A COMPETING CHOICE PROBLEM. ALTERNATIVE DIALYSIS TREATMENTS FOR END STAGE RENAL DISEASE PATIENTS IN SICILY

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Introduction

To efficiently manage scarce resources, planners in the industrial sector have constructed mathematical models to capture key relations between resources and output variables. It is possible to use the set of mathematical techniques known as optimisation to maximize or minimize variables such as benefit or risk.

In health care an important implication of this industrial strategy is that choosing a slightly less costly and equally effective treatment for a given condition may conserve enough resources to permit the "purchase" of several other treatments for more patients. "*Whereas each choice may not be the most cost-effective option for an individual patient, the set of interventions chosen could best improve public health*" (Granata, Hillman, 1998).

Dialysis, that is used to treat end stage renal disease (ESRD) patients can be administered through different methods and, overall, requires considerable resources (see, for example, the report of the National Commission of Dialysis, 1997). Moreover, demographic changes also indicate that the number of patients needing dialysis will continue to increase[1]. This likely increase in the number of patients needing this kind of treatments poses the urgency to proceed with cost-effectiveness analysis and to solve some issues that may arise in order to ensure the best combination of alternative dialysis treatments according to resource constraints.

In this study we use optimisation to show which proportion of alternative dialysis treatments could maximize overall benefit for a population of ESRD patients, and to show, as well, how the proportion of treatments should change according to the extent of resources constraint.

The purpose of this paper, in fact, is to set a problem of competing choice between some alternative dialysis methods, investigating how it can be solved. Measuring effectiveness through patients' survival, and given prices, represented by costs of each treatment, it is possible to calculate in which proportion haemodialysis, haemodialysis administered at limited assistance centres (CAL), haemodiafiltration and peritoneal dialysis should be allocated under a fixed budget constraint. The approach used in this study, relatively easy to perform, could allow the researcher to solve an important allocation problem in a context with scarce resources, even if a definitive solution in the problem here presented is not achieved.

The study is organised as follows: in section 2 the main features of the two treatments are outlined, as well as some evidence about effectiveness as reported in some studies. Section 3 describes data and methods employed. Discussion of the results and some further remarks will conclude the study.

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[1] It has been put in evidence how, in recent years, the criteria for which patients are offered dialysis treatment have been expanded and elderly patients and patients with more comorbidities are now being treated (Sennfalt et al., 2002).

2. Cost-effectiveness analysis of dialysis treatments

In current clinical practice, there are two major modalities of dialysis available: haemodialysis (HD) and peritoneal dialysis (PD), which are different in terms of technique and physiology. One modality (haemodialysis) is frequently preferable to the other. The choice of HD as the preferred treatment may be a result of difference in availability of the dialysis modalities, or may depend on the decision taken by physicians (sometimes motivated by how well trained is the physician or the staff in employing a treatment rather than another). Even though until 15 years ago, patients' survival was significantly greater with haemodialysis, nowadays, after some improvements in PD equipment and methods, both treatments appear to have the same efficacy.

Pros and cons of the two modalities have been outlined in some studies carried out for Italy. Among these ones, see Sisca and Pizzarelli, 2002, that contains further consideration about costs and benefits according to the patients' well-being. The negative reported aspects of HD are the limitation of liquid intake and the use of needles, whilst in PD the negative aspects are linked to the number of exchanges (four per day), and, consequently a higher risks of infections, the presence of fluid in the abdomen. Positive aspect of HD are the patients' reliance on healthcare assistance, given that such treatment has to be administered in a dialysis centre. PD, instead, can be even undertaken at home, determining, in such a way, more independence and freedom of movement.

Overall, there have not been signalled any significant differences between the two methods, although there are different assessments as regards the various aspects surveyed as quality of life, emotional and social well-being, etc. (Cogny, Van Weydevelt et al., 1999).

Until the early 1990s, the survival of dialysis patients was significantly greater with haemodialysis compared to peritoneal dialysis. Due to a shortage of HD units, PD was applied to the most elderly patients with concomitant diseases, and to those who, owing to clinical and social contraindications, had no possibility of undergoing HD. In recent years patients' survival is virtually the same for both procedures (Sisca, Pizzarelli, 2002).

Haemodialysis can be administered at Nephrology units in hospitals or in private centres, both characterised by the continuous presence of physicians and nurses, and at Centres with Limited Assistance (CAL), that are decentralised structures where the physicians' presence is not continuous. As it will be seen later, the amount of reimbursement provided is different according to the place where a patient undertakes dialysis: in solving the optimisation problem haemodialysis at hospitals and haemodialysis at CALs have been considered as different (alternative) types of

treatment. Among the range of different methods through which haemodialysis is administered, one variant is constituted by haemodiafiltration (HDF).

Having considered the existence of alternative treatments[2], the problem to solve will regard a choice between standard haemodialysis (HD), peritoneal dialysis (PD), haemodialysis at CALs (CAL HD) and haemodiafiltration (HDF). Such a choice represents an issue in the context of cost-effectiveness analysis.

Cost-effectiveness analysis (CEA) potentially can be more valuable for decisions that have to be made under a constrained budget. Under the budget system, the budget itself would act as a cost containing or controlling factor[3]. CEA might, hence, change the mix of expenditures: in this regard there is potential for CEA to increase efficiency, even in terms of health outcome, without necessarily lowering total expenditures[4].

In economic literature there have been some studies considering costs of dialysis and/or its perceived quality of life: the most of these studies are either limited cost-analysis (such as Goeree et al., 1995, Piccoli et al., 1997, that has been carried out for Italy) or cost-effectiveness analysis (Croxson and Ashton, 1990, who carry out such an analysis for New Zealand, and Naidas et al., 1998, who, instead, investigate the same issue for Philippine). There are few studies concerning the issue of utility (for example, Nissenson, 1994, Sennfalt et al., 2002). The latter, for example, uses a decision tree modelling to estimate total costs and effects. It compares both health related quality of life and costs for haemodialysis and peritoneal dialysis, for a population of Swedish patients: the results of the study show overall a slightly higher CEA and cost-utility ratio for PD patients, that should be regarded as the primary method of treatment for patients eligible for both PD and HD.

None of the above mentioned studies, instead, refers to analyse specific issues concerning the CEA, such a competing choice problem, as the present paper tries to do.

Overall, an indication that can be drawn off from all these studies, as it has been already pointed out, is that there are no significant differences between HD and PD as regards the benefits. Hence, differences rely mainly on costs and level of reimbursement associated with each treatment.

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[2] Other variants of dialysis could be mentioned, such as haemofiltration (HF) or continuous clinical peritoneal dialysis (CCPD). However, since in the observed sample patients are undertaking only the types of treatment above mentioned, the problem will focus on them.

[3] On the other hand, under the unconstrained type of system, since no direct tradeoffs are required, no direct limit on expenditures is set or forced.

[4] Some of the most recent advances in cost-effectiveness analysis have been reported by Garber (1999), who also outlines the role of CEA as a tool to determine which services an optimal health policy should cover.

3. Data and methods

The data for this study were obtained through the collaboration of physicians in charge of dialysis units in Sicily. Chronic maintenance dialysis program started in Sicily in 1996, involving 110 Sicilian dialysis centres. Such centres provide renal replacement therapy for almost all patients in the Region, covering a total population of about 5 millions of people. The medical records of all dialysis patients made possible to observe yearly a sample of 3640 patients treated both with haemodialysis and peritoneal dialysis in Sicily, in the period between January 1st, 1996 and December 31, 2000. The demographic and medical records of all patients receiving renal replacement therapy were then entered into a database. Such information included age, sex, date of first dialysis, type of renal replacement treatment, number and type of co-morbid conditions, modifications occurred in type of treatment, data about transplantations, health centre where the patient underwent dialysis[5].

For the present study, only patients who started the treatment in 1996 have been considered. Of course, all incomplete information (from which it was not possible to infer months, type and program of treatment) have been excluded. Data have been collected yearly and are reported based on patients' status as of December 31, 2000.

The sample selected for the present study includes 195 patients: 118 (60,5%) are men, while 77 (39,5%) women. Their age ranges from 2 up to 92 years old (mean = 62, median = 65).

130 (66,66%) patients are treated with haemodialysis at public or private centres; 20 (10,25%) patients receive dialysis at CALs; 10 (5,13%) undertake haemodiafiltration; finally, 16 (8,2%) are treated at home with DP. 19 patients undertook transplantation and were so able to quit dialysis treatment.

Sample patients presented, on average, 0,8 comorbidities, among which diabetes is the most frequent. Looking at pathologies that has made necessary dialysis – excluding all patients who underwent transplantation - there are primitive glomerulonephritis (79 patients, 40,5% of the whole sample), pielonephritis (30 patients, 15,4%), other renal disesases (14 patients, 7,2%), secondary glomerulonephritis (46 patients, 23,6%) and miscellaneous (5 patients 2,6%)

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[5] Every patient with end-stage renal diseases (ESRD) who attended the dialysis centres was included in the Registry since the 1st of January 1996. Since the beginning of the observation, the prevalence rate increased from 653 per million of population (pmp) - data of 1996, to 798 pmp - data of 2000. At the same time it has been observed an increase in incidence rate from 89 pmp in 1996 to 123 pmp in 2000.

Mortality data have been surveyed from 1996 on[6]. At the end of the period of observation, 35 deaths occurred (20 men, representing the 17% of all men included in the sample and 15 women, representing the 19,5% of all women in the sample observed).

[Table 1 here]

Every time the problem to select some projects to be implemented under a constrained budget arises, a key issue that has to be solved regards the proportion of each project to choose, which acts as a cut-off point for allocation. Such a problem shows its relevance in a context related to public choice, where public budget has to be split to finance different projects, according to their effectiveness.

In this framework there is a public health authority (SSN, the so called *Servizio Sanitario Nazionale*, that is the National Health Service in Italy), which acts as purchaser. Providers are the dialysis centres. The purchaser has a fixed budget, constituted by the tariffs that have to be reimbursed for all dialysis treatments provided, and must choose among some projects (HD, PD, CAL HD and HDF that are alternative dialysis treatment). It may select as many units of each treatment as it wishes, provided that the resource constraint is not violated. The objective is to maximize total net benefits for patients.

The generic constrained optimisation problem is described by Weinstein and Zeckhauser (1973):

$$J = \Sigma_{i=1}^{M} \delta_i \, x_i^{1} \qquad \textbf{(1)}$$

that is subject to the constraint $\Sigma_{i=1}^{M} \delta_i \, x_i^{2} \leq R$

Here, x_i^{1} is the net benefit that is possible to achieve implementing a given project i and x_i^{2} represent the amount of budget R (i.e., the cost) consumed by the project i.

As stated by Weinstein and Zeckhauser (1973), the task is to select projects in such a way to minimize expenditures subject to meeting a certain level of performance. The same problem can be applied in a situation where the main objective is to provide an efficient division of goods. This same approach has been described by Garber and Phelps (1997): they use as well first order conditions to derive a cut-off cost-effectiveness ratio, which identify up to what point a given policy should be implemented, and clarify when CEA can be used to determine an optimal health resource allocation.

Let us rewrite the problem (1) in order to adapt it to our framework.

$$L = \Sigma \, E_i \, x_i + \lambda \, (B - \Sigma \, C_i \, x_i) + \mu \, (1 - \Sigma \, x_i) \qquad \textbf{(2)}$$

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[6] The database identified and included in the case population also those who died for any cause after the starting point: however, only patients who died for any cause related to the end stage renal disease have been included in the observed sample for the present analysis.

where $x_i = x_1, x_2, x_3, x_4$ (the treatments to be selected: x_1 (HD), x_2 (HDF), x_3 (DP), x_4 (CAL HD)

$\delta L/\delta x_i = E\, x_i - \lambda\, C_i\, x_i - \mu \leq 0$

$\delta L/\delta \lambda = B - \Sigma\, C_i\, x_i = 0$ (that implies the consuming of all the budget)

$\delta L/\delta \mu = 1 - \Sigma\, x_i = 0$ (that implies treating all patients)

B is the budget constraint. C_1, C_2, C_3, C_4 are the costs per patient of each treatment.

In order to solve the problem, hence, the overall cost for each treatment, the whole budget and a measure of the effectiveness of each treatment are required.

The assessment of costs permits explicit consideration of resources consumption in decisions regarding the use of healthcare interventions: costs directly related to the provision of intervention and use of resources (direct costs), and indirect costs, have to be taken into account[7].

The National Society of Nephrology in 1997 has carried out a study in order to evaluate the amount of resources devoted to dialysis, distinguishing different methods of administering the treatment. Each method of dialysis implies the use of different resources and, hence, determines a certain level of reimbursement by the NHS. Beyond the traditional distinctions that have been done regarding haemodialysis (within which there is the modality of haemodiafiltration) and peritoneal dialysis, another distinction has to take into account the place where dialysis is administered. With the exception of PD, that is administered at home, haemodialysis, as it has been seen, can be administered at a centre of limited assistance (CAL), or at hospital.

The budget is represented by the level of reimbursement provided by the SSN, accordingly to the new prospective per-case payment system.

Tariffs reimbursed for dialysis treatments and estimated costs can be seen in Table 2. The data come from the Report of the *Commissione Nazionale Dialisi*. In the report, costs are distinguished in direct costs, indirect costs and total costs, that include a margin to allow the dialysis centre to obtain a minimum level of profits. The amount of total reimbursement, as it has been said, is different according to the type of treatment and the place where the treatment itself is administered.

The most of the times, tariffs constitute only an approximate estimate of estimated costs associated to dialysis treatment and do not take into account the true costs. They could be lower, so that the tariff reimbursed can cover them completely, or, when total costs are considered, higher. This is the

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[7] The direct costs include personnel directly involved in the method, equipment, maintenance and depreciation. The indirect costs include the general common services, such as the health management department, accounting, administration offices, electricity, heating, cleaning, catering, telephone, laundry, etc. Costs not considered in the report later mentioned regard the so called "induced costs" and admission costs due to patients' hospitalization. Induced costs are difficult to quantify: the largest components are the expenditure on transportation, the various financial subsidies incurred by the health or social service, and the loss of working hours incurred by the patients and their relatives. Admission costs depend on the severity of the diagnosis and the consequent DRG (Sisca and Pizzarelli, 2002). Referring to the latter, however, it has been observed that PD patients do not require on average more hospital admissions than those patients receiving haemodialysis.

case occurring in Italian dialysis units: as it is possible to see from the report, the tariff reimbursed is always lower than the estimated costs, hence implying a deficit for dialysis units.

[Table 2 here]

For the present study, it has not been necessary to discount costs and tariffs reimbursed, given that the study, published in 1997, report tariffs already applied in 1996 that have not varied during the period when the sample has been observed.

Costs for observed dialysis units have been calculated taking into account the circumstance that each patient needs, on average, 3 weekly treatments with HD, HDF and CAL HD. Hence, while the tariff reimbursed for HD is higher comparing to the tariff for PD, it should be reminded that the latter, instead, has to be undertaken everyday. The amount of costs for all treatments can be seen in Table 3, as well as average costs per patient.

[Table 3 here]

Here, it is possible to see how HDF is the most expensive treatment while CAL HD implies a lesser cost.

The conditional probability of survival is used as a measure of effectiveness[8].

Survival analysis has been carried out using Kaplan-Meier method (1958). Determining life time through survival analysis means evaluating the probability that the negative event (patient's death) occurs during the observation time. Obviously, observed times of survival (or, alternatively, months of treatment) are likely to influence the survival probability for the following periods.

Time unit that has been selected to construct life tables for each group of patients is the month[9]. Survival is studied for the "yearly" group of patients observed from 1996 on. Its expected probabilities associated with different treatments can be seen observing the survival curves in Figure 1. The higher value for survival (=1) is associated with HDF: however, this result is explained by the circumstance that only 10 patients in the sample have undertaken this treatment and none of them failed. HD, CAL HD and PD, respectively, show a conditional probability value of 0,8153, 0,65 and 0,8125.

[Figure 1 here]

4. Discussion of the results and conclusions

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[8] An alternative outcome measure, that will be eventually employed on a forthcoming study is the impact of dialysis on life expectancy.
[9] Number of observed patients varies during each month: some patients might die and, moreover, new patients might undergo dialysis. Since, in order to construct a life table it is necessary to study a "closed" population, without allowing for new entries of observed units, a survival table for patients who started dialysis in 1996 has been constructed, without considering patients who started dialysis after.

The objective that the present study wants to achieve is to explain how the budget should be split among alternative treatments in order to maximise effectiveness, given costs and number of patients.

Employing the lagrangean to solve such a problem, determines several complications, particularly if there are stringent constraints in the problem[10]. As specified above, the first constraint is not stringent, but is set ≤ 0.

Several cases have been examined. First of all, only direct costs have been taken into account, hence assuming that the tariff reimbursed is higher than costs. Secondly, total costs have been included in the equation[11].

Current employment of treatment sees a prevalence of HD, that is applied for the 74% of patients. The solution to the optimisation problem implies, instead (see Table 4, case 1), an allocation of treatments, given effectiveness and total budget, that should be in favour of HDF currently employed only for the 6% of patients. There should be, as well, an increase in the number of patients treated with PD, going from 9% up to 24%.

This result depends on the choice of outcome measure, that assigns the best probability of survival to HDF. Hence, a higher value for HDF is determined by the high effectiveness reported by survival curves. However, it should be reminded that such a high effectiveness depends on the fact that patients treated with HDF are very few comparing to the whole sample; in fact, none of them failed during the observation period). More than such result, it is worthwhile to look at the data for PD: so far, the scarce employment of this type of treatment is due to physicians' choices, rather than to a effectiveness issues: life expectations with PD are, in fact, more or less, the same that with HD. The low probability of survival (0,65) of CAL HD would suggest to decrease the employment of such a method. Overall, looking the results for case 1, what is required for an efficient allocation is the decreasing of standard haemodialysis.

[Table 4 here]

Case 2 considers a situation when the budget has been increased of 10%, passing from 32 billions of lire up to 36 billions and 208 millions of lire. Here there is a further redistribution of the budget among treatments. No more patients should be treated with PD. CAL HD patients should be lesser too: since this is the type of treatment that involves less resources, such a redistribution with an increased budget would signal the physicians' propensity to select the most expensive and effective

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[10] In setting out the equation to solve with Matlab software, it has been found a non singular matrix of coefficients, in the case that all the constraints are set equal to zero. That would imply that infinite solutions are possible. In such a case, Matlab uses as tool to overcome this problem an algorithm called "Line search" and succeeds in obtaining a solution. However, the first constraint in the problem has to be relaxed.

[11] Total costs as calculated by the Dialysis Commission include a margin to allow a certain level of profit to dialysis units.

(or with equal effectiveness) treatments, as it is, in this example, HDF. Of course, it has to be reminded that the data showing a high effectiveness for HDF comes from the circumstance that none of the patients treated with such a type of dialysis failed during the observation period. There is no variation in the proportion of haemodialysis, even if the budget has been increased: this result could be interpreted as the independence, for the choice of this treatment, from any consideration regarding the budget.

Case 3 and 4 consider again only direct costs, but assume that the constraint on x (first constraint in equation (2)) is not stringent. Here we have the same results both in the case of an increase in the budget. According to this sharing, no patients should be treated with PD. There is neither a redistribution effect in favour of any treatment, unless the budget is increased of a much higher proportion (more than 20% - results not reported here).

The inclusion of total costs in the optimisation problem, determines a variation in the choice of treatments. However, a remark has to be done: since, as it has been seen earlier, the reimbursement provided by the SSN do not cover completely the level of costs as estimated by the National Commission of Dialysis, it should be advisable to redesign the problem in order to include, as terms of the problem, the differences between tariffs and costs. The choice problem should achieve the objective to select a higher proportion of those treatments with a high effectiveness, a low cost and the minimum loss for the dialysis units. However, here, in order to allow the comparison of results for cases 5-8 with cases 1-4, the terms of the problem are not modified.

When total costs are included and constraints are not stringent, there is a decreasing number of patients to treat with HD, a slight increase in PD and a consistent increase for HDF (as it was for all the former cases). There is a redistribution effect in favour of the most expensive treatment when the budget is augmented of 10%; such an effect can be noted when the constraint on the number of patient is not stringent (case 8): here, the proportion of patients to be treated with CAL HD (less expensive method) decreases to 0. Comparing to case 7, there is a slight decreasing in the number of patients to treat with HD and PD, and a corresponding increase in HDF, that, it is useful to repeat, in the observed sample, has shown to be the most effective and most expensive method.

It has to be taken into account how the results above reported are simply preliminary. They still present some incongruities that it is advisable to avoid if they had to be used in order to orient health authorities decisions.

Criticisms concern some key issues: first of all, although the effectiveness of HD and PD is almost the same, it is not explained why the first one is the preferred treatment in comparison with the other. What other studies carried out on the topic have not put in evidence, as well as the present

one, is the role attributed to patients' choices in selecting the treatment. It appears that physicians play a key role in such decision. However, this causes the sample to be unbalanced regarding the proportion of patients treated with HD rather then with HDF, PD or other alternative methods.

As recommended in some studies, PD could be viewed as a way of making it possible to treat more patients without having to construct new facilities or employ more trained staff, given that the treatment can be performed at home (as it has been seen in Table 2, direct and indirect costs for personnel employed are really low comparing to other treatments): it should be considered as an alternative and sometimes superior method to HD, rather than a second option given the current low number of applications, especially when available resources do not permit an expansion of HD use (Sennfalt et al, 2002). PD should be the alternative towards which to redistribute the budget, rather than HDF.

Overall, this study has to be intended as a mere exercise, suffering from some limits. In order to improve the results, in fact, it would be necessary:

- redesigning the optimisation problem, paying attention how to set the constraints (stringent or not stringent);
- widening the observed sample, eventually including data about patients who started dialysis in the years following 1996, in order to perform a more precise survival analysis. With more observations, in fact, it will be possible to identify groups of patients with the same characteristics and their rate of success and/or failure according to the treatment selected. Especially results about HDF effectiveness have to be revised, weighting the number of patients who undertake such a treatment on the whole sample.

Conclusions

In consideration of the results obtained with this study, that are still not conclusive, it must be intended simply as an exercise to illustrate a case where a problem of competing choice is solved.

The solution to the optimisation problem was aimed at identifying what extent some alternative dialysis treatments (reimbursed by the SSN) should be employed. Constraints have been set up on the available budget and on the number of patients to treat. The effectiveness of each treatment, measured by the conditional probability of survival has been taken into account too.

At the moment it is still not possible to derive any conclusion about health policy: the optimisation problem, in fact, presents some difficulties arising in computing the results. Moreover, the observed sample needs to be widened, distinguishing groups of patients with similar characteristics who undertake dialysis treatments in the same proportion.

A correct redesigning of such a problem will allow to achieve remarkable indications to orient physicians' decision making in a context where a lot of resources are requested as for ESRD patients' treatments.

These results will be of interest both for the purchaser and nephrologists. Especially the latter, according to information that an economist could provide about the best way to allocate resources, would be able to know where and how to contain costs under a fixed budget, without adversely affecting the care delivered.

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Table 1 – characteristics of the whole sample

Sample observed	195 PATIENTS
Sex: Male Female	 118 (60,5%) 77 (39,5%)
Age: Mean Median	2 up to 92 years old 62 65
Treatment: Haemodialysis Haemodialysis at CALs Haemodiafiltration Peritoneal dialysis Transplantations	 130 20 10 16 19
ESRD cause: Primitive glomerulonephritis Pielonephritis Other renal diseases Secondary glomerulonephritis Miscellaneous	 79 (40,5%) 30 (15,4%) 14 (7,2%) 46 (23,6%) 5 (2,6%)
Deaths: men Women	35 20 (17% of all men included in the sample) 15 (19,5% of all women included in the sample)

Table 2 – Costs of treatments and tariff reimbursed

	HD at hospitals	HD at CALs	HDF	PD
Direct costs				
Personnel	151.341	106.625	151.341	5.019
Materials	72.380	72.380	187.375	84.000
Other costs (substitutions, etc.)	17.628	17.628	17.628	20.548
Indirect costs				
Personnel	18.590	18.590	18.590	7.945
Services	8.795	9.298	8.795	1.005
Other costs	41.029	33.428	60.579	18.626
TOTAL COSTS (+ π margin)	**325.252**	**270.845**	**466.523**	**144.000**
Tariff reimbursed	**300.000**	**250.000**	**450.000**	**106.000**
Difference tariff-costs	- 25.252	- 20.845	- 16.523	- 38.000

* Source: Report of the Commissione Nazionale Dialisi (1997).

Table 3 – Costs of treatments observed per year

TREATMENTS	NO. OF PATIENTS	Total direct costs per year	Total costs per year	Budget (tariff reimbursed)	Average yearly cost per patient
X_2: haemodialysis	130	19.309.664.453	26.022.510.897	24.002.168.378	200.173.161
X_2: haemodiafiltration	10	2.362.178.766	3.092.547.439	2.983.017.659	309.254.744
X_3: peritoneal dialysis	16	2.846.508.312	3.590.857.935	2.846.549.815	224.428.621
X_4: haemodial. at CALs	20	2.426.691.863	3.342.558.765	3.085.305.955	167.127.938

Table 4 – Effect of redistribution of the budget on the choice of treatments

	case 1 (only direct costs– strict constraints	case 2 (same as case 1, budget + 10%)	case 3 (only direct costs – relaxing the first constraint)	case 4* (same as case 3, budget + 10%)
Budget	32.917.041.807	36.208.745.988	32.917.041.807	36.208.745.988
X_1	0.2418	0.2418	0.2451	0.2451
X_2	0.4319	0.7263	0.6992	0.6992
X_3	0.2443	0	0	0
X_4	0.0818	0.031	0.055	0.055
	case 5 (total costs – strict constraints	case 6 (same as case 5, budget + 10%)	case 7 (total costs – relaxing the first constraint)	case 8 (same as case 7, budget + 10%)
Budget	32.917.041.807	36.208.745.988	32.917.041.807	36.208.745.988
X_1	0.2306	0.2443	0.2418	0.2309
X_2	0.5149	0.6840	0.4319	0.5281
X_3	0.2544	0.009	0.2443	0.2409
X_4	0	0.062	0.0818	0

* in this case, in order to have more substantial modifications, the budget has to be increased of a higher proportion.

Figure 1

Survival curves

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