Dynamics of Dental Care in the Netherlands: a system dynamics approach

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ABSTRACT

During the last five years a system dynamics model of the dental health care system of the Netherlands has been developed. The model consists of six submodels, capturing the major demographical, pathological, psychological, sociological and economical processes of supply and demand of dental care. Two income-categories differentiating between two classes of insurance ("Sickfund" and "Non-Sickfund"), and six age-categories are distinguished. The model comprises ten types of dental treatments. Alternative policies with respect to restoring the lost equilibrium between supply and demand of dental care are tried out, and compared with the base-run. Dependent on the considered time-horizon, and the interests of different parties (dentists, dental students, dental hygienists), different policy-scenario's turn out to be more attractive in redressing the balance.

1. INTRODUCTION

During the past decades the imbalance between demand and supply of dental health care in the Netherlands has been a matter of serious concern. In attempting to tune supply to demand, policy-makers have to deal with characteristics of the systems of dental health-care, which are features of complex socio-political systems in general (Forrester, 1968; Mesarovic et al., 1970; Klabbers et al., 1980; Truin, 1982; Nijland et al., 1984). When preparing and making policy in complex social systems not only research findings from different scientific disciplines, but especially adequate support systems for handling the different dimensions of complexity are needed. Since a couple of decades both the systems-approach and computer-simulation offer favourable perspectives for a more adequate integration of characteristics of policy-problems in complex social systems (Klabbers, 1982).
For the sake of surveying and investigating the structure and behaviour of the dental health care system more systematically a system dynamics computer simulation model of supply and demand of the dental health care system in the Netherlands has been developed (Klabbers et al., 1980; Truin, 1982).
The model resembles in many respects the model developed by Pugh-Roberts Associates (Goodman, 1975). A number of model-characteristics (associated with the different organizational structure of dental health care in the Netherlands compared with the United States) are different; the most important differences are:

- 70% of the population (lower income-categories) is covered by a state health insurance fund, called Sickfund.

- About 50% of dental care in the age-category 6-12 years is performed by the School Dental Service.
- Treatment prices are not primarily determined in a free market, but by intervention of the goverment.

The model can be used to address a variety of principal questions related to dental health care (Truin, 1982). In this paper we will focus attention to the recent policy-issue of the fast growing unemployment of dentists in the near future.
This problem is of current interest in the Netherlands because in 1984 the state government decided for a considerable reduction of dental schools (from 5 to 3 schools) to prevent further rising of unemployment of dentists, and further drastic reductions in enrollment capacity in the near future seems to be inevitable.
The question is, whether such an one-sided policy measure will solve the problem of rising unemployment of dentists, or whether other measures or a mixture of several measures will turn out to be more adequate.
In evaluating alternative student-intake policies special attention will be paid to:
- short-term effects as opposed to long-term effects,
- side-effects for the job market of dental hygienists and for the annual monetary turnover.

For a better understanding of the nature and origin of the problem of persistent imbalance between supply and demand of the dental health care a short historic analysis of the problem will be presented as well as a brief description of the model structure in the next two sections.

2. NOTES ON THE HISTORY OF THE DENTAL HEALTH CARE SYSTEM

Because of a rather low death-rate and a high birth-rate the increase of the population of the Netherlands has been very fast for many decades (Central Bureau of Statistics, 1950-1984). After a five year decline during the Second World-War the growth-rate of the population did rise again to pre-war levels until the late sixties. In 1961 the rate of net increase was still 13.1 per 1000 inhabitants per year -75% higher than in the then Common-Market countries on an average (Demographic Yearbook, 1965).
Concurrent with and successive to the post-war baby-boom a considerable economic revival and its related urbanisation occurred, and the population began to consume increasing quantities (and more frequently) cariogenic foods, such as sugar, candies etc. (Central Bureau of Statistics, 1945-1984). The fast growth of the population and the growth of consumption of cariogenic foods per capita resulted in a very considerable increase in the need for dental care in the sixties and seventies, to cope with various sorts of dental diseases.
Apart from the increase of objective need for dental care (as defined according to professional standards) the adoption of an urban life-style became a favourable condition to frequent the dentist (Ziekenfondsraad, 1948-1983).
Thus during the sixties the supply of dental health care lagged behind the demand, and in the early seventies the Netherlands met with a serious shortage of dentists.
Confronted with those developments policy-makers decided to extend the enrollment capacity substantially. Between 1962 and 1968 two new dental schools were established and the capacity of the other ones was increased (Prof. Mr. Teldersstichting, 1963). Moreover in the period 1968-1972 five schools for dental hygienists were started.

Almost simultaneously with the increase of the enrollment-capacity three changes took place which had tremendous consequences for the extent and

nature of the demand for dental health care:

1. Since the early sixties the birth-rate started to decline drastically because of changing life-styles. Demographic forecasts for the year 2000 had to be adjusted several times from a level of 20 million to a current 15 million or less (Centraal Bureau voor de Statistiek, 1982).
2. During the seventies the application of fluorides in different forms was introduced on a large scale (Ned. Inst. Agrar. Marktonderzoek, 1981), resulting in a considerable reduction of the caries incidence-rate (Kalsbeek, 1982).
3. Simultaneous to the introduction of fluorides, campaigns of preventive dental health care were set up (Kalsbeek, 1982, Truin, 1985).

As a consequence of these developments the demand for dental health care in the late sixties and early seventies did not rise as much as expected, while at the same time the enrollment-capacity for dental students was increased. The Schools of Dentistry generated annually 350 new dentists from 1975 onwards, increasing to 400 from 1984 on.
So hardly 15 years after a shortage of dentists became an issue, the first unemployed dentists appear on the stage in the early eighties. In 1984 the number of unemployed dentists has risen to a rate of about 300, (total employment is currently 5000 dentists), and this rate probably will continue to increase sharply in the near future.

Policy measures so far have been aimed at reducing the annual intake of students from 465 to 300 for the course of 1984/1985, and further reductions to 200, to 120, or even temporary to zero, are being considered. From 1983, initiated by the Sickfund and supported by the professional corporation of dental practitioners, a minimal dentist/patient ratio of 1: 3250 has been introduced. This measure will eliminate free competition between newly graduated dentists and established practitioners, in favour of the latters.
The surplus of young dentists undoubtedly will be aggravated by the economic recession since the late seventies, because of diminishing purchasing power of patients and governmental policies to cut expenses drastically.

However, the problem has still other aspects which are relevant in gauging and mastering the deficiencies of the dental health care system.

- Different interest-groups (patients, dentists, dental students, dental hygienists, insurance funds, the state government) define the problem differently.
- Imbalances in the system take a long time to disappear completely. A birth boom has a birth-echo 25 years later, and potentially results in an increase of demand for comprehensive dental treatments (especially prosthetic treatments) 50-70 years afterwards.
- The conquest of caries may invoke a potential substratum for periodontal-diseases (gum diseases), because people stay dentulous to an older age than in the past.
- Despite the rise of unemployment of dentists still a considerable objective need for dental treatments exists, at least according to professional standards.
- As a response on the emerging unemployment of dentists the attractiveness to study dentistry falls sharply (announcements 1100 in 1980, 977 in 1982, 300 in 1984 and probably 150 in 1985).

There is a real danger that, like two decades ago, the policy-reaction again will be too late, too drastic, too one-sided and too limited of perspective.

3. DESCRIPTION OF THE MODEL STRUCTURE

3.1. The global structure of the model

Our model consists of five interrelated submodels or "model sectors":
1. population.
2. oral health status.
3. demand for care.
4. supply of manpower.
5. delivery of treatments.
6. costs.

In figure 1 these submodels and their interrelations are shown, and they will be discussed next.

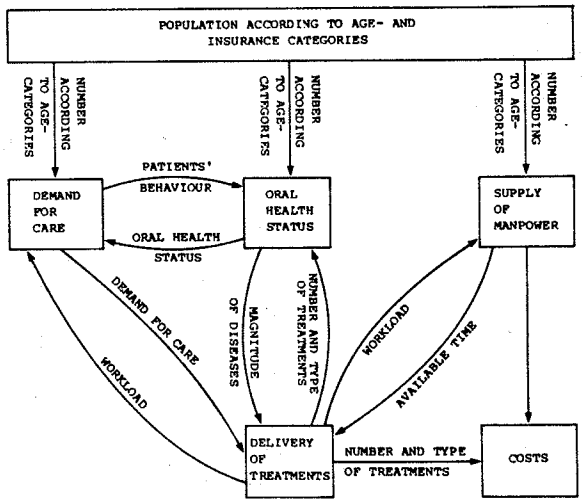

Figure 1: Black box relationships among submodels.

The population submodel

In the model 6 age-categories are distinguished: 0-5, 6-12, 13-17, 18-34 35-54 and 55 years and older. These categories are defined on the basis of similarities of dental diseases.
Two income-categories differentiate between two classes of insurance: the category of private insurance (covering the top three income-deciles (30%) of the population) and the category of Sickfund insurance (the complementary 70%). Of the latter category the costs of some treatments are covered completely by a state health insurance fund ("Sickfund"); other treatments are covered partially, and some are not (such as crowns and bridges).
The definition of the numbers of patients in each age- and income-category as state-variables (levels) enables the model to represent the flow of people between categories.
The submodel "population" has only a function of generating inputs for the other submodels. The relevant variables are:
1. The number of population in each age- and income-category (levels).
2. The number of births, deaths, immigration, ageing and social mobility per unit of time for each category (rate variables).

The submodel "oral health status"

In the "oral health status" submodel processes of development of dentition,

dental-pathology and progression of diseases are represented. Also the influence of the patients' behaviour (input from the demand sector) and of the impact of dental treatments (input from the treatment sector) on the prevalence and seriousness of dental diseases have been included.
Several oral health characteristics c.q. diseases are distinguished:
- the fraction of the population with teeth (dentulous patients).
- the fraction of the dentulous patients without periodontal diseases and the fraction with different degrees of gum disease (gingivitis and pockets)
- the average number of sound, decayed, filled and missing teeth per dentulous patient.

The global structure of the "oral health status" submodel is illustrated in figure 2. The causal relations will be explained briefly.

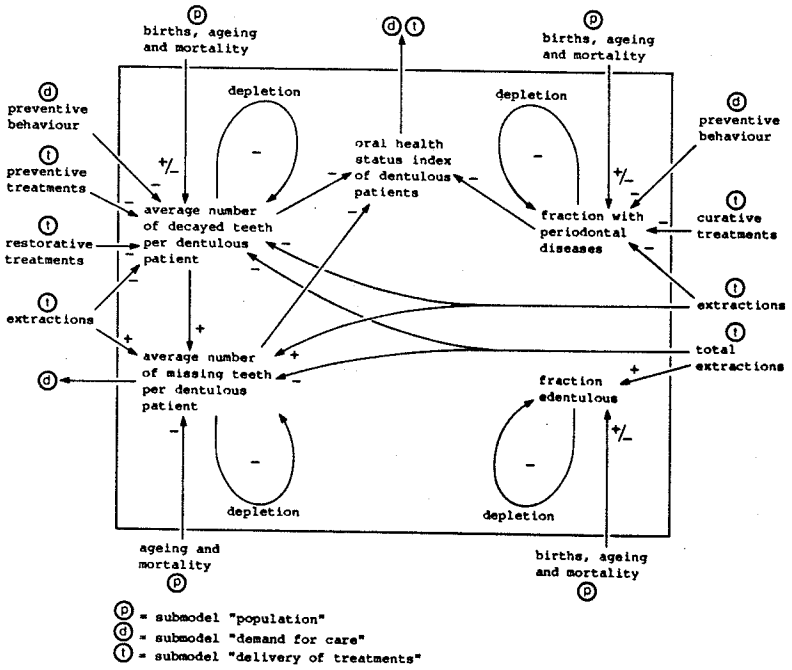

Figure 2. Global structure of the submodel "oral health status".

The average number of decayed teeth (teeth affected by dental caries) per dentulous patient increases when the caries incidence rate increases. The latter is lower as the preventive behaviour (leaving off frequent sugar consumption, use of fluoride and oral hygiene) is better. The number of decayed teeth also decreases as a result of preventive treatments (application of fluorides by dentists) and of restorative treatments and extractions. Extractions result in an increase of missing teeth.
Similar to dental caries the degree of periodontal diseases (gingivitis and pockets in dentulous patients decreases as preventive behaviour (oral hygiene) is better and more surgical treatments, instead of extractions, are performed. The extent of edentulousness (toothlessness) increases through total extraction of the dentition.
It is assumed that total extractions of the dentition have a favourable effect on the average status of all oral health components of the remaining dentulous patients in the age-category concerned, because total extraction is a selective procedure. A similar effect results from the demographical processes of ageing. Effects of a shift in the age-distribution of the

population on the average prevalence of diseases within age-categories thus give the model a long-term memory for the effects of preventive measures in childhood.
Because treatment-decisions of both patients and dentists are often made on the basis of overall oral health characteristcs, a variable, called "oral health status index", was included in the model. The average oral health status index of the dentulous patients depends inversely on the proportion of pockets and the number of carious and missing teeth.

The submodel "demand for care"

The description of the submodel "demand for care" will be illustrated by the global causal network, depicted in figure 3.

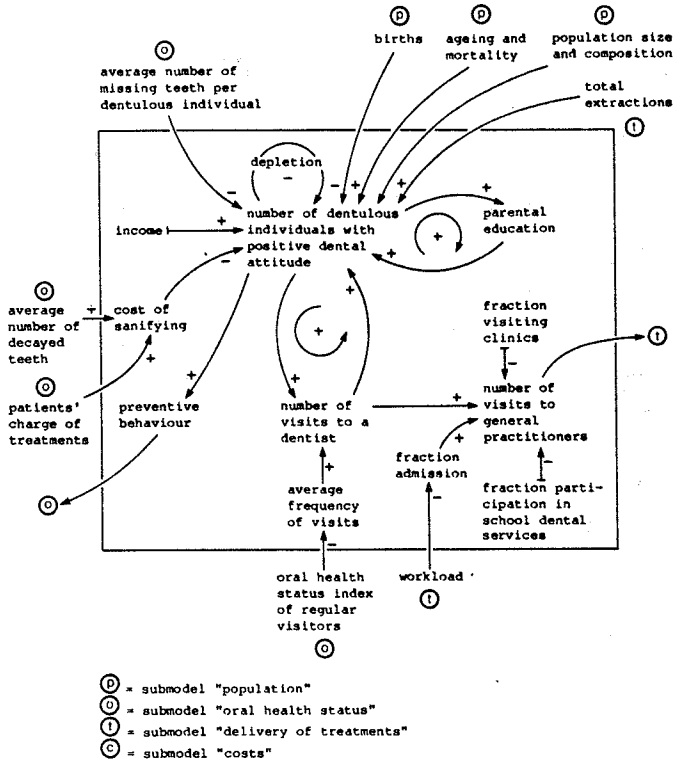

Figure 3: Global structure of the submodel "demand for care".

Changes in the size and demographical composition, or in the oral health characteristics of the population, determine the potential demand for dental health care. The realized demand depends on the potential number of careseekers, the care-seeking attitude and accessibility factors such as the dental workload, and costs of care.
The number of patients with positive dental attitude is also determined by factors as education and instruction through mass media, in schools, by dentists and by parents. The dental attitude of the parental age categories (18-34 and 35-54 years) influences the dental attitude of the childhood age categories (0-5, 6-12 and 13-17 years). The latter feeds back positively on the first mentioned with a delay of about 25 years (parental education loop). "Dental hygiene instructions" is an input-variable from the submodel "delivery of treatments". Another factor influencing the dental-mindedness of the population is the perceived costs of dental care. However not all

potential dental visits are visits in general private practices. Dependent on the average workload a fraction will not be admitted. Other fractions of the potential visits are covered by clinics and by the School Dental Service.

The submodel "supply of manpower"

The manpower supply submodel is composed of two sectors: the dentist sector and the dental hygienist sector. The global structure is given in figure 4.

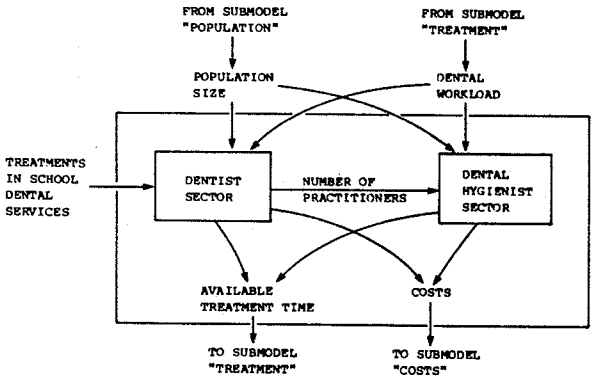

Figure 4. Global structure of the "supply of manpower" submodel.

The inputs from other submodels are:
From the submodel "population":
- The size of the population, determining the potential employment capacity (in case of the option of a policy-determined dentist/patient ratio). The number of individuals in age category 18-34 determines the potential supply of students interested in dentistry.

From the submodel "delivery of treatments":
- The current average dental workload in standard dental practices. This variable controlls the hiring- and firing rate of dental hygienists, the desired number of working hours/year and the potential employment capacity for dentists (the latter only in case of the option of a workload-determined dentist/patient ratio).
- The amount of participation in the School Dental Service, determining part of the employment capacity outside the general private practice sector.

Outputs to other submodels are:
To the submodel "delivery of treatments"
- The total available time for treatments, being the sum of the available treatment time from dentists and dental hygienists.

To the submodel costs:
- The number of employed dentists and dental hygienists, determining part of the man-power costs of dental health care.

There is only one direct relation between the dentist sector and the dental hygienist sector: the potential employment capacity of dental hygienists is determined by the number of practicing dentists.

The dentist sector of the submodel "supply of treatment" will be described in more detail in 3.2.

The submodel "delivery of treatments"

The global structure of the treatment submodel is presented in figure 5.

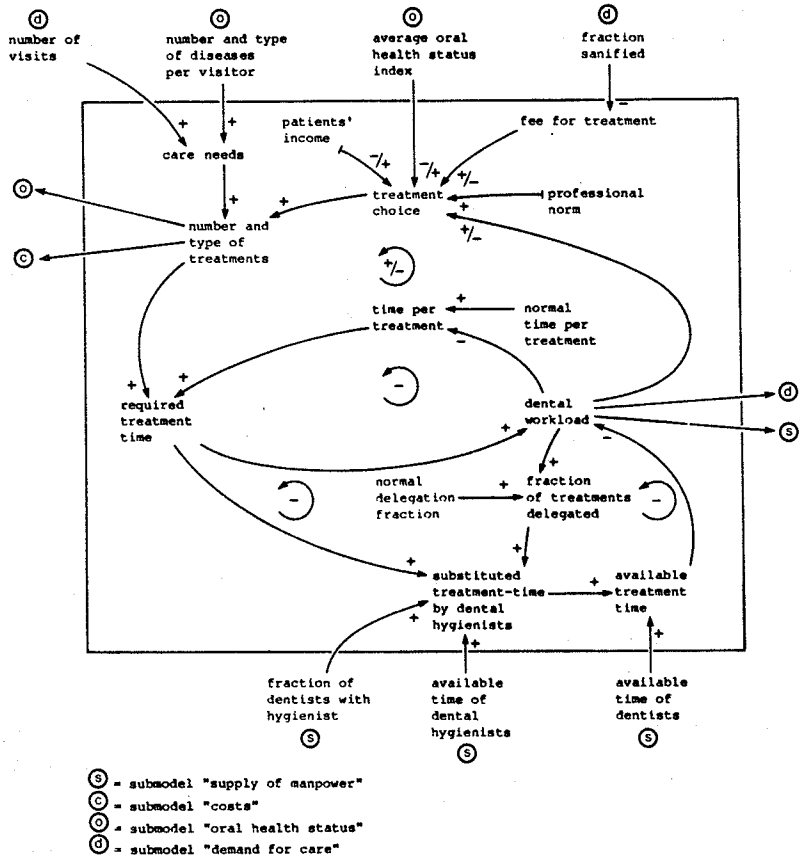

Figure 5: Global structure of the submodel "delivery of treatments".

The nature and magnitude of the dental care-needs depends on the number of dental visits and on the number of oral diseases per visitor. However, not all dental needs will be treated. Many dental conditions leave several treatment options (including "no treatment") open. The dental care actually provided is determined by the treatment decisions made both by patients and dentists. These treatment decisions are influenced by the type and seriousness of the dental diseases (care needs), the "overall" oral health status of the patient, the costs of dental treatments relative to the patients' income, and by the dentists' workload.
This submodel also computes the total amount of dentists' time required to provide treatments for all patients seeking and choosing care. If the treatment-time requested exceeds the treatment-time available, it is assumed that overtime hours are made, and measures are taken to reduce the workload in the future.
Changes in utilization of services or changes in treatment capacity can provide changes in dental workload. Dentists may alter various practice variables such as hours in practice and auxiliary employment.

If the workload increases, the fraction of treatments delegated to dental hygienists will be raised, which reduces the workload again in a feed-back relation.

The submodel "costs"

In the submodel "costs" a number of financial output variables are computed. The major ones are:
- Total treatment expenditures per year as well as expenditures per capita per year, by treatment-type, by age and income category, and by paying instance (patient or sickfund c.q. insurance).
- Turnover from treatments per dentist per year.

3.2. Detailed description of the submodel "supply of manpower"

The structure of the dentist sector will be described in more detail next. The sector is composed of two subsectors: the education subsector and the employment subsector. The flow-diagrams of these two modelsectors are shown in figure 6 and figure 7.

The education subsector

The education subsector (figure 6) represents the inflow, throughput and output of dental students.

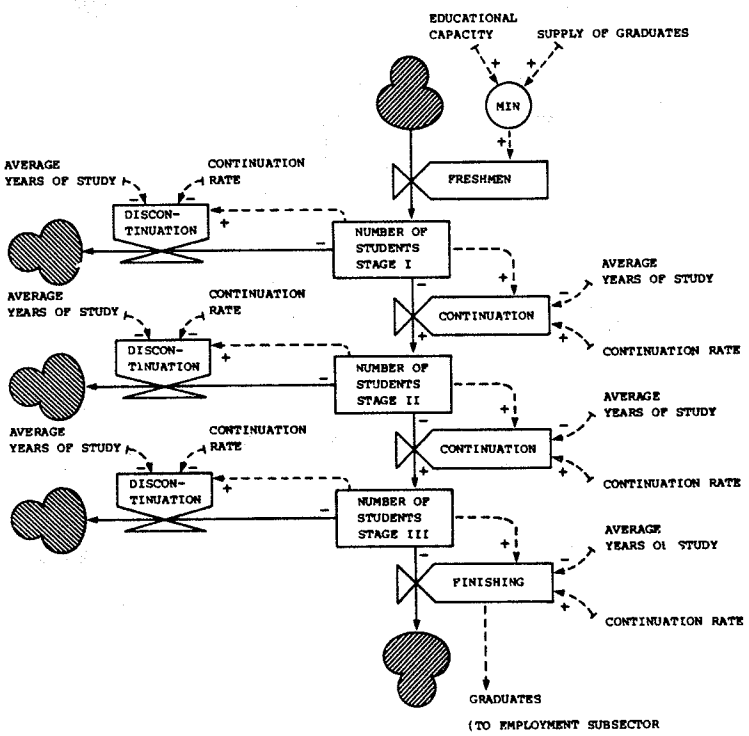

Figure 6: Flow-diagram of the education subsector.

The curricular buildup is condensed to a three cascaded level model. The inflow in the system represents the number of freshmen. It is equal to the enrollment capacity if the potential number of college graduates exceeds the enrollment-capacity. If the inflow is less than the enrollment capa-

city, then the number of freshmen is set equal to the supply of college graduates. "Continuation" stands for the number of students being transferred to the next stage of study, "discontinuation" for the number of students who drop out. The outflow from the last level-variable (stage III) are the graduates (just qualifies students), who apply for a job in one of the dentistry employment sectors. The number of (dis)continuing students in each of the stages depends on the number present in each stage, on the average years of study and on the fraction of students who will proceed to the next stage after all.

The employment sector

Figure 7 shows the flow-diagram of the employment subsector.

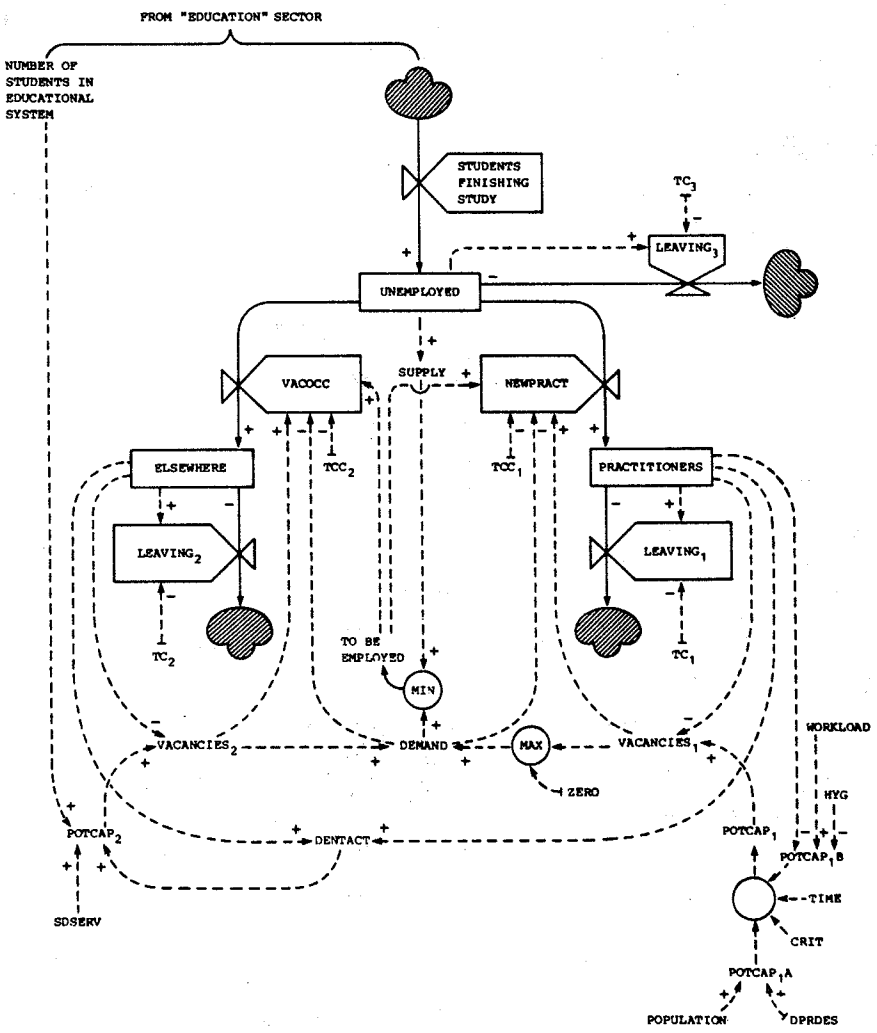

Figure 7: Flow-diagram of the employment subsector.

Three categories of employment, represented by a level structure, are distinguished:

- Employment in private practices.
- Employment elsewhere (a.o. as dental specialists, in dental schools, in clinics, in the School Dental Service and in administrative and policy

positions).
- Unemployment.

The description of the structure of the employment sector is presented below, together with the DYNAMO equations.
The number of private practitioners (PRACTITIONERS) increases by setting up of new practices (NEWPRACT) and decreases by leaving (LEAVING1) the system through retirement, emigration etc.

```
L PRACTITIONERS.K=PRACTITIONERS.J+DT*(NEWPRACT.JK-LEAVING1.JK)
```

For the number of dentists employed in other sectors than the normal private practices (ELSEWHERE) a similar relation holds:

```
L ELSEWHERE.K=ELSEWHERE.J+DT*(VACOCC.JK-LEAVING2.JK)
```

The number of those who leave both employment sectors per unit of time is calculated as a constant fraction (1.0/TC) of the individuals present.

```
R LEAVING1.KL=PRACTITIONERS.K*(1.0/TC1)
```

```
R LEAVING2.KL=ELSEWHERE.K*(1.0/TC2)
```

The number of new practitioners (NEWPRACT) and of occupied vacancies (VACOCC) are proportional to the number of vacancies in both employment sectors ($VACANCIES_1$ and $VACANCIES_2$), while their sum (TO BE EMPLOYED) equals the minimum of the total occupational demand (DEMAND) and the total occupational supply (SUPPLY).

```
R NEWPRACT.KL=(VACANCIES1.K/DEMAND.K*TO BE EMPLOYED.K)/TCC1
```

```
R VACOCC.KL=(VACANCIES2.K/DEMAND.K*TO BE EMPLOYED.K)/TCC2
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```
A TO BE EMPLOYED.K=MIN(DEMAND.K,SUPPLY.K)
```

The total demand of manpower equals the sum of vacancies in both employment sectors:

```
A DEMAND.K=VACANCIES1.K+VACANCIES2.K
```

The total supply equals the number of unemployed dentists.

```
A SUPPLY.K=UNEMPLOYED.K
```

TCC1 and TCC2 are time constants, representing the average time elapsing between the emergence and occupation of vacancies.
The number of vacancies in the sector "elsewhere employed" is the difference between the potential employment capacity (POTCAP2) and the number of vacancies that have actually been occupied (ELSEWHERE):

```
A VACANCIES2.K=POTCAP2.K-ELSEWHERE.K
```

If ELSEWHERE exceeds POTCAP2 then the outcome is negative and represents an occupational surplus which results in dismissals instead of occupations. With regard to the private practice sector vacancies are less straightforward. Dismissals are not defined, thus the variable VACANCIES can only have positive values.

```
A VACANCIES1.K=MAX(0.0,(POTCAP1.K-PRACTITIONERS.K))
```

The potential employment capacity for private practitioners (POTCAP1) is a fuzzy concept. It may be defined as a) the capacity according to standards set by the professional society of practitioners on the basis of actual or anticipated income-political criteria, or b) as the capacity according to criteria of optimal workload (workload no more, no less than 100%). In the baserun until the year 1983 the model works according to option b. From 1983 on it works according to option a. In that year a standard dentist/patient ratio of 1:3250 was introduced.

Employment capacity in accordance with option a (POTCAP1A) is modelled as:

A POTCAP1A.K=POPULATION.K*DPRDES

in which DPRDES (a policy-variable) is the standard dentist/ patient ratio.

Employment capacity corresponding with option b (POTCAP1B) is the capacity which (if occupied) just meets the time required for the total number of treatments according to professional norms under conditions of a dental workload of 100% (no overtime-hours). The concept is formulated as:

POTCAP1B.K=((DENTTIME+HYGTIME)*WORKLOAD-HYGTIME)/(DENTTIME/PRACTITIONERS))

in which:
DENTTIME = available treatment time of practicing dentists.
HYGTIME = available treatment time of dental hygienists.
WORKLOAD = the ratio of required treatment time to available treatment time.
PRACTITIONERS = the number of dentists employed in normal practices.

4. PRESENTATION OF THE BASE-RUN AND SOME POLICY EXPERIMENTS

4.1. Introduction

Although the results of the simulation runs presented in this chapter are based on the dynamics of the complete model, only some criterium variables of the submodel "supply of manpower" and one financial variable are considered. The analyses of the internal dynamics of the submodels "demand for care", "oral health status" and "delivery of treatments" have not been fully completed yet. Results of these runs in combination with manpower-policy-runs will be presented later.
The assumptions underlying the modelstructure and the estimation of parameter values are published in Truin (1982) and Nijland et al. (1984).
The base run and policy experiments will be described on the basis of figures 8 through 12 and table 1.

4.2. The base-run

In figure 8 time-paths of principal model variables are presented. mounting to an equilibrium level of about 9400 dentists in the year 2040. The curve representing the total number of qualified dentists shows an exponential increase during the time-interval 1970-1990. This is due to an annual student intake of 465 between 1975 and 1984 (and 300 from 1984 on). This results in approximately 370 new dentists per year, which decreases to 240 new dentists per year eventually. The number of dentists leaving the system annually during that period is only 100. Beyond 1990 the effect of a gradually increasing leaving-rate (whilst leaving the number of newly qualified dentists constant) is reflected in a saturation type curve. The distribution of qualified dentists over the three employment categories (normal practices, outside normal practices and unemployed dentists) is determined by the potential employment capacities, a) within normal

practices and b) outside normal practices.
The potential employment capacity for dentists outside normal practices retains an almost constant value of 1150 until 1985. In the period 1985-1990 the employment capacity gradually drops to a value of 700. This is due to two policy-measures:

1. reduction of the educational capacity of the dental schools from 465 students to 300 students annually - beginning in 1984 - which reduces the employment-capacity by some 150 faculty positions.
2. gradual shutdown of the institution of the national School Dental Service- beginning in 1984 - giving another loss of 300 jobs.

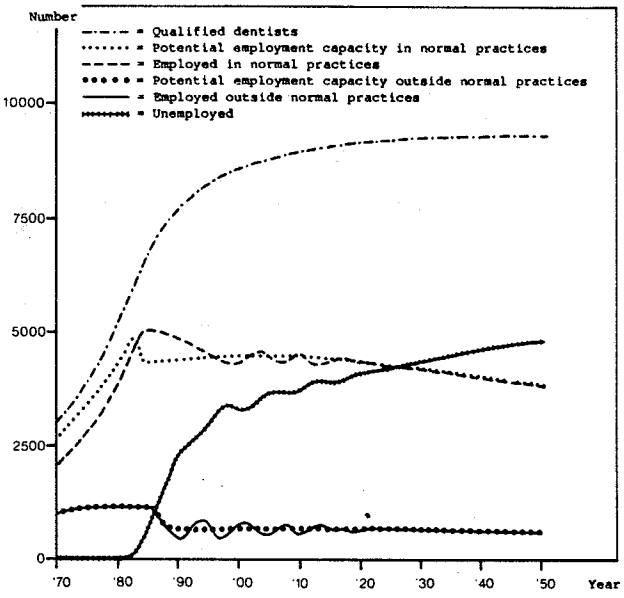

Figure 8: Time-paths of criterium variables in the base-run.

The variables "number of actually employed dentists outside normal practices" follows the variable "potential employment capacity" with a delay of 1.7 years. This results in a damped oscillation of actually employed dentists around the potential employment-capacity, from 1985. Thus dismissals and occupations alternate with a period of about 7 years.
For the calculation of the employment-capacity in normal practices two time-intervals must be distinguished. In the period 1970-1983 the capacity is calculated on the basis of the manpower needed to maintain a workload of just 100%. From 1983 onwards the capacity follows a policy-measure of a fixed dentist/patient ratio of 1:3250. Therefore the potential capacity of normal private practices (doubling in the period 1970-1983, due to an increase of the population-size, more frequent dental visits and a more intensive and time-consuming treatment-pattern), dropped from 4900 to 4460 between 1983 and 1985. Beyond 1985 the capacity only depends on the development of the population-size because a constant dentist/patient ratio is aimed at from that time onwards.

In 1970 the potential employment-capacity for dentists in normal practices lies 30% above the number of actually employed practitioners. The overload gradually decreases until 1983, when actual employment and potential employment are equal. From 1983 on the behavioral mode of the model changes. The potential employment capacity drops beneath the actual number of employed practitioners. Until 1996 reoccupation of vacancies (due to

retirements) ceases. This gradually brings down the level of employment in normal practices to the value of the potential capacity. From 1996 the actual employment exhibits a damped oscillation around the potential capacity norm. Beginning in 1982 the total number of qualified dentists exceeds the sum of potential capacities within and outside the normal practices. As a consequence since 1982 unemployment emerges and rises to a level of 3000 in the year 2000.

Table 1: Development of three criterium variables which are indicative for the interests of different groups (unemployed dentists, dental hygienists, practicing dentists) for the base-run and different policy scenario's.

		Interest groups and criterium variables		
		Unemployed dentists	Dental hygienists	Practicing dentists
Run	Year	Number of unemployed dentists	Index figure workload (base-run=100, 1985)	Annual turnover per dentist (thousands of 1985-guilders)
Base run	1970	0	128	548
	1995	3100	107	379
	2020	4267	108	385
Scenario A	1970	0	128	548
	1995	2600	107	379
	2020	785	109	382
Scenario B	1970	0	128	548
	1995	1500	96	308
	2020	2757	97	318
Scenario C	1970	0	128	548
	1995	1020	96	308
	2020	0	102	341
Scenario D	1970	0	128	548
	1995	600	107	335
	2020	74	105	328

In the period 1970-1995 the index of workload diminishes from 128 to 107 (see table 1) and remains constant at that level up to 2040, while the the annual turnover per dentist drops from 548 to 379 in the period 1970-1995 and does not change considerably there upon. Notwithstanding a tremendous emergence of unemployment, the overload (8%) of the dental system does not vanish completely.

4.3. Policy-experiments

In the next section the short-term as well as long-term effects of four manpower-supply-policy scenarios will be presented and discussed from the point of view of:

a) the development of unemployment of dentists.
b) the job-market for dental hygiensts.
c) the development of the dentists' income.

A. Reduction of the annual educational capacity of dental schools in the Netherlands from 300 to 120 beginning in sept. 1985 (figure 9).

Comparing this scenario with the base-run, the behaviour of the variables "potential employment capacity" and dentists "employed in normal practices" remains unchanged at least until the year 2040. The reduction of the intake of students by 180 per year (accompanied by closing dental schools), ultimately results in a decrease of the employment capacity in the educational sector of about 150 full time jobs - a potential cause for increase of unemployment, (with a delay of 1.7 years). On the other hand the number of students finishing their study annually decreases from 240 to 96 (20% of students drop out sooner or later), with a delay of 5.5 years. So initially the increase of unemployed dentists slightly exceeds that of the base-run (because of a reduction of occupational positions in the educational sector), but as early as 1992 it drops far beneath that in the base-run, and vanishes completely by 2040. In the period 1993-2040 the total number of qualified dentists decreases from a few more than 7500 to less than 5000.

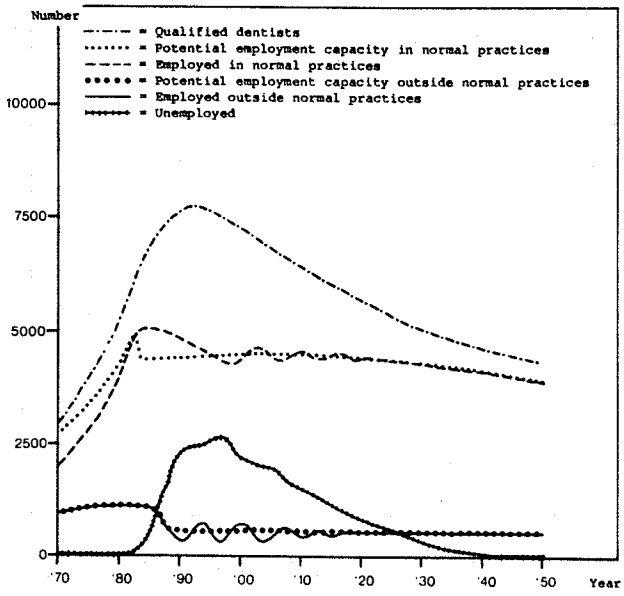

Figure 9: Time-paths of criterium variables resulting from policy-experiment A.

The timepaths of the index figure of the workload and the annual turnover per dentist in this scenario are almost indentical to those of the base run (see table 1). Evidently the reduction of the enrollment-capacity to 120 has no consequences for the development of workload and turnover, as long as the norm of desired dentist/patient ratio can be effectuated by the number of actually employed dentists.

B. Dropping the dentist/patient ratio from 1:3250 to 1:2500 from 1985 (figure 10).

Compared with the base-run scenario B furnishes an elevation of the potential employment capacity for normal practitioners of nearly 1250 positions. The effect of the measure is assumed to operate without delay. On the short term this measure seems far more effective in driving back unemloyment than a reduction of the intake of students (scenario A). In the long run however scenario B lets not disappear unemployment, while scenario A does.

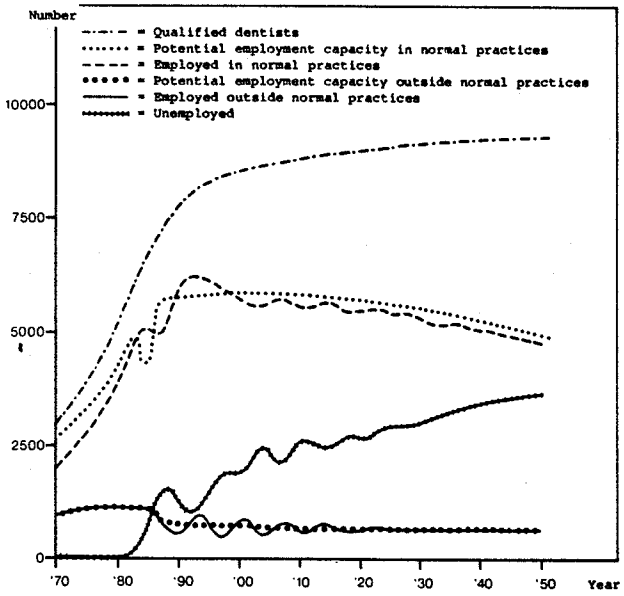

Figure 10: Time-paths of criterium variables in policy-experiment B.

Different from to scenario A the workload is 10% lower, the annual turnover per dentist 19% lower than in the base-run (see table 1). The different responsiveness of workload on the dentist/patient ratio, and turnover on the dentist/patient ratio must be attributed to the model assumption that the average number of treatments per patient is not linearly dependent on the average dental workload (law of diminishing returns), while the reversal causation is a linear one, as well as the relations between the dentist/patient ratio-- workload and dentist/patient ratio-- turnover.

C. A mixed scenario of the measures A and B (figure 11)

1. Reduction of the annual enrollment capacity of dental schools from 300 to 120 beginning in 1985.
2. Decreasing the dentist/patient ratio from 1:3250 to 1:2500, beginning in 1985.

This scenario combines a short-term with a long-term policy measure. However, as early as the year 2000 this scenario evokes a shortage of dentists in normal practices as can be seen from the levels of the curves of the number of dentists employed in normal practices remaining below the matching curves of the potential employment capacities.
As in scenario B the index-figure of workload drops below 100 in 1995, and the annual turnover per dentist decreases to a minimum of 308.000 1985-guilders per year. Contrary to scenario B the workload-index and the turnover later on rise again (see table 1). The latter is due to the dropping of the number of qualified dentists below the number desired according to a standard of 1 dentist per 2500 patients.

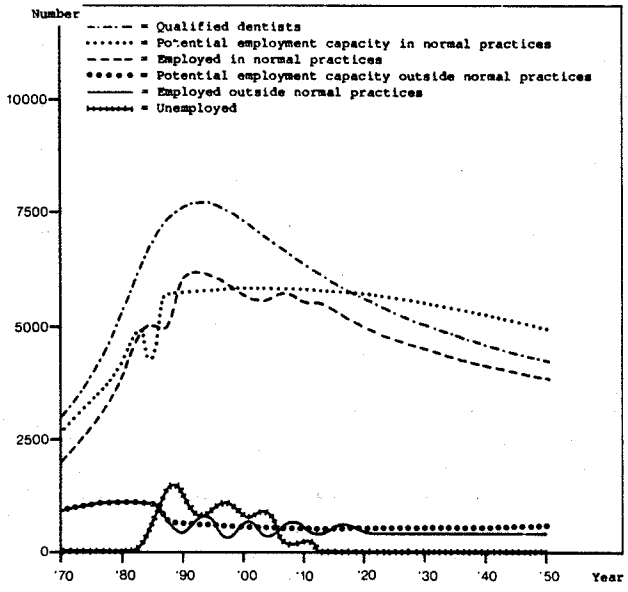

Figure 11: Time-paths of criterium-variables resulting from scenario C.

D. A scenario consisting of a mix of less extreme policy-measures from 1985 onwards (figure 12).

The measures are:
- Reduction of the enrollment capacity from 300 to 180 per year
- Decreasing the dentist/patient ratio from 1:3250 to 1:2750.
- Early retirement at 62.5 years instead of 65 years.
- Shortening of work-time by 10%.
- Raising the annual fraction leaving the unemployment status (through advancement of emigration, occupational change etc.) 10% extra.

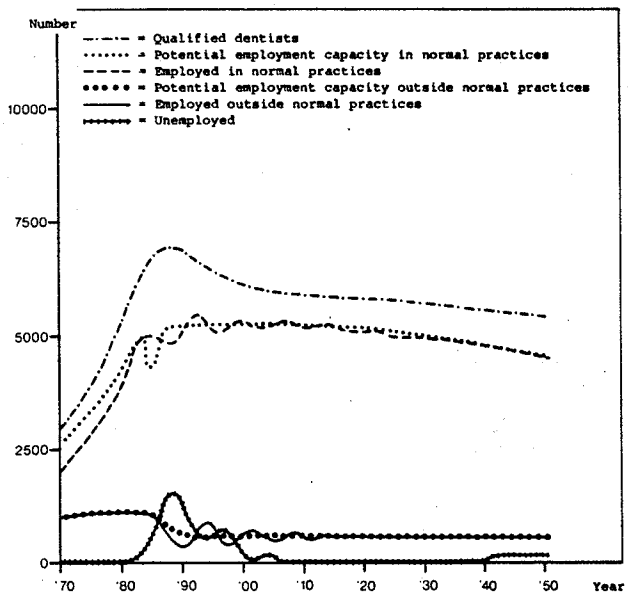

Figure 12: Time-paths of criterium-variables resulting from policy experiment D.

This multi-dimensional scenario seems more adequate in redressing the equilibrium between demand and supply than the preceding measures. The number of unemployed dentists does not exceed the number of 1300. After 1988 the major trend in unemployment (with some fluctuations complementary to those in the number of employed dentists in both occupational sectors) is downward. In the year 2005 unemployement has vanished completely. Moreover the set of policy-measures does not give rise to occuptional shortages in neither of the employment sectors within the time-horizon considered.
The development of the annual turnover per dentist is intermediate between scenario A en B, while the index-figure of dental workload is the same as in scenario A (see table 1).

5. DISCUSSION

Demographical, socio-cultural, economical and pathological changes during the last 40 years have influenced supply and demand of dental care considerably. Because of a lack of understanding of the elemantary dynamics of the system on the part of various policy making institutions (like the government and health insurance organizations), supply and demand of dental care have not been balanced satisfactorily.

After a considerable increase of demand a.o. due to a fast growth of the population, an "explosion" of dental caries and an improved care seeking attitude of the population in the fifties, a serious shortage of dentists developed in the late sixties and early seventies. Because of a rapid decrease of the population growth and the caries-incidence-rate, as well as unforseen time-delays in the care-system, policy-measures (increasing the educational capacity) appeared too late, too one-sided and too drastic. As a consequence the number of qualified dentists increased exponentially during the period 1960-1985, forcing in the early eighties the shortage of dentists to shift in an overshoot. Without adequate policy-measures this results in a considerable volume of unemployed dentists after 1990. Experiments with a number of manpower-planning-scenario's suggest that:

a. The most effective measure for preventing increase of unemployment after the year 2000 seems to be a reduction of the educational capacity of dental schools from 300 to 120 from 1985 on. However this one-sided measure bears the risk of provoking a new shortage of dentists in the long run (after 2020).

b. Reduction of the desired dentist/patient ratio from 1:3250 to 1:2500, beginning in 1985, seems maximal effective in reducing unemployment on the short term (until 2000), but does bot solve the problem in the long run, without additional measures.

c. A combination of both measures a and b is effective on the short term as well as in the far future, but results in a new shortage of dentists in the long run.

d. Different interest groups favour different policy measures. For dentists, finishing their study in the near future, reduction of the dentist/patient ratio is most favourable, because it gives them more opportunity to practice. For dentists finishing their study in the distant future (from the year 2000 on) however and for the current practitioners, reduction of the educational capacity of dental schools seems much more favourable, because it is advantageous for their income. The same holds for dental hygienists, which interests are served most by overload of dental practices. Reduction of the dentist/patient ratio from 1:3250 to 1:2500 gives a drop in workload from 107 to 96 compared with the base-run. This results in less hiring and more firing of auxilary personnel.

e. A combination of less extreme variants of both measures together with other measures viz. effectuating c.q. stimulating of earlier retirement, occupational change, emigration, shortening of working hours, seems to be an alternative that is effective on the short term as well as in the long run, while spreading the disadvantages reasonably well over the interest groups considered.

At last it should be emphasized that the consequences of these policy-experiments for the aspect of the oral health status as such, and for the total expenditures for dental care are not included in this study. They will be studied in the near future.

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