

$$\tilde{U}_1^{el} + \tilde{U}_2^{el} = B + \left(s_1 + H_1\left(h_1|s_1\right) - p_1\right) + \left(s_2 + H_2\left(h_2|s_2\right) - p_2\right)$$

$$e_1 - \tilde{U}_1^{el} = e_2 - \tilde{U}_2^{el},$$

provided they fulfill the restriction that copayments have to be smaller or equal than 1. Formally, for every $i \in \{1, 2\}$

$$\tilde{U}_i^{el} \geq s_i + H_i\left(h_i|s_i\right) - p_i \tag{9}$$

In case (9) is violated for one patient, then the equal-loss solution $\left(U_1^{el}, U_2^{el}\right)$ is obtained by binding the restriction for this patient and allocating the remaining budget to the other one.

Assume, without loss of generality, that patient 1 has a smaller value of $\lambda + p$ than patient 2. It is straightforward to obtain that:

Lemma 4 *The utilities awarded to each patient* ***by the equal-loss criterion with unconstrained claims*** *are given by:*

- *If* $\lambda_1 + p_1 \geq \lambda_2 + p_2 - B$,

$$\begin{aligned} U_1^{el\_u} &= s_1 + H_1\left(h_1|s_1\right) - \frac{\left(p_1 + p_2 - B\right) - \lambda_1 + \lambda_2}{2} \\ U_2^{el\_u} &= s_2 + H_2\left(h_2|s_2\right) - \frac{\left(p_1 + p_2 - B\right) - \lambda_2 + \lambda_1}{2} \end{aligned}$$

- *If* $\lambda_1 + p_1 < \lambda_2 + p_2 - B$, *then:*

$$\begin{aligned} U_1^{el\_u} &= s_1 + H_1\left(h_1|s_1\right) - p_1 \\ U_2^{el\_u} &= s_2 + H_2\left(h_2|s_2\right) - p_2 + B. \end{aligned}$$

As in the constrained case, the equal-loss solution is divided in two different regions depending on the utility that patients achieve when equalizing across groups their losses in utility relative to their ideal health state. If the equalization implies that one patient is worse off, relative to his initial (unsubsidized) utility, then the solution leaves this patient at their initial utility, and allocates the whole budget to the other patient.

Once the utilities are computed, it is straightforward to obtain that:

Proposition 4 *The copayments charged to each patient ($i = 1, 2$)* ***under the equal-loss criterion with unconstrained claims*** *are given by:*

- *If $\lambda_1 + p_1 \geq \lambda_2 + p_2 - B$, then for every $i, j \in \{1, 2\}$, with $i \neq j$,*

$$c_i^{el\_u} = \frac{(p_1 + p_2 - B) + (\lambda_j - \lambda_i)}{2p_i}.$$

- *If $\lambda_1 + p_1 < \lambda_2 + p_2 - B$, then:*

$$\begin{aligned} c_1^{el\_u} &= 1 \\ c_2^{el\_u} &= 1 - \frac{B}{p_2}. \end{aligned}$$

As in the constrained case, the equal-loss solution may leave some patients unsubsidized. The only difference is that before, the prioritization was solely based on the treatment costs, while in this scenario the sum of the health cost (λ) and the monetary cost (p) are the basis for the prioritization. As a result, if one patient has a very low value of $\lambda + p$ then he may have to bear the full cost of the treatment.

In the case when both patients receive a positive share of the budget, the copayment structure results from the combination of two effects. First, analogously to the proportional prioritization, there is a *fair innings* effect: the larger the unrecoverable health of patient i (i.e., $\lambda_i = e_i - (s_i + H_i(h_i|s_i))$) the smaller the copayment he is entitled to pay. Secondly, there is an effect that compensates for the differences in the costs of the drugs.

To understand the distributional differences with the proportional case, let us compute, first when the copayment charged to one patient will exceed that of the other. Straightforward algebra leads to:

$$c_1^{el\_u} > c_2^{el\_u} \Longleftrightarrow \lambda_1 < \lambda_2 - (p_1 - p_2)\left(\frac{p_1 + p_2 + B}{p_1 + p_2}\right).$$

First, as in the proportional case, ceteris paribus the agent with a lower value of λ will be charged a higher copayment. Nevertheless, contrary to the proportional case, the higher the cost of a drug, the lower the copayment the patient will face. Consider now, as we did before, the overall amount of resources allocated to each patient from the health authority.

$$Sub_1^{el\_u} < Sub_2^{el\_u} \Longleftrightarrow \lambda_1 + p_1 < \lambda_2 + p_2.$$

This condition is exactly the same as in the proportional case. Therefore, the two rules share a main basic distributive property: the patient that faces a larger overall cost (i.e., the sum of his unrecoverable health loss and the monetary cost of the drug) should receive a larger share of the budget. What differs under the two sharing rules is the intensity of the cost compensation, that is larger for the equal-loss rule that is, on the overall, more egalitarian.

5 Efficiency Considerations

As we have said in the Introduction in this paper we implicitly acknowledge that the responsibility of the choice of treatment rests in the doctor or in the provider. Our analysis, thus, explicitly departs from the usual efficiency-enhancing role assigned to pharmaceutical copayments as we have not aimed at designing copayments that rationalize consumption or influence patients' choice among different treatment possibilities. However, at this point we can easily assess how the copayments that emerge from both the proportional and the equal-loss criterion provide incentives to the patients. Note that, as the copayments with constrained claims do not depend on the health benefits of the patient, we restrict the efficiency analysis to the unconstrained scenario.

Consider that, instead of having two patients each one with its prescribed medicine and with no possibility to substitute among drugs, we face a single patient who has the capacity to choose among drugs 1 and 2, both of them being alternative treatments. In such a setting, the incentive role of copayments becomes relevant. We would like copayment schemes that induce the patient to make the "right" choice, i.e., that patients decide to buy the drug with the highest cost-effectiveness ratio or net benefit.

If we compare the net utility of a patient when purchasing either of the two drugs we can conclude that:

Proposition 5 *With unconstrained claims the proportional criterion generates a copayment scheme that provides the patient with incentives to purchase the drug with the highest net benefit, while the equal-loss criterion does not.*

Proof. *See Appendix A.1.* ■

We observe how only the proportional copayments are compatible with providing the patient with right incentives. The main reason lies in the higher egalitarianism of the equal-loss rule. As it downgrades the impact of the price of the drug on the value of the copayment, this is detrimental for the provision of incentives.

6 Introducing Income Effects

The purpose of this section is to illustrate how the introduction of income considerations, will not alter the main insights that can be extracted from our analysis. For this purpose, assume that agents are endowed with a simple utility function that is non-separable in health (η_i) and income (I_i) of the form $U_i(\eta_i, I_i) = \eta_i I_i$. Since the utility function is not quasilinear in money, income effects will be present. For this exercise, let us focus on the case with unconstrained claims and, therefore, assume the claim of agent i is given by e_i.[17].

Taking into account that the net income of an agent is the difference between his initial wealth (measured by m_i) and the cost of the treatment ($c_i p_i$) we have that:

$$U_i(\eta_i, I_i) = \eta_i I_i = \eta_i(m_i - c_i p_i) \Rightarrow c_i p_i = m_i - \frac{U_i}{\eta_i}.$$

This allows us to write the budget constraint faced by the health authority as:

$$p_1 + p_2 - B \leq m_1 - \frac{U_1}{\eta_1} + m_2 - \frac{U_2}{\eta_2},$$

with $\eta_i = s_i + H_i(h_i|s_i)$ being the post-treatment health of agent i.

This restatement of the budget constraint allows us to recompute the copayments under the two rules under consideration.

Proposition 6 *When the utility of the agents is of the form $U_i(\eta_i, I_i) = \eta_i I_i$, the copayments charged to each patient ($i = 1, 2$)* ***under the proportional criterion with unconstrained claims*** *are given by:*

$$c_i^{pr} = 1 - \frac{(\lambda_i + p_i\eta_i)\,\eta_j}{p_i(\eta_2(\lambda_1 + p_1\eta_1) + \eta_1(\lambda_2 + p_2\eta_2))} B$$

Proof. *See Appendix A.2* ■

We can see how, despite the introduction of income effects alters the shape of the copayment rate, it preserves the main insight of the analysis: the larger the value of the unrecoverable utility loss the agent will face, the smaller the copayment. Note that, in this case, the value of $\lambda = e_i - \eta_i m_i$ captures two effects. First, there is the fair-innings effect by which, an agent with worse health recovery potential should be prioritized in order to avoid a double-jeopardy. Second, with income effects, the initial wealth of the agent also plays a role. The poorer the patient (i.e., the lower m_i) the smaller should also be the value of the copayment.

We now show how these same insights emerge under the equal-loss prioritization.

[17] Note that, in this case, the claim is not defined only in terms of health benefits. e_i measures the ideal level of utility the agent would like to enjoy.

Proposition 7 *When the utility of the agents is of the form $U_i(\eta_i, I_i) = \eta_i I_i$, the copayments charged to each patient ($i = 1, 2$) **under the equal-loss criterion with unconstrained claims** are given by:*

- *If for every $i = 1, 2$, with $j \neq i$, it holds that $p_i\eta_i + \lambda_i \geq p_j\eta_j + \lambda_j - B\eta_j$, then*

$$c_i^{el} = \frac{(p_1 + p_2 - B)\,\eta_1 + (\lambda_j - \lambda_i)}{p_i\,(\eta_1 + \eta_2)}$$

- *If there exists $i = 1, 2$, with $j \neq i$, such that $p_i\eta_i + \lambda_i < p_j\eta_j + \lambda_j - B\eta_j$, then*

$$\begin{aligned} c_i^{el} &= 1 \\ c_j^{el} &= 1 - \frac{B}{p_j} \end{aligned}$$

Proof. *See Appendix A.3* ■

7 Design of Copayments with n Patients

In this Section we compute the complete vector of copayments in a more general environment where there are n different types of illnesses and where it may be possible to fully subsidize some (but not all) types of patients.[18] As it will become clear in what follows, the possibility that for some patients the cost of the drugs is fully subsidized makes the complete characterization of the solutions be more complex. In particular, to compute the copayment vector we need to resort to an iterative process.

Let us start, first, with the proportional criterion. First of all, order the set of patients according to $\frac{\lambda_i}{p_i}$, in such a way that $\frac{\lambda_1}{p_1} \leq \frac{\lambda_2}{p_2} \leq ... \leq \frac{\lambda_n}{p_n}$.

The algorithm is defined iteratively. At any iteration t there is a set of patients $N_t = \{1, 2, ...n_t\}$ whose subsidization remains undecided, with n_t identifying the patient with the highest order in N_t. The remaining budget to share is B_t. For the first iteration let us define $N_1 = \{1, 2, ...n\}$, i.e., the whole set of patients according to the ordering above and also let $B_1 = B$ (the whole budget is available to share).

The algorithm would be as follows:

At any iteration $t \geq 1$,

a) If $N_t = \{n_t\}$, then $c_{n_t}^{pr} = 1 - \frac{B_t}{p_{n_t}}$ and the algorithm stops. Otherwise, move to *b)*

[18] We focus on the unconstrained claims case, as it is the one involving the higher complexity in the resulting copayments.

b) Split the budget B_t between the set of agents in N_t according to the Proportional criterion. This is done by finding the vector $\tilde{\mathbf{U}} = \{\tilde{U}_1, ...\tilde{U}_{n_t}\}$ that solves the following system of equations:

$$\sum_{j\in N_t} \tilde{U}_j = B_t + \sum_{j\in N_t} (s_j + H_j(h_j|s_j) - p_j).$$

$$\forall i, j \in N_t, \quad \frac{\tilde{U}_i - (s_i + H_i(h_i|s_i) - p_i)}{\lambda_i + p_i} = \frac{\tilde{U}_j - (s_j + H_j(h_j|s_j) - p_j)}{\lambda_j + p_j}$$

Compute the vector $\tilde{\mathbf{c}} = \{\tilde{c}_1, \tilde{c}_2, ...\tilde{c}_{n_t}\}$ using:

$$\tilde{c}_i = \frac{s_i + H_i(h_i|s_i) - \tilde{U}_i}{p_i}$$

If $\tilde{c}_{n_t} \geq 0$, then for every $i \in N_t$

$$c_i^{pr} = \tilde{c}_i$$

and the algorithm stops. Otherwise, move to c).

c) $c_{n_t}^{pr} = 0$, and move to iteration $t+1$ with $B_{t+1} = B_t - p_{n_t}$ and $N_{t+1} = N_t \backslash \{n_t\}$.

This iterative process computes the whole vector of copayments. These can have two configurations. It can be the case that all copayments are strictly positive (i.e., there is no type of agent that is fully subsidized). This occurs if no patient has a very large $\frac{\lambda_i}{p_i}$, relative to the others. In this case, copayments for all types of patients are given by:

$$c_i^{pr} = 1 - \frac{\lambda_i + p_i}{p_i \sum_{j=1}^{n} (\lambda_j + p_i)} B,$$

that is simply the n-type generalization of the copayments obtained in Section 4. In the other configuration some types of patients, those with a large $\frac{\lambda_i}{p_i}$, face a zero copayment, while for the remaining ones, the budget that is left after fully subsidizing this set of patients, is split according to the rule above.

Two issues are key in this proportional prioritization. First, what determines whether the patient will face a positive or a zero copayment is *how large is the unrecoverable health, relative to the cost of the treatment*. The larger is this health loss, the more likely it is that the patient's treatment is fully subsidized.[19] Secondly, analogously as in the case with two types, no patient has to face the whole cost of the treatment. The prioritization always subsidizes a fraction of the cost of the treatment.

The principles that lie behind the proportional prioritization can be better illustrated if we focus on the case where the copayment is positive and smaller than 1 for all types

[19] Note that this feature did not appear in Section 4, as there we assumed that the budget was not enough to fully subsidize any of the two groups of patients.

of patients. In this case, i.e., if $c_j \in (0,1)$ for every j, if we compute the total amount of subsidy that each type of patient receives (denote it by $Sub_j \equiv p_j - c_j p_j$) we get that:

$$Sub_j = \frac{\lambda_i + p_i}{\sum_{j=1}^{n} (\lambda_j + p_i)} B.$$

Hence, the fraction of the budget that is allocated to each type is determined by the total cost faced by these patients, i.e., not only the monetary cost (p_i) but also the health loss (λ_i) they incur.

Let us move now to the equal-loss criterion and order the set of patients according to λ_i, in such a way that $\lambda_1 \leq \lambda_2 \leq ... \leq \lambda_n$.

The algorithm is again defined iteratively. At any iteration t there is a set of patients N_t whose subsidization remains undecided, with n_t identifying the patient with the highest order in N_t. The remaining budget to share is B_t. Also, at each iteration define α_t as the element in N_t that minimizes $\lambda_i + p_i$. Formally, $\alpha_t = \arg\min_{i \in N_t} \lambda_i + p_i$.

For the first iteration let us define $N_1 = \{1, 2, ...n\}$, i.e., the whole set of patients according to the ordering above and also let $B_1 = B$ (the whole budget is available to share).

The algorithm would be as follows:

At any iteration $t \geq 1$,

a) If N_t, consists of more than one type of patients, move to b). Otherwise, denote by h this remaining type of patient. We compute $c_h^{el} = \min\left\{1 - \frac{B_t}{p_h}, 0\right\}$. If $c_h^{el} > 0$ the algorithm stops. Otherwise, move to the first iteration of sub-routine a').

b) Split the budget B_t between the set of agents in N_t according to the Equal-loss criterion. This is done by finding the vector $\tilde{\mathbf{U}}$ that solves the following system of equations:

$$\sum_{j \in N_t} \tilde{U}_j = B_t + \sum_{j \in N_t} (s_j + H_j (h_j | s_j) - p_j).$$
$$\forall i, j \in N_t,\ e_i - \tilde{U}_i = e_j - \tilde{U}_j.$$

Compute the vector $\tilde{\mathbf{c}}$ using:

$$\tilde{c}_i = \frac{s_i + H_i (h_i | s_i) - \tilde{U}_i}{p_i}$$

If $\tilde{c}_{\alpha_t} \leq 1$, move to c). Otherwise, $c_{\alpha_t}^{el} = 1$, and move to iteration $t+1$ with $B_{t+1} = B_t$ and $N_{t+1} = N_t \backslash \{\alpha_t\}$.

c) If $\tilde{c}_{n_t} \geq 0$, then for every $i \in N_t$,

$$c_i^{el} = \tilde{c}_i,$$

and the algorithm stops. Otherwise, $c_{n_t}^{el} = 0$, and move to iteration $t+1$ with $B_{t+1} = B_t - p_{n_t}$ and $N_{t+1} = N_t \backslash \{n_t\}$.

Sub-routine a'). At any iteration τ there is a set of patients N'_τ whose subsidization can be altered with respect to what the main routine of the algorithm proposed. The remaining budget to share is B'_τ. Also, at each iteration define ω_τ as the element in N'_τ that maximizes $\lambda_i + p_i$. Formally, $\omega_\tau = \arg\max_{i \in N'_\tau} \lambda_i + p_i$. In the first iteration of the sub-routine, we let N'_1 be the set of patients who, in the main routine of the algorithm, received no subsidization. Formally N'_1 is such that for every $j \in N'_1$, $c_j^{el} = 1$. Also, we let $B'_1 = B_t - p_h$.

At any iteration of the sub-routine $\tau \geq 1$:

i) Take agent ω_τ and recompute its copayment according to $c_{\omega_\tau}^{el} = \min\left\{1 - \frac{B'_\tau}{p_{\omega_t}}, 0\right\}$.

ii) If $c_{\omega_\tau}^{el} > 0$ the algorithm stops. Otherwise, move to iteration $\tau+1$ with $N'_{\tau+1} = N'_\tau \backslash \{\omega_\tau\}$ and $B'_{\tau+1} = B'_\tau - p_{\omega_\tau}$.

The fact that when the prioritization is based on an equal-loss argument, it may lead to the exclusion of some of the patients, complicates the computation of the optimal copayments. Now, the resulting vector of copayments might feature: i) Some patients facing a zero copayment (those with a large unrecoverable health loss, relative to the others), ii) some patients facing a full copayment (those with a small value of $\lambda + p$), and iii) the remaining ones being only partially subsidized. Copayments for these latter types of patients are given by:

$$c_i^{el} = \frac{1}{p_i}\left(\frac{\sum_{j=1}^n p_j - B}{n} + \left(\frac{\sum_{j=1}^n \lambda_j}{n} - \lambda_i\right)\right).$$

Analogously as in the proportional scenario, the principles that lie behind the equal-loss prioritization can be better illustrated if we focus on the case where the copayment is positive and smaller than 1 for all types of patients. In this case, i.e., if $c_j \in (0,1)$ for every j, if we compute the total amount of expenditures that each type of patient bears (denote it by $Exp_j \equiv c_j p_j$) we get that:

$$Exp_j = \frac{\sum_{j=1}^n p_j - B}{n} + \left(\frac{\sum_{j=1}^n \lambda_j}{n} - \lambda_i\right).$$

Hence, under the equal-loss criterion, the expenditures that all types of patients have to incur are the sum of: i) An equal division of the shortage of resources relative to the total expenditure in prescriptions and ii) a correction term that depends on the value of the unrecoverable health of each type of patient, relative to the average of the whole population. If one patient faces a larger than average permanent health loss, he pays less.

8 Conclusions

In this paper we have proposed a new way to address the problem of designing pharmaceutical copayments. We have departured from the traditional efficiency argument that advocates for copayments that are inversely related to the health benefits of the pharmaceuticals. We have proposed, instead, an environment where moral hazard arguments are absent, as we assume the responsibility of the choice of treatment rests in the doctor or in the provider, rather than in the patient himself. The rationale for positive copayments in this setting lies in the impossibility of the health authority to fully subsidize the costs of the treatments.

We have used results from the literature on axiomatic bargaining with claims to incorporate criteria of distributive justice into the design of copayments. We have studied two alternative rules, the proportional and the equal-loss rules, under two alternative interpretations of the claims of the agents.

Under constrained claims we have found copayments that replicate the two most common systems currently employed in Europe. The proportional criterion suggests that copayments should be a fixed percentage of the cost of the treatment (as it occurs in France or Spain, for instance); while the equal-loss criterion advocates for copayments of a fixed magnitude (as in the UK).

We, then, analysed the unconstrained claims scenario, where we showed, interestingly, that arguments based on equity and not on efficiency can justify the use of different copayments according to health benefits. However, equity arguments lead to a relation between copayments and clinical status that diverges from proposals based on efficiency arguments. In particular, we have shown that equity-based copayments should be *increasing* rather than decreasing in the health benefits that the treatments provide the patients. The main reason is that a low health benefit implies the patient has an important permanent health loss that cannot be avoided with the medication. The allocation rules try to avoid a double jeopardy where on top of the health loss, the patients also face a substantial monetary cost. As a result, the agent who has a worse health-recovery possibility is favoured through a larger subsidization

We have also shown that, if we analyse the efficiency performance of the copayments proposed, only the proportional criterion yields a copayment system that provides patients with incentives to purchase the most cost-efficient treatment. The higher egalitarianism of the equal-loss rule prevents it from providing the appropriate incentives to the patient.

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A Appendix

A.1 Proof of Proposition 5

Consider, without loss of generality that drug 1 has a larger net benefit than drug 2, and recall that $\beta_i = H_i(h_i|s_i) - p_i$ denotes the net benefit of drug i.

First of all, since it is a single patient who chooses among the two drugs, we have that $s_1 = s_2 = s$ and $e_1 = e_2 = e$.

With this simplification we can write the net utility of the patient, under the proportional rule, when purchasing drug i as:

$$U_i^{pr} = s + \beta_i + \frac{e - s + \beta_i}{2(e - s) - \beta_1 - \beta_2} B.$$

Since we have assumed that $\beta_1 > \beta_2$, the copayment will provide the right incentives if $U_1^{pr} > U_2^{pr}$. Rearranging terms we have that

$$U_1^{pr} - U_2^{pr} = (\beta_1 - \beta_2)\left(1 - \frac{B}{2(e - s) - \beta_1 - \beta_2}\right).$$

Since $\beta_1 > \beta_2$, we have that $U_1^{pr} > U_2^{pr}$ if and only if

$$1 - \frac{B}{2(e - s) - \beta_1 - \beta_2} > 0 \Longleftrightarrow 2(e - s) - \beta_1 - \beta_2 > B$$

Using the fact that $\beta_i = H_i(h_i|s_i) - p_i$, and $\lambda_i = e_i - (s_i + H_i(h_i|s_i)) \geq 0$, the above condition is equivalent to

$$\lambda_1 + \lambda_2 > B - p_1 - p_2.$$

And this always holds since, by construction, $B < p_1 + p_2$.

We proceed analogously for the equal-loss rule. We can write the net utility of the patient when purchasing drug i as:

$$U_i^{el} = \frac{2s + B + \beta_1 + \beta_2}{2}.$$

From here it follows directly that $U_1^{el} = U_2^{el}$. This completes the proof.

A.2 Proof of Proposition 6

The proportional solution (U_1^{pr}, U_2^{pr}) is given by the utility levels $\left(\tilde{U}_1^{pr}, \tilde{U}_2^{pr}\right)$ that simultaneously satisfy:

$$p_1 + p_2 - B = m_1 - \frac{\tilde{U}_1^{pr}}{\eta_1} + m_2 - \frac{\tilde{U}_2^{pr}}{\eta_2}.$$

$$\frac{\tilde{U}_1^{pr} - \eta_1(m_1 - p_1)}{e_1 - \eta_1(m_1 - p_1)} = \frac{\tilde{U}_2^{pr} - \eta_2(m_2 - p_2)}{e_2 - \eta_2(m_2 - p_2)},$$

provided they fulfill the restriction that copayments have to be smaller or equal than 1. Formally, for every $i \in \{1, 2\}$

$$\tilde{U}_i^{pr} \geq \eta_i (m_i - p_i)$$

From the first equation of the system we get

$$\tilde{U}_1^{pr} = \frac{e_1 - \eta_1 (m_1 - p_1)}{e_2 - \eta_2 (m_2 - p_2)} \left(\tilde{U}_2^{pr} - \eta_2 (m_2 - p_2) \right) + \eta_1 (m_1 - p_1)$$

Plugging this expression into the second equation and after some tedious but straightforward algebraic manipulations we get:

$$\tilde{U}_2^{pr} = \frac{(B - p_2 + m_2) \eta_1 \eta_2 (\lambda_2 + \eta_2 p_2) + (\eta_2)^2 (m_2 - p_2)(\lambda_1 + \eta_1 p_1)}{\eta_1 \lambda_2 + \eta_2 \lambda_1 + \eta_1 \eta_2 (p_1 + p_2)}$$

Now, using the fact that $c_i = \frac{1}{p_i} \left(m_i - \frac{U_i}{\eta_i} \right)$, we can simplify and obtain:

$$c_i^{pr} = 1 - \frac{(\lambda_i + p_i \eta_i) \eta_j}{p_i (\eta_2 (\lambda_1 + p_1 \eta_1) + \eta_1 (\lambda_2 + p_2 \eta_2))} B.$$

It is straightforward to see that $c_i^{pr} < 1$ and, hence, that $\tilde{U}_i^{pr} \geq \eta_i (m_i - p_i)$. This completes the proof.

A.3 Proof of Proposition 7

The equal-loss solution $\left(U_1^{el}, U_2^{el} \right)$ is given by the utility levels $\left(\tilde{U}_1^{el}, \tilde{U}_2^{el} \right)$ that simultaneously satisfy:

$$p_1 + p_2 - B = m_1 - \frac{\tilde{U}_1^{el}}{\eta_1} + m_2 - \frac{\tilde{U}_2^{el}}{\eta_2}.$$

$$e_1 - \tilde{U}_1^{el} = e_2 - \tilde{U}_2^{el},$$

provided they fulfill the restriction that copayments have to be smaller or equal than 1. Formally, for every $i \in \{1, 2\}$

$$\tilde{U}_i^{el} \geq \eta_i (m_i - p_i)$$

From the second equation of the system we get

$$\tilde{U}_1^{el} = e_1 - e_2 + \tilde{U}_2^{el}$$

Plugging this expression into the first equation and after some algebraic manipulations we get:

$$\tilde{U}_2^{pr} = \frac{-(p_1 + p_2 - B)(\eta_1 + \eta_2) + \eta_2 (e_2 - e_1 + \eta_1 (m_1 + m_2))}{\eta_1 + \eta_2}$$

Now, using the fact that $c_i = \frac{1}{p_i}\left(m_i - \frac{U_i}{\eta_i}\right)$, we can simplify and obtain:

$$c_i^{el} = \frac{(p_1 + p_2 - B)\,\eta_1 + (\lambda_j - \lambda_i)}{p_i\,(\eta_1 + \eta_2)}.$$

This is the solution, provided $c_i^{el} < 1$ (i.e., $\tilde{U}_i^{el} \geq \eta_i\,(m_i - p_i)$). It is direct to check that

$$c_i^{el} < 1 \Longleftrightarrow p_i\eta_i + \lambda_i \geq p_j\eta_j + \lambda_j - B\eta_j.$$

Otherwise, we have that $c_i^{el} = 1$ and $c_j^{el} = 1 - \frac{B}{p_j}$. This completes the proof.