Table of Contents

Go Back

# Modelling the system of health care and drug addicts

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**Abstract**

Drug addiction is a very intriguing problem all over the world. In Germany about 2-4% of heroin consumers die every year, although a very differentiated care system is established. For this reason the idea comes up that this system is not organized in a proper way. For further analysis of functionality the tools of mathematical systems analysis seems to be appropriate. Quantitative analysis however must be based on sufficient empirical data. With regard to drug care systems there is a lack of adequate data in epidemiology and in care system's indicators.

Several methodological problems and theoretical issues of this study are described in the paper. A global model is proposed based on estimation on regional data of the area of Munich (FRG). The model is built by Stella®. The problems to establish a valid computer-based model are discussed.

## 1. Aim of study

One of the important health problems is *heroin addiction* which in Germany is related to about 1800 young people dying a year out of a population of about 100.000 heroin user (comp. Simon et al. 1997). The total expenses for heroin problems are about 6.5 billion Euro. The complexity of those heroin-related health problems shows a need for a sufficient theoretical understanding of those processes. A stepwise utilization of systems modeling to identify the dynamics of epidemiology and of health care units as a system seems to be useful. For this reason the development of a basic model is proposed considering the various problems and deficits of empirical data and social epidemiological and organizational theory building. The model should help to examine on a qualitative level the system's dynamics. This should lead in a further step to gathering of more adequate empirical quantitative data and to more precise model building.

## 2. Background

### 2.1 Epidemiology of drug consumption

***Empirical basis***

One of the most extensive problems in public health is related with the addiction of psychoactive substances. In Germany – as in most other industrialized countries - we have a high rate of about 12 % of the population, that are about 10 Mio addicts in 82 Mio inhabitants (comp. Simon et al. 1997 ; s. tab. 1).

Tab. 1:

7 Mio persons dependent on nicotine

2,5 Mio alcohol dependent persons

1 Mio persons dependent on legal psychoactive drugs

150.000 ecstasy user

150.000 heroin addicts

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= approx. 10 Mio persons (there is an overlap because of multiple substance dependence)

If one considers the number of relatives – let's take 2 persons (e.g. parents and/or children) – one sees that about 20 Mio additional persons are affected by addiction.

We focus on heroin addicts here. With regard of quantity they show a steady state since the 60s. One has to consider however, that the number of heroin addicts can only be estimated as nobody wants to report on his heroin consumption in surveys as it is illegal.
Although there is a steady state it is very likely that the level of consumers is oscillating. External factors like police actions or variations of heroin supply influence the collective behavior of the addicts, also the attraction of therapy is fluctuating.
For understanding the total system some components must be considered in detail.

***Modeling population dynamics in consumers***

The occurrence of the drug problem is not only determined by genetic factors but also by social and geographical factors ( comp. "Social Ecology" of the drug problem see Tretter 1995). Up to now there is not yet done enough empirical research on all important variables. For this reason also not many models for simulating dynamics of the drug scene were developed. One model was constructed by Roberts et a. (1983) testing the interdependence of heroin consumption, supply, prices and criminality. The modeling method was described for instance by the technique provided by VENSIM ®. Although this model is an interesting and necessary step for understanding systemic dynamics in drug epidemiology there are some restrictions with regard to the empirical data basis: the variables being used are not measured in the context of the model but are arbitrary. Also the testing of influences of police actions on prices and criminality is not bringing about realistic quantities (doubling the crime rate , huge increase of drug prices). Unfortunately this model has not much impact in the development of drug epidemiology (comp. Shreckenghost 1985) but probably in economics of substance abuse and addiction (comp. Petry & Bickel 1999).
Another approach of modeling drug epidemiology is related to the HIV/AIDS epidemiology, basically introduced by the work done by Kaplan and coworkers (comp,. Kaplan & Heimer 1992, Greenhalgh & Hay 1997). Lately Zaric et al. (1999) have demonstrated a model with 12 compartments, 10 variables and 14 parameters which describes the epidemiological dynamics and the economic implications of it. The modeling procedure conceptually is based on compartment models and is designed by a graphical layout and defined by several differential equations. The calculation was done after a discretization procedure on the basis

of EXCEL ®. The impact of injectors for HIV infection is relevant however there are significant changes in heroin consumption in several cities in Europe now (heroin smoking) so that those models do not fit to reality any more. Thus for increasing validity of modeling regional effects have to be considered and local models might be constructed. Besides this, still most influencing variables in drug epidemiology are not yet known or not measured in an appropriate way.

A very good compromise between analytical goals and empirical data basis can be found in the modeling the epidemiology of alcohol consumption done by the group around Holder (Holder 1987, 1998). This Californian research group has collected a huge collection of data on alcohol consumption over years. Then they simulate various conditions by a special program which is called SIMCOM (© by Prevention Research Center Berkeley, Cal.). By this simulation model it can be found that price increase might be a good interventional variable to reduce consumption and thus to reduce the number of consumers (Holder & Blose 1987). However in this model the influence of therapy is not tested .
Other epidemiological models are based on utility theory (e.g. Behrens et al. 1999, Levy & Friend 2002). They can not be used in our case of global analysis .

**2.2 Health care system for addicts**

The health care system for addicts is an extremely complex system of services, professional skills, institutional organizations and rules of financing (Sonntag & Tretter 2001). The system has a *serial operation structure* starting with *substituting* the very dangerous intravenious application of heroin by better controllable oral methadone. *Counseling* should transfer the patients to *detoxification* and finally guiding him to *drug free programs*.
Each unit is organized and financed by a different institution:
Thus the care system for heroin addicts provides some special units (costs per capita):

1. *Substitution* as a special unit of the system for heroin addicts. It reaches probably 60% of the local drug scene. Mainly methadone is used for substitution. It costs about 1500 Euro/year.
2. *Consulting services* are available for all addicts. They have contact to about 60% of the drug scene. The services are financed by public money by district administration, Counseling (450 Euro/year, i.e. 15 hours for 30 Euro)

3. *Detoxification* is financed by health insurance and Detoxification (5000 Euro/year). These units reach about 30 % of addicts.
4. *Drug-free long-term treatment programs (*inpatient or outpatient; comp. fig. 2) are paid by pension insurance. (15.000 Euro/year up to three times in seven years). They treat about 10 % of addicts.
5. *Survival services* (e. g. heroin prescription programs under study)

For heroin addicts regional estimations for analysis must be used as there are no valid data available: Out of the drug scene in Munich (N = ca. 3500 persons) about 60% (e.g. n = ca. 2100) consult counseling units. In parallel way only a part of the drug scene (60%; e.g. n = 2100) uses other opportunities for substitution with other medications. Out of the counseling units about 60% (n = ca. 1300) participate in withdrawal. About 30% (n = ca. 400) of these quit the treatment before being detoxified. 30% of discharged patients (n = ca.400) start a drug-free treatment program, 30% (n = ca. 130) of them also quit treatment before being finished. Only 70% (n = ca. 270) finish therapy regularly. After one year about 30% of patients having finished treatment regularly still are clean (n = ca. 90). This means that two years after only about 3 % of the patients having entered the system are in a goal-related state (comp. fig. 1). The care system for drug addicts shows a high rate of drop outs in each unit of the system (comp. Hirsch & Tretter 2000, Sonntag & Tretter 2001). What one sees is that the number of persons being treated by the system becomes reduced drastically. The transfer rate from instance to instance becomes reduced stepwise.

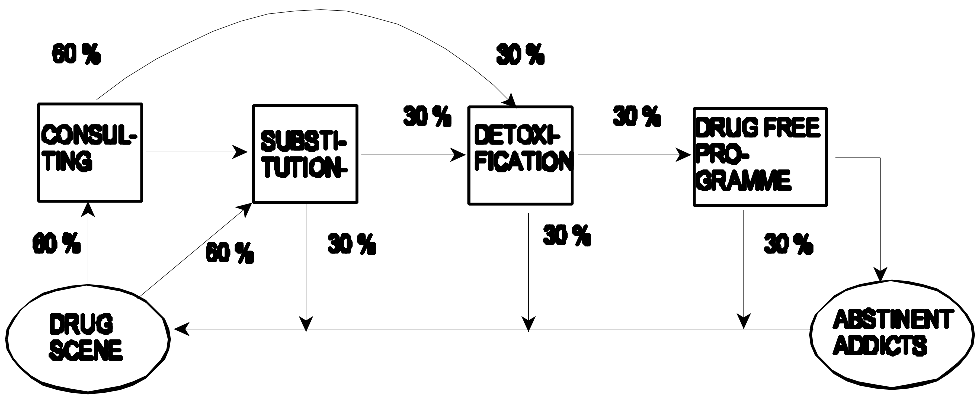


Fig. 1: The structure and function of the care system for drug addicts: estimated flow of patients during one year

As there are not sufficient empirical data on the epidemiology and also not on the functional structure of the care system for drug addicts theory building can not be based on a solid data basis yet. On the other hand there must be started with model making for a principal understanding of the function of the system. Only by doing so one can expect to reach a sufficient theory in the next time. Also by precise modeling the need for more and also other data gets evident. Only by this way one can convince authorities to spend money on such type of research.

## 3. Systems methodology and understanding complex health care systems

Theory building in social sciences is faced with several problems which were discussed lately in the context of "second order cybernetics" (v. Foerster 1981):

- there is a lack of hard data as subjective information must be used (e.g. surveys)
- the subjects are influenced by the investigator
- mathematical theory building in most cases is not appropriate

When trying to analyze a complex social system one usually uses a special procedure which very seldom is explicated. In the last time *verbally formulated procedures* and *theories* were predominant. *Mathematical tools* were only used rarely. Other researchers just use an attractive mathematical formalism which had been successful in other disciplines like physics and engineering in other disciplines and applies it to social problems. This especially was the case with „chaos theory„. However, in theory and model building there is the problem of misfits between mathematics and the empirical data and the theory of the respective discipline (s. fig. 2).

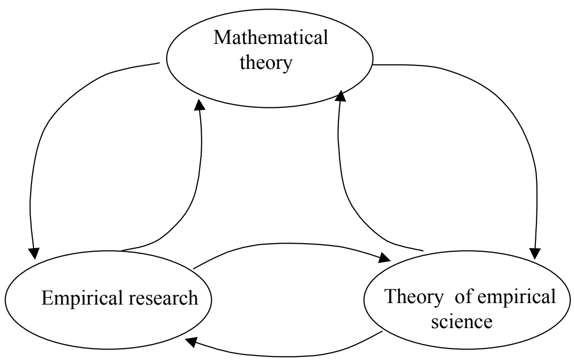


Fig. 2: The relationship between empirical research, theoretical fields of the respective empirical research field and mathematical theory construction. Empirical data must fit into the theory of the respective discipline and the theory of that discipline must influence strategies of data acquisition. Those data must also fit into the mathematical model but there is also a need to collect a new type of data to support or test the mathematical theory. Furthermore the interrelationship of mathematical theory and theory of the field to be studied must be considered.

For a functional understanding of complex care systems which is important for management and planning of health care units and also for health administration an organizational analysis of functions is the appropriate way (Emery & Trist 1972, Daft 1997). In this field of analysis systems methodology might be a useful instrument (Bailey & Thompson 1975, Reichertz & Anderson 1977, Schwartz & Busse 1998). Analytical approaches which are concerned with the individual client might have some disadvantages for a global understanding of the health care function compared to a holistic approach like system dynamics (comp. Taylor & Lane 1998).

With regard to systems methodology we can distinguish several steps: analysis which is practiced only by verbal tools and other approaches which are basically made up by mathematics. Although every scientist agrees that „mathematization„ reaches the highest level of scientific analysis and theory building social scientists sometimes claim that verbal methods can not be substituted as social systems are constituted by semantic systems and that they can not be described and explained by subject-free terms. At least there is a considerable gap between mathematical tools and the available data.

***Systems methodology***

For structured proceeding in model construction a stepwise strategy might be useful which is allowing both, verbal and formal languages. Some steps and issues are mentioned here (comp. Tretter 1979, 1982, Tretter & Küfner 1992):

- proceeding from qualitative level to quantitative level
- selection of technique of modeling
- choice of mathematical reference models
- managing mismatch of data and requirements for elaborated mathematics
- computer simulations
- model testing and modifying the model
- suggestions for new design of the real system

***Type of models***

At present very much experience is available with predator prey models. They represent principal types of interactions between systems components: *competition* and *cooperation*, *stimulation* and *suppression* (or: inhibition). They are based on explicit mathematics by the use of difference and differential equations. Empirical requirements are in many cases continuos variables. For this reason such models are not really appropriate for our modelling task.

However from a metatheoretical point of view the development of models starts with a stage of *explorative heuristic modelling* , then testing the model and making the structure more adequate etc. (comp. Zeigler 1985, Bossel 1994, Richmond 2001).

In this situation we only can design a projection of a procedure of modeling.
With this aim, the following descriptions are made to provide an approach for rational analysis.

## The systems model

### *The basic model*

We use a Top-down approach as there is not enough data or empirical basis for description of the system. Also the theoretical basis of health care for addicts neither in sociology nor in organisation research shows enough elaborations. For this reason a very simple approach of functional analysis is used.

First we distinguish two subsystems (s. fig. 3):
(1) The population of heroin consumers (HC), measured in number of individuals.
(2) The spezialized system of health care for drug addicts (SYS), in principle being measured by number of service places.

The basic functional structure is in that way (comp. Fig. 3):
- The increase and the reduction of the number of heroin consumers (= approx. addicts) is influenced by several variables. One variable is the influence of the health care system.
- The number of places in the health care system is influenced by the number of sick individuals and other factors mentioned later.

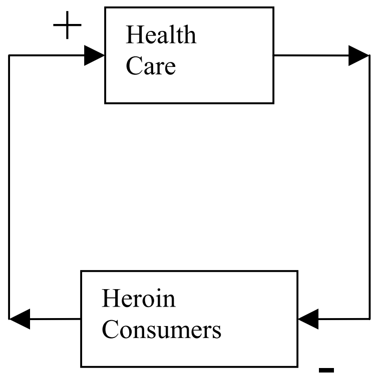


Fig. 3: The loop between the population of heroin consumer and specific health care. The quantity (and "quality") of heroin consumers is counterbalanced by establishing care units. In long-term perspective the number of heroin consumers should get reduced. However there is a steady state since the 60s which indicates an insufficient care system and several deficits in health policy.

***Formal description of the global system***

From a practical point of view the following seven components of the total system are of interest. They are interconnected in various stimulatory and inhibitory loops (s. fig. 4). Here they are characterised roughly by a short description defining the respective outputs (out) and inputs (in), the appropriate quantification can not be explicated now:

***(1) Heroin Consumers = HC***

*Out*: They stimulate (i.e. increases) the health care system (SYS) and the heroin supply (HS) and also criminality.
*In:* Heroin supply is increasing HC, the number of consumers becomes reduced by police captures and also by therapy realized by SYS.

***(2) Health care system = SYS***

This system is composed by several subunits as it was described above. Here it is not differentiated any more.

*Out: R*eduction of the financial resources, reduces also the number of heroin consumers.
*In*: SYS gets enhanced by the number of heroin consumers stimulated by policy and by financial resources.

***(3) Heroin Supply = HS***

*Out:* Stimulates heroin consumption and also police action.
*In:* Gets inhibition and reduction of amount of heroin by police actions and gets stimulation by heroin consumers.

***(4) Police = POLIC***

*Out:* Inhibits crime and heroin supply and also number of heroin consumers for a certain period.
*In:* Heroin supply stimulates criminality and also police actions.

***(5) Criminality = CRIM***

*Out*: Stimulates politics and police.
*In*: heroin consumption induces criminal activities, inhibition is performed by police actions.

***(6) Politics = POLIT***

*Out:* Stimulates financial ressources and also stimulates the installation of units for health care.
*In*: Gets stimulated by criminality.

***(7) Finances = FIN***

Out: stimulates the health care system.
In: Becomes reduced by the care system and gets stimulated by politics.

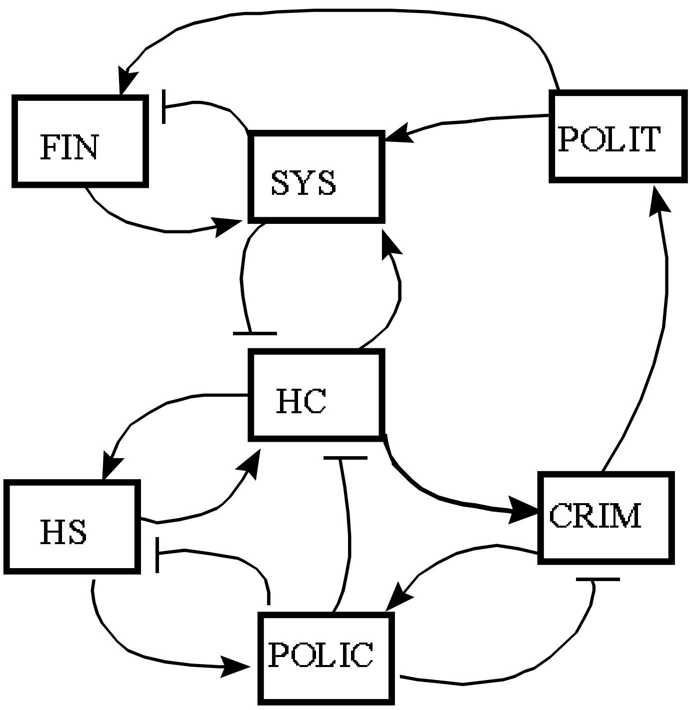


Fig. 4 : The network of factors which determine the dynamics of the population of heroin consumers (HC) and the health care system (SYS). For details see text. Arrows indicate increasing  the number or the activity of the unit, lines with a stroke od line symbolizes reduction of number or activity of the respective unit.

For further explication an qualitative interaction matrix can be built up (Tab. 1). For optimization of fitting empirical data and theory a collaboration between empirical and theoretical researchers should be established which is not yet the case.

| | HC | SYS | HS | POLIC | CRIM | POLIT | FIN |
|---|---|---|---|---|---|---|---|
| HC | / | + | + | + | + | 0 | 0 |
| SYS | - | / | (-) | 0 | 0 | 0 | - |
| HS | + | 0 | / | + | (+) | 0 | 0 |
| POLIC | - | 0 | - | / | - | 0 | 0 |
| CRIM | 0 | 0 | (+) | + | / | + | (-) |
| POLIT | 0 | + | 0 | (+) | - | / | + |
| FIN | 0 | + | 0 | 0 | 0 | 0 | / |

Thus only in principal the various further steps can be sketched.
The interactions must be formalized in a next step. This can be done by differential equations.

A preliminary sketch of the system of differential equations could be described in this way, the coefficients a to y need empirical based estimations.

(1) HC '[t] == a*HC[t] - b*HC[t]*SYS[t] + c*HS[t]*HC[t] - d* POLIC[t]*HC[t]
(2) SYS'[t] == e* SYS[t] + f*HC[t]*SYS[t] + g* POLIT[t] + h*FIN[t]
(3) HS'[t] == i* HS[t] + j*HC[t]*HS[t] - k*POLIC [t]
(4) POLIC'[t] == l*POLIC[t] + m*HC[t] + n*HS[t]*POL[t] + o*CRIM[t]
(5) CRIM '[t] == p*CRIM[t] + q*HC[t] - r*POLIC[t] –s*POLIT[t]
(6) POLIT'[t] == u*POLIT[t] + v*CRIM[t]
(7) FIN'[t] == w*FIN[t] - x*SYS[t] + y*POLIT[t]

The formal and quantitative structure of the equations must be modified according to empirical, to social theory and also to mathematical considerations.

In a further step computer-assisted modelling by STELLA ® should be performed. STELLA ® might be very useful tool in this stage of theory building as it offers various different approaches to develop a model. Stella is one of the first computerized methods to build systemic models in a multimodal way: there are several ways to build the model, for instance by mathematical formulas, by intuitive graphical design, by graphs of functions which can be drawn qualitatively etc. This multimodal approach of modelling helps to bridge gaps in knowledge of the total system. Because of a severe lack of empirical data of the drug scene and the care system only a sketch of a model can be presented at the conference (s. Fig. 5). However the appropriate steps for further research will be presented and discussed.
The actual state will be presented at the meeting.

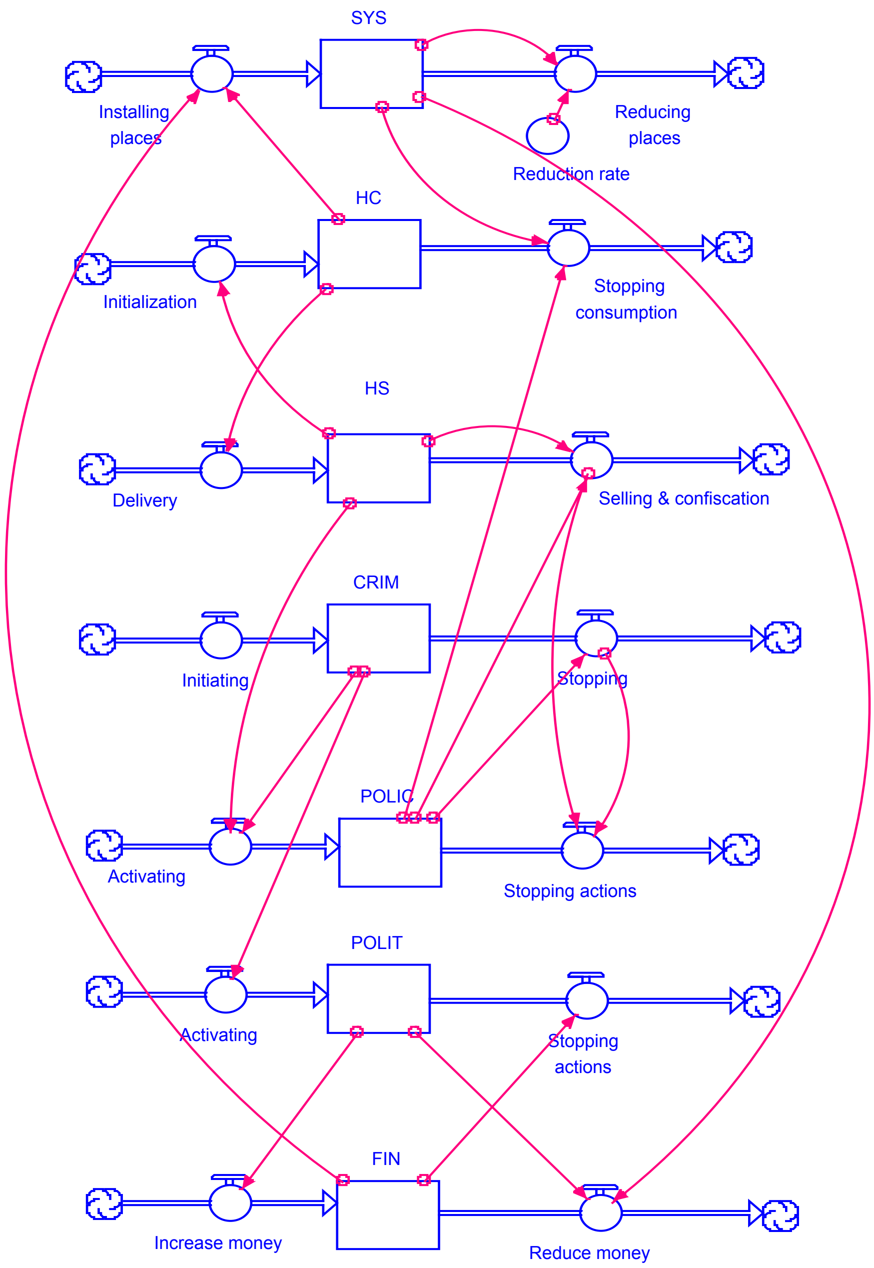


Fig. 5: A rough draft of a computer-based model of relevant factors determining the dynamics of the scene of heroin consumer and the care system and other influencing factors. The model is designed by STELLA® technology.

## Perspectives

As a next step the model must be transformed in a computerized version. Thus it can be tested on a social theoretical level and also with regard to mathematical considerations. Then a revised version should be tested with more realistic assumptions.

This procedure is related to the metatheoretical understanding of model building in social sciences outlined before.

## Conclusion

The empirical description of processes in the care system for heroin addicts must be extended with regard to several variables determining the dynamics of the drug scene. Also the description of the functions of the health care system for drug addicts must be improved. With such tools an appropriate detailed model can be used for exploratory and explanatory simulation.

For this reason the cooperation between various units of the care system must be realized. For developing the appropriate methods and models close interaction between actors within the system and scientists should be organized.

## References


Bailey, N.J.T., Thompson, M. (Hrsg)(1975): Systems aspects of health planning. North Holland, Amsterdam

Behrens, D.A., Caulkins, J.P., Tragler, G., Haunschmied, J.L:, Feichtigner, G. (1999): A dynamic model of drug initiation: implications for treatment and drug control. Math Biosci 159(1):1-20

Bossel, H. (1994): Modeling and simulation. Vieweg, Braunschweig

Daft, R.L. (1997): Organization – theory and design. South Western College Publ. , Cincinnati

Emery, F.E., Trist, E.L. (1973): Towards a social ecology. Penguin, Harmondsworth

Foerster, H.v. (1981): On cybernetics of cybernetics and social theory. In: Roth, G., Schwegler, H. (Eds): Self organizing systems. Campus Frankfurt, pp. 102-105

Greengalgh, D., Hay, G. (1997): Mathematical modelling of the spread of HIV/AIDS amongst injecting drug users. IMA J Math Appl Med Biol 14(1):11-38

Hirsch, D., Tretter, F. (2000): Einflussfaktoren für Therapieabbrüche beim qualifizierten Drogenentzug. Suchtmedizin Forschung Praxis 2:31-37

Holder, H.D. (1987): Alkoholism treatment and potential health care cost saving. Med Care 1: 52-71

Holder, H.HD. (1998): Planning fro alcohol-problem prevention through complex systems modeling: results from SIMCOM. Subst Use Misuse 33(3):669-692

Holder, H.D., Blose, J.O. (1987): Reduction of community alcohol problems:computer simulation experiments in three countries. J Stud Alcohol 48(2):124-135

Kaplan, E.H., Heimer, R. (1992): A model-based estimate of HIV infectivity via needle sharing. J AIDS 5:1116-1118

Levy, D.T., Friend, K. (2002): A simulation model of policies directed at treating tobacco use and dependence. Med Dec. Making 22(1):6-17

Parra-Luna, F. (Hrsg)(2000): The Performance of Social Systems. Plenum, New York

Petry, N.M., Bickel, W.K. (1999): A behavioral economic analysis of polydrug abuse in heroin addicts. In: Chaloupka, F.J., Grossman, M., Bickel, W.K., Saffer, H. (eds): The economic analysis of substance use and addcition. Univ Chicago Press, Chicago, pp. 213-238

Reichertz, P.L., Anderson, J. (1977): Systems view of health care organizations. In: Laudet, M., Anderson, J., Begon, F. (Hrsg): Medical computing. Taylor & Francis, LondonS.87-98

Richmond, B. (2001): An introduction to Systems Thinking. High Performance Systems. Hanover / USA

Roberts, N., Anderson, D., Deal, R., Garet, M., Shaffer, W. (1983): Introduction to Computer Simulation: A Systems Dynamics modeling Approach. Addison Wesley, Schwartz, F.W., Busse, R. (1998): Denken in Zusammenhängen. Gesundheitssystemforschung. In Schwartz, F.W., Badura, B., Leidl, R., Raspe, H., Siegrist, J.(eds.) : Das Public Health Buch. Urban u. Schwarzenberg, München, pp. 385-413

Shreckengost, R.C. (1985): Dynamic simualtion models: how valid are they? In: Rouse, B.A., Kozel, N.J., Richards, L.G. (eds): Self-reported methods of estimating drug use: meeting the current challenges to validity. NIDA Research Monograph 57, Rockville, D-4463: 1-11

Simon, R., Tauscher, M., Gessler, A. (1997): Suchtbericht Deutschland. Schneider, Hohengehren

Sonntag, G. & Tretter, F. (2001): Versorgungssystem. In: Tretter, F. & Müller, A. (eds): Psychologische Therapie der Sucht. Hogrefe, Göttingen, pp.

Taylor, K:, Lane, D. (1998): Simulation applied to health services: opportunities for applying the system dynamics approach. J Health Serv Res Policy 3(4):226-232

Tretter, F. (1979) : Cybernetics - a revised conception and its relevance for theoretical human ecology. In: Knötig, H. (Hrsg): Proceedings of the second international meeting on human ecology. Vienna 1977, St. Saphorin Georgi, S. 209-232

Tretter, F. (1982): On the development and multidisciplinary relevance of a qualitative analytical systems technology for biology, psychology and sociology. In: Trappl, R., Klir, J., Pichler, F. (Hrsg) (1982): Progress in Cybernetics and systems research. Bd. 3, Mc Graw Hill, New York, S. 179-184

Tretter, F. (1995): The Social Ecology of the Drug Problem. In: Wright, S., Borden, R., Bubolz, M., Hens, L., Taylor, J., Webler, T., Meeker, D., Griffore, R. (Hrsg): Human Ecology - progress through integrative perspectives. Society for Human Ecology, Bar Harbour, S. 338-356

Tretter, F. , Küfner, H. (1992): Netzwerke der Sucht. *Psycho.* Supplement 1/1992:2-10

Tretter, F., Sonntag, G. (2001): Ansätze zur Systemanalyse der Suchthilfe. Gesundheitswesen 6:212-220

Zaric, G.S., Brandeau, M.L., Barnett, P.G. (2000): Management Science 46(8):1013-1031

Zeigler, B.P. (1985): Theory of modeling and simulation. Kreiger, Matabar

Back to the Top