Supervised Injectable Heroin Treatment and Fatal Overdose: a system dynamics model to assess the impact of Supervised Injectable Heroin Treatment on fatal overdoses in Bergen, Norway

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Foreword and acknowledgment

There has been a rising concern in Norway during the past year about the heroin related deaths, with focus on overdose deaths; this has led to a debate about measures to prevent overdoses. The Supervised Injectable Heroin (SIH) treatment, was one of the measures proposed by Haukeland University Hospital in Bergen but no further actions were instigated since the government opposed such measures. This thesis focuses on the processes of overdoses with the intention of analyzing the way SIH treatment could contribute and provide positive results in terms of preventing overdoses. Fatal overdoses do not happen as randomly as is commonly assumed and this fact provides a fruitful starting point for interventions, whatever they might be.

This thesis is the final part of the Masters degree in System Dynamics at the University of Bergen and was written between August 2013 and June 2014. Erling Moxnes has been my supervisor throughout this period and I would like to thank him for his guidance and advice.
I would also like to thank my family for their patience, support and advice.

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ABSTRACT

Background: The city of Bergen, Norway, is troubled by a large number of deaths caused by opioid related overdoses. The number of deaths is also an indication of drug addict suffering, close family worries, drug trade and other criminal activities, costs of policing and health care etc. While all of these are important problems, focus in this thesis is on the number of deaths and on the effects of a policy called Supervised Injectable Heroin (SIH) treatment.

Method: A system dynamics model is built in order to explain the high mortality rate among heroin users in Bergen and to test the impact of SIH treatment. The model explains the flow of drug users from recruitment, through imprisonment and opioid substitution treatment (OST), to quitting or death. In particular the model is explicit about which periods the drug users are most susceptible to overdose deaths, when leaving prison and when leaving OST. The data comes from existing literature and interviews with drug users. The model behavior is analyzed with and without the policy impact, in order to understand how such a policy could contribute to a lower death rate among opioid users.

Results: The findings show that users recently released from prison and users who quit OST constitute the majority of the victims of heroin related overdoses. When tested in the model, the SIH treatment showed positive results towards reducing the fatal overdoses, especially among users quitting or being discharged from OST. SIH treatment could contribute to a reduction in the overdose fatalities among the experienced users of up to 37% per year with a clinic capacity of approximately 50-60 places.

Conclusions: The results shown by the model are a conservative estimation of the impact of SIH treatment. In a small city like Bergen, with a stable number of injecting users where, many of them are also known by the social services, good planning would be easier and the impact of this policy could be even greater, especially when combined with actions aiming to protect the users recently released from prison.

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“There is no such thing as moral phenomena, but only a moral interpretation of phenomena”

-Friedrich Nietzsche, Beyond Good and Evil

1 Introduction

This thesis is about Supervised Injectable Heroin treatment (SIH), also known as Heroin Assisted Treatment, specifically the way this treatment affects the number of fatal overdoses. Despite many preventive and harm reduction measures, opioid addicts suffer many physical and psychological problems which lead to a high rate of premature mortality and morbidity. In Norway the average mortality rate among injecting users is between 2% to 4% annually (Norwegian Annual Report (NR) to the European Monitoring Centre for Drugs and Drug Addiction EMCDDA, 2012), which is between 1% to 2% higher than most of the western countries. As a result, there has been an increasing concern about finding new effective ways to alleviate the problem. In the following pages of this thesis the focus is on injecting heroin users, since they are the once most susceptible to fatal overdoses, though the data about the registered deaths might include a minority of other opioid related deaths (see chapter 2.1 for the definition of drug related deaths by EMCDDA).

Opioids are primarily powerful analgesic drugs. There are legal opioids such as Vicodin, OxyContin, Percocet and morphine and illegal ones such as heroin. Opioids give the users a strong feeling of euphoria and can, in many cases, result in addiction. The majority of the studies presented in this paper are about heroin addicts. Heroin addicts die from various causes, among which overdoses, suicides and accidents, with overdose being the major cause of death (Darke et al., 2007). Darke and Hall (2003) have identified some major contributing factors associated with the risk of overdose: the gender, the duration of use and its inversely proportional relationship to the user's tolerance, the polydrug use, which means the use of multiple drugs including alcohol, and the purity of the heroin (Darke et al., 2007a). There is also evidence of a direct relationship between reduced tolerance, which leads to increased risk of overdose, and users recently released from prison, as well as users who have recently been more or less abstinent (Darke and Hall 2003,Ingrid A. Binswanger et al., 2007,S R Seaman et al.,1998, Elizabeth L. C. Merrall et al.,2010, Farrell and Marsden 2008, David Shewan et al.,2000). Under the light of these observations the hypotheses that will be tested in this paper is whether the higher risk of fatal overdoses, under certain circumstances, which include the duration of use and low tolerance periods after release from prison and after leaving OST, can explain the high mortality rate of the users in the city of Bergen. Another question to be tested is whether the SIH policy could have a positive effect on the high mortality rate among the heroin users in Bergen, and if so, how such a goal would be reached.

In order to test this hypotheses a system dynamics model is built. The model includes the stocks the users go through, from recruitment, through prison and OST, to quitting or death, as well as the high risk stocks the users go through during their addiction period. The users are divided into new and experienced users not only because the experienced users are most likely to experience a fatal overdose as mentioned above, but also because they are the target group of the SIH policy tested in model. By using data from Bergen, the model in an equilibrium situation, constitutes an explanatory model for the city. The robustness of the model is tested and sensitivity analysis is conducted.

The SIH policy is applied in order to find out if such a policy would change the behavior of the model in terms of a decreasing death rate.

Having the death rates as exogenous variables, the model focuses on the time periods the users are most susceptible to a fatal overdose. However, the model does not include several factors which, according to literature, contribute to the specific number of overdoses for each stock. Such factors would be the gender of the users, the purity of the heroin and the polydrug use. The most important reason for such variables not to be included in the model is that there is still research to be done in order to determine to what extent these factors affect the number of fatal overdoses. Furthermore, only the flows of experienced users are explicit in the model, not those of the new users. This is done in order to avoid a "black box" model which fails to show in a simple way the basic loops the users go through.

The Haukeland University Hospital of Bergen, recently proposed SIH as a way for the city to deal with the high mortality rate among the heroin addicts. Due to a dramatic increase in heroin related deaths between the 1980s and the 1990s, the SIH policy was introduced in Switzerland. Research for the evaluation of this policy has shown that it is an effective measure in order to reduce the number of fatal overdoses (Rehm et al., 2005), especially among the old, once thought to be "untreatable", users. The goals of the SIH policy can be summarized into four broad categories (Cattaneo et al., 1993):
(1) Reduce the number of new drug consumers/addicts.
(2) Increase the number of addicts who become abstinent.
(3) Reduce opiate-associated health consequences and the social discrimination and stigmatization of consumers and/or addicts.
(4) Protect society against drug-related harm and fight against drug-related organized crime.

The SIH policy is definitely not the solution to the heroin problem, and is not a substitute policy to the OST treatment, rather than it has a different and more specific target group than the already existing policies. The implementation of such a policy requires special facilities and trained clinical teams since direct medical supervision is necessary. In addition, political and moral impediments need to be surpassed in order for policies to be effective and directed towards serving the general interest.

The outline of the thesis will be as follows: First the theoretical basis for this paper will be introduced in chapter 2. A closer examination of the problem through a review of the related literature and an overview of the existing policies in Bergen, are included in this chapter. Chapter 3 describes the research methods used for the purposes of this thesis; descriptions of the structure of the model and some of the variables used are included in this chapter. Chapter 4 presents the findings as well as the results of the sensitivity analysis and observations. Chapter 5 contains an analysis of the policy and discussion of the findings and other results of the data collection. Chapter 6 contains the conclusion based on the data analysis and discussion.

2 Mortality among heroin users and the development of heroin related policies in Bergen

There is a variety of reasons which explain the high mortality among heroin users compared to non users. This chapter approaches the problem through a review of the relevant literature. Some sociodemographic characteristics are also apposed, aiming to a better understanding of the problem. There have been some inconsistencies among definitions and data which are also explained. The second part of the chapter presents the development of the main heroin related policies in Bergen.

2.1 The mortality problem through a review of literature

There is a significant amount of research dedicated to the heroin problem and the varying heroin addiction treatment options. However, a common characteristic across the board is the shortage of data to a greater or lesser extent. Computer-based treatment registrations did not exist in Norway, until as recent as 2010, when the Norwegian National Patient Register (NPR) started to collect data through a personally identifiable register (NR 2011). The lack of discipline from the users' side when they are in treatment, further enhances the difficulty of data collection. The shortage of data is also a result of the illegal nature of drugs. Thus big part of the results of the research presented below and the one I conducted, should be interpreted with caution.

There is a relatively small amount of data about Bergen compared to the amount of data about Norway as a whole and Oslo in particular. The shortage of data about Bergen has been partly covered by data about the whole country. The most essential source of data about Norway for this thesis was the Norwegian Annual Reports to the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA). Furthermore, Føre var and Utekontakten i Bergen reports provided me with some valuable data about Bergen. The 10 interviews with heroin addicts I conducted, although limited in number for statistical conclusions, were a very important source of insight into the heroin problem.

Despite the lack of data, the heroin problem is an old phenomenon and various aspects of it and its negative outcomes have been studied. We can separate the literature about heroin into three broad categories of research: a) research related to the supply side of the problem, b) research on the demand side of the problem and c) research on treatment and treatment outcomes. In this paper the last two categories are of interest in order to illustrate who the heroin addicts in Bergen are and why and how these people become victims of their own habit. Due to the fact that the users of each country develop some trends which might differ from user trends in other countries, the literature about Norway and Bergen in particular, is preferred over similar research from other countries.

The EMCDDA defines problem use as “Injecting use of drugs or prolonged/regular use of opiates, cocaine and/or amphetamines'. This means that everyone undergoing opioid substitution treatment (OST) who is prescribed methadone or Subutex is a problem user according to the EMCDDA's definition"(NR 2013). Moreover, the EMCDDA definition of drug related deaths takes into consideration people who are recreational users or users of legal medicinal drugs that contain opioids and are exposed to the risk of a fatal overdose. This is relevant to this thesis in the sense that the data taken from the Norwegian reports to the EMCDDA, will include a minority of deaths not relevant to injecting heroin users which this thesis deals with.

Bergen is the second largest city in Norway and belongs to the county of Hordaland. Estimations based on the number of patients in OST and visits to nursing services, such as Strax huset, indicate that there are around 1500 injecting users in the city. According to "Føre Var" reports, this number has been fairly stable until 2007 and since then, it has slightly increased. However, this increase might not derive from an increase in new users recruitment, but possibly from the effect of the wide participation in OST programs which extends the life expectancy of the users. There are no data about the number of people who only inject heroin, amphetamine or methamphetamine in Bergen, but calculations about Oslo showed that approximately 30% to 35% of the total injecting users, primarily inject amphetamine (NR 2013).

There is a general consistency among research from many countries, about the sociodemographic conditions of the users. A recent ten-year prospective cohort study (Lauritzen, Ravndal and Larsson, 2012) among users in treatment, conducted by the Norwegian Institute for Alcohol and Drug Research (SIRUS), shows low educational background and limited working experience. According to the same study the addicts suffer enduring mental disorders such as recurring anxiety, depression and cognitive difficulties. There is evidence towards similar mental disorders in a variety of research (Farrell et al.,1996; SINTEF 2003 Helsetilstand hos tunge rusmiddelmisbrukere & SINTEF 2003 Helsetjenester for tunge rusmiddelmisbrukere). In 2012 the proportion of those unemployed was as high as 80% of the total number of users in treatment in Norway (NR2013). In addition, the gender distribution among people in treatment has been approximately 30% for women and 70% for men for several years, with men in treatment being on average older than women (NR 2005).

The majority of the heroin users are polydrug users. (Bretteville-Jensen, 2005; Waal, 2007; Darke and Hall, 2003; Francesco Leri et al., 2003; Darke and Ross 1997, Douglass and Khavari,1978, Darke and Ross, 1997). The 2012 survey about patients in OST showed parallel use of illegal morphine, cannabis and benzodiazepines. To the question whether they take other drugs along with heroin, some heroin addicts I interviewed, mentioned amphetamine, alcohol and Lyrica. The "Føre var" report (2012) about drug trends in Bergen also supports these findings. To my question why they mix the drugs most of them answered that getting a stronger effect is their goal, whereas one person treated with Suboxone, which contains an opioid antagonist, said that he used amphetamines because he would need to stop his treatment for three days in order for heroin to have an effect. This might be revealing for the practices of other users who are also under treatment with opioid antagonists such as naloxone, which is widely used in Norway.

There is empirical evidence that the annual mortality rate among illicit opiate users is between 1% to 2% (Fischer et al.,2002; Hall et al., 1999; Waal,1997; Rehm, 1990-1993; Darke and Ross, 2002; Gronbladh et al.,1990; Oppenheimer et al.,1994; EMCDDA report 2011). In Norway the corresponding percentage is between 2% to 4% annually (NR 2012). Figure 1 shows the estimated mortality rates among all adults (15-64 years) due to drug-induced deaths. According to the EMCDDA report, opioids were present in between 80% to 90% of all cases. The toxicology of the drug related deaths showed that substances often found in addition to heroin are alcohol, benzodiazepines, other opioids and, in some countries cocaine, which is consistent with the data from Norway. Figure 1 illustrates the high mortality rate in Norway, bringing the country in the second place, after Estonia, among other European countries.

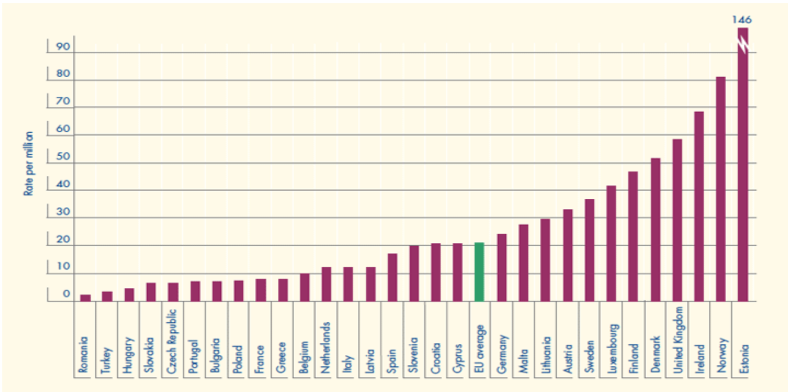

Figure 1: Estimated mortality rates among all adults (15-64 years) due to drug-induced deaths (EMCDDA 2011)

The number of deaths in Norway reached a peak in 2001. Since then there has been a decline, a trend which is possibly attributable to the increasing number of patients entering OST (NR2013). Table 1 shows the number of deaths from 1991 to 2010 from Kripos and Statistics Norway.

1991–2010	Number of deaths according to Kripos			Number of deaths according to Statistics Norway		
	Men	Women	Total	Men	Women	Total
1991	74	22	96	66	22	88
1992	78	19	97	81	23	104
1993	77	18	95	76	17	93
1994	102	22	124	105	19	124
1995	108	24	132	114	29	143
1996*	159	26	185	173	31	204
1997	149	28	177	160	34	194
1998	226	44	270	228	54	282
1999	181	39	220	191	65	256
2000	264	63	327	302	72	374
2001	286	52	338	327	78	405
2002	166	44	210	240	67	307
2003**	134	38	172	193	62	255
2004	168	55	223	220	83	303
2005	146	38	184	176	58	234
2006	152	43	195	187	64	251
2007	162	38	200	217	58	275
2008	148	31	179	210	53	263
2009	146	37	183	222	63	285
2010	n.a	n.a	n.a	181	67	248
2011	n.a	n.a	n.a	201	61	262
2012	n.a	n.a	n.a	---	---	---

Table 1: Drug-related deaths 1991–2011. Total number of deaths and deaths broken down by gender (Kripos and Statistics Norway)

In Table 1, there are obvious differences between the number of deaths registered by the two agencies. The numbers from Statistics Norway are higher than the deaths registered by Kripos. These differences derive from the fact that, since 1996, the Statistics Norway figures are based on the EMCDDA definition for drug related deaths which is broader than the definition used by Kripos. The EMCDDA definition includes suicides and the deaths of the elderly above the age of 65 which, if removed, these differences become very small until 2009, although bigger after 2009 and until today. The numbers I will used are also based on data from Statistics Norway.

Figures 2 and 3, illustrate the number of deaths in 2010 and 2011 broken down by substance. Heroin was responsible for the majority of the drug related deaths in 2011. The difference among heroin and other drugs is even more obvious in the past years. Another observation about the numbers shown in Figures 2 and 3 is that the number of methadone related deaths is increasing.

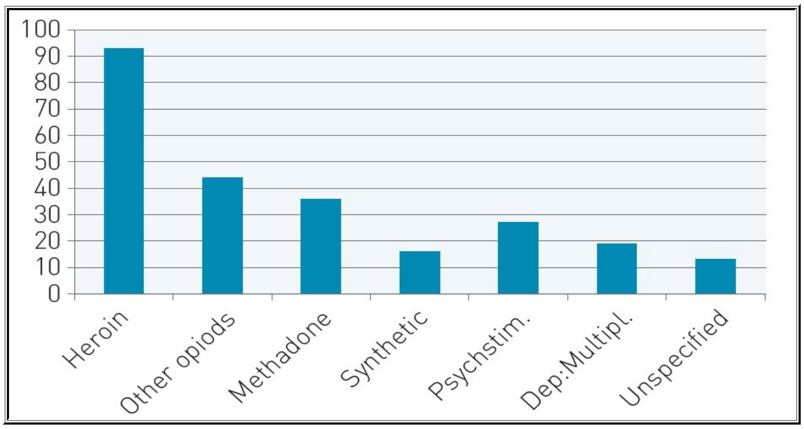

Figure 2: Drug-related deaths in 2010 broken down by substance. (SIRUS and Statistics Norway)

Two comments are of importance about this observation: first, there is no differentiation between deaths caused by methadone and deaths where methadone was present in the blood at the time of death and second, the majority of methadone-related deaths occur among persons not enrolled in the OST program (NR 2012).

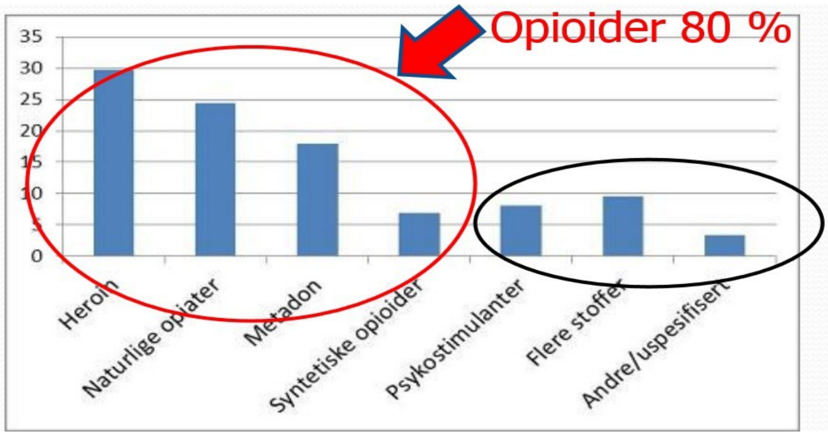

Figure 3: Drug-related deaths in 2011 broken down by substance. (SIRUS and Statistics Norway

Among the most common causes of death we find overdoses, suicides, accidents and somatic causes such as liver diseases, due to Hepatitis C infection and AIDS (EMCDDA 2011). According to Statistics Norway though, there were only 9 deaths of problem drug users between 2006 and 2008 which had AIDS as the underlying cause of death (NR 2010). The incidence of HIV among injecting users in Norway has remained relatively low for many years with only 10-15 new cases per year (NR 2013). In addition, a 25-year follow-up study by Gjeruldsen et al., 2003, on drug addicts hospitalized for acute hepatitis, showed that drug addicts with Hepatitis die as often as non drug addicts with the same infection and that the difference between the two groups is attributable, almost exclusively, to overdose mortality and suicide by use of drugs. Deaths indirectly related to the use of drugs are not registered neither by Statistics Norway nor by Kripos (NR 2010) and are not included in this study.

Overdoses prevail over other causes of death among the heroin users (Darke and Hall, 2003; Toprak et al., 2009; Risser and Schneider, 1994; Farrell et al., 1996; Wood et al., 2003; Davidson et al., 2003; Warner and Smith et al., 2002; Preti et al., 2001). Literature about overdoses in Norway, also provides similar evidence. Andersen et al.,1996, found that poisoning fatalities account for 63% of the mortalities whereas, Eskild et al.,1993 concluded that 67% of the total number of drug related deaths are due to overdoses (NR 2005). In addition, two studies conducted by SIRUS showed the corresponding percentages to be 70% according to the former study and 82% according to the latter study. Other causes of death contributing to the high mortality and revealed by these two SIRUS studies, are included in the violent death category and are suicide, murder and accidents (NR 2006).

In Bergen there is a high number of fatal overdoses and also a relatively high number of women victims. After reaching a peak of 32 overdoses in 2000, the number of fatal overdoses has been stable since 2006. As shown in Figure 4 there has been an increasing trend since then, with 23 people dying due to overdose in 2010 (Utekontakten i Bergen, 2011). According to the same report, Oslo and Bergen had a similar fatal overdose rate in 2009 with between 8,7 to 8,8 fatal overdoses per 100000 inhabitants. The corresponding figures for Bergen in 2010 were around 11,3 per 100000 inhabitants. This is twice as many fatal overdoses as in Trondheim, the third largest city in Norway.

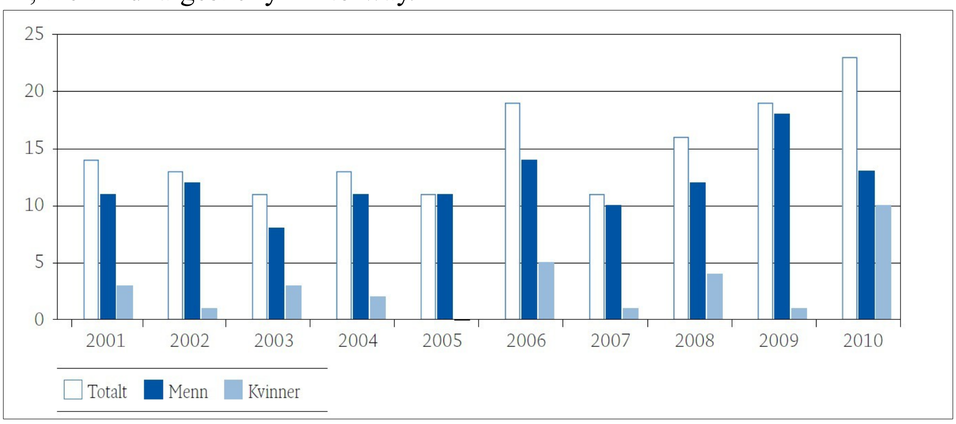

Figure 5: Number of fatal overdoses in Bergen divided by gender (Hordaland police)

There is an apparent consensus throughout literature about the factors which lead to overdoses, fatal and non fatal. The most important of them are the polydrug use, including alcohol (Darke and Hall, 2003; Kerr et al., 2005; Backmund et al., 1999; Darke et al., 1996; Cook et al., 1998; Grass and Sticht, 2001; New York City Department of Health and Mental Hygiene, 2011; Perret et al.,2000; Schmidt-Kittler and von Meyer, 2000; Risser and Schneider, 1994; Darke and Hall, 1995), the gender with respect to fatal overdose, since men are more susceptible to fatal overdoses than women (Darke and Hall, 2003; Darke and Zador, 1996; Steentoft et al.,1995, Simonsen et al., 2007), the route of administration (Darke and Hall, 2003; Kerr et al., 2005; Bretteville and Amundsen, 2010), the purity of heroin (Darke and Hall, 2003; Toprak et al., 2009;Darke et al., 1998) and the users' tolerance (Darke and Hall, 2003; Merrall et al., 2010; Farrell and Marsden, 2007; Shewan et al., 2000). In many of the Norwegian reports to the EMCDDA, based on research within the country, there are references to the same reasons as the causes of fatal overdoses (Ødegård et al., 2007; Ravndal and Amundsen, 2010; Clausen et al., 2009; Bretteville and Amundsen, 2010).

The majority of the heroin users go through certain stages during their addiction period and imprisonment is one of those stages. The proportion of imprisoned users though, depends both on the social conditions of the country and the users, and on the legislation of the country. However, I will include below some numbers from other countries along with Norway as an indication of the extent of the criminality problem among the users.

Since the majority of the users are unemployed, as mentioned above, it is of no surprise that they turn to criminal activities, often repeatedly, in order to finance their habit. In NR 2007 it is mentioned that, according to the Statistics Norway, from 17168 people convicted for property crimes 56% were convicted again within 5 years and 10% were reconvicted for a drug offence as the most serious crime. The results of a meta-analysis of 60 studies for the statistical association between drug misuse and crime (Bennett et al., 2008) showed that the odds of offending (property crime, theft, prostitution, crime, arrest, conviction, prison and shoplifting consist the list of crime measure of the studies the meta-analysis was based on) are between 3 and 3.5 times higher for heroin users than for non heroin users. By all means, it is not implied that every user has a criminal background. For example, a study conducted in England showed that in a sample of 1075 treatment clients, only 10% of those sampled was responsible for three-quarters of the 27000 acquisitive criminal offences committed during a three months period.

In Norway there is a remarkable increase in the drug related criminality (SSB, Kriminalitet og rettsvesen, 2009). Ødegård (2008) in his study, which included all Norwegian prisons, found that a percentage as high as 70% of the total inmates reported using drugs. Of them 25% reported injecting use of heroin which corresponds to 80% of the total number of heroin users in prison. As an indication of offending behavior, the majority of the users I interviewed, when I asked them if they are aware of other heroin users dealing drugs, answered that it is a common practice among the users in Bergen, to resort to dealing as a means to make some extra money to finance their habit.

There are various studies on deaths caused by overdose among heroin addicts after release from prison (Binswanger et al., 2007; Seaman et al., 1998;Farrell and Marsden, 2007, Seymour et. al., 2000; Darke et. al., 2000). According to Darke and Hall, the fact that the users in prison inject heroin less frequently than they normally do, leads to a substantial reduction of their tolerance to the drug. The high risk period is considered to be the first two weeks after release from prison. A meta-analysis of drug-related deaths soon after release from prison showed a 3 to 8 times increased risk the first two weeks after prison compared to the 3-12 week with "notable heterogeneity between countries" (Merrall et, al., 2010). In a study among former inmates in Washington the risk of death in the first two weeks after prison was 12.7 times the risk of deaths of other residents of the state (Binswanger et al., 2007).

A similar procedure to the one mentioned above, seems to be the cause for the elevated mortality rate reported right after OST. A study conducted by SIRUS for the evaluation of different kinds of treatment in Norway, showed that during OST, there was a reduction in street heroin use, corresponding to 69%. There are various studies (Gerra et al., 2004; Kakko et al., 2003; Yancovitz et al., 1991; Hartel et al., 1995), which also provide supportive evidence of the reduction in heroin use during OST, something that can further lead to the users' low tolerance. A national study conducted by Clausen et al.,2008 in Norway, showed that the post-treatment mortality rate was higher than both the pre-treatment and the during-treatment mortality rates (3.5 vs 2.4 and 1.4 respectively). Overdoses prevailed among the causes of death, both before and after OST.

It is interesting to note that, while the high mortality rate after OST and after prison seem to have the same causal factor (low tolerance due to limited use of drugs), the fatal overdose rate after prison is reported to be much higher than the one after OST. However, since there are no data about the after prison overdose rate in Norway, this comparison is between the post treatment mortality rate in Norway and the mortality rates after prison reported by research in other countries. One possible explanation for this difference might be that the users in OST, being free, are more able to be in contact with heroin while in treatment than the imprisoned users. Another possible explanation could be that, release from prison combined with a celebration mood, could lead to a greater intake of heroin and other drugs.

In the past, only few system dynamics models have been built in order to analyze drug related issues. L. Keith Gardiner and Raymond C. Shreckengost (System Dynamics Review, 1987) have built a system dynamics model for estimating heroin imports into the United States. JB Homer has built a model for the estimation of the national cocaine prevalence in the United States (System Dynamics Review, 1993). As far as I am aware of, there are no system dynamics models dedicated either to treatments or to mortality among heroin users.

2.2 Development of the heroin related policies in Bergen

Since the late 1960s' when drugs became a social problem in Norway, successive governments have always been against the legalization and decriminalization of all drugs. " The Government declared that the ambitious goal of a drug-free society would be firmly upheld, as a necessary expression of attitude towards drugs. The Storting confirmed its negative attitude towards legalization or decriminalization, while also stressing that greater emphasis must be given to prevention, and not least prevention carried out within the framework of NGOs (Innst. S.nr.40 (1998-99)." (NR 2001).

Although prevention oriented, policy makers in Norway realized already many years ago the need for harm reduction measures. In 1991 the first trial of substitution treatment was initiated, including only HIV positive users (NR 2001). Until then, the treatment system was abstinence oriented and was characterized by "an unwillingness to regard addiction as an illness" (NR 2010). The appearance of HIV was a decisive factor towards harm reduction policies (Wodak, 2009) both in Norway and in other countries. Substitution treatment with methadone officially started in 1998 and in 2001 buprenorphine (preferably with naloxone) was added to the program and has been steadily gaining ground since then. In 2012 only 44% of the patients in OST were treated with methadone while the rest 56% were under buprenorphine treatment (NR 2013). There are two main reasons contributing to this development. The first reason is that overdose fatalities happen more often among patients treated with methadone, than among those treated with buprenorphine. Secondly, it is easier for the users to shift from buprenorphine to methadone, if necessary, than vice versa (NR 2010). In Bergen there are seven OST clinics today with around 950 clients.

According to the same EMCDDA report (NR 2010), buprenorphine (in combination with naloxone) being the first choice in substitution treatment, is one of the deviations from the WHO guidelines about substitution treatment. There are two more deviations from the WHO guidelines. The second essential deviation is that substitution treatment in Norway is not the first choice of treatment, as it is in other countries, "unless it is the most appropriate and adequate treatment option based on a professional assessment". To conclude, there is one more deviation with respect to the doses of methadone and buprenorphine.

Since 2006, within the framework of a pilot project, the drug addicts arrested for drug offences can avoid imprisonment on the condition of joining a rehabilitation program. In Bergen, 17 people served alternative sentences in 2008. This policy appears to be successful, in the sense that it keeps some users out of prison by offering rehabilitation options and it was only a small minority among these people who re-offended. The time frame, however, for such an observation appears to be small.

One of the most promising developments of the present year, regarding fatal overdoses in Bergen, is the decision to start up a trial of distribution of naloxone spray. Naloxone is an opioid antagonist which can prevent fatal overdoses by reversing the effect of the opioid substance used by the addict. Such a policy, specifically targeting fatal overdoses, could have a positive impact against the overdose fatalities. The other recent development concerning heroin addicts is the decision to close down the biggest "heroin park" in Bergen, but such policies aim to improve the situation in the neighborhood and do not usually have any impact on the heroin problem itself. According to the police, when the same closing of the park happened in the 1980's "drug users simply spread into the city and then returned as soon as the police stepped down their activity" (The Local, June 4, 2014)

3 Research method

In order to test my hypothesis I used a system dynamics model. This approach has a number of attractive features: To begin with, it provides the potential to show average trends of the various and undisciplined behaviors of the users in order to gain a better understanding of the mechanisms which contribute to the high number of deaths. In addition it allows us to test, through simulations, the possible effects of a policy in the future. The first part of this chapter contains descriptions of the boundaries of the model and in the second part, the structure of the model is described.

3.1 Setting the model boundaries

The focus of this model is on the trends of the behaviors of the users, from recruitment to death and the time periods when the users are more susceptible to death in order for interventions against overdose deaths to be more effective. Thus, among the most important boundaries of this model is the users' recruitment. In some papers, the amount of new users is proportional to the availability of the drug (Gardiner and Shreckengost, 1987). Without violating common sense, it seems natural to assume that the users recruitment is also a result of the combination of two effects: the positive effect of the number of people who are users, since recruitment usually occurs within friendly environments and the negative effect of the reputation of heroin either by recognizing heroin users in the street or by being informed about the deadly outcomes of the drug through the media and school, friends or family. It is important to mention here, that the majority of the users I interviewed told me that it is a matter of principle to only sell the drugs to people who are already known to be users thus, they would not be part of new recruitment, at least not by selling drugs. The model described below, does not deal with the this issue and, in an equilibrium situation, has the recruitment of the users as an exogenous variable which is equal to the total outflows of model, attributable to death and quitting drugs.

Another important boundary is that the fractions of overdose and deaths from other causes, which are variables in the model that affect the mortality flows, are also exogenous. Because it is impossible to predict the personal behaviors of the users, I assume here that the users' practices, through a certain consumption of street heroin, in combination with polydrug use, their gender and the other causal factors of fatal overdoses and fatalities in general mentioned above, lead to these specific mortality fractions. Unless there are policies, aiming to eliminate the deaths, for instance OST treatment, the injection rooms in Oslo, or the distribution of naloxone spray, recently introduced in Bergen, we can only expect that the death rate among the users will be similar to previously reported death rates.

The same applies to the fraction of users who leave OST treatment, which is exogenous in the model and is based on data on the retention rate in OST, from the national Norwegian reports to EMCDDA. The focus of the model is on the increased risk of overdose after leaving treatment and not on the factors which lead to such a decision. Furthermore, the fraction of users who complete treatment is based on such data. The fraction of users arrested is also exogenous and again reveals the focus of the model on the users who are in prison and more specific, the users who are released from prison and have an increased risk of overdose.

3.2 Overview of the model

In order to understand the mechanisms responsible for the deaths, the model is in dynamic equilibrium, which means that despite the fact that the stocks remain unchanged, there are both inflows and outflows in the model. The model is relatively small, with six stocks describing the different phases the users go through, and one stock describing the SIH treatment policy. In order to achieve a better description, the model has been disaggregated below into four subsystems: recruitment, OST, prison and the SIH treatment which is the policy structure.

3.2.1 Recruitment

In an equilibrium situation, the recruitment of the users is equal to the total outflows of the model. As shown in Figure 6, the users are divided into new and experienced users. The model does not include an outflow for new users quitting heroin or starting OST at this point, because the majority of the injecting users look for help for their drug problem after a considerable time period spent "on the street". In the NR 2013, it is mentioned that, only 2.5% of the total users in OST are in the age group 21-25. In addition, in NR 2005 it is reported that the average age of the first injection has shifted from 15.8 years in the 1970s to 25.1 years, whereas the average age of clients in OST, as reported in the status survey of 2012 (NR 2013), was around 42 years. It is also assumed here that the majority of the users will not quit injecting use of heroin by themselves, due to the addictive nature of the drug.

Another reason for the subdivision of the users into New and Experienced, is that the causal factors of the fatalities mentioned in chapter 2.1 affect more the experienced users. Thus, the only outflow from the New Users stock, is the total death rate for New Users, which is responsible for around one third of the total number of deaths (NR 2013).

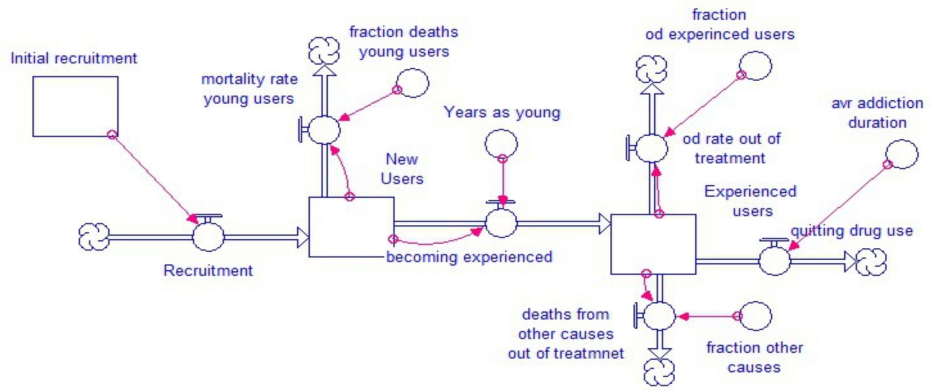

Figure 6: Stock and flow diagram for recruitment

The total death rate depends on the number of users in the New users stock multiplied by the fraction of these users dying each year. After spending 10 years, on average as New Users, the heroin addicts move to the Experienced Users stock. There are three outflows from the Experienced users stock as shown in Figure 6: one is the overdose rate, given by the number of Experienced Users in the stock multiplied by the fraction of overdose deaths, the other is the deaths from other causes and the last one is the quitting drug use flow. The fraction of overdose deaths in the model is set to 0.01 as it is assumed that 70% of the total deaths (0.03) are overdoses.

In NR 2006 it is mentioned that there are only few users over the age of 60. In the model, the average addiction duration is 20 years after the users have entered the Experienced Users stock, thus, the users would quit drug use in their mid 50s. The quitting drug use flow is given by the following equation:

quitting drug use = Experienced__users/avr_addiction_duration

The rest of the outflows from the Experienced Users stock are not shown in Figure 6 but are explicitly illustrated in the following descriptions of the model structures.

As stated previously in chapter 2.1, there is a considerable number of methadone related deaths. Since, the majority of these deaths do not happen within OST, there might be a leakage of methadone from OST, though such data were not found. In the model there could be a causal relationship between the number of users in OST and the leakage of methadone which has an effect on the mortality rate outside of treatment, either it is the experienced or new users who die from methadone overdose. Since the data were insufficient to justify such a causal relationship, I preferred not to include it in the model. These deaths in the model, are included in the mortality rate of young users and in the overdose rate from the Experienced Users stock.

3.2.2 The OST structure

The reason for OST being chosen over other kinds of treatment, is that OST attracts a larger number of users compared to other kinds of treatment available in Bergen. The stock and flow structure of the users starting and leaving OST is shown in Figure 7. The users' flow into OST depends on the number of the experienced users, the OST capacity, and the total number of people leaving OST willingly, by being discharged or by dying.

The following flow equation allows users to start OST:

starting OST = MIN(Experienced__users,(OST__capacity-OST_patients)/0.1+total_OST__outflow)

where total OST outflow is an auxiliary variable including the sum of the three outflows from the OST stock as illustrated in Figure 7 and 0.1 is the time period for the OST administration to deal with the new clients issue. It is assumed here that all the experienced users are willing to become OST clients.

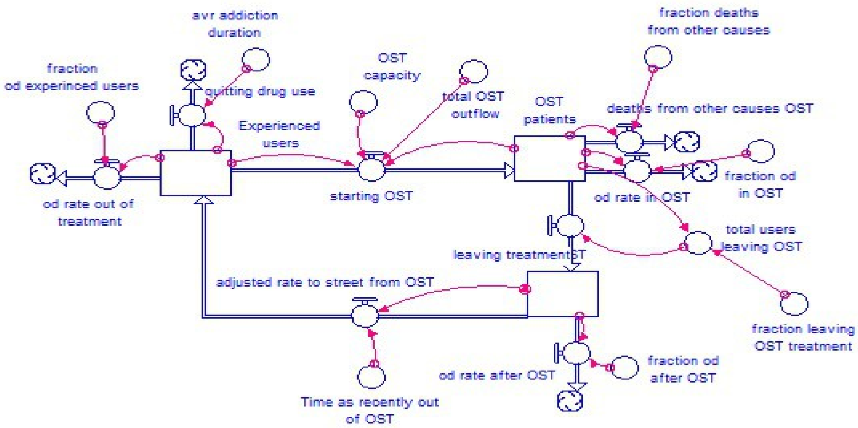

Figure 7: OST structure Stocks and Flows

This assumption is a result of the rapid expansion of OST capacity, the fact that OST always works at full capacity and the existence of waiting lists for OST. Furthermore, in NR 2012 it is reported that 9 out of ten users were in OST in the end of 2011. The gap in OST created in the model by the lack of New Users, is further filled, for all practical purposes, by the assumption that all the experienced users are willing to start treatment.

In the model the OST capacity is stable at 800 clients. The last official data from "Føre Var" (2012) state that the capacity of OST was 591 in 2010 and 728 in 2011.The capacity of OST today has been recently reported to be around 1000 clients (Torheim,Bergens Tidende, May 30, 2014). In the model there is a stable capacity of 800 people, chosen as an average number during the simulation years.

Due to a lack of computer-based registrations which allow observations on the time spent in treatment by each user, it is difficult to make assumptions about the duration of treatment. In NR 2004 the average duration is reported to be 450 days for buprenorphine patients and 862,5 days for methadone patients. There were no further references on this issue in the following reports to the EMCDDA and it was not mentioned whether the users leave treatment as cured or not. This means that in the model some people may stay in the OST stock for an unrealistically long period. However, it is more important for the purposes of this thesis to follow the distribution of users between the different stocks and the users who go through the high risk stocks every year. The quitting drug use outflow, from the Experienced Users stock is the only way for the users to be cured in the model during the 15-year simulation period.

The Norwegian data about the retention rate in OST showed very good results compared to the majority of the countries. Data from the whole country show that the retention rate in OST is around 0.92% per year. According to NR 2010, the retention rate is calculated through the annual surveys from OST, by measuring the total number of clients in the end of the year, in relation to the number of clients in the beginning of the year and the number of new admissions that particular year. In the model the fraction leaving OST is 0.08 according to the data, although the kind of measurement mentioned above does not include some patients leaving treatment before and after the survey is conducted.

As shown in Figure 7, there are three death flows related to the OST structure. The overdoses while the users are in treatment, the deaths from other causes in OST and the fatal overdose rate after OST. The two death rates in OST, are subdivided because there is a considerably low overdose rate in OST, while most of the users who die during treatment have somatic causes as the underlying cause of death. According to the NR 2012, the total death rate in OST is, 1.4, with only 27% of the total number of deaths caused by overdoses.

Due to the fact that the time unit in the model is years and in order to allow a realistic accumulation of users in the After OST stock, the users stay in the After OST stock for around 2,5 months with an increased mortality rate of 0.5 which applies for the whole year and creates, in equilibrium situation, a death rate of 6 people per year. If the retention rate is somewhat higher than 0.08 mentioned above, and the mortality rate post treatment is between 3.5% (NR 2012) and 8.2% (Zanis and Woody,1998) then the death rate per year produced by the model is quite realistic. In this stock the users have a lower than usually tolerance for heroin which leads to a higher fraction of fatal overdoses. No data were found about the time needed to develop such a low tolerance. However, given the fact that withdrawal symptoms from heroin can begin 6 to 12 hours after the last dose, we can assume that it does not take a long time for the users' tolerance to decrease. This structure describes the double impact of OST on the fatal overdose rate, which is positive on the one hand, for the users who stay in treatment, negative, on the other hand, for those who decide to quit.

3.2.3 The prison structure

Although in Bergen and Oslo there is a chance (under certain circumstances) for dependent users to serve their sentences within a treatment institution and based on Ødegård's report (2008), there is still a considerable number of injecting users in the prisons of the country. The structural components of the imprisonment part of the model, are illustrated in Figure 8.

The process described by this structure is similar to the OST structure described above in chapter 3.2.2. A fraction of users with either more serious or repeated offending behavior is not punished by fines as is common practice in Norway, but with imprisonment instead. The value of the average time spent in prison is difficult to determine due to the fact that the judges in Norway seem to evaluate each case separately, using their discretionary power.

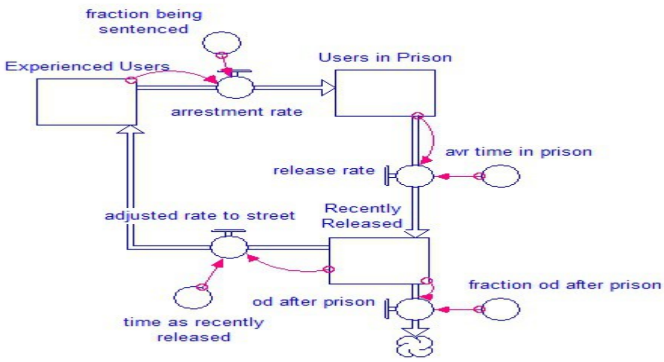

Figure 8: Prison stock and flow diagram

The offences the majority of the users commit (Snertingdal, 2010), are "punished pursuant to the Act relating to Medicinal Products (Act No 132 of 4 December 1992) Section 24, which provides for a maximum sentence of up to two years' imprisonment" (NR 2013). One of the users I interviewed had recently been sentenced to serve 2,5 years in prison and this also indicative of prison related practices in Bergen. In the model this value of the time spent in prison is set to one year, as an average between some months and 2 years spent in prison.

It is assumed here that only the experienced users spend time in prison. Although this is not a realistic assumption it serves the simplicity purposes of the model. In order to avoid 6 additional flows (in and out of prison and through the Recently Released stock, for both the New Users and the OST patients), I decided to have an increased arrest rate from the Experienced Users stock which would create in the model the same number of imprisoned users as there would be if the Users in Prison were arrested from all the three stocks. Thus, in the model, the fraction of the Experienced users being sentenced is set to 0.5, which results in 50 people per year serving sentences in prison. According to Ødegård's study (2008), and given the prison capacity in Bergen, this is a realistic number.

After having served their sentence, the users go through the Recently Released stock back to the street. A higher mortality rate, due to low tolerance, is applied here, than in the After OST stock (see chapter 3.2.2). I have set the mortality rate to 0.9 in the model which gives a total of 8 overdose deaths per year among the recently released users. Based on a meta-analysis (Merrall et al., 2010) the risk of drug related deaths increases from 3 to 8 times the first weeks after release from prison. This result adjusted to the mortality rate and the number of people released from prison gives us approximately 8 people per year. The structure of the model as illustrated above, shows that the more users are imprisoned, the more users will have to go through the high risk Recently Released stock.

3.2.4 The SIH treatment structure

The SIH treatment was proposed by the Haukeland University Hospital in Bergen as a solution to the problem of the high mortality rate among the heroin users of the city. This policy is applied in the model as shown in Figure 9. The SIH treatment is a policy with a limited target group of users. This group consists of experienced users, who have failed with other kinds of treatment and are deemed to be untreatable. Such users in the model would be the ones who leave OST treatment, but instead of going to the high risk After OST stock, a fraction of them is transferred to the SIHT stock.

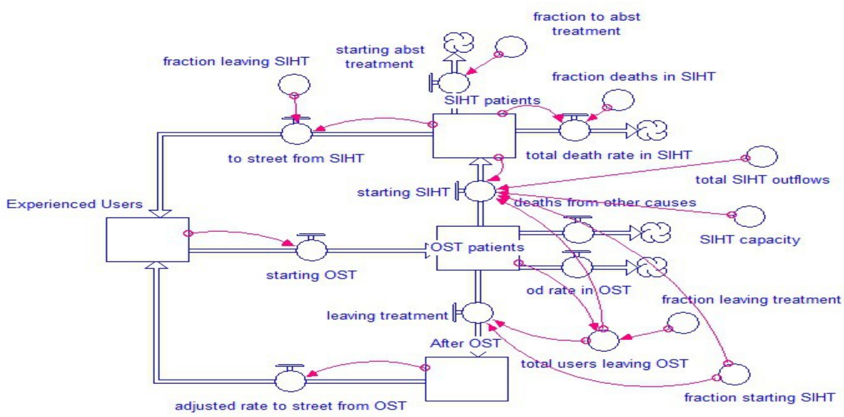

Figure 9: The SIH treatment (SIHT) structrure

The starting SIHT flow in the model is a rate resulting by the following equation:

starting SIHT= MIN(total_users_leaving_OST*fraction_starting_SIHT,(SIHT_capacity-SIHT_patients)/0.1+total_SIHT_outflows)

Thus, the recruitment of the users to the policy stock, depends on the users leaving OST, the fraction of them we choose to recruit, and the capacity of the clinic adjusted to people who quit or may die each year. 0.1 is the time needed to for new people to be recruited. According to the EMCDDA report (2012) on the insights about heroin assisted treatment (Strang et al.,2012), the capacity of such clinics vary from, on average 30-65 clients in the 6 European countries and Canada, where such clinics exist. Some sensitivity analysis tests on the capacity of the clinic, are included below, in the policy analysis chapter.

Moreover, the leaving treatment flow to the After OST stock is given by the equation:
leaving treatment = total_users_leaving_OST*(1-fraction_starting_SIHT)

In the model, the fraction starting SIHT is 0 until 2014 and in 2015 impact of the policy is tested.
There are three outflows from the policy stock: one death rate flow which, adjusted to the death causes shown in the rest of the model is set to 0.005, one of SIHT clients going back to the street and one of SIHT clients going to abstinence treatment. I considered the results from Switzerland to be more representative of the impact of SIHT policy since, in contrast with results from other countries, the Swiss results cover a six year period (1996-2000). The Swiss experience showed that the majority of deaths in SIHT happened due to AIDS (Rehm et al.,2005). In Norway the prevalence of AIDS among injecting users is very low and since other causes of death such as cancer are not included in the "deaths from other causes" the fraction of people dying in SIHT, set to 0.005 is quite representative. The mortality rate from other countries, is equally low (Strang et al.,2012) and fatal overdoses is a rare phenomenon in SIHT. In addition,

The retention rate in SIHT was observed to be on average 70% per year (EMCDDA, 2012). Relevant research has revealed a higher retention rate for clients in SIHT that for clients in OST. If that is the case, then the retention rate among SIHT clients in Norway would be more than 92% which is the retention rate in OST. In the model the fraction leaving SIHT is set to 0.08% of the total number of clients, which is the same as in OST.

To conclude, in the SIH treatment structure, there is also one outflow to abstinence treatment. Only the Swiss experience was long enough, to reveal such a behavior. It is, however a very interesting response of the users to shift to abstinence treatment after their experience with SIHT. In the model this fraction is set to 10% per year as an average of the results from the Swiss results (Rehm et al.,2005). The model does not include an abstinence oriented treatment sector. If it would, there would also be an after treatment high risk stock, but again these users could be further absorbed by SIHT in order to avoid this high risk stock. The sensitivity analysis I conducted on the impact of the policy on the fatal overdoses, as shown below in chapter 5.1, includes simulations with and without this outflow to abstinence oriented treatment. The structure, as shown in Figure 9, clearly illustrates that the clients of SIH treatment will not have to go through the 2 high risk stocks. With a high retention rate and a low overall death rate the SIHT clients are considerably less likely to die, especially from fatal overdoses.

4 Findings

The validation and verification part of the model is a very important part of the modeling process in order to ensure that the model meets the specified requirements and the targets set in the beginning of the process. In addition, sensitivity analysis is equally important as a means of revealing to which variables the model is most sensitive thus, which variables considerably change its behavior. The first part of this chapter contains a description of the validation process of the model as well as some of the most important results of the sensitivity analysis and observations. In the second part, there is a description of the findings through simulation graphs of the model behavior and some discussion about them.

4.1 Validation of the model

Since the model is small and based on simple equations, the validation process was taking place during the building process of the model. In addition, the model corresponds to the description of the problem mentioned above. The loops the users go through, are based on research results and despite the fact that the model deals with the personal decisions of the users, it captures the dominant trends among them. Moreover, the stock and flow structures serve the purpose of this model; to show which users are more susceptible to death and provide a basis for interventions such as the SIH treatment. The equations are dimensionally consistent and all the parameters used have a real world meaning.

I have also conducted some extreme conditions tests which showed that the model is robust in such conditions. For example, when there are no users, all the stock and flows of the model are equal to 0.

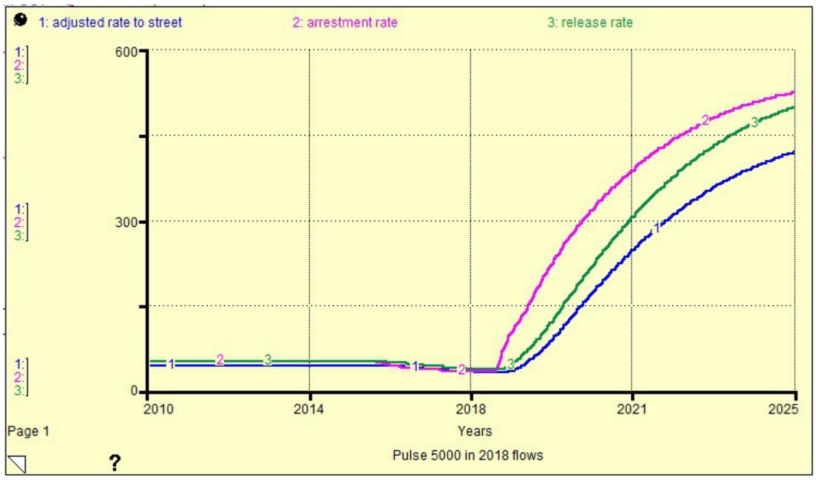

Figure 10: Model response to a pulse of 5000 new users in 2018, during the validation process

When I introduced a pulse of the unrealistic number of 5000 new users in 2018 the model reacted as expected, with an increase in the stocks and flows as shown in figure 10.
To conclude, a detailed documentation of each variable of the model is provided in the APPENDIX.

4.1.2 Model sensitivity to some parameters

It is very important to test the sensitivity of the model to some important parameters or some parameters with questionable values. In order to achieve this goal I conducted some sensitivity analysis tests.
One parameter the model is sensitive to, is the retention rate in OST. Retention rate per year is the number of users staying in treatment during that year and in the model this number is determined by the fraction leaving

OST per year. The data about Norway give a notably higher retention rate than the one reported in the literature. For example, according to Fischer et al, 2002, "Treatment study reviews suggest that 30–70% of subjects leave methadone treatment within the first 12–24 months, and many resist methadone treatment altogether". Due to the fact that no data about the retention rate in Bergen's clinics were found, the initial value of 0.08 is taken from the Norwegian reports to EMCDDA and is about the country as whole.
I run four simulations of the model with the fraction leaving treatment set from 0.08(initial parameter value) to 0.35 which is a relatively low average of the retention rates reported from other countries. The values were 0.08 for the first simulation and 0.17, 0.26 and 0.35 for the following. There is a marked increase in the total number of overdose fatalities after every simulation. The results are shown in Figure 11.

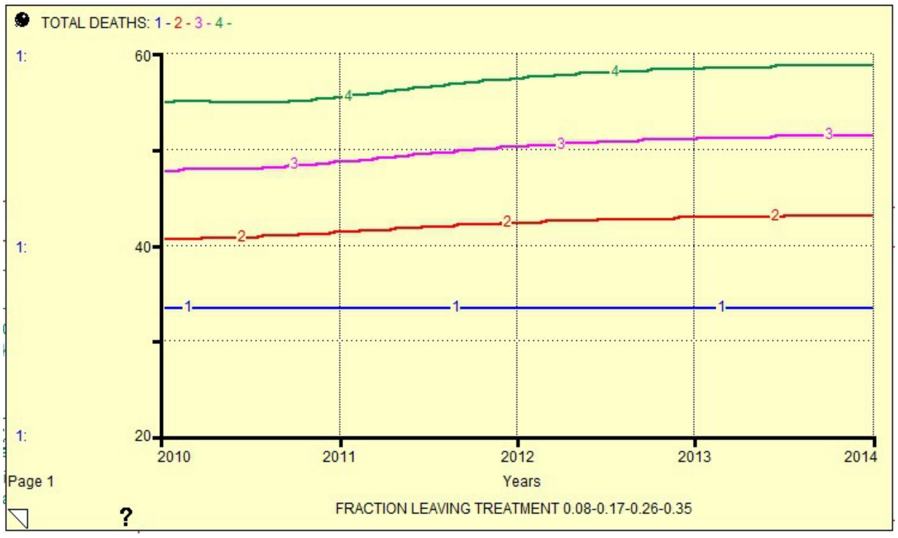

Figure 11: Change in the number of total overdose deaths during sensitivity analysis

Fraction leaving treatment: 1- 0.08, 2- 0.17, 3- 0.26, 4- 0.35

The main reason for such an increase is the number of people in the After OST stock. Figure 12 illustrates the differences between the four simulations.

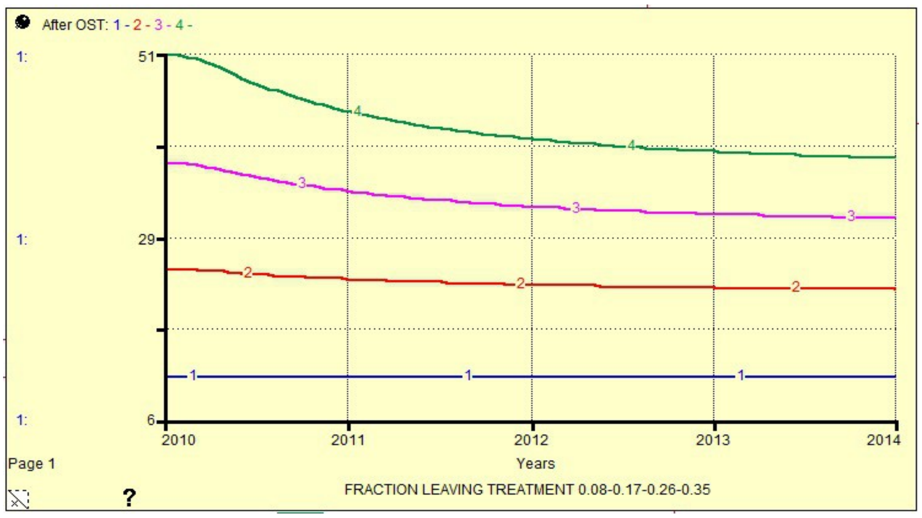

Figure 12:Accumulation of users in the After OST stock, sensitivity analysis

Fraction leaving treatment: 1- 0.08, 2- 0.17, 3- 0.26, 4- 0.35

Another variable the model is, as expected, sensitive to, is the OST capacity. I set the value from 200 people (first simulation) to 1000 people (last simulation) and the results of the total overdose rate are shown in Figure 13.

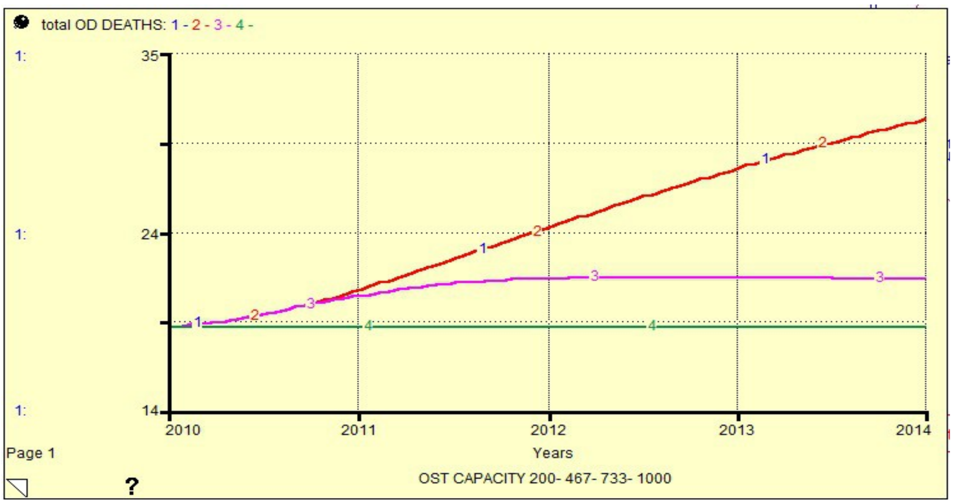

Figure 13: Total number of overdose fatalities, sensitivity analysis.

OST capicity : 1- 200 2- 467 3- 733 4- 1000

As shown in Figure 13 and as it has been proven in practice, the contribution of OST in reducing the number of deaths among the injecting heroin users is essential. Without the OST there would be an accumulation of experienced users without any kind of treatment, since for many of them, the abstinence oriented treatment is a difficult option and they have already failed with it, often more than once.

Another variable which the model was sensitive to, as regards the overdose deaths, was the fraction of people being sentenced. The results are illustrated in Figure 14.

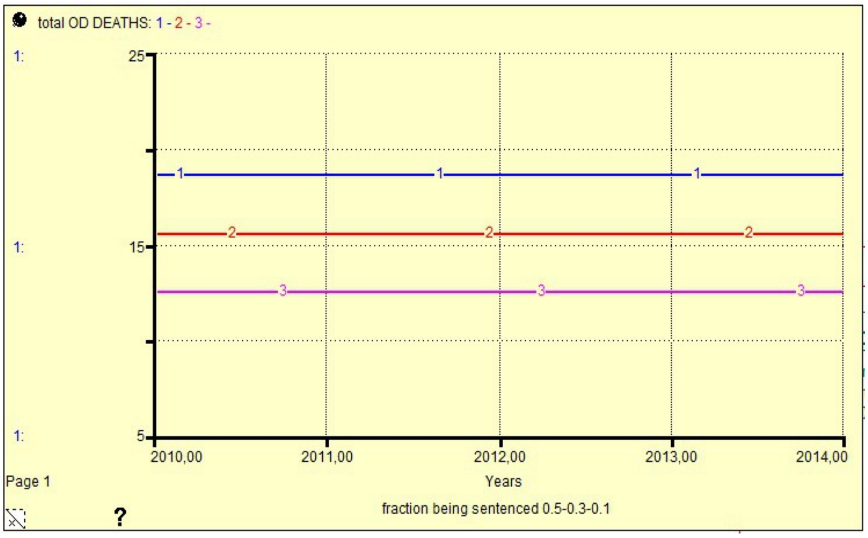

Figure 14: Total number of overdose fatalities, sensitivity analysis

Fraction being sentenced 1-0.5 2-0.3 3-0.1

4.2 Model behavior

The model was able to regenerate the historical data quite well. The total number of the injecting users in Bergen, is estimated to be stable and around 1500 people. Of them, and according to the Føre Var report (2012) around 130 people primarily inject amphetamine and/or methamphetamine. These people are not of interest for this thesis because the treatments the model deals with, have nothing to offer to people addicted to amphetamine and methamphetamine. The model gives a number of 1537 people which is higher than the 1370 heroin users estimated in Bergen, according to the information mentioned above. On the other hand, it is often the case that the users inject these drugs and heroin as well, so they are absorbed by OST. In addition, underestimations about the number of drug users is a usual phenomenon due to the illegal nature of the drugs. Although, different social services are likely to be familiar with the experienced users, there is a "hidden" population of new users with small possibilities to be known by such services and clinics. The results of the simulation and comparison with the historical data are seen in Figure 15.

Figure 15: Total number of injecting users, comparison of the model results with the historical data

The last few years the average number of drug related deaths in Bergen was 44 (Bergens Tidende). However, based on the data from SIRUS and Statistics Norway about the percentage of deaths, broken down by substance, as shown in chapter 2.1 (Figure 3), 80% of these deaths are attributable to opioids. That would give us an average of 35 opioid related deaths per year. As shown in Figure 16, the model matches the data by producing 33 opioid related deaths per year.

Figure 16: Total number of deaths, comparison of the model results with the historical data

Recent data about the number of fatal overdoses in Bergen due to opioids specifically, were difficult to obtain. The data I used in the model, were an average of the overdose deaths between the years 2010 and 2012. In 2010 and 2011 there were 23, per year, fatal overdoses in Bergen and 15 during the first half of 2012 (Utekontakten i Bergen, Figure 5- ch.2.1, Bergensklinikkene). The simulation results in comparison to the historical data are illustrated in Figure 17.

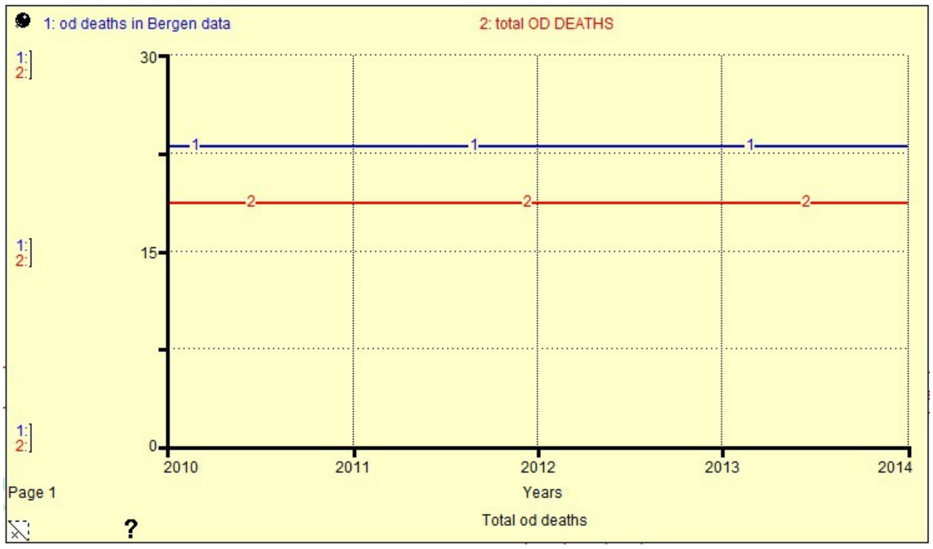

Figure 17: Total number of overdose deaths, comparison of the model results with the historical data

The data shown in Figure 17 are not further elaborated in order to show only the opioid related overdoses because no such data about Bergen were found. However, if we multiply the total of 35 opioid related deaths by 0.7 which, according to the literature about Norway, is an approximation of the number of the overdose deaths among the total number of drug related deaths, we would get 25 opioid related fatal overdoses. The data about Bergen show a total of 23 drug related fatal overdoses. Thus either it is the case that, in Bergen, some overdoses are considered suicides (according to literature it is difficult to differentiate between the two causes of death, see also Farrell et al.,1996) or the vast majority of the fatal overdoses in Bergen are attributable to opioids.

The model shows 19 deaths due to opioid overdose per year. However, there is no separate overdose outflow from the New Users stock but a total mortality rate per year instead. If we apply the percentage of fatal overdoses to the mortality rate of the New User, we will get 4 additional fatal overdoses per year which would give us 23 fatal overdoses. The reason for not having a separate overdose rate among the new users is that, the majority of these users, still feeling healthy and like they can control their problem (see also Hausser et al.,1999), they do not ask for help, thus interventions at this point although important, would probably be of little value.

Figure 18 shows the overdose rates from each stock. The model shows that the majority of the fatal overdoses happens after leaving OST and after getting released from prison with 6 and 8 overdoses deaths per year respectively. The results show that the two loops the users go through, one through prison and one through OST, are responsible for around 74% of the total number of fatal overdoses among the experienced users, 61% of the total number of fatal overdoses and 42% of the total number of drug related deaths.

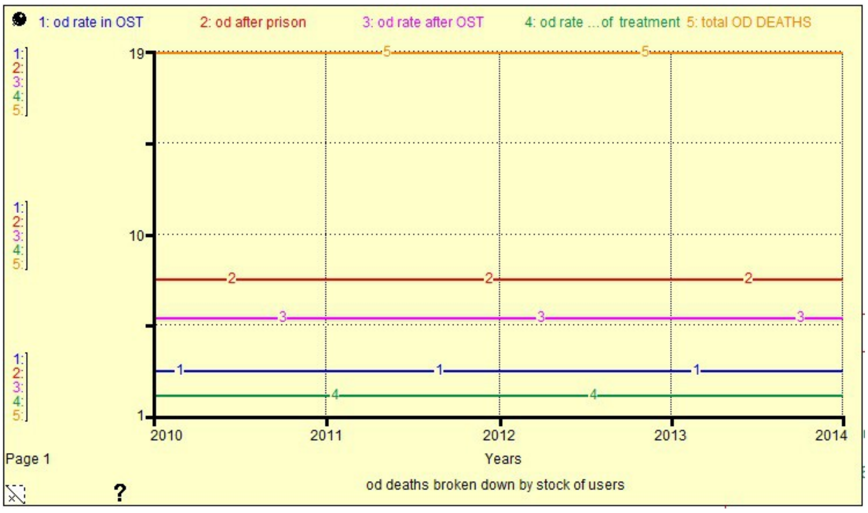

Figure 18: fatal overdose rates broken down by stock of users

4.2.1 Observations

The model, replicates quite well the historical data with around 167 additional users. The data from Bergen give a mortality rate of around 2.6% per year, whereas the model produces a lower death rate than expected of around 2.14% of the total number of injecting users per year. This deviation might derive from some differences between the Norwegian data and the data based on research from other countries. In Norway there are more data about the injecting users as whole whereas the majority of the studies I used are dedicated to heroin abuse. In addition, as described above, some of the data used in the model are not about Bergen in particular, but about Norway as whole. Thus, a smaller retention rate in Bergen's OST could easily result in a higher mortality rate in the model as shown in the sensitivity analysis chapter (4.1.2) above. Furthermore, the overdose rates I used for the two low tolerance stocks, Recently Released and After OST, were low averages of the numbers mentioned in different studies. The uncertainty of the data based on statistical information could further explain such deviations.

Another important observation about the model is that, if there are no experienced users outside of OST, there will be no imprisoned users. What we know is that people enrolled in OST and new users, also serve sentences in prison. However the treatment which, essentially reduced the criminal activity among the users, is SIH, since pure heroin is provided to them and they do not need to resort to criminal activities in order to buy it. This means that, unlike the other stocks in model, the majority of SIHT clients would not be part of the imprisonment loop as shown in the model.

According to Torheim (Bergens Tidende, May 30, 2014), in 2012 there were 18 fatal overdoses in Hordaland with methadone as the underlying cause of death. There are not any data yet, about whether these people were enrolled in OST or not. The results from previous years suggest that in the majority of methadone-related deaths, the users were not enrolled in OST (NR 2012). A study in New South Wales, Australia (Darke et al., 2009) showed that methadone cases were significantly more likely to be diagnosed with pre-existing systemic pathology such as cardiac, pulmonary, hepatic and renal disease and multiple organ system pathology. According to the same study there are good reasons to believe that systemic disease plays an an important role in fatal opioid overdose cases.

The model does not include separate fractions for methadone and heroin related overdoses. Due to the polydrug use and the different kinds of systemic diseases the users might suffer, it is difficult to predict or categorize such deaths. However, this observation does not negate the fact that such deaths are more likely to happen among experienced users going through the high risk stocks as shown in the model. It does underline, though, the possibility of leakage of methadone from OST. Such phenomena can be prevented to a certain degree by reducing as much as possible the take away doses and informing the users, even those not enrolled in OST, about the dangers of methadone. The contribution of OST has long been proven and arguments about the deaths caused by methadone cannot obscure the fact that the majority of the users benefit from OST.

At this point, it is important to mention that despite the fact that there is research evidence about the relationship between the combination methadone- benzodiazepine and respiratory depression (Lintzeris et al., 2006, 2007; Darke et al.,2009), it seems to be the case in Norway that around one third of the total number of OST patients, are being prescribed benzodiazepines by a doctor (NR 2013). Although, it is not mentioned in the report whether benzodiazepines are prescribed to methadone or buprenorphine patients, a simultaneous leakage of methadone and benzodiazepines in the black market could contribute to such a high number of methadone related overdoses.

To conclude, the model does not include the residential (abstinence oriented) treatment. In Norway there are around 1900 in-patient places for people with alcohol and drug problems. The lack of data about the patients in residential treatment for Norway and Bergen in particular, did not allow for inclusion in the model. It is a fact though, that among the heroin users, those who choose abstinence oriented treatment are a minority. This kind of treatment would be of interest for this paper since the retention rate in treatment is connected to a higher fatal overdose rate after leaving treatment.

5 Policy analysis

The first part of this chapter contains the results of the simulations of the impact of the SIH treatment on the fatal overdoses and the total number of deaths, as well as some sensitivity analysis results regarding this policy. In the second part, the most important aspects of this policy are discussed, as experienced by countries which have already implemented SIHT or have run trials in order to test its effects. Further discussion about the policy and some implementation issues are also included in the second part of this chapter.

5.1 Testing the policy in the model

The model described above constitutes the bases for testing the SIH treatment's impact on the fatal overdoses in Bergen. This policy works as follows: a certain fraction of experienced users who have failed with OST, are being offered the chance to be part of a supervised, self- administration of heroin system at a clinic. The number of people to be part of SIH treatment as well as additional acceptance criteria are at the discretion of the administration, however, some sensitivity analysis tests were conducted in the model and the results are discussed below.

Of the people leaving OST per year (0.08% of the number of people in OST) a certain fraction is transferred into SIHT depending on the desirable capacity of the clinic. It is common practice among the countries where SIHT is implemented, to recruit users who have failed with OST at least twice. In the model however, the only admission criteria applied is to be along term user and to have failed with OST once. The simulation period for the policy is from 2015 to 2025. Figure 19 illustrates the impact of SIHT on overdose deaths among long term users, with different clinic capacities from 30 to 60 clients.

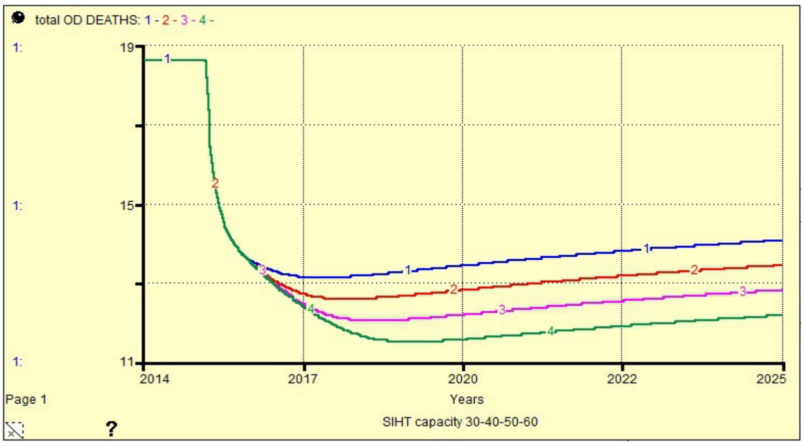

Figure 19: Policy impact on overdose deaths, sensitivity analysis

SIHT capacity : 1-30 2-40 3-50 4-60

The model showed that SIHT policy could contribute to a decrease in the overdose deaths equivalent to, between 26% and 37% per year, thus between 5 and 7 fewer overdose deaths per year, depending on the clinic capacity. This would be a very conservative approximation since in the model, clients are recruited into SIHT under the sole condition of being experienced users and quitting OST. In the model 30 additional clients in SIHT result in only 2 fewer overdose deaths. In practice however, people responsible for the selection of users to start SIHT, can use more sophisticated criteria such as the duration of use and the other risk factors for overdose fatalities, as were stated previously in chapter 2.1.

The results shown in Figure 19, require that a fraction of 10% of the total clients in SIHT would leave heroin assisted treatment to start with abstinence oriented treatment. This behavior was observed in Switzerland, where the SIHT exists long enough for these kind of observations. When I simulated the model, setting the fraction to abstinence oriented treatment to 0 the corresponding decrease in the overdose fatalities was between 21% and 26%. However, a better a selection of SIHT clients, as mentioned above, could still result in a further decrease.

In the model, the reduction in the number of deaths is mostly attributable to the OST loop, "cut" by the SIHT policy. Regardless the SIHT capacity, the model shows that if people who leave OST are recruited in SIHT there will be a considerable reduction in the number of overdose deaths from the After OST stock, as shown in Figure 20.

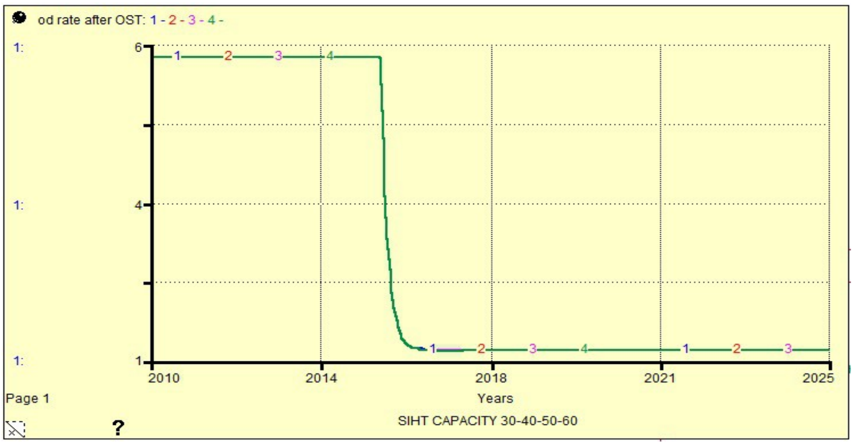

Figure 20: Impact of SIHT policy on overdose deaths after leaving OST

There is also a small reduction in the fatal overdose rate after prison but, as mentioned above in chapter 4.2.1, the structure of the model, with users being imprisoned only from the Experienced Users stock, does not allow this part of the model to be sensitive to the policy. In addition, two of the clinics in Europe are inside prison (Strang et al.,2012) and such a policy, would lead to greater reductions in the fatal overdose rates from the Recently Released stock of users.

5.2 The experience of SIHT from other countries

Ernest Drucker quoted the American baseball player Yogi Berra when referring to the history of medically controlled prescription of injectable heroin: "It’s déjà vu all over again". According to Strang et al.,2012 EMCDDA report, for a brief period in the early 1900s there where clinics in 12 states in the United Stated, which legally provided opiates to addicts. The Harrison Narcotic Act, passed in 1914, restricted the capability for doctors to prescribe such drugs and by 1919 such practices were officially illegal. In 1926, the Rolleston Report gave the guidance for prescription of morphine and heroin to addicts. These drugs could be prescribed to people with serious withdrawal symptoms and to people for whom such drugs were necessary in order for them to be functional and live a "normal" life. The gradual reduction method, when possible, was recommended to the doctors. By the 1970s, the responsibility of prescribing heroin and morphine, was transferred to drug clinics in order to avoid private doctors' malpractices. The limited prescription of heroin and morphine and to a limited number of patients has continued until today, but the British model did not include supervision of the users, like the model developed in Switzerland.

In the mid 1990s, Professor Ambros Uchtenhagen and colleagues concluded that the British model could be improved and implemented in Switzerland. This improvement refers to the strict supervision of a limited number of treatment -resistant users, while injecting heroin into special clinics. After the positive results, in terms of health and social well being of users from the Swiss trial became known, other countries also begun trials on the Swiss model. Today Germany, the Netherlands, Denmark and the United Kingdom have granted approval for SIHT, whereas Spain, Canada have not been able to implement SIHT despite the fact that the results from their trials are deemed to be positive. In addition, Belgium has recently started a trial of SIHT (Strang et al.,2012).

The positive effects of SIH treatment, as regards the high mortality rate among the opioid users, can be separated into to broad categories, the direct and indirect effects. The most important direct effect of this policy, is that the users most susceptible to fatal overdoses are being supervised while injecting. According to Darke and Zador (1996) instant death after an overdose is a rare phenomenon and in the majority of the cases, an interval greater than 2 hours between overdose and death, is reported. This is a time period long enough for interventions by the specialized teams in a SIHT clinic. Among the trials of SIHT, fatal overdoses were rare. Furthermore, another important effect was the reduction of “street” heroin use as reported by Strang et al., 2010. In addition, in SIHT, there are no fluctuations in the purity which, according both to literature (Darke et al.,1999) and to the interviews I conducted, such fluctuations also play a role in the overdoses, fatal and non fatal.

As shown in the model, the SIH treatment interferes into one of the most dangerous for fatal overdoses loops the users go through. By absorbing long term users soon after they have quit OST, the users do not have to go back to the “street” with low tolerance but they are being offered some kind of protection into SIHT instead. To conclude with the direct effects, injecting into the clinic prevents needle sharing between these users and the street users which can also help in the direction of limiting the spreading of Hepatitis and other infections which are common among the users in Bergen.

The most important indirect effect, regarding the fatal overdoses, is the remarkable reduction in the criminal activities noticed during the trials. The proportion of users reported income from illegal activities in Switzerland, declined from 69% to 10% (Strang et al.,2012 EMCDDA). Thus, the majority of people recruited in SIHT, will not have to go through the high risk Recently Released stock, as shown in the model. A SIHT clinic into a prison or a recruitment in SIHT of recently released users, could further contribute to a reduction in overdose fatalities.

Another important finding from the Swiss trial, is that some users became interested in abstinence oriented treatment. According to Rehm et al., 2001, during a 3 year period, 29% of SIHT clients in Switzerland left SIHT for abstinence oriented treatment. This behavior is revealing of the treatment having a positive impact on the mental and psychological situation in order to take such a decision despite the fact that heroin is being "offered" to them.

On the other hand, compared to OST, more serious adverse events (SAEs) seems to happen within SIH treatment. The definition of SAE according to Strang et al.,2012 is "an unanticipated problem involving 'risk' to participants that ultimately results in harm to the participant (impacts on the participant's morbidity and mortality) (e.g. unanticipated 'risk' requiring hospitalization or prolongation of existing hospital stay) or to others. Many of the SAEs reported were overdoses and required treatment with opioid antagonists.

5.3 Discussion on the policy

Since SIHT is a relatively new treatment, the results of it can been seen either through trials or through the longer Swiss experience. In most of the trials the SIHT clients were compared to OST clients. One common characteristic among the practices during the trials is that there are no take away doses. This way leakage of heroin from SIHT became impossible. However, the design of SIHT trials varies across the countries. In the Swiss trials, for example, some clinics provided heroin along with methadone whereas in other trials the users were encouraged to take methadone if the weren't able to attend SIHT (Strang et al.,2012)

I will mention here some common characteristics of the outcomes of different trials that were also statistically significant (for a more detailed description of the findings, also see Strang et al.,2012). To begin with, the mental and physical status of the users was improved along with the family relationships and social reintegration. Furthermore, among the most important findings, as stated previously, is the reduction in criminal activity compared to OST clients. The fact that users with the most problematic behaviors enter this treatment add value to the outcomes when compared to OST clients.

The SIHT treatment was found to be cost effective compared to OST. The cost per patient per year was estimated to be EUR 12700- 14500 depending on the clinic capacity (Switzerland), EUR 19000 (Germany) and EUR 20400 (Netherlands). The costs of SIHT were found to be much higher than the costs of OST. This difference mostly derives from the staffing costs of the SIHT clinics, since at least two people have to be there in order to supervise the users and the clinics must be open every day and for extended hours (Strang et al.,2012). Despite the high cost, SIHT was found to be more cost effective than OST both in Germany and the Netherlands, where such estimations were available. The advantage of SIHT in terms of costs, came from reduced costs in criminal procedures and imprisonment.

6 Conclusion

In this thesis, I have tried to combine up to date research findings about opiod related deaths, with focus on fatal overdoses, with some trends among the behaviors of heroin users into a system dynamics model. Understanding the dynamics of such behaviors and the dynamics of fatal overdoses provide the opportunity for a better assessment of the new, controversial heroin assisted treatment and a base for the selection criteria of the users into this treatment, in order to make it more effective and prevent as many deaths as possible.

My research has shown that in Bergen 74% of the fatal overdoses among the long term users are attributable to low tolerance towards opioids, which is developed while the users are in OST and in prison. The corresponding proportion of these deaths among the total number of fatal overdoses is 61%. Using the system dynamics model, I tested the SIHT policy in order to find out its contribution towards a reduction in the overdose fatalities during a 10-year simulation period. With the SIHT policy targeting only the long term users who are also former OST clients, the model showed that this policy could lead to a reduction of 37% in the number of deaths due to overdose among the long term users. This goal can be achieved into a special clinic with capacity of around 50-60 clients, which is an average capacity compared to the existing SIHT clinics in Europe and Canada. This is a conservative approximation of the reduction of fatal overdoses, since in the model only limited number of selection criteria to start SIHT could be applied. In real life though, people responsible for the recruitment of users in SIHT can use more information about the situation of each user and the possible risks. Even greater reductions in the number of fatal overdoses can be achieved through a simultaneous recruitment of users recently released from prison in SIHT, even for a short period of time.

Heroin addiction is a multifaceted problem and that is the reason for preventive measures being very important. However, the extent of problem, with users facing the risk of death from multiple causes, makes harm reduction measures essential for lives to be saved. Norway can be characterized as a conservative country in regard to heroin policies. The high prevalence of injecting users in Norway calls for more harm reduction measures, since there are some people who do not respond to the already existing policies. Erroneous interpretations of the problem of addiction and moral impediments should not stand in the way of implementing policies targeted towards saving human lives.

6.1 Further research

The process of the model building revealed the need for further research in order to define some of the variables as well as the need for further categorization of some data. There is very little research concerning the contribution of the purity fluctuations and the polydrug use in the opioid related deaths. Such variables could be useful both in the direction of further explaining the causes of overdoses and to better evaluate the outcomes of different kinds of treatment such as OST and SIHT.

Research on heroin addiction and treatment reveals a shortage of data pertaining to how many people manage to quit drugs and what happens to the heroin users after leaving treatment. In addition, it would be useful to categorize data about the people who quit OST with criteria such as the duration of use and the number of discharges or willing exits from OST, so that treatment resistant users can be identified and offered help in time.

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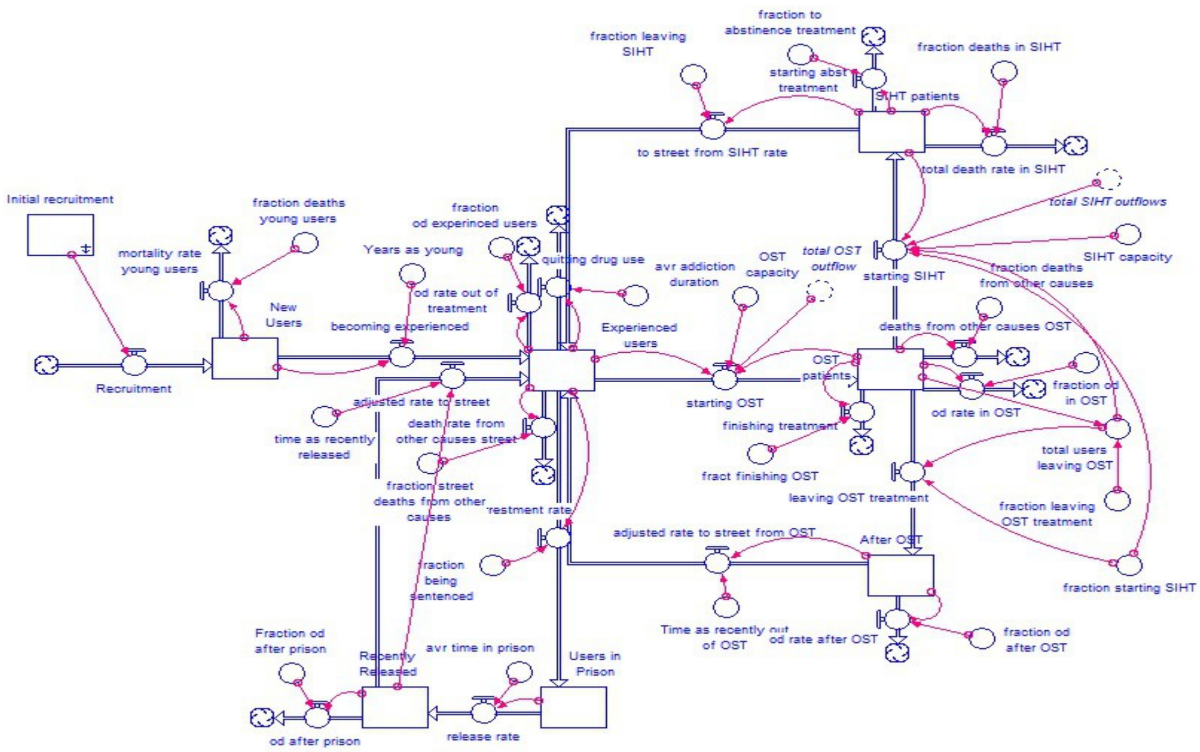
Articles:

Torheim Ø. Minst 24 LAR-pasienter døde av overdose I fjor ,Bergens Tidende, May 30, 2014
Jansen K. Vil gi heroin på resept, Bergens Tidende, 07.01.2014

Appendix

1 Model overview



2 Model equations

The following equations are in iThink format. The letters before each equation indicate whether it is a STOCK (**S**), a flow (**F**), a constant (**C**) or an auxiliary variable (**A**). The documentation of the values used is in the third part of the Appendix.

S Initial_becoming_experienced(t) = Initial_becoming_experienced(t - dt)

INIT Initial_becoming_experienced = OST_patients*(fraction_deaths_from_other_causes+fraction_od__in_OST+fract_finishing_OST) +After_OST*fraction_od_after_OST+Recently__Released*Fraction_od__after_prison+Experienced__users *(fraction_od_experinced_users+fract_other_causes+1/avr_addiction_duration)

S Initial_recruitment(t) = Initial_recruitment(t - dt)

INIT Initial_recruitment = Initial_becoming_experienced+New_Users*fraction_deaths_young_users

F Recruitment = Initial_recruitment

S New_Users(t) = New_Users(t - dt) + (Recruitment - becoming_experienced - mortality_rate_young_users) * dt
INIT New_Users = Initial_becoming_experienced*Years_as_young

F mortality_rate_young_users = New_Users*fraction_deaths_young_users

C fraction_deaths_young_users = 0.01

F becoming_experienced = New_Users/Years_as_young

C Years_as_young = 10

S Experienced__users(t) = Experienced__users(t - dt) + (becoming_experienced + adjusted_rate_to_street + to_street_from_SIHT_rate + adjusted_rate_to_street_from_OST - starting_OST - od_rate_out_of__treatment - other_causes - arrestment_rate - quitting_drug_use) * dt
INIT Experienced__users = 100

F od_rate_out_of__treatment = Experienced__users*fraction_od_experinced_users

C fraction_od_experinced_users = 0.02

F death_rate_from_other_causes = Experienced__users*fraction_street_deaths_from_other_causes

C fraction_street_deaths_from_other_causes = 0.01

F quitting_drug_use = Experienced__users/avr_addiction_duration

C avr_addiction_duration = 20

F arrestment_rate = Experienced__users*fraction__being_sentenced

C fraction__being_sentenced = 0.5

S Users_in__Prison(t) = Users_in__Prison(t - dt) + (arrestment_rate - release_rate) * dt
INIT Users_in__Prison = Experienced__users*fraction__being_sentenced*avr_time_in_prison

F release_rate = Users_in__Prison/avr_time_in_prison

C avr_time_in_prison = 1

S Recently__Released(t) = Recently__Released(t - dt) + (release_rate - adjusted_rate_to_street - od_after_prison) * dt
INIT Recently__Released = (Users_in__Prison/avr_time_in_prison)/(Fraction_od__after_prison +1/Time_as_recently_released)

F od_after_prison = Recently__Released*Fraction_od__after_prison

C Fraction_od__after_prison = 0.9

F adjusted_rate_to_street = Recently__Released/time_as_recently_released

C time_as_recently_released = 0.2

F starting_OST = MIN(Experienced__users,(OST__capacity-OST_patients)/0.1+total_OST__outflow)

C OST__capacity = 800

C total_OST__outflow = deaths_from_other_causes_OST + od_rate_in_OST + leaving_treatment + finishing_treatment

S OST_patients(t) = OST_patients(t - dt) + (starting_OST - leaving_treatment - od_rate_in_OST - deaths_from_other_causes_OST - starting_SIHT - finishing_treatment) * dt
INIT OST_patients = 800

F finishing_treatment = OST_patients*fract_finishing_OST

C fract_finishing_OST = 0.03

F od_rate_in_OST = OST_patients*fraction_od__in_OST

C fraction_od__in_OST = 0.004

F deaths_from_other_causes_OST = OST_patients*fraction_deaths_from_other_causes

C fraction_deaths_from_other_causes = 0.01

A total_users_leaving_OST = OST_patients*fraction_leaving__OST_treatment

C fraction_leaving__OST_treatment = 0.08

F leaving_treatment = total_users_leaving_OST*(1-fraction_starting_SIHT)

S After_OST(t) = After_OST(t - dt) + (leaving_treatment - od_rate_after_OST - adjusted_rate_to_street_from_OST) * dt
INIT After_OST = (OST_patients*fraction_leaving__OST_treatment)/(fraction_od_after_OST+1/Time_as_recently_out__of_OST)

F adjusted_rate_to_street_from_OST = After_OST/Time_as_recently_out__of_OST

C Time_as_recently_out__of_OST = 0.2

C fraction_starting_SIHT = IF TIME <2015 then 0 else 0.8

F starting_SIHT = MIN(total_users_leaving_OST*fraction_starting_SIHT,(SIHT_capacity-SIHT_patients)/0.1+total_SIHT_outflows)

C SIHT capacity = 60

A Total SIHT outflows = to_street_from_SIHT_rate+starting_abst_treatment+total_death_rate_in_SIHT
S SIHT(t) = SIHT(t - dt) + (starting_SIHT - to_street_from_SIHT_rate - total_death_rate_in_SIHT - quitting_heroin) * dt
INIT SIHT = 0

F total_death_rate_in_SIHT = SIHT*fraction_deaths_in_SIHT

C fraction_deaths_in_SIHT = 0.005

F quitting_heroin = SIHT*fraction_to_abstinence_treatment

C fraction_to_abstinence_treatment = 0.1

F to_street_from_SIHT_rate = SIHT*fraction_leaving__SIHT

C fraction_leaving__SIHT = 0.08

A total_injecting_users = Experienced__users + OST_patients + SIHT + Recently__Released + Users_in__Prison + After_OST+New_Users

A TOTAL_DEATHS = total_OD_DEATHS + mortality_rate_young_users + death_rate_from__other_causes_street + deaths_from_other_causes_OST

A total_OD_DEATHS = od_rate_after_OST+od_after_prison+od_rate_in_OST+od_rate_out_of__treatment

3 Documentation

In this part of the appendix there is a list with the values of each variable, the sources of the values and explanation when the numbers were further elaborated. In the parenthesis after the values, there the units of each variable as used in the model.

fraction_deaths_young_users = 0.01 (1/year)	NR 2013, p.50, Fig 7
Years_as_young = 10 (years)	NR 2005, p.35 - NR 2012 p.31
fraction_od_experinced_users = 0.02 (1/year)	NR 2012, p.37- NR 2005p.44 – NR 2006 p.31
fraction_street_deaths_from_other_causes = 0.01 (1/year)	NR 2012, p.37- NR 2005p.44 – NR 2006 p.31
avr_addiction_duration = 20 (years)	NR 2006, p.78
fraction__being_sentenced = 0.5 (1/year)	Ødegård, E(2008) - Plan for opplæring innan kriminalomsorga i Hordaland 2007-2008, http://www.bergenfengsel.no/avdelingene.html
avr_time_in_prison = 1 (years)	NR2013, p.62
Fraction_od__after_prison = 0.9 (1/year)	In order to determine this value I multiplied the total number of released users per year (50) by the average of the increased mortality rate after prison (Merrall et al., 2010). That would be 8 people per year. Then I adjusted the mortality rate, because the inflow in the stock is per year and the outflow is per 2,5 months.
time_as_recently_released = 0.2 (years)	I chose this value in order to allow some accumulation of users in the Recently Released stock
OST__capacity = 800 (people)	Føre Var (2012). In the model there is a stable capacity of 800 people, chosen as an average number during the simulation years.

fract_finishing_OST = 0.03 (1/year)	NR 2001, p.69, http://www.heroin-detox.com/detoxing-buprenorphine-subutex-suboxone/19995-what-percentage-sube-bupe-methadone-users-do-really-manage-quit.html Stimmel et al., 1978
fraction_od__in_OST = 0.004 (1/year)	NR 2012, p.37
fraction_deaths_from_other_causes = 0.01 (1/year)	NR 2012, p.37
fraction_leaving__OST_treatment = 0.08 (Unitless)	NR 2013, p.42
Time_as_recently_out__of_OST = 0.2 (years)	I chose this value in order to allow some accumulation of users in the After OST stock
fraction_deaths_in_SIHT = 0.005 (1/year)	Rehm et al.,2005. The fraction of deaths is 0.01, but I subtructed the AIDS cases (which were the majority) and the cancer cases. These causes of deaths are not included in the EMCDDA definitions of drug related deaths used in this model
SIHT capacity = 60	Strang et al., 2012 p
fraction_to_abstinence_treatment = 0.1 (1/year)	Rehm et al.,2005
fraction_leaving__SIHT = 0.3 (1/year)	Rehm et al.,2005, EMCDDA insights New heroin-assisted treatment Recent evidence and current practices of supervised injectable heroin treatment in Europe and beyond

The unit for all the flows in the model is person/year and for the stocks is people.