# Epidemiological models of heroin epidemics and social outcomes to evaluate Illicit Drug Policy in various countries

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Presented at the XIII Conference of the International Society for the Study of Drug Policy, Paris, May 22-24 2019.

Preprint

#### Premise.

Modelling can be a valuable complementary tool for policy decisions and can be especially useful at levels of larger aggregation (national, international). It is often, however, not well understood, both because non-modellers may have little understanding or interest in the mathematical presentations of modellers, and because modellers may have little understanding or interest in the practical consequences of their work and its relation to other disciplines, often being more interested in theoretical mathematical advances. Part I aims to discuss the potential for modelling in drug epidemiology in a manner accessible to non-modellers. (EMCDDA, Monograph 6, 2001, p. 17).

#### Introduction.

Researchers have recognized, for over half a century, the similarities of the spread of drug use and that of infectious diseases. The epidemiological approach makes it possible to model available administrative data, regarding "visible" consequences of drug use with the aim of describing the spread in a population to provide evidence for public-health-oriented interventions and policies. The approach is also useful to carry out the impact assessment of drug policies and interventions and to provide short and long term forecasts of visible and hidden aspects of the drug use and supply phenomena.

Using specific models it is also possible to estimate the prevalence of users and dealers and the incidence of specific consequences as, for instance, deaths or therapy requests.

The epidemics of infectious diseases and of drug consumption also share an important qualitative characteristic: the presence of "waves" after an initial eruption followed by the endemic trend, and then new epidemic waves in the absence of effective control interventions. A disease that spreads by epidemic, if not intervened with vaccination, indeed recurs with successive waves when the proportion of susceptible subjects increases sufficiently, through births and immigration.

A specific operational model, with an open population (Rossi, 2001, 2004), can be used to explain the trend of the second epidemic wave concerning the supply and use of heroin in western countries. The model can also be used to assess how the specific aspect of Swiss policy, regarding therapeutic assistance, has modified specific variables and has prevented the development of the second epidemic wave of heroin use and supply there.

In the following section the second epidemic wave of heroin use in western countries is shown through different indicators based on administrative data linked to the consequences of the use and of supply, in particular, of heroin: deaths, admissions to therapy, seizures, complaints of drug dealers. Also the estimated market size is considered.

Then specific methodological tools, in particular mathematical models, are introduced and used to link the observed data with the hidden phenomena that generate them, making it possible to evaluate specific interventions implemented to control the spread and consequences of drug use by reducing the demand and supply of illicit drugs. Also the evaluation of the policy interventions and the resulting trends in Italy and in Switzerland are treated.

Some general conclusions, including those of a political nature recently also addressed by international organizations requesting for changes to be made by UNODC and all countries in the world, will also be reported. They are supported by the results of the evaluation of Swiss policy with respect to the general ones applied by Western countries through the use of the methodologies considered.

# Second heroin epidemic wave in western countries and endemic behaviour in Switzerland.

The United States and Canada show, in general, trends in the use of drugs that arrive shortly afterwards in Europe, so it is useful to investigate what has happened in North America and, as far as Europe is concerned, in the United Kingdom and in other European countries, as for instance in France and Netherlands and, with particular attention, in Italy.

# Analysis of death indicator of the use of "opioids" in the USA and in Canada

When prescription opioids started to become too difficult or too expensive to procure, dependent people started turning to heroin, a change that created an epidemic of heroin use in entire groups of people. Now, a new opiate is increasing in use and overdose: fentanyl, a synthetic opiate, which is 50-100 times more potent than morphine, according to a recent statement on fentanyl by the Drug Enforcement Administration (DEA), and 25- 50 times more powerful than heroin. Its spread seems to increase dramatically, which means that, given its power, opiate deaths in general are also increasing (Figure 1).

The trend of the curve relative to deaths due to heroin clearly shows two trends in two periods: endemic trend first and epidemic recently (second wave).

Figure 1. Trends in heroin and opioids overdose deaths in the United States from 1999 to 2016.



The situation in Canada is very similar; in a the Lancet article it says<sup>1</sup>:

"A chief coroner investigation in British Columbia, Canada, identify an "inordinately high number" of drug-related deaths related to a "very real and very serious" drug problem, and recommended unconventional measures to reduce mortality. This occurred 25 years ago, in 1993, the number of drug-related deaths in British Columbia peaked at 330. Today, the epidemic of primarily opioid- related deaths in Canada is far worse than it was a quarter of a century ago. In 2017, there were 1473 drug-related deaths in British Columbia and 3996 in Canada in total— an increase of more than 400% from 1993—and these deaths now account for substantially greater mortality than motor-vehicle accidents and other leading causes of premature deaths."

The observed delay of 25 years (one generation) is that generally expected by models with open population where, due to the development of a new epidemic wave, it is necessary to reconstitute the susceptible group sufficiently.

# Analysis of opioid deaths in the UK.

The trend of opiate deaths in England and Wales is shown in Figure 2 and a similar behaviour can be observed in Northern Ireland.

As can be seen also in the UK the trend shown is endemic in a first period and then epidemic.

### Figure 2. Trends in heroin overdose deaths and synthetic opioids in the United States from 1999 to 2016.

<sup>1</sup><u>https://www.thelancet.com/journals/lanpub/article/PIIS2468-2667(18)30232-9/fulltext?utm\_campaign=update-</u> lanpub&utm\_source=hs\_email&utm\_medium=email&utm\_content=70207065&\_hsenc=p2ANqtzz6L6XUEEY1Q68lg3imOecoAFxE3aDdXEPRL7S3bZJn49xDwQKz2V8Puzc0H7yVmlrh9Qr9zsCvnfWtiGCpgXrz-Pz6Q&\_hsmi=70207065



Analysis of the incidence of heroin treatment in public services in France and Netherlands.

The graphs included in the EMCDDA country reports (Figure 3) show two behaviours in two periods showing the recent growth of problem heroin use and health consequences in France and Netherlands (second wave).

Similar trends also appear in other country reports.

Taking into account that the average latency time to access the treatment is about 10 years, we can say that the increasing trend of the use of heroin began in 2005/2006 in these two countries.

Figure 3. Incidence of heroin therapy request in France and Netherlands.



# Second wave of heroin epidemic in Italy.

Also in Italy there is an increase in the incidence of heroin treatment since 2014 (Figure 4) and, being the delay of only 6.5 years, it can be estimated that the increase in the incidence of heroin use dates back to 2007/2008 immediately after the increase in France and Netherlands.

# Figure 4. Incidence of heroin therapy request in Italy.



Similar trends also appear in other administrative data, such as reports for personal use, hospital admissions, reports of heroin dealing, etc.

Estimate of the heroin market size in Italy using two different methods.

The estimate of the heroin market in Italy, using the Eurostat method based on the estimation of the prevalence of users and implemented in Italy by the National Statistics Institute (Istat), shows the trend reported in Figure 5 for the years from 2011 to 2016. The percentage increase between 2011 and 2014, according to such Eurostat estimate, is 43.8%.

An independent estimate of the market size, expressed in kg, was carried out on the basis of data on heroin seizures, and reports a 40.3% increase between 2011 and 2015 (Fabi & Rossi, 2016).

This confirms the second wave of heroin use and supply in Italy and the inefficacy of drug policies in recent decades, but also the usefulness of estimates of the size of the market obtained by using both methods based on the use and on the supply of substances (Rossi, 2013).

Figure 5. Estimate of the market size regarding family expenses on the basis of Eurostat method of PDU prevalence estimate (retail purchases of heroin).



The new heroin epidemic, which could be scientifically predicted and with adequate policies limited a lot, shows in general the inadequacy of anti-drug policies in western countries and, in particular, in Italy.

Indeed in all the legal contexts in force in Italy since 1990, the political approach has always been analogous of a prohibitive and repressive and even **ascientific** type, as can be seen from data on the consequences related to heroin and opiates (supply and demand) already shown.

Similar drug policy can be observed in most countries, except partially in Portugal and in Czech Republic, where the overdose death recently increased anyway as shown in the EMCDDA country reports (<u>http://www.emcdda.europa.eu/countries en</u>); but the more efficient drug policy of Switzerland will be analysed in depth, as Switzerland is the only western country showing just endemic behaviour of heroin use in recent years as shown in Figure 6. Unfortunately, the data concerns total deaths for opioids, which in the early years were mainly for heroin, but in recent years, albeit slight, they are also influenced by the widespread use of synthetic opioids, as in the rest of the world; in any case the epidemic trend decreased before 2010 and then the endemic trend started.

To further support the endemic trend of heroin use in Switzerland, it is useful to consider the data on deaths related to youth and to older users, in particular for subjects under the age of 20 and subjects over the age of 40 (Figure 7), and then compare with the data relating to Italy (Figure 8), reported in Rossi (2019), where heroin epidemic wave is in act (<u>http://www.ce3s.eu/2019/04/18/seconda-epidemia-di-eroina/</u>).

Similar comparisons could be made on the second epidemic wave of heroin and indicator of deaths with Canada, USA or other Western countries such as the UK or the Netherlands instead of Italy.



Figure 6. Trend of opioid deaths in Switzerland (<u>https://www.suchtmonitoring.ch/de/3/7.html</u>).



Figure 7. Trend in the percentage of deaths of subjects with age less than 20 (left axis) and greater than 40 (right axis).

# Figure 8. Trend in the percentage of deaths of subjects with age less than 20 and greater than 40 in Switzerland and Italy.



Now it is important to use the methodological tools that allow to evaluate, at least qualitatively, a particular aspect of Swiss drug policy: the treatment of heroin addicts, who are particularly problematic, with controlled heroin therapy, first introduced in an experimental form and, after the evaluation of the results, in medical form standard for specific cases throughout the country.

In Switzerland the use of heroin is considered as a disease that must be treated by a doctor, and it is not seen as a criminal act and the problem is no longer new consumers, but long-term consumers (Nordt and Stohler, 2006).

### Operational dynamic models for heroin drug policy evaluation.

The methodological tools that allow to evaluate "a priori" and forecast the consequences of situations linked to the drug policy are dynamic mathematical models of the epidemiological phenomenon. Such models enable prevalence and incidence to be estimated, scenario analyses to be carried out and trends to be predicted, on the basis of indirect indicators such as therapy presentations, incarcerations, deaths and so forth.

They have been widely used in the study of the AIDS epidemic and to model epidemics related to the use of psychotropic substances, in particular heroin (first wave) and opiates as there are similarities between the spread of drug use, in particular the spread of use of addictive drugs such as heroin, and that of infectious diseases. The use of drugs is communicated, obviously, not as an organic agent, but as a kind of "innovative" social practice or custom, and not to everyone but only to those who, for whatever reason, are not immune (prone individuals).

The dynamic models proposed for the problematic use of heroin (or other substances) can be with closed populations or open populations. The former ones consider a group of subjects, in which new subjects do not enter, demographic inputs are not taken into account; such models are only suitable for short-term forecasts and represent just the evolution of the use of substances in a single group.

The open population models take into account the incomes due to births or immigration in the population, so they can be used for, at least, qualitative forecasts even in the medium and long term. In models with open populations it is important to subdivide subjects, that are not yet users, into two categories: those who are not likely to be induced into use (such as subjects vaccinated in models for infectious diseases) and those that risk being induced to use. In formal words the former can be referred to as **"stayers"** and as **"movers"** the latter.

This distinction would also be appropriate for closed-population models that generally do not apply it as they consider all the subjects of the group as **movers**.

The model we are going to use is a Mover-Stayer compartmental model with open population. Such kind of models are suitable to make scenario analyses to study the impact of various proportions of vaccinated persons in order to estinguish a given epidemic and interventions of prevention etc. Due to the interactions between infectious individuals (users who are also drug dealers) and the susceptibles some of these may pass to the drug user compartments and begin a "drug user career". The present model comprises two different stages of hidden drug use. The first (light use) stage, which can be more strictly defined, is the initial (or non problematic) stage of drug use, then light drug users can either stop using drug or pass to hard drug use (or die). Other interesting stages taken into account comprise: therapy stage, recidive use (either light or hard) stages and temporary non-use stage (these latter are visible stages). The graphic representation of the model is shown in Figure 9.

### Figure 9. Compartmental representation of the system Mover-Stayer dynamic model of drug use epidemic.



Where the state variables are:

- Exposed population «Susceptibles», of which a fraction S is not at risk ("stayers") and the other fraction 1-S is at risk ("movers"). State variable: **X**. Entrances and exits linked to the natural movement of the population and exits linked also on start of drug use.
- "Light" drug users (at an early stage). State variable: Y1;
- "Hard" drug users (in the problem phase). State variable: Y<sub>2</sub>;
- Drug-related health service users. State variable: **Z**;
- "Recidivist" drug users. State variable: W<sub>1</sub>;
- «Ex» drug users (in temporary non-use phase). State variable: W2;
- Deaths, for whatever reason. State variable: D.

The interactions and the dynamics of the variables are described by the connections represented on the graph, which also allow to derive the equations of the model, which are not reported.

- The arrows in the graph completely describe all the possible transitions of a drug user career. Linear terms in the equations of the model.
- The curves connecting the drug use (infectives) compartments and the susceptible or temporary nouse compartments represent the possible interactions between drug users and susceptibles, regulated by the mass-action law which produces bi-linear terms in the equations of the model. Such interactions may cause infections, that is, transitions from susceptibles (or temporary no-use) to drug use compartments.

The value (order of magnitude) of the parameters of the various terms, as the value of the state variables, influence the endemic or epidemic phases, as it is shown using the epidemic coefficient  $\rho(t)$  defined as:

$$\rho(t) = 1 - \frac{S(t+dt)}{S(t)}$$
  
=  $[1 - \frac{S_0}{S(t)}] \frac{\mu_{01}X(t) + \mu_{71}W_2(t)}{X(t+dt)} - \frac{X(t)}{X(t+dt)} [1 - S(t)][\mu_{12} + \nu_{12}Y_1(t) + \nu_{13}Y_2(t) + \nu_{16}W_1(t)]$ 

In particular, if  $\rho(t) \ge 0$ , then the epidemic is decreasing and going towards the endemic phase, whereas if  $\rho(t) < 0$  the epidemic is spreading (Rossi, 1991). These two situations are characterised by the following relationships:

$$\rho \ge 0 \text{ if and only if } \left[1 - \frac{S_0}{S(t)}\right] \frac{\mu_{01}X(t) + \mu_{71}W_2(t)}{X(t+dt)} \ge \frac{X(t)}{X(t+dt)} \left[1 - S(t)\right] \left[\mu_{12} + \nu_{12}Y_1(t) + \nu_{13}Y_2(t) + \nu_{16}W_1(t)\right].$$

where

$$[1 - \frac{S_0}{S(t)}] \frac{\mu_{01}X(t) + \mu_{61}W_2(t)}{X(t + Dt)}$$

represents the demografhic contribution, whereas the following is the epidemic contribution:

$$[1 - S(t)][\mu_{12} + \nu_{12}Y_1(t) + \nu_{13}Y_2(t) + \nu_{16}W_1(t)]$$

If the epidemic contribution is equal to or lower than the demographic contribution the epidemic is decreasing towards the endemic phase, this happens if the policy interventions produce lower values of the state variables  $Y_1$ ,  $Y_2$  and  $W_1$ .

Now we consider the main results, scientifically evaluated, of the heroin-assisted treatment (HAT) influence on such variables of the epidemic contribution term that, if it is high, favors the epidemic phase, while if it is low brings (and preserves) the endemic phase.

An important analysis of HAT implemented worldwide was carried out as part of the Cochrane collaboration and published in 2011 (Ferri et al., 2011).

A particular aspect considered in the meta-analysis of many scientific evaluation papers is the retention in treatment that results significantly higher if, among the possible therapies for heroin addicts, also the HAT is included for specific subjects and this implies a greater value for the variable Z and lower for W<sub>1</sub>.

Also the number of  $Y_2$  subjects is reduced as there is a greater afference of  $Y_2$  subjects in therapy as the heroin addicts, who had failed with other substitution therapies, were able to enter and remain in treatment. Also those who were dealing drugs to get the money decreased ( $Y_2$  and  $W_1$ ) and, therefore, the contact with the X(1-S) movers at risk to be infected decreased, therefore the variable  $Y_1$  decreased.

All these results imply that the probability of  $\rho(t) \ge 0$  is much higher, then the endemic phase is longer.

In summary, the main results reported in the HAT evaluation work are:

• Consumption of illicit heroin has been significantly reduced.

• A major reduction in criminal activity related to fundraising among HAT participants. (Only this advantage has exceeded the cost of treatment).

• The heroin of the administration has not been diverted to illicit markets.

• The start of the new use of heroin has decreased (the medicalization of heroin has made it less attractive) and, in turn, there have been reductions in the sale of street sales and recruitment by user-pushers (epidemic transmission).

• Taking non-HAT treatments, particularly methadone, has increased rather than rejected (as some had feared).

A number of other countries, besides Switzerland, such as the United Kingdom, Germany, the Netherlands and Canada, but only in some cities and not nationally, prescribe heroin under medical supervision, as a therapeutic program for treating consumers for a long time of illicit opioids and not responding to other replacement therapies. HAT, even in the relatively small number of countries where it exists, is available only on the basis of strict criteria, including long-term use and failure to respond to other treatment programs. It is possible that the benefits can be extended if access barriers are widened, given that it is legally recognized as a medical intervention and therefore not prohibited by UN conventions on drugs.

Many other evidences can be read on online documents, in particular on the EMCDDA website (http://www.emcdda.europa.eu/publications/insights/heroin-assisted-treatment\_en) and Transform (https://transformdrugs.org / heroin-assisted-treatment-in-switzerland-successfully-regulating-the-supply-and-use-of-a-high-risk-injectable-drug /), and on scientific articles searching on the internet with suitable keywords and radical radio archive, for example https://www.radioradicale.it/scheda/556099/svizzera-politica-delle-droghe-e-sommistrazione-controllata-di-eroina-intervista-a.

# Conclusions.

Legally recognised as a medical intervention and therefore not prohibited by the UN drug conventions, HAT shows the wider potential benefits – locally, nationally and internationally – of moving the supply and use of an illicit drug into a completely legal, strictly regulated market. The experience of Switzerland, which became a pioneer of HAT in the 1990s, represents the most comprehensive source of empirical evidence on the outcomes of such a transition. It suggests that if this form of treatment were rolled out widely – particularly in major consumer countries – it could have major benefits for many people dependent on heroin, and a significant impact on the scale of illicit drug markets. (Transform: Heroin Assisted Treatment in Switzerland, https://transformdrugs.org/heroin-assisted-treatment-in-switzerland-successfully-regulating-the-supply-and-use-of-a-high-risk-injectable-drug/).

Unfortunately what can be concluded is that, despite the extensive scientific evidence on the effectiveness of HAT, it is not generally applied in any country and this shows the **ascientific** approach of governments to the study and control of problematic heroin use, except the Swiss ones.

This also shows why in all Western countries there is a worrying second epidemic wave of heroin use, except in Switzerland where the endemic phase is going on, as also reported in EMCDDA European Drug Report 2016:

"The problem of opiates in Europe remains a central issue in the 2016 analysis, which reflects the significant impact that these drugs continue to have on mortality and morbidity. We are currently witnessing an increasingly complex relationship between the consumption of heroin and synthetic opiates, accompanied by a worrying increase in global estimates of opiate-related deaths. In Europe, treatment services must now also respond to the increased complexity of the health needs of an aging cohort of heroin users; in this regard, those responsible at the political level must resolve the difficult question of which are the most appropriate long-term therapeutic goals for this group. At the same time, the new heroin epidemics reported in other parts of the world remind us that this is an area that requires vigilance and in which it remains essential to exercise constant surveillance.

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The amount of heroin seized in the EU has fallen over the long term, from 10 tonnes in 2002 to 5 tonnes in 2012, before increasing significantly to 8.9 tonnes in 2014."

Antiprohibitionism, at least on therapies, must be more widespread in the world as requested officially by 334 NGO (<u>https://idpc.net/alerts/2019/04/ngos-call-on-world-leaders-to-address-global-health-and-human-rights-crisis</u>).

# Some essential bibliographic references

Fabi F. & Rossi C., Proibizionismo: chi ci guadagna, in Farina Coscioni M.A. & Rossi C. editors, *Proibizionismo, criminalità, corruzione*, Universitalia di Onorati s.r.l., Roma, 2016, 93-119.

Ferri M, Davoli M, Perucci CA. Heroin maintenance for chronic heroin-dependent individuals. *Cochrane Database of Systematic Reviews* 2011, Issue 12.

Nordt C. & Stohler R., Incidence of heroin use in Zurich: a treatment case register analysis, *the Lancet* 2006 (<u>https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(06)68804-1/fulltext</u>).

Rossi C., A stochastic mover-stayer model for HIV epidemic, *Mathematical Biosciences*, 107, 1991, 521-545.

Rossi C., A Mover-Stayer type model for epidemics of problematic drug use, *UN Bulletin on Narcotics*, Vol. LIII, Nos 1-2, 2001, 39-64.

Rossi C., Operational models for epidemic of problematic drug use: the Mover-Stayer approach to heterogeneity., *Socio-Economic Planning Sciences*, 38, 2004, 73-90

(https://www.academia.edu/13150470/Operational models for epidemics of problematic drug use the <u>Mover Stayer approach to heterogeneity</u>).

Rossi C., Monitoring the size and protagonists of the drug market: combining supply and demand data sources and estimates, *Current Drug Abuse Rev. 2013 Jun;6(2),*122-129.