Priority Setting in Health Care and Higher Order Degree Change in Risk

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ABSTRACT

This paper examines how priority setting in health care expenditures is influenced by the presence of uncertainty surrounding first the severity of the illness and second the effectiveness of medical treatment. We provide necessary and sufficient conditions on preferences for which a social planner will allocate more health care ressources to the higher risk population. Change in risk is defined through the concept of stochastic dominance up to order n. Both inequality neutrality and inequality aversion are considered to modelise the aggregation of health benefit by the social planner. We show that for higher order risk changes, usual conditions on preferences such as prudence are not necessarily required to prioritise health care under uncertainty.

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1. Introduction

Uncertainty is an intrinsic characteristic of health care. As stressed by Arrow (1963) in his seminal work, uncertainty in health care relates mainly to two sources, the uncertainty surrounding the severity of illness and the uncertainty surrounding the effectiveness of medical treatment. Another characteristic of health care is that its consumption is steadily increasing in most countries worldwide, calling for prioritising health care expenditures among populations. Surprisingly few theoretical works, to the best of our knowledge, have addressed the issue of priority setting in health care in the face of more uncertainty (Hoel, 2003; Bui *et al.*, 2005). This paper tries to fill this gap.

As an illustration, consider a population confronted to the same disease for which a medical treatment is available. The population is composed of two types of individuals identical in all respects except for the fact that the severity of the disease is more uncertain for the first type of patients than for the second type of patients. This could be illustrated by the first type being confronted to co-morbidity or other health risks which increase the uncertainty of the health level. Consider a social planner that has to allocate

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a fixed budget of the treatment across the population. Should the decision-maker allocate more ressources to the patient who is more at risk? The aim of this paper is to provide necessary and sufficient conditions on preferences for which the social planner will allocate more health care resources to the higher risk population. Following Arrow's (1963) classification, this paper considers two sources of risks; either on the severity of the disease or on the efficiency of the treatment. So as to define change in risk, we use the framework of *nth*-order stochastic-dominance. Stochastic-dominance encompasses very general forms of risk changes and provides a useful tool to modelise these changes as shown in various works (see e.g. Gollier, 2001). In particular, stochastic-dominance includes the well-known concept of mean-preserving increase in risk introduced by Rothschild and Stiglitz (1970) as well as increase in downside risk as defined by Menezes *et al.* (1980).

Our work relies on the Expected Utility framework, also generally referred as QALY Utilitarism in the context of health. Under this approach, each individual in society gets the same weight independently of his health status. Yet, such an approach has been criticised on the grounds that it does not take into account equity considerations. Hence, we also consider a second approach enabling to weigh individuals with respect to their health level, reflecting inequality aversion of the social planner. This approach is referred to as the Rank-Dependent QALY model (Bleichrodt *et al.*, 2004).

In the case of uncertainty on the severity of the disease, we show how the most commonly used utility functions, i.e. those whose successive derivatives to any order n alternate in signs, lead to prioritise the patients more at risk for any *nth*-order increase in risk. In the case of a risk on the efficiency of the medical treatment, conditions on preferences needed to prioritise the patients more at risk are more limiting and necessitate conditions on *nth*-order relative risk aversion.

This paper is organised as follows. In the next section, we introduce the general model and present the concept of increase in *nth*-degree risk (Ekern, 1980) as a special case of *nth*-order stochastic dominance. Section 3 deals with uncertainty on the severity of the disease. Section 4 addresses the case of uncertainty on the efficiency of health care. Section 5 considers the case of an inequality averse social planner. Finally, a short conclusion is provided in the last section.

2. The model

The model is based both on Dardanoni and Wagstaff (1990) model in the way uncertainty in health care is defined and on Hoel (2003) and Bui *et al.* (2005) models in terms of the health care allocation problem. Individuals derive utility according to the vNM utility function $u(H)$ where H is the level of health and with $u'(.) > 0$ and $u''(.) < 0$. Health is produced by medical care c according to the health production function, $H(c)$. Following Dardadoni and Wagstaff (1990), $H(c)$ is assumed to be linear and of the form:

$$H(c) = a + mc, \tag{1}$$

where a can be interpreted as the basic level of health reflecting the severity of the disease and m is the productivity, or efficiency, of health care ($m > 0$). Uncertainty on the health level $H(c)$ can take two forms, either $\widetilde{H}(c) = \widetilde{a} + mc$, or $\widetilde{H}(c) = a + \widetilde{m}c$.

In the first situation, m is known with certainty but there is uncertainty on the severity of the disease, i.e. a is random. In this case, uncertainty enters in the health production function in an additive form. In the second situation, there is uncertainty about the efficiency of health care, i.e. m is uncertain[2] and a is certain. In that later case, uncertainty enters in the health production function in a multiplicative form.

Consider a population composed of two types of individuals with α_i representing the share of persons of type-i (with $i = 1, 2$) and such that $\alpha_1 + \alpha_2 = 1$. Individuals have the same utility function u, and differ in the uncertainty on the health production function.

Consider the optimal allocation in health care of a fixed budget r that has to be made at the level of society. The decision-maker must choose the level of health care expenditures c_1 and c_2 respectively allocated to type-1 and type-2 patients, and does this so that his expected utility is maximised.

The optimisation problem is then represented by the Lagrangian expression L:

$$L(c_1, c_2, \lambda) = \alpha_1 E[u(\tilde{H}_1(c_1))] + \alpha_2 E[u(\tilde{H}_2(c_2))] + \lambda(r - \alpha_1 c_1 - \alpha_2 c_2) \tag{2}$$

In the additive case, the agent i $(i = 1, 2)$ health production function writes as $\tilde{H}_i(c_i) = \widetilde{a}_i + mc_i$, and agents differ in the uncertainty on the severity of the disease, $\tilde{a}_i$. In the multiplicative case, the agent i $(i = 1, 2)$ health production function writes as $\tilde{H}_i(c_i) = a + \tilde{m}_i c_i$, and the two types of the population differ in the uncertainty on the efficiency of health care.

The changes of risk we consider in this paper are based on the concept of stochastic dominance. Stochastic dominance establishes a partial ordering of probability distributions.

Let F and G denote two cumulative distribution functions, defined over a probability support contained with the open interval (a, b). Define $F_1 = F$ and $G_1 = G$. Now define $F_{k+1}(z) = \int_a^z F_k(t)dt$ for $k \geq 1$ and similarly define G_{k+1}. The distribution F dominates the distribution G via stochastic dominance of order n (denoted nSD) if and only if $F_n(z) \leq G_n(z)$ for all z, and if $F_k(b) \leq G_k(b)$ for $k = 1, .., n-1$.

A special case of stochastic dominance is the concept of an increase in risk as developed by Ekern (1980) which restricts to pairs of random variables that have the $(n-1)$ first moments identical. Following Ekern (1980), $\widetilde{x}_2$ has more n^{th}-degree risk than $\widetilde{x}_1$ if and only if $\widetilde{x}_1 \; nSD \; \widetilde{x}_2$, and $E(\widetilde{x}_1^k) = E(\widetilde{x}_2^k)$ $\forall k = 1, 2, ..., n-1$.

Ekern's (1980) definition includes the well-known cases of mean preserving increase in risk of Rothshild and Stiglitz (1970) and of increase in downside risk defined by Menezes *et al.* (1980) as respectively increase in 2^{nd}-degree risk and in 3^{rd}-degree risk.

3. Uncertainty on the severity of the disease

Let us first consider the case where there exists two types of individuals in the population who differ in the uncertainty on the severity of the disease, with α_i representing the share of persons with a risk $\widetilde{a}_i$ on their basic level of health, and such that $\alpha_1 + \alpha_2 = 1$. The optimisation problem is then represented by the Lagrangian expression L:

$$\underset{c_1, c_2, \lambda}{MaxL} = \alpha_1 E[u(\widetilde{a}_1 + mc_1)] + \alpha_2 E[u(\widetilde{a}_2 + mc_2)] + \lambda(r - \alpha_1 c_1 - \alpha_2 c_2) \tag{3}$$

If interior solutions prevail, denoted c_1^* and c_2^*, the first order conditions (FOC) imply:

$$E[u'(\widetilde{a}_1 + mc_1^*)] = E[u'(\widetilde{a}_2 + mc_2^*)]. \tag{4}$$

[2]This could also reflect uncertainty on the quality of health care as stressed by Arrow (1963).

So as to compare c_1^* and c_2^*, we follow Ingersoll (1987) who shows that if the risk $\widetilde{a}_1$ dominates $\widetilde{a}_2$ via n^{th}-order stochastic dominance, this is equivalent to $E[v(\widetilde{a}_1)] \geq E[v(\widetilde{a}_2)]$ for all functions v such that $(-1)^{k+1}v^{(k)} \leq 0$ $\forall k = 1, 2, ..., n$. Using this result, and substituting v by u',we can write that $E[u'(\widetilde{a}_1 + mc_1^*)] \leq E[u'(\widetilde{a}_2 + mc_1^*)]$ for all utility function u such that $(-1)^{k+1}u^{(k+1)} \leq 0$ $\forall k = 1, 2, ..., n$. Hence, using equation (4), we have $E[u'(\widetilde{a}_2 + mc_2^*)] \leq E[u'(\widetilde{a}_2 + mc_1^*)]$ which is equivalent to $c_2^* \geq c_1^*$, because $u''(x) < 0$ $\forall x$. We obtain the following proposition.

Proposition 1. *Given two types of risk-averse patients confronted to the same illness for which the risk on the severity of illness is respectively $\widetilde{a}_1$ and $\widetilde{a}_2$ such as $\widetilde{a}_1$ nSD $\widetilde{a}_2$, the social planner should allocate more ressources to type-2 patients than to type-1 patients if and only if* $(-1)^{k+1}u^{(k+1)} \leq 0$ $\forall k = 1, 2, ..., n$.

Using the concept of n^{th}-degree increase in risk defined by Ekern (1980), we can easily extend proposition 1 to the following corollary.

Corollary 1. *Given two types of risk-averse patients confronted to the same illness for which the risk on the severity of illness is respectively $\widetilde{a}_1$ and $\widetilde{a}_2$* such that *$\widetilde{a}_2$ has more n^{th}-degree risk than $\widetilde{a}_1$, the social planner should allocate more ressources to type-2 patients than to type-1 patients if and only if* $(-1)^{k+1}u^{(k+1)} \leq 0$ $\forall k = 1, 2, ..., n$.

Let us illustrate these results. First consider the case where $\widetilde{a}_1 = 0$ and $\widetilde{a}_2 = -\delta$ with $\delta \geq 0$. The shift from $\widetilde{a}_1$ to $\widetilde{a}_2$ is a first-degree change in risk. Type-2 patients face the disease with higher severity than type-1 patients. In that case, proposition 1 says that a social planner should allocate more resources to the patient for whom the severity of the disease is higher if and only if $u'' \leq 0$. Obviously if $\delta = 0$, the severity of the disease is the same for the two patients and thus $c_1^* = c_2^*$. Note that an increase of the probability of being in the worst health state is also a first-degree change in risk, meaning that under risk aversion, a social planner should prioritise the patients with the higher probability of being in the worst state.

Next, let us consider the case where $\widetilde{a}_1 = 0$ and $\widetilde{a}_2 = \tilde{\epsilon}$ with $E(\tilde{\epsilon}) = 0$. The shift from $\widetilde{a}_1$ to $\widetilde{a}_2$ is a second-order change in risk. Type-2 patients face a risk on their health while not the case for type-1 patients. In that situation, the social planner should prioritise the patients at risk if and only if $u''' \geq 0$ which is defined as prudence. This has to be linked to the results of Hoel (2003) and Bui *et al.* (2005) who look at the introduction of uncertainty on the optimal allocation of health care[3] and highlight the dominant role of prudence. As indicated before, a mean-preserving increase in risk as defined by Rothschild and Stiglitz (1980) is also a second-order increase in risk.

Going one step further, third-order change in risk relies on the skewness of the distribution. Skewness is a measure of the asymmetry of the probability distribution. Skewness is equivalent to what Menezes *et al.* (1980) call downside risk. So as to illustrate third-order

[3]While Hoel (2003) and Bui *et al.* (2005) looked at the effect of adding uncertainty on the optimal allocation of health care for each type, we compare the optimal allocation of health care for one type with respect to the other where types differ in the uncertainty on their health status and where risk increases are defined at higher orders.

change in risk, we rely on Eeckhoudt and Schlesinger's (2006) framework which provides a unified approach based on preferences over specific class of lotteries to explain the meaning of the signs of the successive derivatives of the utility function. Their approach relies on preferences for disaggregation of harms. Using such lotteries, a third-order change in risk can be illustrated by the shift from $\widetilde{a}_1 = [-\delta, \tilde{\epsilon}; \frac{1}{2}, \frac{1}{2}]$ to $\widetilde{a}_2 = [0, -\delta + \tilde{\epsilon}; \frac{1}{2}, \frac{1}{2}]$. Under $\widetilde{a}_1$, the individual is confronted to either a sure loss or a zero-mean risk on his health with the same probability. While under $\widetilde{a}_2$, the individual is confronted to either both a sure loss and zero-mean risk on his health or to nothing with the same probability. Still applying proposition 1, we have that a social planner should allocate more resources to the patients for which health status is more risky in terms of downside risk if and only if $u^{(4)}(x) \leq 0$. A negative fourth derivative of the utility function was labelled temperance by Kimball (1992) who showed its relevance for risk management in the presence of a background risk. Hence, in the case of third-order change in risk, prudence is not required to prioritise health care under uncertainty.

In the same vein if $\widetilde{a}_1 = [\tilde{\epsilon}_1, \tilde{\epsilon}_2; \frac{1}{2}, \frac{1}{2}]$, and $\widetilde{a}_2 = [0, \tilde{\epsilon}_1 + \tilde{\epsilon}_2; \frac{1}{2}, \frac{1}{2}]$ then $c_2^* \geq c_1^*$ if and only if $u^{(5)}(x) \geq 0$. This last condition is known as edginess and was recently introduced by Lajeri-Chaherli (2004) to explain precautionary saving behaviour in the presence of a background risk. Naturally, we could illustrate higher risk changes and link them to higher derivatives of the utility function.

Let us quote a few illustrations of health risks found in the literature. For instance, Edwards (2008) uses the probability of being in the worth state of the world, a first-degree change in risk, as indicator of health risk. Jappelli *et al.* (2007) take as health risk the variance associated with falling into the worst possible health state. Also Palumbo (1999) measures health risk with the variance of out-of-pocket health expenditure, a second-order phenomena.

4. Uncertainty on the efficiency of treatment

We now assume that the two types of population differ in the uncertainty on the efficiency of health care with α_i representing the share of persons with a risk $\widetilde{m}_i$, and with $\alpha_1 + \alpha_2 = 1$. The optimisation problem is now represented by the Lagrangian expression L:

$$\underset{c_1, c_2, \lambda}{Max} L = \alpha_1 E[u(a + \widetilde{m}_1 c_1)] + \alpha_2 E[u(a + \widetilde{m}_2 c_2)] + \lambda(r - \alpha_1 c_1 - \alpha_2 c_2) \tag{5}$$

If interior solutions prevail, the first order conditions (FOC) imply:

$$E[\widetilde{m}_1 u'(a + \widetilde{m}_1 c_1^*)] = E[\widetilde{m}_2 u'(a + \widetilde{m}_2 c_2^*)]. \tag{6}$$

So as to compare c_1^* and c_2^*, let's define $h(m) = mu'(mc)\ \forall m$. Straightforward calculations show that $h'(m) = u'(mc) + mcu''(mc)$. Thus $h'(m) \leq 0$ holds for all m if and only if $\frac{-xu''(x)}{u'(x)} \geq 1\ \forall x > 0$. It follows from standard induction arguments, for any $k > 1$, that $h^{(k)}(m) \leq (\geq 0)$ holds for all k if and only if $\frac{-xu^{(k+1)}(x)}{u^{(k)}(x)} \geq (\leq) k\ \forall x > 0$, as long as $u^{(k)}(x) \neq 0$.

Assuming that $\widetilde{m}_1\ n\text{SD}\ \widetilde{m}_2$, we have $E[h(\widetilde{m}_1)] \leq E[h(\widetilde{m}_2)]$ for all function h such that $(-1)^{(k+1)} h^{(k)} \leq 0\ \forall k = 1, 2, ..., n$, that rewrites as $E[\widetilde{m}_1 u'(a+\widetilde{m}_1 c_1^*)] \leq E[\widetilde{m}_2 u'(a+\widetilde{m}_2 c_1^*)]$. Using equation (6), we obtain $E[\widetilde{m}_2 u'(a + \widetilde{m}_2 c_2^*)] \leq E[\widetilde{m}_2 u'(a + \widetilde{m}_2 c_1^*)]$. Let's define

$Z(c) = E[\widetilde{m}_2 u'(a + \widetilde{m}_2 c)]$. The previous inequality rewrites as $Z(c_2^*) \leq Z(c_1^*)$. We obtain then $c_2^* \geq c_1^*$ since $Z'(c) < 0$ for $u'' < 0$.

We finally have the following proposition:

Proposition 2. *Given two types of risk-averse patients confronted to the same illness for which the risk on the efficiency of health care is respectively $\widetilde{m}_1$ and $\widetilde{m}_2$ such as $\widetilde{m}_1$ nSD $\widetilde{m}_2$, the social planner should allocate more ressources to type-2 patients than to type-1 patients if and only $[-xu^{(k+1)}(x)]/u^{(k)} \geq k \;\; \forall k = 1, 2, ..., n$.*

Similarily to Corollary 1, we can induce from Proposition 2 the following corollary.

Corollary 2. *Given two types of risk-averse patients confronted to the same illness for which the risk on the efficiency of health care is respectively $\widetilde{m}_1$ and $\widetilde{m}_2$* such as *the risk $\widetilde{m}_2$ has more n^{th}-degree risk than $\widetilde{m}_1$, the social planner should allocate more ressources to type-2 patients than to type-1 patients if and only $[-xu^{(k+1)}(x)]/u^{(k)} \geq k \;\; \forall k = 1, 2, ..., n$.*

Corollary 2 says that priority setting results are governed by the value of the n^{th}-order relative risk aversion (RRA-n) coefficient, $\frac{-xu^{n}(x)}{u^{n-1}(x)}$. The importance of the 2^{nd}-order relative risk aversion coefficient or also labelled relative risk aversion, i.e. $\frac{-xu''(x)}{u'(x)}$, has been long known. Indeed, portfolio decisions, insurance decisions or saving decisions depend, among other things, on a comparison between unity and the value of the RRA-2 coefficient (e.g. Rothshild and Stiglitz, 1971). Since the concept of prudence is more recent, the 3^{rd}-order relative risk aversion coefficient also known as relative prudence, defined by $\frac{-xu'''(x)}{u''(x)}$, is much less discussed. Yet, in some recent papers, the comparison between the RRA-3 coefficient and 2 is shown to drive various economic decisions (e.g. Choi *et al.*, 2001). This is confirmed by Eeckhoudt *et al.* (2009) who show that relative prudence in excess of two seems rather natural.

As before, let us illustrate these results. If the efficiency of health care is higher for type-2 patients than for type-1 patients, i.e. $\widetilde{m}_1 = M_1$ and $\widetilde{m}_2 = M_2$ with $M_1 > M_2$, then the social planner should allocate more ressources to the patient for whom efficiency of health care is lower if and only if relative risk aversion exceeds one. While such a result might be surprising at first sight since one could think that more ressources should be allocated to health care which efficiency is higher, the implicit decision rule is to allocate more ressources to the patient who is in the more unfovarable situation, where the more unfavorable situation is defined in terms of dominance stochastic. In the current illustration, the more unfavorable situation is to receive health care which efficiency is lower.

Next, let us consider the case where the efficiency of health care for type-1 patients is certain and is equal to M, while it is risky for type-2 patients and such that $\widetilde{m}_2 = M + \tilde{\epsilon}$ with $E(\tilde{\epsilon}) = 0$. The social planner should then allocate more resources to the patient for whom efficiency of health care is risky if and only if relative prudence exceeds two.

In the same way, if there is an increase in downside risk of the efficiency of health care, the social planner should prioritise the patients more at risk if and only if the RRA-3 coefficient is superior to 3, meaning that conditions on relative risk aversion and relative prudence become obsolete to prioritise health care ressources in the face of more uncertainty.

5. Attitude towards inequality

One of the weaknesses of the QALY Utilitarism model used so far is that it does not take into account equity considerations into economic evaluations of health care (Bleichrodt *et al.*, 2004). Indeed, health benefit of individuals is aggregated by unweighted summation, i.e. the weight each individual gets is equal to his proportion in society. Since recently, an alternative model has been proposed that weighs individuals with respect to their health level. This model is known as Rank-Dependent QALY model (Bleichrodt *et al.*, 2004). Such model makes it possible to separate attitudes towards health to attitudes towards inequality[4].

Under the Rank-Dependent QALY model, the proportion of patients involved is transformed to reflect inequality aversion of the social planner. The ranking of individuals' preferences is crucial as higher weights are assigned to individuals who are worse-off under inequality aversion. This section looks at the effect of inequality aversion on the optimal allocation of health care.

Consider the case of uncertainty on the severity of the disease. Assume (as in proposition 1) that $\widetilde{a}_1$ nSD $\widetilde{a}_2$ then, from Ingersoll (1987), $E[u(\widetilde{a}_1 + mc)] \geq E[u(\widetilde{a}_2 + mc)]$ for all utility function u such that $(-1)^{k+1}u^{(k+1)} \leq 0$, $\forall k = 1, ...n$. Let w be the equity weighing function such that $w(\alpha_2) > \alpha_2$ to reflect inequality aversion, since for any given medical care c, type-2 patients are in a more unfavorable situation. The optimisation problem is then represented by the Lagrangian expression:

$$L(c_1, c_2, \lambda) = (1 - w(\alpha_2)E[u(\widetilde{a}_1 + mc_1)] + (w(\alpha_2))E[u(\widetilde{a}_2 + mc_2)] \\ + \lambda(r - (1 - \alpha_2)c_1 - \alpha_2 c_2) \quad (7)$$

If interior solutions prevail, denoted c_1^{**} and c_2^{**}, the first order conditions (FOC) imply:

$$\frac{1 - w(\alpha_2)}{(1 - \alpha_2)} E[u'(\widetilde{a}_1 + mc_1^{**})] = \frac{w(\alpha_2)}{\alpha_2} E[u'(\widetilde{a}_2 + mc_2^{**})] \quad (8)$$

Comparing this equation to the respective FOC under inequality neutrality (see equation (4)) shows that under inequality aversion the optimal allocation of health care depends on the weight assigned to the two types, and thus on the (degree of) inequality aversion. It is easy to show that $w(\alpha_2) > \alpha_2$ is equivalent to $w(\alpha_2)/\alpha_2 > 1 > (1 - w(\alpha_2))/(1 - \alpha_2)$. Hence equation (8) becomes

$$E[u'(\widetilde{a}_1 + mc_1^{**})] \geq E[u'(\widetilde{a}_2 + mc_2^{**})] \quad (9)$$

Reasoning as before, we know that if the risk $\widetilde{a}_1$ dominates $\widetilde{a}_2$ via n^{th}-order stochastic dominance, then $E[u'(\widetilde{a}_1 + mc_2^{**})] \leq E[u'(\widetilde{a}_2 + mc_2^{**})]$ for all utility function u such that $(-1)^{k+1}u^{(k+1)} \leq 0$ $\forall k = 1, 2, ..., n$. Hence, using equation (9), we have $E[u'(\widetilde{a}_1 + mc_2^{**})] \leq$

[4] In a recent paper, Bleichrodt *et al.* (2008) compared some priority setting's results under both models and showed that policy implications could be highly sensitive to the choice of model.

$E[u'(\widetilde{a}_2 + mc_2^{**})] \leq E[u'(\widetilde{a}_1 + mc_1^{**})]$ which is equivalent to $c_2^{**} \geq c_1^{**}$, because $u''(x) < 0$ $\forall x$.

Therefore under inequality aversion, results are not modified in the sense that the social planner continues to allocate more resources to patients in the worst situation for the same conditions on the utility function. However, inequality aversion amplifies the distortion in the allocation of health care. Indeed, it is straightforward to show that $c_2^{**} - c_2^* > 0 > c_1^{**} - c_1^*$. Under inequality aversion, the social planner allocates even more health care to the patient that is more at risk than under inequality neutrality. These results also apply in the case of uncertainty on the efficiency of health care.

6. Conclusion

Confronted with high demands of health care and a limited budget, most countries need to prioritise health care expenditures among their population. This paper addressed this issue when populations differ in the uncertainty on their health. Following Arrow (1963), we consider two sources of uncertainty, one on the severity of the illness and the other on the efficiency of the treatment. When the severity of illness is risky, the social planner should invest more resources in the patient whose risk of the severity of the illness is n^{th}-degree more at risk than the other if and only *if* $(-1)^{k+1}u^{(k+1)} \leq 0$, $\forall k \geq 1$. When there is an increase in nth-degree risk in the efficiency of health care, the social planner should allocate more resource to the patient who is more at risk if and only if $[-xu^{(k+1)}(x)]/u^{(k)} \geq k$, $\forall k \geq 1$.

These results are valid when the social planner is either inequality neutral or inequality averse. Yet, inequality risk aversion amplifies the distortion in the allocation of health care. Indeed, under the above conditions on preferences, the social planner allocates even more health care to the patient who is more at risk under inequality aversion than under inequality neutrality.

While these conditions look rather complex, they encompass many common assumptions used in the health literature. Indeed, when change in risk is measured by an increase in the probability of the worst state of health, then only risk aversion is required. Yet, when changes in risk concern higher orders, conditions such as prudence, temperance and edginess are required in the allocation of health care. This shows that depending on the change of risk considered, further conditions on preferences need to be considered so as to prioritise health care amongst risky populations.

While this paper considers the case of uncertainty either on the severity of the disease or on the efficiency of health care, it may happen that individuals differ both on the severity of illness and the efficiency of care. A natural extension of this current work would be to consider priority setting in health care where individual differ in multiple sources of uncertainty.

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