Costs and Effectiveness of a syringe distribution and needle exchange programme for HIV prevention in a regional setting

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Abstract

Objective: To estimate the costs and effectiveness of a HIV prevention intervention consisting of distribution of an anti-Aids kit and needle exchange, in operation since 1993 in Navarra, Spain. Methods: Total costs of the programme, namely production, storage and distribution as well as management, are estimated getting a cost figure per sterile syringe distributed. Effectiveness, defined as the number of averted HIV infections among IDUs due to their injecting behaviour, is estimated as a function of the level of coverage of the programme, using a mathematical model. Results: The estimated number of averted HIV infections ranged from 7.59 (in 1995) to 1.23 (in 2000). Yearly incremental cost-effectiveness ratios (ICER) ranged from 8.331 (in 1994) to 44.287 (in 2000) euro per HIV infection averted. With estimated health care costs of treatment of an HIV infection of 99.371 euro, the programme has been cost saving along the whole period considered. One way sensitivity analysis for 5 uncertain parameters was performed. These were the number of active IDUs in the region, number of annual injections among IDUs with non sterile syringes, percentage of lost and unused syringes of the total provided, probability of HIV infection due to injecting behaviour, and life expectancy of HIV+ persons. The results confirm our findings. We conclude the programme has been cost saving from the health care system perspective. [1]

Keywords

Cost-effectiveness, HIV prevention, needle exchange programme, sterile syringe.

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Introduction

Economic evaluation can help decision-makers in assigning scarce funds to different health programs leading to prevent HIV infection. Cost-effectiveness analysis is one of the methods that compares alternatives in terms of incremental cost per unit of results (Drummond and McGuire 2001, Drummond et al 1997, Gold et al 1996).

Access to sterile syringes may prevent HIV infection among injection drug users (IDUs). Recently, needle exchange programmes and sterile syringe distribution costs and effectiveness have been estimated in different settings (Laufer 2001, Gibson et al 2001, Holtgrave et al 1998, Lurie et al 1998, Jacobs et al 1999, Gold et al 1997).

On the effectiveness side, Kaplan and Heimer (1995) estimated a needle exchange programme effectiveness using a mathematical model, by way of testing the syringes collected through the exchange programme. It was in this context where *the circulation theory of needle exchange* was developed, saying that a programme is more effective, the shorter the non-sterile needle circulation period (Kaplan 1994, Kaplan et al 1994, Kaplan and Heimer 1994a, 1994b, 1995). This theory was rescued later by Holtgrave et al (1998) to develop a simple mathematical model in which effectiveness depends on programme coverage level.

Moreover, several studies on the cost of a new HIV infection have been published, showing that advances in antiretroviral therapy have made HIV treatment more costly (Hellinger 1993, Lurie and Drucker 1997, Lurie et al 1998, Pinkerton et al 1998, Schrappe and Lauterbach 1998, Laufer 2001, Cabasés and Sánchez 2001, Bouhnik et al 2002).

In this paper we estimate the costs and effectiveness of an HIV prevention intervention. The programme consists of distribution of anti-Aids kits containing one syringe with needle, one condom, paper towel, and distilled water. Distribution is done through pharmacies and through a needle exchange procedure run by a NGO. The programme has been in operation since 1993 in the region of Navarra (500.000 inhabitants), Spain.

The registered new cases of HIV infections in Navarra amounts 772 during the period 1993-2000, with a decrease from 171 in 1993 to 35 in 2000. By transmission categories, the main decrease has been produced in the IDUs group (Moreno et al 2002), with an estimated total number of infections in this category of 502 in the period (112 in 1993 and 20 in 2000). Of these, 326 would be due to injection behaviour (73 for 1993 and 13 for 2000), the target group of the programme.

Materials and Methods.

We run a naturalistic retrospective analysis for the 8 years since programme inception (1993-2000). We compare programme costs with effectiveness, measured as the number of averted HIV infections among IDUs due to their injecting behaviour, yielding incremental cost-effectiveness ratios (ICER) for each year of the programme as compared to no programme. We also compare costs of the programme with avoided costs of treatment of HIV infections, to get a net cost (or benefit) figure.

Total costs of the programme are estimated for the two distribution strategies: a needle exchange programme, and sale of anti-Aids kits in pharmacies. These costs are run by the public health care sector, NGO, pharmacies and drug users, who have to pay a small price for the kits in pharmacies. Cost data were collected from public accounts and other agents involved, getting a cost figure per sterile syringe distributed.

Effectiveness is defined as the number of averted HIV infections among IDUs due to their injecting behaviour. We use a mathematical model of HIV transmission adapted from Holtgrave et al (1998) that expresses effectiveness (E_c) as a function of the level of coverage of the programme (C) (i.e. at 100% coverage level, full effectiveness is achieved, ensuring access to sterile syringe for every injection).

We depart from Holtgrave et al model by defining coverage as the dependent variable, instead of the total cost of the programme. Then, once known the level of programme coverage, we can obtain point estimates of effectiveness for each of the years of the

programme. We also transform the model to make it possible to be applied to a programme already in operation, which is our case.

Programme coverage is defined as the degree of substitution between non-sterile by sterile syringes provided by the programme to the IDUs population. Annual level of coverage can be expressed as:

$$C = K / [N \cdot I \cdot (1 + L)] \qquad (1)$$

where

K is the yearly number of anti-Aids kits provided by the programme

N is the number of active IDUs in the population

I is the yearly number of injections with non-sterile syringes per IDU, and

L is the fraction of lost and unused of the total provided sterile syringes.

Now, we can obtain the probability of transmission of HIV infection for an IDU due to his or her injecting behaviour (P), through a Bernouilli distribution (Sachs, 1978). This describes the probability that an uninfected IDU be infected as a result of a single injection with each of the non-sterile syringes randomly selected, n.

$$P = 1 - (1 - \gamma)^{n} \qquad (2)$$

Where γ represents the relative frequency of virus transmission by an injection if the syringe was infected.

The level of programme coverage affects the probability of transmission with the programme trough two different ways. First, an increase in the coverage level reduces the number of potentially risky injections, as the number of non-sterile syringes (n) decreases. And second, coverage affects the relative frequency of infection per injection, since an increase in coverage reduces the average number of injections per syringe. Thus, the probability of transmission per IDU with programme (P_c) for a level of coverage C is defined by the following equation:

$$P_c = 1 - [1 - (1 - C)\,\gamma]^{(1-C)\,n} \qquad (3)$$

P_c might be narrowly approximated by the product (Pinkerton and Abramson 1998):

$$P_c \approx (1 - C)^2\,\gamma\,n \qquad (4)$$

E_c may be calculated as the difference between the number of new infections without programme due to the injecting behaviour ($P_0 \cdot N$) and the number of new infections with programme due to the injecting behaviour ($P_c \cdot N$), that is:

$$E_c = P_0 \cdot N - P_c \cdot N \qquad (5)$$

Where P_0 represents the probability of transmission per IDU without programme.

Programme effectiveness may also be expressed in terms of the level of coverage and the number of new HIV infections among IDUs due to injecting behaviour with programme. Thus, we define reduction in the probability of transmission (R_c) due to the programme as the quotient between the effectiveness and the number of new infections due to injecting behaviour without programme.

$$R_c = E_c / P_0 \cdot N \qquad (6)$$

The reduction in the probability of transmission can be expressed as a function of the level of coverage exclusively, by substituting E_c by the precedent function (5) and then P_c and P_0 by their corresponding proximate values (4):

$$R_c = 1 - P_c / P_0 = 1 - (1 - C)^2 \qquad (7)$$

where $(1 - C)^2$ is approximately equal to the value of the probability of transmission of HIV infection with programme (P_c) with respect to the *status quo* (P_0).

Now, from (7) the effectiveness may be expressed as

$$E_c = R_c \cdot P_0 \cdot N = R_c \cdot (E_c + P_c \cdot N) \qquad (8)$$

where

$$E_c = R_c \cdot P_c \cdot N / (1 - R_c) \qquad (9)$$

where $P_C \cdot N$ represent the new HIV infections among IDUs with programme due to injecting behaviour. The step from equation (8) to equation (9) making E_c dependent on P_c instead of P_0 makes it feasible its calculation from data of the programme already in operation.

Programme costs are compared to the health care costs of treatment of the averted infections estimated for years 1996 to 1999 after the introduction and generalisation of highly active antiretroviral therapy (HAART) in the region. This estimation was done in a 4 year retrospective study of the costs of annual treatment of 600 HIV patients treated in the general hospital of Navarra, the reference hospital for HIV treatment in the region. The estimated costs include hospitalisation, laboratory tests, antiretroviral therapy and ambulatory care. No costs for patients, families and the society at large were included (Cabasés and Sánchez 2001).

We consider a life expectancy of 25 years for HIV infected IDUs receiving treatment. Future values are discounted at rate of 3% (Gold et al 1996).

Data source

Data were obtained from the programme information and from the literature when needed. Production, management, distribution and disposal costs of the anti-Aids kits and the costs of running the programme were collected from public and other agents involved (pharmacies and NGO) accounts.

The government of Navarra provided information on yearly number of anti-Aids kits provided by the programme and estimates of the number of active IDUs in the population (Urtiaga et al 1991).

The yearly number of injections with non-sterile syringes per IDU are estimated by substracting the average number of sterile syringes per IDU provided in the market outside the programme, from the mean number of injections per IDU. The mean number of injections per IDU was estimated from a survey of a cohort of 120 IDUs in Navarra, performed in 2000 specifically for a wider study. We assume this number to maintain stable along the period considered (Heimer et al 1998). The average number of sterile

syringes per IDU provided in the market outside the programme is estimated by the government of Navarra from the syringe market.
The fraction of lost and unused of the total provided sterile syringes was taken from Holtgrave et al. (1998), in absence of own data.

The number of new infections due to injecting behaviour, $P_C \cdot N$, are weighted estimations of the new HIV infections in Navarra from the HIV register. First, we weigh all new registered HIV infections in Navarra by the percentage of IDUs diagnosed of HIV in Spain (Ministerio de Sanidad y Consumo 2001), to get the number of new infections among the IDU population in Navarra, assuming the same proportion than in Spain. Second, this figure is weighted by the proportion of new HIV infections caused by injecting behaviour (Holtgrave et al 1998). The use of that parameter is justified on the grounds that an IDU HIV infection might be caused by other causes, such as sexual transmission, apart from the injecting behaviour. Not considering this weighting would cause overestimation of the effectiveness of the programme.

Results

A cohort of 1231 active injection drug users (IDUs) in Navarra is considered. Direct costs of the programme range between 27.490 and 79.887 euro for the different years. Out of these, 50% are production costs of the anti-Aids kits, and 50% correspond to distribution and management. The cost per sterile syringe provided amounts 1.45 euro per kit.

Table 1 shows the main results: Costs, coverage, probability reduction of HIV transmission, number of averted HIV infections and Incremental Cost-Effectiveness Ratios (ICER) of the programme. Yearly incremental cost-effectiveness ratios (ICER) ranged from 8.331 (in 1994) to 44.287 (in 2000) euro per HIV infection averted.

The estimated total number of averted HIV infections since the programme inception is 34. Figure 1 shows the level of coverage and the effectiveness of the programme. It can be observed that the annual level of coverage parameter remains stable along the period,

between 5% and 7%. However, the effectiveness, measured by averted infections, have continuously decreased, from 7.59 averted HIV infections in year 1995 to 1.23 in 2000. The reason of the decrease lies in the reduction of the number of infections in the region along the period considered (Moreno et al 2002).

Figure 2 shows cost per averted infection due to the programme for each year of the analysed period, as compared with the resources saved of preventing one infection. The annual cost per averted HIV infection, although increasing each year, is much lower than the cost of treating one infection estimated at 99.371 euro.

Although the cost of the programme has been decreasing in the last three years, the cost per averted HIV infection has increased in these years (49%, 67% and 25%, respectively). This is due to the high decrease of HIV infections averted by the programme.

The results show that the programme is cost saving for each of the 8 years of the period studied. Even in the year for which the cost per averted infection is the highest, year 2000, the cost of the programme amounts only 43% of the avoided cost of treating a new infection.

Sensitivity analysis

We performed one way sensitivity analysis with several variables under uncertainty. These were the number of active IDUs in the region, the number of annual injections among IDUs with non-sterile syringes, the percentage of lost and unused syringes of the total provided, the probability of HIV infection due to injecting behaviour, and life expectancy of HIV+ persons. We assume a uniform distribution of these variables and use a range of up to a 40% variation as lower and upper limits.

The cohort of 1231 active IDUs in Navarra considered is the official figure estimated by the public health authorities since the beginning of the decade, considered stable along the period. If we assume a higher number of IDUs, then the programme coverage will decrease and also its effectiveness. We estimated an increase up to 40% more IDUs,

finding that the cost per averted infection does not reach more than 65% of the resources saved per infection, thus remaining the cost saving result (Fig 3).

Similarly, we assumed an increase of 40% in the number of annual injections with non-sterile syringe, *ceteris paribus*. We observe that the number of averted infections decreases along the period from 34 to 24, and the ICER increases (from 44.287 to 63.242 in year 2000) (Fig 4).

In our index case, the probability of HIV infection due to injecting behaviour among IDUs is 65%. A increase of 40% in this parameter leads to an ICER of 73.811 in year 2000 (Fig 5). Threshold analysis shows that health care costs of treating an infection with new antiretroviral therapy keep higher than the costs of preventing one infection with the programme at any figure of the parameter above 29%.

Another uncertain variable is life expectancy of HIV+ persons. We initially considered a life span of 25 years. Assuming any life expectancy higher than 8.9 years, the programme remains cost saving along the period considered.

Discussion

We have calculated the costs and effectiveness of a syringe distribution programme in a regional setting using a mathematical model that relates effectiveness, defined as the number of averted HIV infections due to infecting behaviour, to the programme coverage level. Mathematical modelling has helped us to establish a relationship between preventive policy and HIV infection reduction. Other preventive policies can be evaluated on these grounds and priorities may be established between competing alternatives.

Some of the assumptions that may influence the results deserve consideration. First, the provision of sterile syringes does not imply their utilisation. This is considered in the lost and unused sterile syringes variable (L). Although we used estimations from the literature, this variable affects very little to the results.

Second, the increase in the cost per averted HIV infection in the last years is caused by a decrease in effectiveness. This is explained by the reduction in the number of new infections due to injecting behaviour, what may be due to a reduction in the IDUs group susceptible of HIV infection (group saturation effect).

Third, since the programme is oriented towards prevention of new infections, the number of non-sterile injections among the already infected IDUs should not influence the level of coverage. This is not considered in our estimation, what suggests that we are overestimating the number of non-sterile injections and then underestimating coverage level and, consequently, the programme effectiveness.

Fourth, in our study we have considered a 25 life year expectancy assuming that with the new antiretroviral therapy HIV infection has become a chronic illness. However, we have not contemplated adverse events of the new therapies that may affect patient life expectancy and the cost of treatment. Lipodystrophy, lactic acidosis, and other adverse events may compromise current treatment costs and effects (Brinkman et al 1999).

We have evaluated one distribution alternative of syringes among IDUs, the combination of market distribution through pharmacies and the help of an NGO to facilitate needle exchange, but it would be of interest, for the sake of efficiency analysis, to evaluate other alternative strategies of improving access to sterile syringes, such as dispensing mobile units, direct provision in specific consumption areas, dispensing machines, and the like (Moatti et al 2001).

Prevention efforts through risk reduction programmes such as the one analysed here may generate positive externalities. Needle exchange programmes decrease transmission of other illnesses such as Hepatitis B and C (Steffen et al 2001) or tuberculosis (Perlman et al 2001). Moreover, condom utilisation reduces sexually transmitted diseases and unwanted pregnancy. Consideration of these effects would increase effectiveness in a wider scope of averting infectious diseases.

We conclude that the cost of a risk of HIV transmission reduction programme that increases access to sterile syringes to the IDU population is lower than the direct cost of treatment of the HIV infections that averts. This is consistent with findings in other settings (Laufer 2001, Holtgrave et al 1998, Lurie et al 1998, Jacobs et al 1999, Gold et al 1997). The programme evaluated is cost saving from the health care system perspective.

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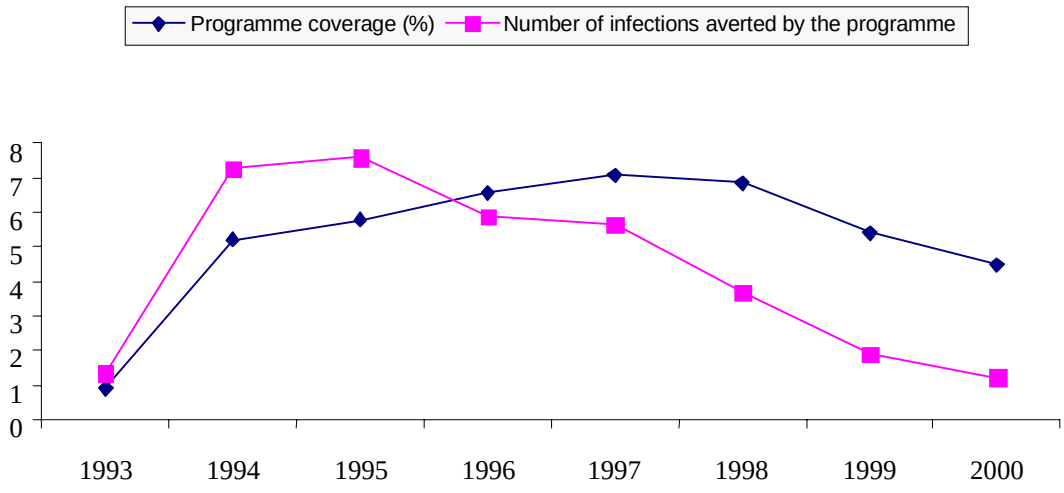

Figure1.
Programme coverage and nº of infections averted by the programme

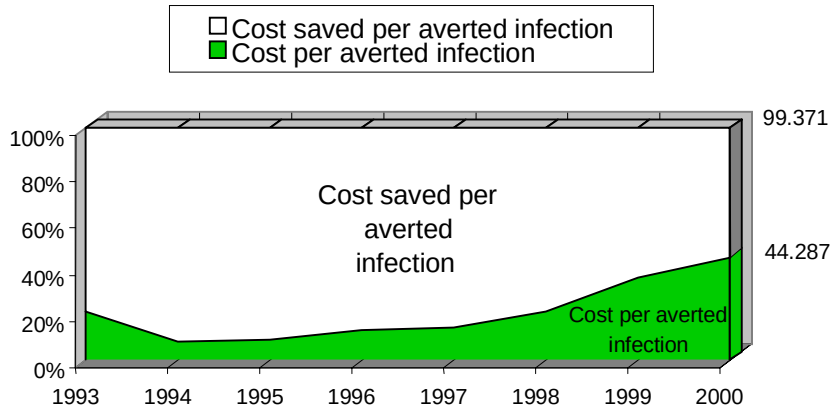

Figure 2.
Incremental cost effectiveness ratio (Cost per averted HIV infection) as a proportion of the cost of infection treatment

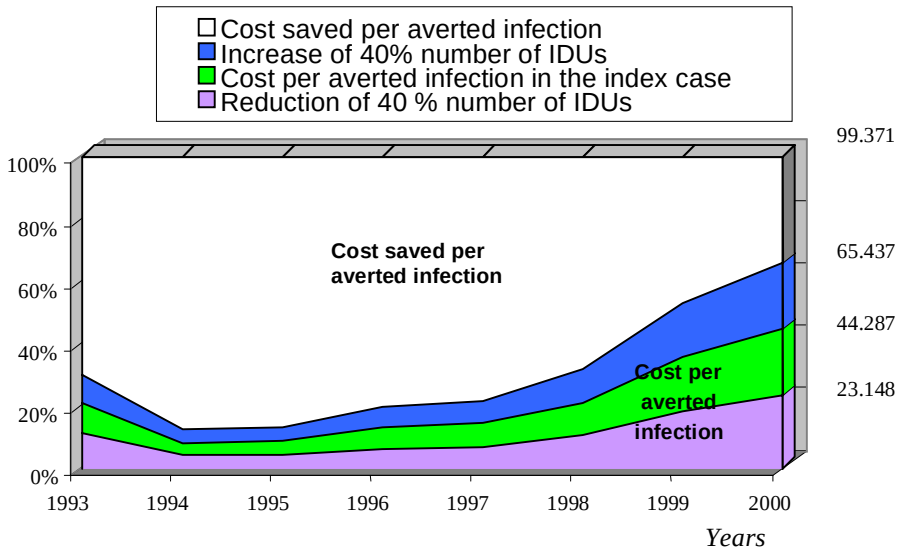

Figure 3.
Sensitivity analysis: Number of active IDUs in the population

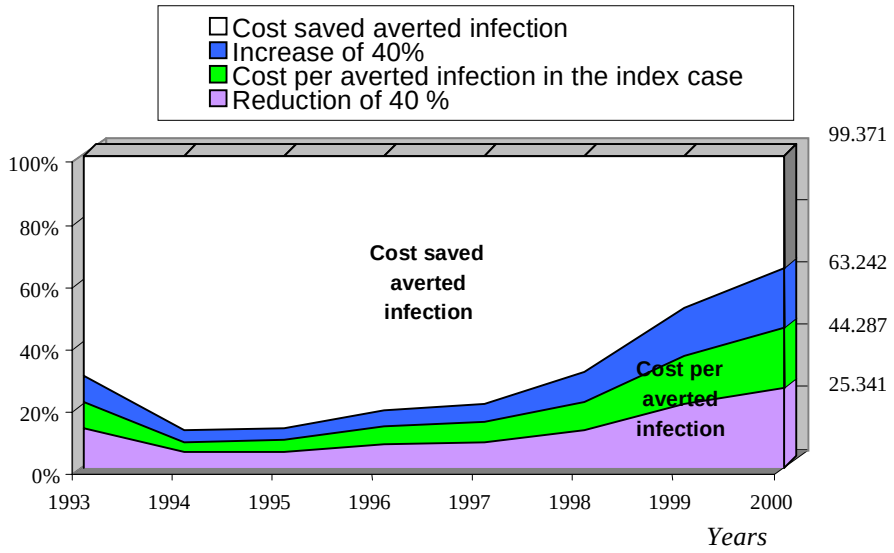

Figure 4.
Sensitivity analysis : Yearly number of infections with non-sterile syringes per IDU

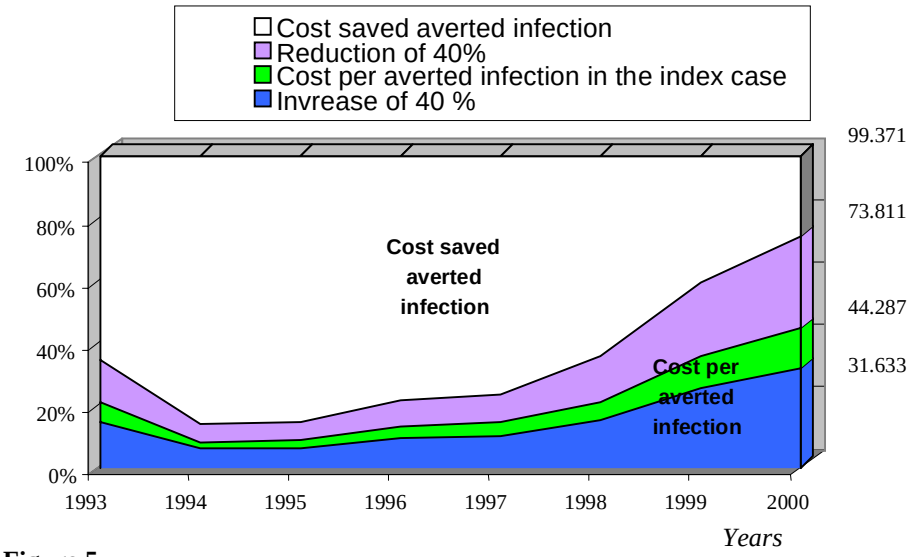

Figure 5.
Sensitivity anaysis: Proporcion of new HIV infections caused by injecting behaviour

Table 1. Costs, coverage, probability reduction of HIV transmission, Number of averted HIV infections and Incremental Cost-Effectiveness Ratios (ICER) of a syringe distribution and exchange programme.

Year	Total cost of the programme (euro)	Coverage (%)	Probability of transmission reduction (Rc)	Number of HIV infections averted (Ec)	Incremental Cost-Effectiveness ratios (Cost per averted HIV infection)
1993	27.490	0,91	0,018	1,34	20.533
1994	60.505	5,20	0,101	7,26	8.331
1995	66.410	5,78	0,112	7,59	8.752
1996	75.405	6,57	0,127	5,88	12.826
1997	79.887	7,08	0,137	5,65	14.137
1998	77.445	6,84	0,132	3,67	21.080
1999	66.947	5,41	0,105	1,90	35.274
2000	54.478	4,48	0,087	1,23	44.287