

Modelling Methadone Treatment Outcomes for Opiate Use

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Declaration

I hereby declare that the work described within this thesis is entirely my own except where otherwise stated. This thesis has not been submitted as an exercise for a degree at this or any other university.

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Summary

Presented within this thesis are modelling applications for methadone treatment data in Ireland. The primary aim is to aid and inform policy makers and service planners in decisions relating to the provision of methadone services in a time of limited and ever reducing resources. It should always be borne in mind that behind the data and statistics presented here are people at various stages of a journey through addiction, many of whom have children in their care. It is in their best interests to provide the most effective treatment possible. However, taking an economic approach, it is also important to provide cost-effective targeted treatment which maximises treatment outcome. Research findings that aid and inform policy and planners and provide a service for the individual and for society are essential.

It is also cost-effective to utilise available drug-treatment data-sets to obtain as much information as possible given the rarity and sensitivity of these data-sets and the enormous resources that can be invested in collecting the information.

To that end, findings within this thesis show that:

- Within Ireland, methadone maintenance within clinic settings are provided on a statutory and non-statutory basis. There is great variation within and between these clinics across a number of variables including staffing, treatment process and ancillary services provided.
- The Ball and Ross model of methadone treatment evaluation, although recommended for use by the EMCDDA (European Monitoring Committee on Drug and Drug Addiction) is not easily applicable for Irish treatment data and has many limitations.
- Looking at methadone treatment outcomes across a range of measures, individuals

experience largely positive treatment outcomes in terms of drug-use, overdose and crime.

However, health outcomes were found to be largely poor.

- Taking a primary treatment outcome at one year to be abstinence from heroin, gender and age were found to be important contributing variables. Specifically it was found that males over the age of 22 years were a treatment sub-population that perhaps require a targeted treatment response.

- Proximity to treatment does not appear to have an effect of drug treatment outcome.

Further, it was shown that in terms of statistical and mathematical modelling of drug issues, there is and has been a limited number of people working in this area in Ireland and contributing to Irish drug treatment policy treatment policy. Looking specifically at spatial models of drug issues, there has been little work carried out on these and there is a huge scope for further work within this area given the international pattern of drug diffusion from urban to rural regions.

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Chapter 1

Introduction

Nobody will laugh long who deals much with opium: its pleasures even are of a grave and solemn complexion.

(DeQuincey 1821)

The aim of this thesis is to aid and inform policy makers and other stakeholders in the decision-making process with regards to methadone maintenance treatment provision. Methadone maintenance is a substitute replacement therapy used in Ireland and other countries to treat opiate dependence, in particular heroin addiction. According to a recent report, heroin, particularly when it is injected, accounts for the greatest portion of morbidity and mortality related to drug-use across the European Union (EMCDDA 2010). The data used in this work was collected as part of a longitudinal project to evaluate drug treatment, the Research Outcome Study in Ireland (ROSIE), so this thesis also demonstrates how existing data can be used to produce new research. Therefore, this work provides added value and is cost effective in maximising the utility of available data. However, behind the statistics lie people who are availing of drug treatment. They and their families are reliant on treatment-services and it should always be borne in mind that each and every one has their own story to tell.

This thesis tells a story that has a beginning, a middle and an end which can be succinctly described in the following way: The Ball & Ross (1991) classic model was applied to Irish methadone treatment data to assess methadone treatment effectiveness as defined in their terms. Surprisingly, this oft-cited model failed when applied *a posteriori*. However, further

work found that a decision tree model and a spatial model were suitable and policy relevant results were elicited.

This thesis contains nine chapters. The present chapter describes the history of opium and its derivative heroin, including heroin use and heroin treatment in Ireland. Chapter two discusses the statistical models that have been applied to drug issues. Chapter three begins the journey of the Ball & Ross (1991) model by describing the details of the methadone clinics that were selected and the methodology by which they were identified. Chapter four describes the relevant characteristics of the clients of the chosen clinics. Chapter five then describes the application of the Ball & Ross (1991) model and discusses the reasons why this model failed. As the Ball & Ross (1991) model failed, the restriction of using the data connected to certain chosen clinics was lifted and the cohort was then extended. This cohort is the subject of chapter six. In chapter seven, two models are applied to the data for the extended cohort and one model proved successful. Within chapter eight, a further model, a spatial model, is successfully applied to the treatment data. Chapter nine then discusses the conclusions reached from carrying out this work and the implications nationally and internationally for treatment service provision.

1.1 An Introduction to Heroin: Use and Treatment.

This section begins by giving a brief history of opium and heroin and the effects on the body, then moves on to discuss the philosophy of harm reduction and methadone treatment in Europe and in general. The timing and reasons for the well documented heroin epidemic (Dean et al. 1985, Keenan 2002) in Dublin, Ireland are discussed along with the history of drug treatment in Ireland from past to present. The advent of methadone treatment in Ireland and the numbers of heroin users in treatment in Ireland over the years are also set out. These figures show that heroin, once a problem associated only with Dublin, is spreading out to the rest of the country where resources for heroin treatment have not traditionally been available. The rationale for this chapter is to illustrate the increasing need, both abroad

and in Ireland, for a greater understanding of how methadone treatment works.

1.1.1 Brief History of Opium and Heroin

Opium has been around for a very long time. According to Palfai & Jankiewicz (2001), there are ancient references to opium scattered throughout the cultures of the Eastern Mediterranean and opium was evident in many facets of Greek culture being used to treat many ailments. The word ‘*opium*’ comes from the Greek word ‘*opios*’ meaning “a little vegetable juice”. Opium seeds made the journey to China around AD 600-700. Arab merchants returned opium to the West in Medieval times and laudanum (a pill or mixture with opium as the chief ingredient) first appeared in the West in the 1400’s and was held up as a treatment for many diseases.

In the mid 1500-1600’s evidence of opium dependence and withdrawal began to appear in the West. In the early 1800’s Thomas DeQuincey’s famous ‘Confession of an English Opium Eater’ was serialised in a London newspaper and addiction to opium was generally perceived in the same vein as drunkenness. By the mid 1800’s opium and, increasingly, morphine, were beginning to be seen as a social problem. Morphine had been isolated from opium in 1803 and was used during the American Civil war as an anaesthetic and an analgesic. In 1853 the hypodermic syringe was invented and the introduction of the needle into medical practice allowed morphine to be injected under the skin (skin popping) or into the vein (mainlining) which led to increased illicit use as injecting the drug into a vein ensured it reached the brain quickly and efficiently (Goldstein 2001, Palfai & Jankiewicz 2001).

Heroin, another derivative of opium, came onto the market in 1898 having been first synthesised in London in 1874 by a chemist named Wright. Later, Henrich Dreser, who worked for the German company Bayer, named this substance from the German *heroisch* meaning “a small potent unit”. He endorsed this substance as a non-addictive analgesic and clinical popularity spread. In America in 1914, President Wilson signed into effect the Harrison Act, the first federal anti-narcotic legislation. American physicians could still prescribe opiates with special permission at the time and morphine was the predominate drug

of abuse. Heroin was still relatively new and a black market for it grew from the anti-drug pressure on morphine. Heroin came to the public's attention again during the outbreak of World War I when soldiers were discovered using it. It was demonised along with other opiates, with the Surgeon-General in America declaring it a menace to public health. By 1924, domestic use was effectively outlawed, by the 1930's heroin had overtaken morphine as a drug of abuse (Palfai & Jankiewicz 2001).

Later, heroin was also popular with American soldiers in Vietnam, coinciding with a general boom in heroin use throughout America. However, any soldier that brought his addiction home from Vietnam with him could then be treated with methadone. In 1969 the first major methadone maintenance programme was established in America (Goldstein 2001). In 1970 the Comprehensive Drug Abuse Prevention and Control Act was passed by Congress which listed heroin as a high abuse potential substance with no medical use (Palfai & Jankiewicz 2001).

1.2 Heroin: The Drug

The source of opium is the opium poppy *papaver somniferum*. This plant grows to three or four feet tall with red, white or purple flowers, and is harvested for its opium when the seed pod matures. The harvesters cut the seed pod and from this cut exudes a thick milky substance. This substance dries to a gummy brown resin which is collected by the harvesters and can be dried and powdered, pure heroin being white in colour (Drugscope 2010). In 2010, the global area under opium production was reported to be 195,700 hectares. Afghanistan accounted for the bulk of this cultivation at 63% of the global total. Actual production of opium in Afghanistan was seen to fall in 2010, mainly attributed to diseases of the opium poppy plant that has affected opium yield. Even with the reduction in yield, Afghanistan is the worlds largest producer of illicit opium and accounted for 74% of global production. Heroin produced from Afghan opium is either consumed within the region or is trafficked to Europe (UNODC 2011).

1.2.1 Types of Opioids

There are four main types of opioids; opiates, semi-synthetic opiates, synthetic opiates and endogenous opiate-like chemicals. Opiates are compounds that can be extracted directly from opium, the substance removed from the opium poppy. Opium is a complex soup of alkaloids and other substances and contain, among other substances, morphine and codeine. Heroin is an example of a semi-synthetic opiate as it is derived from morphine. The chemical name of heroin is diacetylmorphine and the chemical process which converts morphine to heroin, in simple terms, attaches acetic anhydride to the morphine molecule. Synthetic opiates are man-made and do not originate in any part from opium. These include drugs such as methadone, oxycodone, pethidine and fentanyl which are mainly utilised for their analgesic properties. Endogenous opioids include endorphins which occur naturally in the human body and have a similar action to that of morphine (Moraes 2000, UNODC 2011)

1.2.2 The Effect on the Body

Heroin or diacetylmorphine is active through its bio-transformation into morphine and therefore has the same effect on the body. However, when heroin is injected into the muscle or vein (IM or IV), heroin is three times more potent than morphine. It is thought that this may be because heroin has a higher lipid (or fat) solubility than morphine, allowing it to cross the blood-brain barrier more efficiently (Palfai & Jankiewicz 2001).

For example, when morphine is injected, it reaches the brain slowly; whereas heroin floods the brain within seconds of entering a vein, its chemical structure favouring a more rapid transition than morphine from blood into brain tissue (Goldstein 2001). Once in the brain tissue, heroin is hydrolysed into morphine molecules (Palfai & Jankiewicz 2001). This morphine then reaches all body tissues and can cross the placental barrier in pregnant women.

The major effects of morphine are on the central nervous system (CNS) which includes the brain and spine, and on the enteric nervous system (ENS) including the gastrointestinal (GI) tract. Mu or μ -opiate receptors present are responsible for such effects as analgesia,

euphoria and GI motility, reducing the GI action leading to constipation. These analgesic and constipatory actions were historically sought-after therapeutic effects; the constipatory action providing relief from diarrhoea and dysentery (Julien 2000, Moraes 2000).

Opiates in general are thought to be calming and sleep-inducing although this effect is not always seen as they are valued clinically for the ability to dull pain without rendering the patient unconscious. Respiratory depression and subsequent suffocation is the most significant side effect of heroin use and it is this effect that kills when an overdose of the drug is taken. This is especially a risk after someone has been through a detoxification treatment or has been separated from the drug for a time and returns to use. The individuals' tolerance has lowered and their usual previous dose is now an overdose.

The WHO (2011) define dependence syndrome under the Tenth Revision of the International Classification of Diseases and Health Problems (ICD-10). Within this definition, tolerance is described as the individual requiring increased doses of the psychoactive substance they are dependent on in order to achieve effects originally produced by lower doses where daily doses may be sufficient to incapacitate or kill non-tolerant users.

The length of time for tolerance to develop depends on the person. Tolerance does not describe the repeated administration process, tolerance is the effect that the individual experiences as a result of the repeated administration process. This leads to a loss of the effect of the drug and more of the drug is needed to produce the same effect. The body adapts to the drug and develops a greater and greater capacity to break it down (Goldstein 2001). The presence of the drug in the brain destabilises the chemical equilibrium and the body reacts by trying to restore this balance. A greater dose is then required to overcome the restored equilibrium and achieve a 'high'. The neurotransmitters become increasingly less sensitive with continued exposure leading to the loss of effect. Excitement and euphoria decrease and dependency on heroin increases as most users build up their doses to regain the 'kick' There does not seem to be a ceiling for opiate tolerance and one individual can habitually be taking a dose that would by itself be fatal to another (Booth 1996, Goldstein 2001).

Other physical effects of the drug include vaso-dilation with the vessels in the skin dilating, providing a warm feeling throughout the body (Palfai & Jankiewicz 2001). An injection of heroin has been described as leading to a very rapid ‘rush’ and a warm flushing of the skin followed by a pleasant dream-like state of peacefulness and contentment; pain is reduced, as are aggressive tendencies. Vomiting is a well known side-effect due to the effect on the upper gastrointestinal tract but is mainly seen in new users. The injecting of heroin is very risky and, among other things, can lead to the transmission of diseases such as human immunodeficiency virus (HIV) or Hepatitis (Corrigan 1994), although the use of unsterilised water to flush out and ‘clean’ used needles, the failure to clean the skin in preparation for injecting and the sharing of needles also contributes to disease spread. Even re-use of ones own needles is risky and can lead to collapsed veins and abscesses as the tip of a hypodermic blunts after just one use (Palfai & Jankiewicz 2001). Abscesses can also be caused by the use of lemon juice, vinegar and citric acid which are used to break down the heroin in preparation for injection.

As for withdrawal from the drug, the degree and character of withdrawal depends on the dosage, the frequency of use, and duration of dependence. Heroin withdrawal symptoms begin 4 to 12 hours after the last dose and this is commonly called ‘cold-turkey’ because of the chills and goose pimples on the skin that come with them. Other withdrawal symptoms include hot and cold flashes, runny nose, sweating, restlessness, insomnia, tension, anxiety, stomach cramps, vomiting and explosive diarrhoea. These are precisely the opposite of the side-effects of taking heroin in the first place (Corrigan 1994, Palfai & Jankiewicz 2001).

One treatment option for heron is methadone substitution treatment. The following section explores in detail methadone and its part in a treatment approach called “harm reduction”.

1.3 The Philosophy of the Harm Reduction Approach to Opiate Treatment

In Ireland, methadone is part of a harm reduction strategy adopted towards the treatment of opiate addiction (DoCRGA 2009). Harm reduction is a concept which aims to prevent

or reduce the negative health consequences associated with drug-use. These include the transmission of HIV and other infections which are associated with injecting as well as other social and personal harms which are included. One primary goal of harm reduction is the reduction of drug-related harm rather than the drug-use *per se* (Lenton & Single 1998). This approach has gained popularity since the emergence of HIV and acquired immune deficiency syndrome (AIDS). Harm reduction approaches include provision of information, education, needle exchange and drug-substitution treatment. Harm reduction is considered to be the opposite of or an alternative to prohibition and abstinence. For example, according to Poulin & Elliot (1997), harm reduction education urges safer drug-use practices as opposed to total abstinence. Those in favour of abstinence would see this as collusion with drug-use, where the education's focus is *about* rather than *against* drug-use i.e. the *problems of use* as opposed to the *problems with use*.

Harm reduction is also seen by many as a human rights issue, although Hathaway (2001) argues that this is never really articulated. It respects drug-users' rights and free will, is respectful of the motivation and decision to use, acknowledges the appeal of drug -use and seeks to provide accurate information about such use. This value-neutral approach is seen as weak when in opposition to a strong moral anti-drug stance. Strang (1993) as cited in Keane (2003) sees the value-neutral approach as a great strength in harm reduction; instead of being concerned with the rights and wrongs, it is the outcome that matters. However, Keane (2003) sees this as naive in a society that does make a judgement on drug-use and the user. The human rights approach also gains no ground in countries where human rights may not be to the fore. In any case, this argument is not readily accepted by most governments especially when health benefits and cost-benefit analyses are more winning approaches. Keeping the argument within the framework of a therapeutic model maintains more credibility among policy makers (Hathaway 2001).

The temperance mentality, according to Alexander and van der Wijngaart (1997) as cited in Hathaway (2001), still exists, where drug-use is seen in the stark black and white dichotomy

of abuse and abstinence. After the emergence of HIV and AIDS, the notion of harm reduction made some progress but there is still considerable opposition from moral conservatives.

It is difficult to quantify aspects associated with harm reduction, for example, social stigmatisation (Hathaway 2001). Besides, how does one define harm? And if there is no global consensus as to exactly how to define it, how can it be measured and compared? However, there is clear evidence that methadone maintenance treatment reduces unsafe injecting practices (WHO 2005). In Ireland, while the primary goal of drug treatment is abstinence, supporters of harm reduction say that for drug-users who cannot or will not stop using, continued use of a drug like methadone under safe and supervised conditions is the best possible outcome (Moore *et al.* 2004).

1.4 Methadone Treatment

Methadone was developed in Germany near the end of World War II as a substitute for diminishing supplies of morphine. German scientists had discovered pethidine and were seeking to develop other similar compounds (UISCE 2003). They were specifically searching for water-soluble hypnotic (sleep-inducing) substances to slow the gastrointestinal tract in order to make surgery easier, and effective analgesics that were structurally dissimilar to morphine, in the hope that they would be non-addictive and escape the strict controls on opiates. In the aftermath of the war, the American intelligence services found the details on the chemical composition and process used to create methadone (The Methadone Briefing 1996, Palfai & Jankiewicz 2001). Methadone binds to opiate receptors in the brain and mimics the action of morphine or heroin without causing the euphoria. It is equally as potent as morphine as an analgesic and does qualify as a drug of abuse.

There are clear advantages of methadone as a treatment for opiate dependence:

- It is easy to administer as it is taken orally.
- It has a long action and its effects persist through persisted use.
- It is relatively cheap.

- It does not provide a euphoria.
- It prevents withdrawal.

Given these advantages, the two clinical uses of methadone are to block the withdrawal symptoms associated with heroin and to maintain the person in treatment in a heroin-free condition (Palfai & Jankiewicz 2001).

Methadone can be used in two ways to combat opiate addiction. The first way is as a detoxification, where the opiate user is prescribed methadone with a plan to reduce this dose in the short-term until the person is opiate-free. The second way is as a long-term maintenance opiate-substitute. This involves taking a dose of methadone every day. The person does not experience heroin withdrawal symptoms or euphoria. It is envisaged that the heroin use then stops (or decreases) thereby reducing the person's exposure to blood-borne viruses and the many problems connected to injecting (Palfai & Jankiewicz 2001). This treatment is known as a drug-substitution treatment and must be medically supervised (Moore *et al.* 2004).

Dole and Nyswander introduced the use of oral methadone as a form of treatment in New York in 1964 (UISCE 2003). The Dole and Nyswander approach produced consistently good results. Soon, other doctors began to use oral methadone in the treatment of heroin addiction. Early reports were almost unanimous in finding that those who remained in treatment showed a sharp drop in their use of heroin, a marked decrease in criminal activity, and an increase in legitimate employment as compared to their behaviours prior to entry into treatment.

Oral methadone, as mentioned above, has several advantages, most importantly, its long duration of action. It was important to have a substitution drug that would have a stable level of tolerance so that progressive escalation of dosage would be unnecessary. Also, because methadone is chemically different from heroin and morphine, it was possible, through urinalysis, to clearly demonstrate a decline in the use of heroin by addicts on methadone programmes, illustrating the effectiveness of the treatment.

1.4.1 Methadone in the European Union (EU)

According to UNODC (2011), of the 1 million people in Europe who received drug treatment in 2007, more than half were given opioid substitution treatment, mainly methadone treatment. The countries reporting the highest estimates were Ireland, Malta, Italy and Luxembourg. Estimates have shown that of the approximately 1 million people who received treatment for illicit drug-use in the EU during 2007, more than half received treatment for opioid use. An estimated 670,000 people received substitution treatment for opioid use in the EU, Croatia and Norway with approximately 70-75% receiving methadone. The consensus is that substitution treatment is a beneficial approach to the treatment of opiate use. Methadone maintenance treatment began in Europe in 1967, in Sweden. It was introduced to the Netherlands the following year, to the United Kingdom in 1968 and Denmark in 1970. In the late 1980's, the rate of introduction of this type of treatment accelerated. By 2001, 24 EU countries along with Norway, Bulgaria and Romania had introduced this form of treatment (EMCDDA 2006).

According to recent figures (EMCDDA 2010), estimates of the prevalence (the proportion of people in a population who have a specific condition or disease at a at a specific point of period in time (Long *et al.* 2005)) of problem opioid use in EU countries between 2003 to 2008 ranged roughly between one and eight cases per 1,000 population aged between 15-64 years. The average prevalence of problem opioid use in the EU and Norway during the same time period and for the same age range was estimated at between 3.6 to 4.6 cases per 1,000 population corresponding to approximately 1.35 million users in the EU and Norway in 2008.

1.4.2 The Irish Situation: Drug-Use, Heroin and Treatment

Introduction

The Working Party on Drug Abuse (1968-1971) was the first official committee to examine the drug problem in Ireland. Their recommendations were balanced between treatment and prevention. This committee completed its final report in February 1971. The report (Working Party on Drug Abuse 1971) contained the first published statistics on the prevalence of drug

use in Dublin at this time. There were approximately 940 drug users known to Gardaí (the Irish police force) by December 1970. The most commonly used drugs were cannabis and LSD; neither heroin nor any synthetic opiates were in common use.

There was however, according to Butler (2002a), to be a dramatic change in the drug scene in Dublin commencing in 1979-80. This change involved the increased availability of heroin, which was now being 'pushed' for the first time on a commercial scale and was being used intravenously by increasing numbers of young people in some of the most disadvantaged inner-city and peripheral working-class neighbourhoods. The influx of relatively pure and cheap heroin into Ireland at this time was part of an international change in the pattern of drug trafficking, in which the 'Golden Triangle' area of South East Asia was replaced, as the major exporter of natural opiates, by the 'Golden Crescent' of Iran, Afghanistan and North-West Pakistan.

Media and political comment on the growth of a heroin scene began to increase around November 1981. Unfortunately, this came at a time of flux in the position of the Irish Health Ministry, (there were five Ministers between 1979 and 1982) and when the country was experiencing economic difficulties. This put pressure on the funding of drug prevention and rehabilitation programmes. The scene was set for the heroin epidemic that subsequently swept Dublin.

The Heroin Epidemic and Methadone Introduction in Ireland

Public disquiet at the increasing indications of drug-use in Dublin resulted in the setting up of the Garda Drug Squad (Moran *et al.* 2001) in 1968. The following year, the National Drug Treatment and Advisory Centre was established in Jervis Street hospital as a result of the report by the Working Party on Drug Abuse (Keenan 2002). It was the first statutory out-patient treatment facility in the country (Moran *et al.* 2001) and it was the beginning of treatment-services in Ireland. In fact, it was for 20 years the only medical drug treatment facility in Dublin (Butler 2002b).

In 1971 methadone was introduced as a standard therapeutic approach for the treatment

<i>Year</i>	1979	1980	1981	1982	1983
All Patients	294	429	643	1,004	1,314
Opiate-users	182	301	497	761	1,028

Table 1.1: Numbers presenting for treatment for problem drug-use in Jervis Street 1979-83 (Dean et al. 1985)

of those dependent on opiates and synthetic opiates. During the 1970s, this option was available only to the small number of clients attending services in Jervis Street (Keenan 2002). Methadone treatment was used primarily for detoxification purposes, the main exception being pregnant women and women immediately after childbirth (Moran *et al.* 2001). The principal aim was to maintain the individual on as low a dose as possible, between 25-50 milligrams per day (Keenan 2002). In the emerging Irish system of drug treatment, the tendency was to view abstinence as the usual and most desirable form of treatment outcome. However, policy and practice have changed over the past number of years and harm reduction is now a key feature of Irish drug policy (Moran *et al.* 2001).

In 1979, following the fall of the Shah in Iran, heroin was easily available and relatively cheap in the streets of Dublin. In that year, five people were being treated per month in Jervis Street for heroin use. In the early 1980's, the numbers of heroin users presenting to Jervis Street increased dramatically (Dean et al. 1985), as can be seen in Table 1.1. The profile that emerged of typical opiate users in treatment was that they were male; single; from a depressed socio-economic background; had low educational achievements; and poor employment record (O'Gorman 1996). In 1983, a report by the Medico-Social Research Board, commonly called the Bradshaw Report (Bradshaw 1983), found that in one part of Dublin, 10% of 15-24 year-olds had used heroin in the last 12 months and that many were injecting. Jervis Street, faced with a serious escalation of heroin injection in young people, responded by providing methadone detoxification to those who presented (therefore opting for an abstinence-orientated approach) (Keenan 2002).

On a worldwide basis there was evidence emerging that methadone maintenance was believed to be having a beneficial effect on decreasing rates of HIV (Butler 2002b) following the identification in the mid 1980's of the link between needle-sharing and HIV transmission (Moran *et al.* 2001). While the overall number of AIDS cases was relatively low in Ireland, injecting drug-users accounted for the largest proportion of cases (42%) (O'Gorman 1996).

In 1988, following the closure of the National Drug Treatment and Advisory Centre at Jervis Street hospital, the drug treatment clinic was moved to another city-centre location known as the National Drug Treatment Centre, Trinity Court where it was established on a more formal legal basis than had previously been the case (Butler 2002b). In the late 1980's, amid increasing concern about HIV/AIDS and in the interest of public health, the existing abstinence model of treatment was extended to include the harm reduction approach in order to minimise the risks involved (Moran *et al.* 2001).

During the early 1990's certain General Practitioners (GPs) within Dublin had begun to prescribe methadone to opiate users. However, the absence of formalised structures for delivering a methadone programme led to considerable difficulties. The health board therefore introduced what is commonly referred to as the methadone protocol to control the prescribing and dispensing of methadone (Keenan 2002). On October 1st. 1998, the Misuse of Drugs (Supervision of Prescription and Supply of Methadone) Regulations came into operation in Ireland, effectively creating a licensing system for the prescription of methadone by GPs. Under the new regime or protocol, methadone prescribing by GPs was restricted to those doctors who were deemed to have appropriate training and who were specifically authorised by the regional health authority to carry out this therapeutic function. Another element of the new scheme was the establishment of a register or central treatment list (CTL) of patients for whom methadone was prescribed, aimed at the avoidance of multiple prescribing for individual drug-users and prevention of the leak of methadone onto the streets (Methadone Treatment Services Review Group 1998).

Certain key events led to the establishment of the methadone protocol. In 1990, the Irish

College of General Practitioners produced a policy statement on the management of problem drug-users in general practice. In 1991 the regularisation of methadone prescribing by GPs was taken a step further in an official policy document called Government Strategy to Prevent Drug Misuse (DoH 1991). In 1992, the then Minister for Health appointed a committee designated the Expert Group on the Establishment of a Protocol for the Prescribing of Methadone (Butler 2002b) to consider the following:

1. methadone prescribing;
2. registration of drug-users;
3. licensing of GPs to treat drug-users;

They set out recommendations in the form of a protocol for the involvement of GPs and community pharmacists in the methadone maintenance programmes. This protocol recommended that GPs should become involved by taking on responsibility for the care of persons whose methadone treatment had first been established at community drug treatment centres. It also outlined the criterion necessary to ensure that methadone prescribing occurred in a controlled and responsible fashion (Methadone Treatment Services Review Group 1998). This report was completed in March 1993 (DoH 1993).

In March 1996, a methadone maintenance pilot project, involving GPs and pharmacists in the Eastern Health Board region, commenced. It involved the selection of a number of patients who had been stabilised in drug treatment centres and who were referred to GPs in their own local area for continuation of methadone treatment and overall care (Methadone Treatment Services Review Group 1998).

In late 1996 (Butler 2002b), the proposal to expand GP involvement in methadone prescribing received public support from a committee of junior ministers on the Ministerial Task Force on Measures to Reduce the Demand for Drugs (1996). The chairman wrote that not only did Ireland have a drugs problem but that it was specifically an opiate problem and the main opiate in question was heroin. Also, he wrote, this was mainly a Dublin problem. While

substantial resources had been made available, from IR£1million in 1992 to IR£9million in 1996, the Task Force concluded that the level of services currently available fell short of what was required to address the problem. The Task Force recommended that the methadone prescription/dispensing scheme continue to be expanded, evaluated and strictly regulated (Methadone Treatment Services Review Group 1998).

In its policy document on drug-use, which was published in October 1996, the Pharmaceutical Society of Ireland acknowledged the valuable role played by methadone in the treatment of opiate addiction (Methadone Treatment Services Review Group 1998). In 1997 another committee, the Methadone Treatment Services Review Group, was established within the Department of Health to take forward the work of the Expert Group. In March 1997 the government published a report called 'A radical approach to drugs and drug related crime' (Fianna Fáil 1997) which said that the government viewed methadone as a second-best solution, they preferred detoxification and rehabilitation (Butler 2002b). In May 1997, the Irish College of GPs published a report of the Task Group on Drug Misuse. This report recommended that GPs should become involved in the treatment of opiate-users in their own local communities. It also recommended that methadone treatment as described in the Expert Groups protocol should continue as a valid form of treatment for opiate dependence (Methadone Treatment Services Review Group 1998). The Methadone Treatment Services Review Group recommended *inter alia* the following:

1. GPs and pharmacists should provide methadone treatment to opiate-users in their local area.
2. Methadone prescribing by GPs should be restricted to special prescription forms issued by the regional health board.
3. GPs participating in the new protocol should do so through a contract with their regional health board which would involve basic training in the management of drug problems, acceptance of registration of patients through the CTL, restriction on the

numbers of patients for whom they might prescribe and agreement to accept payment for this service from the health board and not the patient.

4. All these proposals should be put on a statutory footing through the making of regulations under Section 5 of the Misuse of Drugs Act 1977.

(Butler 2002b)

The methadone protocol was enacted in 1998. The methadone service was decentralised and made available on a more widespread basis, in the local areas of Dublin. On contact with the service each person was assessed individually for suitability to methadone treatment (Moran *et al.* 2001).

Methadone Treatment in Ireland

Two databases record details of treated drug-use in Ireland. The National Drug Treatment Reporting System (NTDRS), an epidemiological database, was set up in 1990 to cover the Greater Dublin Area but was expanded nationwide in 1995. One form per calendar year is completed for each client entering a new treatment episode (except for needle exchange). Information on demographics, substance-use and risk behaviours are collected. These data are aggregated and used at national and European level as indicators of treatment demand, drugs of abuse and service performance (Long 2005).

The CTL, as mentioned previously, is a complete register of all patients receiving methadone treatment. It is managed by the Drug Treatment Centre Board and was set up following the Department of Health and Children (Methadone Treatment Services Review Group 1998) report. When a person is considered eligible for methadone detoxification or maintenance, the prescribing doctor applies to the CTL for a place on the list and a treatment card for the client. The card is retained by the nominated dispensing pharmacy. The client can only obtain their methadone from that particular pharmacy and pharmacies only administer methadone to those clients whose cards they hold. Entry and exit forms keep a record of numbers of clients entering, leaving or re-entering treatment. The CTL retains the client's name,

address, date of birth, gender, date of commencement of methadone, type of methadone treatment, prescribing doctor and dispensing pharmacist. Each client also receives a unique identifying number. GPs have a statutory obligation to keep this paperwork up to date and they are remunerated for each client (DMRD 2004, Long 2005).

In Ireland, clients seeking admission to methadone maintenance treatment should meet the International Classification of Diseases and Related Health Disorders, Tenth Revision (ICD-10) criteria for addiction or specifically, dependence syndrome (WHO 2011). The client must also have been using drugs intravenously for one year but, in practice, this is not enforced. Priority is given to pregnant clients, clients who have a partner in treatment and clients who have tested HIV positive. Clients who are under 18 years of age require parental permission to enter methadone maintenance treatment and must have at least one failed attempt at a detoxification treatment. All clients must provide three opiate-positive urine samples to confirm use and the client's motivation to change is assessed. There is no set time limit for methadone maintenance treatment and according to the methadone protocol, the treatment is free (Moran *et al.* 2001). Prior to 1998, the only form of methadone available in Ireland was physeptone linctus (two mg methadone per five ml of syrup). From 1998, this was replaced by Methadone DTF mixture (one mg per one ml syrup) (Methadone Treatment Services Review Group 1998). Stable clients, those who have provided opiate-negative samples over a prescribed period of time, may be dispensed 'take-home' doses of methadone. This may be one week's worth of doses, allowing the clients to administer their daily dose themselves at home, so that he or she is not required to visit the clinic or pharmacy each day (Moran *et al.* 2001).

As stipulated in the methadone protocol, GPs and pharmacists receive training in the provision of methadone treatment, and care and management of the methadone clients. GPs participating in the scheme are trained to two levels. Level one trained GPs can accept a maximum of 15 stable methadone patients referred to them from a health board treatment centre. Level two trained GPs can initiate treatment themselves and can treat up to 35

clients (although if two such doctors are at the same practice they are allowed 50 patients for the practice in total). They must have worked for at least a year at a methadone clinic before undergoing the training. As for pharmacists, ideally a maximum of 50 clients can be registered with a pharmacist permitted to administer methadone DTF (Moran *et al.* 2001, DMRD 2004).

In May 2001, the government launched the National Drugs Strategy 2001-2008 (DoTSR 2001). Initially the strategy consisted of four pillars; supply reduction, prevention, research and treatment. Two of the overall strategic aims of the strategy were to:

- reduce the risk behaviour associated with drug-use;
- reduce the harm caused by drug-use to individuals, families and communities.

Specifically, the treatment pillar sought to:

- encourage and enable those dependent on drugs to avail of treatment with the aim of reducing dependence and improving overall health and social well-being, with the ultimate aim of leading a drug-free lifestyle;
- minimise the harm to those who continue to engage in drug-taking activities that put them at risk.

A fifth pillar of rehabilitation was added by the mid-term review of the strategy in 2005 (DoCRGA 2005) with the overall goal of providing an integrated rehabilitation service to current, stabilised and former drug-users. In September 2009 a new strategy was launched (DoCRGA 2009). The five pillars were retained and the overall strategic objective now is to continue to tackle the harm caused to the individual and society.

Numbers in Treatment in Ireland

In Ireland, methadone maintenance is normally provided in an out-patient setting. These include drug treatment centres, satellite clinics and general practices, the policy being to provide treatment locally where possible. Thus, in addition to some central treatment-services, a network of addiction centres and satellite clinics has been developed. This is particularly evident

<i>Year</i>	1995	1996	1997	1998	1999
<i>New cases, main drug heroin</i>	1870	2014	1465	1621	1636
<i>Percentage of all new cases</i>	54.6%	63.2%	58.4%	55.7%	53.5%

Table 1.2: Clients presenting for first treatment episode in Ireland 1995- 99

in the former Eastern Region Health Authority (ERHA), called the Health Services Executive (HSE) Eastern Region (which included administrative counties Fingal, Dun Laoghaire, South Dublin, Dublin City, Kildare and Wicklow) (Moran *et al.* 2001) and following an interim period of reorganisation is geographically spilt between HSE Dublin/North East Region and HSE Dublin/Mid-Leinster region (Long *et al.* 2005).

Numbers in Treatment: Dublin/Eastern Region

In 1979, the National Drug Treatment Centre, Jervis Street, treated 55 heroin users. In 1980, 213 heroin users were treated and this rose to 417 in 1981 (Lawless & Cox 2000).

In 1990, in Dublin, there were 2037 in treatment for illicit drug-use of all kinds. For 80% of those, the primary drug of use was reported as an opiate or opioid, but mainly heroin (O'Hare & O'Higgins 1992). The numbers in treatment for heroin alone were not reported. The number of cases who received treatment for problem drug-use in the Dublin increased steadily from 1990 to 1994. Prevalence figures were not available until later and this increase may be due to the expansion of services. The most commonly-used primary drug recorded in that period was heroin (O'Higgins 1996). Table 1.2 shows numbers of clients presenting for treatment in the late 1990's in Ireland. Each year, over 50% of all clients requiring drug treatment indicated heroin was their primary drug of choice.

Contrast: Dublin/Eastern Region and the rest of Ireland

Data combined over health board areas outside of Dublin, which existed up until 2005, shows a sharp contrast with the ERHA. During 1995 the total number of cases treated in the other eight areas was 803. In these other health board areas, the primary drug of use was reported

Year	1997	1998	1999	2000	2001	2002	2003
ERHA	2859	3610	4269	4936	5466	5813	6204
Outside ERHA	-	-	63	96	170	211	277
Prisons (nationwide)	-	-	-	-	229	425	402
Total	2859	3610	4332	5032	5865	6449	6883

Table 1.3: Clients receiving methadone treatment in Ireland 1997- 2004 (DMRD 2004)

to be cannabis at 42% (n=337) with heroin at 20% (n=161) (O'Higgins & Duff 1997). This trend is seen in a 1997 Southern Health Board survey. This particular community survey looked at tobacco, alcohol and drug-use in Cork and Kerry. Of a sample of 2100 aged 15-44 years, only 1% had reported taking opiates in their lifetime. Heroin was scarcely detected and there was no injecting drug-use (Jackson 1996).

The HRB (Health Research Board) Statistical Bulletins published in 1997 and 1998 demonstrate the difference in the numbers attending methadone maintenance treatment in the ERHA when compared to the rest of the country (Moran *et al.* 2001) as illustrated in Table 1.3. As of July 2000 under 2% (n=90) of a total of 4851 clients registered on the CTL were receiving substitution services outside the ERHA.

A contrast can also be seen with the location of services. Of the 158 GPs prescribing methadone in Ireland in 2000, 83% (n=131) were located in the ERHA area leaving just 17% (n=27) methadone prescribing GPs for the rest of the country. There were 207 pharmacists dispensing methadone to those attending both methadone clinics and those attending a methadone prescribing GP. Of the 207, 74% (n=154) were located in the ERHA and 26% (n=53) in the rest of the country. In 2000, 49 clinics within the ERHA were prescribing methadone to their attendees with only 8% (n=4) offering the same service outside the area. These figures demonstrate the concentration of methadone treatment services in the Dublin area. However, opiate-use was beginning to spread out beyond Dublin and the east coast with pockets of heroin-use becoming apparent in a number of urbanised areas and regional

Estimate of Prevalence of Opiate-Use			
Year	Ireland (95% CI)	Dublin (95% CI)	Ireland(except Dublin) (95% CI)
1996	-	13,461 (12,037-15,306)	-
2000	14,158 (12,884-15,883)	12,268 (11,204-13,725)	2,526 (1,893-3,639)
2001	14,452 (13,405-15,819)	12,456 (11,519-13,711)	2,225 (1,934-2,625)
2006	20,790 (18,136-23,576)	14,904 (13,737-16,450)	5,886 (4,399-7,126)

Table 1.4: Capture-recapture studies of the prevalence of opiate use in Ireland

locations (Moran *et al.* 2001).

A report from the National Advisory Committee on Drugs (NACD) (Kelly *et al.* 2003) on the prevalence of opiate-use estimated the numbers of opiate-users in Dublin and in the rest of Ireland as shown in Table 1.4. The figure for Dublin alone was 12,456 which is in line with the Comiskey (1998) study which estimated around 13,461 opiate-users in Dublin in 1996, although it should be noted Comiskey (1998) examined the 15-54 age group whereas the Kelly *et al.* (2003) study included ages 15-64. Kelly *et al.* (2003) estimated that there were 14,452 people using opiates in Ireland in 2001 and just over 14% (2,225) of those were outside of Dublin. This study was updated for 2006 (Kelly *et al.* 2009) and shows a rise in rates across the three geographies examined (as illustrated in Table 1.4) but a more notable rise is seen in the estimated prevalence of opiate-use outside of the Dublin area (EMCDDA 2010). These studies are further examined in chapter two.

As of August 2003 in the ERHA, there were 64 satellite clinics providing methadone maintenance treatment, two mobile units providing low-threshold services to four areas in this region (low-threshold services include low dose methadone or drop-in facilities) and 167 GPs prescribing methadone. These numbers contrast greatly with the rest of the country. Outside of the ERHA there were six health board clinics and 34 GPs providing methadone maintenance treatment (DMRD 2004). Figures show that both the incidence (the number of new cases of disease or events that develop among a population during a specified time

Estimate of Prevalence of Opiate-Use, rates per 1,000			
Year	Ireland	Dublin	Ireland (except Dublin)
1996	-	21.0	-
2000	5.6	15.9	1.4
2001	5.6	15.9	1.2
2006	7.2	17.6	2.9

Table 1.5: Capture-recapture studies of the prevalence of opiate use in Ireland: Rates

interval (Long *et al.* 2005)) and prevalence of treated problem drug outside this region, use trebled between 1998 and 2002 with the numbers reporting opiate-use steadily increasing (Long *et al.* 2004).

More recent figures show that at the end of 2009, there were 277 GPs prescribing methadone and 70 clinics in Ireland. Figures also show how there has been a steady rise in those receiving methadone treatment outside of Dublin. From 2002 to 2009, the numbers trebled to over 1,200 according to the CTL. Heroin-use and injecting heroin-use has not remained confined to Dublin and methadone treatment services have developed in places such as Athlone, Galway, Limerick, Waterford, Carlow and Portlaoise. It has been suggested that services do not meet treatment demand in a number of areas outside of Dublin and this issue requires a re-focusing of services (Farrelly & Barry 2010). For example, it has been reported that there are no methadone treatment facilities in Wexford, Gorey or New Ross where there are a significant number of heroin users (O’Sullivan 2011). According to Merchants Quay Irelands (MQI) Annual Review for 2010 (MQI 2010), the drugs crisis is a national crisis as it is not confined to Dublin. Where once MQI mainly provided services in Dublin, it now has a presence in eleven counties across Ireland.

1.5 Conclusion

The use of opiates such as morphine and heroin have a long history. Ireland's particular difficulty with heroin began 30 years ago. Since the early 1980's in Ireland, and especially Dublin, has seen heroin-use become increasingly problematic, both in terms of the number of people using them, and the associated health, crime and other problems. These problems have centred mainly in economically depressed areas. The numbers in treatment have grown as the numbers of users have grown. Reports have consistently shown opioids, including heroin, to be the primary drug of choice for people entering treatment.

Given the rise in treatment-services available for opiate addiction in Ireland, the imperative is to assess the effectiveness of the treatment. Identifying that there is a problem is the first step to implementing treatment. The next step must be to ensure that people who seek treatment are offered a treatment suitable for their needs.

International studies recognise the effectiveness of methadone in treatment for problem opiate use. Closer to home, the ROSIE (2008) (Research Outcome Study in Ireland) Study, reported very positive outcomes associated with methadone treatment, including substantial reductions in injecting drug-use after one year of methadone maintenance treatment. In chapter two, statistical models are discussed which have been used internationally and in Ireland to enumerate opiate-users and investigate other aspects of opiate-use.

Chapter 2

History of the Application of Statistical Models to Drug Datasets

There are very complex problems of methodology in trying to calculate possible rates of drug-use prevalence because of the types of data available, how accurately it is recorded, and whether that data is actually usable, let alone the associated problems of statistical analysis.

(Murphy-Lawless 2002)

2.1 Introduction

The application of epidemiology to the study of drug-use is relatively recent and began in the 1960's in the United States (Kozel & Adams 1986). Epidemiological models followed in the 1970's. According to Lindsey (2005), the role of the scientist is to endeavour to explain rather than simply to describe phenomena. As models can be built to help explain scientific theories, these models, which are in essence simplifications of reality, help to highlight essential characteristics of the theory in question. Within this chapter is a discussion of when modelling was first applied to drug data, the Ball & Ross (1991) model and modelling of drug data in Ireland to date.

2.2 Epidemiological Approach to Drug-Use

Epidemiology is mostly an applied or problem-driven science and, according to Slobda (2005), reasons for assessing drug-use in a community may include the need to understand the type

of drug being used, the extent and pattern of new use, the emergence of new drugs or new forms of old drugs, new administration patterns, new populations at risk and health risks and consequences. Answers to these maybe sought through statistical modelling to build a picture of the particular process under examination and, if possible, predict outcomes.

Modelling disease in general underwent an intense period of development in the wake of the emergence of HIV/AIDS as policy makers, medics and society in general looked to scientists to describe, quantify and predict a future with this disease (Kretzchmar 2001) with many recent modelling advances made with the field of HIV/AIDS research.

The basic driving forces behind all modelling are simple questions which may be quite difficult to answer but are important for planning, policy and treatment providers. Models do not provide all the answers either. A model may provide a ‘global guideline’, as all empirical data contains variability, no two humans being the same (Lindsey 2005). Models do not reach down to the level of the individual, although data can be collected at this level, but rather models endeavour to describe what is happening in general. Good and useful models provide the ‘bigger picture’ (Weissing & Hartnoll 2001). This larger view of the structure of a process, whether, in terms of drug-use or it’s spread, addiction or treatment, may then highlight elements, relationships and underlying processes that are missed at the individual level.

During the 1960’s in the United States there was an “outbreak” of heroin-use which became known as a “Heroin Epidemic” (Kozel & Adams 1986). Using this nomenclature shows that some scientists were then considering the spread of heroin-use as having similar properties to the spread of disease, and that the application of epidemiological tools were relevant. This required a shift in thinking as drug-use is, in the first instance, a voluntary action and becoming infected with disease may not be. However it was argued that the drug could be seen as the infectious agent, the human as the host and reservoir and drug-using peers as vectors. Research on the drug using career has since established that addiction is a chronic relapsing condition (Hser *et al.* 2005).

There has been a long-standing debate on whether drug-use is a medical or social problem but it is now seen as a public health issue (Slobda 2005). This has come to pass due to the link injecting drug-use has with HIV/AIDS. There are few studies on the health consequences of drug-use itself, partly because the voluntary nature of drug-use has stigmatised its use in the eyes of policy makers and the general public. Interestingly Kozel & Adams (1986) say that at one time the consideration was whether the field of epidemiology was appropriate for the field of drug-use, but now, the creativity of epidemiological study is actually being driven by this field. One common problem with epidemiological models of drug-use is lack of available data as models require specific data to produce as accurate a model as possible to produce reliable results.

Later in this chapter, it will be seen that the 1990's was when Europe began to look at epidemiological modelling for drug data as a real and useful tool.

2.3 Ball and Ross: Models of Treatment

As discussed in chapter one, methadone maintenance treatment was established in New York City in 1964 by Dole and Nyswander. Outcome studies from these first years reported favourable results in terms of retention, criminality and social rehabilitation. During the 1970's, this treatment was expanded through out the United States and by 1989 there were 667 methadone maintenance programmes in the United States. Naturally, not all of these programmes provided the same service and, as is the situation now, treatment for addiction varied considerably. With time and geographical spread, some evolution of services has occurred. Given this diversity, Ball and Ross sought to investigate which characteristics of service provision contributed to a successful treatment outcome.

Ball & Ross (1991) describe the pervasive lack of knowledge that they saw surrounding the components and dynamics of treatment as a black box. Previous studies could show that 'something' in the treatment worked or was effective but there was a reluctance to describe or measure this 'something'. In their opinion, this situation existed because there was just no

interest in evaluating treatment programmes as it was costly, difficult, problematic and was not in the realm of ‘hard science’, nor did it fall within the remit of any particular academic discipline. Hendriks (1999) highlights the fact that the actual mechanics of treatment and its active ingredients have still not been uncovered. He points out that studies have rarely involved treatment or treatment process factors in an evaluation model. His reasoning is that the ‘something’ that happens during treatment is very difficult to identify or quantify.

The Ball & Ross (1991) study was one of the first studies to model drug data from the aspect of treatment outcome and therefore effectiveness. It was the first study to relate treatment programme quality factors to patient treatment outcomes. The study was sponsored by NIDA (National Institute on Drug Abuse) in the United States in the early 1980’s and was undertaken to answer the simple question ‘Is methadone treatment effective?’ Ball and Ross took the approach, which was unusual at the time, of using regression modelling of outcomes in their assessment of treatment effectiveness. As models used in the analysis of drug-use at this time were mainly concerned with spread of use, this was a different approach which was interested in treatment outcome. Regression modelling was suitable as it enabled the highlighting of key elements of treatment as a function of treatment outcome. The main findings were that methadone maintenance treatment was effective in reducing heroin-use and criminal behaviour associated with heroin addiction and that elements of treatment such as the effectiveness of the director of the clinic tended to produce more favourable outcomes. That methadone treatment was found to be substantially effective in reducing heroin-use and associated criminal behaviour was consistent with the findings of several previous independent evaluations. The unique importance of this study is that it moved beyond the over-broad questions of general effectiveness of ‘methadone programs’ to the specifics of the treatment process. In general, methadone treatment programmes differed in treatment philosophy, techniques and resources.

Evaluators on the Ball & Ross (1991) study selected a set of programmes with considerable variance in treatment techniques, and therefore for the first time in evaluation history, were

able to join a statistical analysis of process to an analysis of outcome. Their multivariate regression model looked at five outcomes recorded at the second interview which was one year after the first or baseline interview. The cohort for this multivariate analysis consisted of 407 individuals who were in treatment six months or longer at baseline interview. The outcomes investigated were:

- Days of heroin-use in the last 30 days.
- Days of cocaine-use in the last 30 days.
- Use of any opiates or cocaine in the last 30 days.
- Months since last IV drug-use.
- Number of crime days during the last 30 days.

The general form of each model was:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_p x_{ip} + e_i \quad (2.1)$$

-a multiple linear regression equation.

The model can also be written as

$$\boxed{\text{Outcome}} = \boxed{\text{constant}} + \boxed{\text{patient variables}} + \boxed{\text{programme variables}} + \boxed{\text{process variables}} + \boxed{\text{error}} \quad (2.2)$$

where the patient component comprised of the variables:

- age;
- race;
- employment;
- age at onset of addiction;
- years of regular heroin-use;

- years of regular other opiate-use;
- years of regular cocaine-use;
- number of prior treatments;
- number of arrests;
- crime rate per week in last addiction period.

The programme component consisted of the results of a principal components analysis which summarised 89 variables describing various aspects of the treatment facility. Principal components are a result of a data reduction technique. In short, principal components are derived in decreasing order of importance, accounting for decreasing proportions of the variation of the original variables, providing a summary of the data (Everitt & Dunn 1991).

Finally, the process component of the linear regression model comprised of variables on:

- The length in treatment up to first interview.
- The number of days of missed methadone in the last 30 days prior to first interview.
- Take-home methadone dose per week prior to the first interview
- Methadone maintenance dose at the first interview.
- Whether the treatment was terminated before the second interview.

Later on, in chapter five, this regression modelling approach is critically analysed and with principal components analysis applied for the first time to Irish drug treatment data.

2.4 Modelling in Europe and Ireland

In 1993 the EMCDDA (European Monitoring Commission on Drugs and Drug Addiction) was established with the focus on improving the comparable data on drugs and drug-use across Europe. In 1997 and then again in 1998, the EMCDDA gathered a group of modelling

experts from across Europe (Weissing & Hartnoll 2001). The main focus of these meetings was to discuss future modelling of drug-use using contemporary quantitative mathematical and statistical approaches. It was noted at the time that there were few examples of these types of models used for modelling drug-use and the problems connected to drug-use. One reason put forward was the relative isolation of the modellers up to that point. It was also noted that to build these models, not only was suitable and good quality raw data required but a sound knowledge of the social processes around drug-use was essential. Further, work of this kind would draw on research from many different academic disciplines. Therefore, models such as GIS (Geographic Information Systems) models concerning the spread of drug-use, or economic models concerning the cost of drug treatment require professionals in these fields to have an interest in and an understanding of drug-use, treatment and spread.

Little modelling of drug data to date has taken place in Ireland with a few notable exceptions. These are discussed in the following section.

2.4.1 Models Implemented in Ireland

In 2003 in a report published by the National Advisory Committee on Drugs (NACD) (Cox 2003), the capture-recapture method was described as an indirect method favoured by the EMCDDA for estimating the numbers of drug -users and the prevalence of drug-use on a local level, primarily for opiate-use. The main advantage of this method is that it is relatively cheap as existing data sources are used. The main disadvantage is that data is not always available or accurately recorded and takes considerable statistical skill to develop estimates from the samples. Capture-recapture methods have a long history, and they were first applied in the study of fish and wildlife populations before being applied to other purposes. This method can, in principle, be applied to any situation in which there are two or more incomplete lists. In the case of epidemiology, lists can be constructed from a variety of sources such as hospital records, doctors' medical records, medical prescriptions, and so on (IWGDMF 1995).

Long before the NACD report, Comiskey (1998) estimated the prevalence of opiate drug-use in Dublin in 1996. The capture-recapture method was used to derive estimates of a hidden

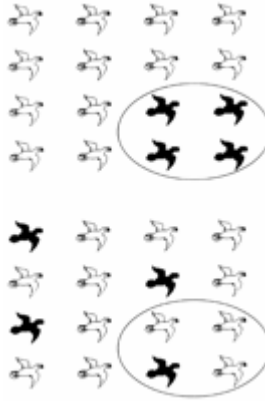


Figure 2.1: Capture-recapture method

opiate drug-user population. Up to then there had been no comprehensive study on the true prevalence of drug-use in Dublin, let alone Ireland. Simply, when working with two or three samples or data sets with capture recapture, the first sample provides the individuals for marking or tagging and is returned to the population. The second or third sample provides the recaptures.

Figure 2.1 provides a simple visual demonstration of capture-recapture in animal counting. A sample of the bird population is captured and marked (top). They are then released and later recaptured (bottom). From the 1:4 dilution of marked birds, the total population (four times the captured birds) can be calculated (Gill *et al.* 2001).

There are four assumptions of this model:

- There is no change to the population during investigation.
- There is no loss of tags, individuals can be matched from capture to re-capture.
- For each sample, each individual has the same chance of being included in the sample.
- The samples are independent.

The method put forward by Comiskey (2001) had three data samples in a 2^3 table with one cell missing as detailed in Table 2.1.

1 st . Sample	2 nd . Sample Present,	2 nd . Sample Absent,	2 nd . Sample Present,	2 nd . Sample Absent,
	3 rd . Sample Present	3 rd . Sample Present	3 rd . Sample Absent	3 rd . Sample Absent
Present	x_{111}	x_{121}	x_{112}	x_{122}
Absent	x_{211}	x_{221}	x_{212}	-

Table 2.1: Three-sample capture-recapture example

From the table then let,

$$n = x_{111} + x_{121} + x_{211} + x_{221} + x_{112} + x_{122} + x_{212} \quad (2.3)$$

In addition let m_{ijk} be the expected value for the number of individuals in the (ijk) cell. Let P_{ijk} be the underlying probability corresponding to the (ijk) cell. P_{111} is the probability of being in all samples. The probability of being in none of the samples is P_{222} and assume $P_{222} > 0$ Therefore

$$m_{ijk} = p_{ijk}(n/(1 - p_{222})) \quad (2.4)$$

for $(i, j, k) = (2, 2, 2)$

The loglinear models are interpreted as follows:

1. The three sample are independent: $\log(m_{ijk}) = u + u_{1(i)} + u_{2(j)} + u_{3(k)}$
2. The third sample is independent of the first two: $\log(m_{ijk}) = u + u_{1(i)} + u_{2(j)} + u_{3(k)} + u_{23(jk)}$
3. Two pairs of sample are related: $\log(m_{ijk}) = u + u_{1(i)} + u_{2(j)} + u_{3(k)} + u_{12(ij)} + u_{23(jk)}$
4. All pairwise relationships are present: $\log(m_{ijk}) = u + u_{1(i)} + u_{2(j)} + u_{12(ij)} + u_{23(jk)} + u_{13(jk)}$

The model chosen can then be used to estimate the contents of the missing cell.

The main finding of Comiskey & Barry (2001), which used this method, was that in 1996 it was estimated that there were 13,460 opiate-users in Dublin, Ireland (with a 95% confidence

interval of 12,037 - 15,306). The report went on to highlight the wider implications of these findings. For example, as some estimates say 80% of drug-users who have been tested are Hepatitis C positive, it was recommended that an analysis of the true extent of this disease be conducted.

Later, a report by Kelly *et al.* (2003) also used the three-source capture-recapture method and was the first national capture-recapture-method exercise in Ireland. According to the foreword by the Minister of State at the time, this report, which estimates the number of opiate-users in Ireland, was seen as a valuable update on the Comiskey report and provided estimates for the Republic of Ireland including and excluding Dublin.

The Kelly *et al.* (2003) report itself was then updated in 2009 (Kelly *et al.* 2009) providing prevalence estimates for opiate-use in the Republic of Ireland, Dublin alone and Ireland excluding Dublin for 2006. The results for these the reports were presented in chapter 1, Tables 1.4 and 1.5.

These works, Comiskey & Barry (2001) and Kelly *et al.* (2003), used similar data sources:

- The Central Patient Methadone Treatment List which lists all those in receipt of methadone in Ireland.
- The Hospital Inpatient Enquiry Database (HIPE) which records all discharges from Irish hospitals and diagnoses.
- Garda data on illegal drug-use.

Figure 2.2 illustrates the three data sources used by Kelly in the form of a venn diagram detailing where individuals may be found in the data. These include:

1. $T \cap H$ -individuals common to the treatment list and the HIPE list.
2. $T \cap G$ -individuals common to the treatment list and the Garda list.
3. $H \cap G$ -individuals common to the HIPE list and the Garda list.
4. $T \cap H \cap G$ -individuals common to the treatment list, the HIPE list and the Garda list.

Figure 2.2: Kelly: Capture-recapture method

5. T -individuals in the treatment list only.
6. H -individuals in the HIPE list only.
7. G -individuals in the Garda list only.

Other work has focussed on the progression of individuals through periods of drug-use on to treatment and then re-lapsing back to addiction and drug-use. Work by White & Comiskey (2007) have used mathematical modelling to study the progression through the drug using career. The model used to described this is shown is Figure 2.3. We have, in the following three equations,

$$\frac{dS}{dt} = \Lambda - \frac{\beta_1 U_1 S}{N} - \mu S \quad (2.5)$$

$$\frac{dU_1}{dt} = \frac{\beta_1 U_1 S}{N} - pU_1 + \frac{\beta_3 U_1 U_2}{N} - (\mu + \delta_1)U_1 \quad (2.6)$$

$$\frac{dU_2}{dt} = pU_1 - \frac{\beta_3 U_1 U_2}{N} - (\mu + \delta_2)U_2 \quad (2.7)$$

The parameters of this model are:

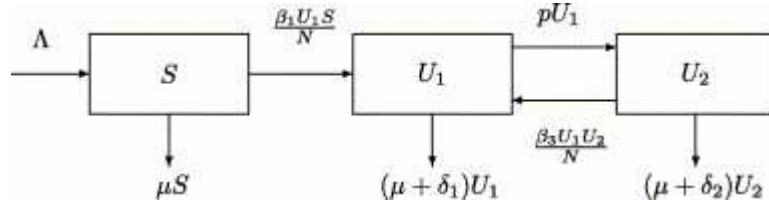


Figure 2.3: White and Comiskey: A model of the opiate using career.

- N , the population size.
- S , the number of susceptibles.
- U_1 , the number of drug-users not in treatment.
- U_2 , the number of drug-users in treatment.
- Λ , the number of individuals entering the susceptible population.
- μ , the natural death rate.
- δ_1 , a removal rate including drug-related deaths of those not in treatment.
- δ_2 , a removal rate including drug-related deaths of those in treatment.
- β_1 , the probability of becoming a drug-user.
- p , the per capita probability per unit time of drug-users entering treatment.
- β_3 , the probability of a drug-user relapsing.

Results from research utilising this model found that prevention is better than cure; efforts to prevent drug-use are more effective than efforts to increase the number in drug treatment when trying to control drug-use.

Recently, work by Dempsey & Comiskey (2011) applied the back calculation method, for the first time to Irish drug-use data, with a view to estimating untreated drug-use. The method was based on the following,

$$T(t) = \int_0^t U(t-u)f(u)du \quad (2.8)$$

where $T(t)$ is the known density of new first treatments, $U(t)$ is the density of untreated opiate use and is defined as the number of opiate users between t and $t + dt$ who have never been in any form of treatment for their opiate use. The latency period of opiate use is denoted by $f(t)$. For the period 1999 to 2005, results predicted a decreasing number of annual cases of new opiate users in the hidden population.

All in all, however, there are few modellers working on drug data in Ireland whether it be on spread, prevalence, treatment or outcome. To date there has been relatively little use of quantitative modelling in the area of drug-use in Ireland. Research that has been carried out in Ireland comes mainly from the traditionally qualitative field of research. This gap can be filled by using modelling to test social theories and run hypotheses. This has been recognised by the EMCDDA and has been carried out in other countries. The Comiskey & Barry (2001) findings were both ground breaking and controversial in estimating the number of opiate drug-users in Dublin. It was known that there was a heroin problem in Dublin and it had been written about widely but the application of a mathematical method to estimating the extent of the problem was a new approach. There has been little development outside of this team with only a handful of trained modellers applying their techniques to drug-use research across Ireland, the UK and Europe.

2.5 Conclusion

The multifaceted nature of the problem of drug-use has allowed the application of investigative techniques from a variety of disciplines in public health, medicine, and the social services. According to Kozel & Adams (1986), epidemiology has become a staple in the methodological tools available when conducting drug abuse research.

This process began in the 1960's and 1970's where epidemiological methods were applied to the spread of drug-use. This thinking evolved to applying epidemiological methods and then modelling to other aspects of drug-use. In Europe, the EMCDDA embraced this thinking in the late 1990's when they gathered experts in epidemiology and modelling together to plan

and implement modelling strategies. However, to date, there have been very few statistical or mathematical modellers working either on Irish or international drug-use data.

In general, the need for evaluation of treatment effectiveness has been widely recognised. However, few systematic longitudinal studies have been undertaken and information on outcome of treatment in different modalities is scarce. In fact, drug treatment studies have rarely involved treatment or process variables in their evaluation model. This is why, from a modelling aspect, the Ball & Ross (1991) study stands out and was recommended by as a template for use in Europe (Hendriks 1999).

Chapter 3

Ball and Ross: Methadone Programme Variables

3.1 Introduction

The main aim of this chapter is to explain and describe the provision of services within methadone clinics in Ireland. In their study Ball & Ross (1991) described this information as methadone programme data.

Heroin-use and treatment has historically been focussed in Dublin. This chapter therefore describes seven clinics located in the eastern region of the country. In their study, Ball & Ross (1991) chose six clinics on which to base their study. Led by this, eight methadone clinics were contacted and invited to take part in this research. Seven clinics responded and those seven clinics are the subject of this chapter. Ethical approval for the overall study was obtained from the National University of Ireland, Maynooth (NUIM) ethics committee.

3.2 Methods

Data pertinent to the running of seven methadone maintenance clinics including staffing, security and policy was collected using a survey. This data collection exercise was carried out with a view to assembling the data in a format suitable for inclusion in a regression model as a clinic component along with patient and process components to attempt to explain the elements of effective methadone maintenance treatment.

The survey was conducted on four health board clinics and three community clinics located in the east coast region of Ireland. A letter seeking permission for an interview with a member

of staff was sent to the seven methadone clinics followed by a telephone call to arrange an interview. An informal interview was arranged with the aim of filling out a questionnaire similar to the questionnaire used by Ball & Ross (1991) when conducting their programme evaluation. See Appendix A for details of the questions asked.

3.2.1 Sampling

The main objective of the Ball & Ross (1991) study was to investigate methadone maintenance treatment effectiveness in the United States. But, for reasons of practicality, authors chose two clinics in each of three cities located on the east coast, New York, Philadelphia and Boston. Those cities were chosen as they had the greatest concentration of heroin users in the United States at that time. Later, Magura et al. (1999), again in the United States, attempted to replicate the Ball and Ross study and chose 17 clinics, all based in New York. The emphasis on this work leaned more toward deriving programme level effects. These 17 clinics were chosen due to past interest or participation in previous research.

The seven methadone clinics described within this chapter were chosen from methadone clinics operating in the eastern region of the country using purposeful sampling. Taking time and resources into consideration, it was decided to restrict the coverage to this area due to the concentration of methadone maintenance clinics there, arising from the longer history that the east coast region has in relation to opiate and heroin treatment. As was discussed in chapter one, the Dublin area was the epicentre of the so-called heroin epidemic which began in the early 1980's in Ireland. Therefore, the administration of treatment in this region of the country is well established. The clinics were chosen to represent different sizes of clinic, different geographical location within the region and across the two broad types of community or health board clinics. Therefore the clinics chosen and described here provided a sample of methadone clinics and methadone treatment provision in Ireland. These seven clinics were being attended by 58 of ROSIE study clients for their methadone maintenance treatment.

Context and Scale

As detailed in chapter one, this research was carried out in association with the ROSIE (2008) study. Although the ROSIE (2008) study included several treatment modalities or treatment types in its analysis, the work presented within this thesis focuses on the methadone clients and their methadone treatment outcomes. The seven methadone clinics described here are a subset of the, in total, 26 methadone clinics which agreed to take part in the ROSIE (2008) study. Table 3.1 illustrates these figures and shows that the clinic survey detailed here relates to 27% of the methadone clinics that took part in ROSIE (2008).

	HB Clinics	Community Clinics	Total
ROSIE Study	16	10	26
Clinic Survey	4	3	7
Clinic Survey (as a percentage of ROSIE)	25%	33.3%	27%

Table 3.1: Participating methadone clinics

The clinic survey presented here represented a sample of methadone clinics in Ireland. These figures compare favourably to the Ball and Ross study. When the Ball & Ross (1991) study began in 1989 there were approximately 80,000 adults in methadone treatment in the United States attending 667 methadone clinics. Researchers initially interviewed 633 male clients attending six clinics. Therefore, their cohort was less than one percent of the national cohort, much lower in percentage terms than the cohort represented here. Further, the six clinics which took part in the Ball & Ross (1991) study represented under one percent of the number of methadone clinics operating in the United States at that time.

3.2.2 Development and Design

The questionnaire used to gather the Irish clinic data was based on the 89 variable questionnaire used by Ball & Ross (1991) to gather information from the six methadone treatment clinics that took part in their study. This questionnaire was a good model to use as it was

wide ranging, comprehensive and designed to illicit information on the level of service being provided in similar type clinics.

	Programme Variables
Section A	funding, treatment policy, patient records
Section B	facility, neighbourhood, ancillary services
Section C	treatment/dose
Section D	number of patients/waiting list
Section E	urine sampling
Section F	clinic manager
Section G	counsellors
Section H	counselling sessions
Section I	staff

Table 3.2: Measures of treatment domain

Table 3.2 details the various sections that constituted the Ball & Ross (1991) questionnaire. These sections of the questionnaire attempted to encompass and describe in a general way a methadone treatment facility. Questions concerning staff, waiting lists and the adequacy of the clinic building itself, all seek to give an overall view of the clinic by including as many aspects of the treatment domain that may affect treatment and treatment outcome.

3.3 Results

3.3.1 Treatment Process Within Clinics

Table 3.3 details the replies given when asked about treatment policy and what happens to someone who enters the clinic seeking treatment. All prospective methadone clients in Ireland are required to go through an assessment before they can be prescribed methadone which is a prescribed procedure as detailed in the Methadone Treatment Protocol (Methadone Treatment Services Review Group 1998) referred to in chapter one. Clinic one and clinic

Treatment policy of clinic	
Clinic number	
1	Carry out assessment, refer to clinic team, add to waiting list
2	Treatment as soon as possible.
3	See nurse, doctor and counsellor, possible referral to another clinic, take urine samples.
4	Carry out assessment, add to waiting list, possible outreach service required, refer to doctor, draw up treatment plan.
5	Carry out assessment, urine tests, refer to doctor and psychiatrists.
6	Open referral system, carry out assessment, possible further referrals.
7	Accept walk-ins and referrals, carry out assessment.

Table 3.3: Treatment policy of programme attended

four were similar in that their assessment of the client was very in-depth and detailed. This included, not only drug history as might be expected, but also legal issues the client might have, social background and psychological health. Clinic two was very straightforward in that their policy was to endeavour to treat anyone who came to them seeking assistance with their addiction and not refuse treatment. While a number of the clinics had a waiting list, clinic four operated a community outreach programme for those who were on their waiting list. The aim was that while the prospective client was waiting for methadone treatment, the outreach service would prepare them in their community for the treatment regime at that clinic. For clinic seven, it's long term goal was to wean the client off methadone and this weaning was carried out in the community. Clinic three and six spoke of further referrals to other services. The larger clinics tended to have more services on site, for example psychiatric services. The smaller clinics had to refer clients on to services that were strategically linked with the clinic but not physically part of the clinic.

Records

Table 3.4 details the responses given when asked what details the clinics recorded in their treatment client notes. One of the clinics kept computerised patient records at the time of interview.

Patient details recorded	
Clinic number	
1	Medical details, demography, family drug-use, client drug history, psychiatric issues, incidents at the clinic.
2	Educational courses, other courses taken (connected with the clinic), disciplinary actions.
3	Social and medical care given. 'No personal stuff'.
4	Medical notes, medical issues. Psychological notes (v. detailed), criminal history, warrants, letters written on behalf of the client, drug-use, times attended for urines, training and employment, family history, counselling.
5	Copies of birth cert, copies of information on interactions at the clinic, notes for court, letters for housing, warrants. Very detailed.
6	Name, address, assessment form, probation forms, letters, from where client signed up for the programme, patient charter of rights.
7	DOB, proof of address, I.D., client's interactions at the clinic.

Table 3.4: Details recorded in patient records

Treatment/Dose

The seven methadone clinics were open between five and seven days per week. The number of hours open ranged from 38 to 65 hours per week. Between 20% and 80% of the clients were collecting daily methadone doses. The maximum dose of methadone being prescribed ranged from 90ml to 130ml. The minimum dose of methadone ranged from 2ml up to 40ml. The number of clients attending the clinic varied from 20 up to over 500 clients.

Urine Sampling

All clinics asked for at least one urine sample per week. The actual sampling regime differed between clinics. For example, three clinics took random samples, one clinic took samples on specified days, one clinic let the clients themselves decide when to provide a sample and another clinic took one random and one scheduled sample per week.

Staff

All the seven clinics had counsellors attached to them in some way. Three had counsellors employed full-time on-site. Four out of seven did not know if any of their counsellors were ex-drug-users. One clinic, out of four full-time counsellors employed, has one counsellor who was an ex-drug-user. All clinics said attendance at counselling sessions was voluntary and counsellors referred clients on to ancillary services. When asked what constituted a 'good counsellor' at their clinic the interviewee for clinic six, said they felt that their counsellors needed to be open to the notion of harm reduction.

When detailing medical staff who were specifically located on-site, two of the clinics had full-time doctors employed, three had full-time nurses employed and one had a full-time pharmacist employed on-site. One clinic had no full-time, part-time or community pharmacist connected to the clinic as their clinic nurses dispensed the methadone doses. One small clinic had no medical staff employed on-site. The other six clinics had between six and 38 medical staff (doctors, nurses and pharmacists) employed on-site, both part-time and full-time.

The health board clinics did not have an overall clinic general manager in their staff structure. Staff included a clinic manager, a nurse manager and a doctor manager. The managers of the nurses and the doctors were not based on-site and were responsible for a number of clinics, with the clinic manager responsible for the treatment aspect of the clinic and not the everyday running of the treatment facility. The larger community clinics did employ a general manager. However, the medical staff in the community clinics were still employed by the health board, and reported back to their own nurse or doctor manager.

One clinic had a very small premises that was used to meet new clients and was an administrative centre. Any other services, including the prescribing doctor, were located off site but were available to the clinic clients. Therefore, there was no methadone prescribed or dispensed ‘on-site’ as on-site staff were administrative staff only. This clinic, even though treatment elements were geographically spread out, operated together as a unit and was the only such service in a large suburban and rural area.

Ancillary Services

As can be seen from the Table 3.5, each clinic offered a range of ancillary services. The most common services offered was viral screening for HIV, Hepatitis B and Hepatitis C. These services may be expected from a methadone clinic. However, other services were intended for the client profile of the area in which the clinic was operating in. For example, the homeless services and needle exchange service catered to a specific need within the community where the clinic operated.

Clinic number	Viral screening/vaccination	Counselling/psych service	Family planning/sexual health	Homeless service	Holistic/complementary therapies	Crche	Needle exchange	Rehab/aftercare programme
1	x	x	x	x				
2	x			x				
3	x					x		
4	x	x	x	x	x			x
5	x	x			x		x	
6								x
7	x		x	x	x	x		x

Table 3.5: Ancillary services available (x)

3.3.2 Clinics and Structure

As mentioned earlier, the clinics were divided into two broad types, health board clinics, run on a statutory basis and community clinics, although, given this dichotomy, results highlight similarities as well as differences between them.

In the main, it was found that the most obvious differences were staff structures and the actual physical premises out of which the clinics operated. Staffing structures within the health board clinics having a defined structure replicated through-out each clinics of that type. The type of building or premises, and where they are located varied between clinics; from a large city clinic with many clients and a large staff to a small suburban clinic that was basically an administrative centre. The three community clinics felt that their funding was inadequate, in contrast to just one of the health board clinics. Interestingly, one of the community clinics received extra funding from a corporate sponsor.

There were differences across a number of approaches to treatment. It could be argued that the clinic that only preformed random urine sampling had the aim of catching out a client who had been using opiates on top of their methadone dose. Other clinics who let the client decide when to provide urine or had scheduled for sampling were possibly letting the client take more of a role and responsibility in their own treatment. These differences imply different approaches to treatment philosophy. Another difference was the range of maximum and minimum methadone doses between the clinic clients. Also, the needle exchange service is an interesting ancillary service to be offered at a methadone clinic. It fits in with the philosophy of harm reduction that methadone clinics operate within but acknowledges that a number of client may be using heroin or other injectable illicit drugs on top of their methadone medication. There were also obvious differences between what client information the clinics held on record. Clinic three in particular kept 'no personal stuff' which contrasts strongly with clinic five who kept a very detailed account of the client, from a copy of birth certificates to notes on court appearances. It was also interesting to note that one interviewee said that for their clinic, a 'good counsellor' was one that was open to the notion of harm reduction. This

was a surprising response given that the counsellor would be working in a treatment facility that operated under a harm reduction approach by prescribing a substitution treatment such as methadone.

One of the main similarities between the clinics is that they must adhere to the Methadone Treatment Protocol (Methadone Treatment Services Review Group 1998). This was evident in the carrying out by each clinic of an assessment of every prospective client. What differed was how this assessment was carried out.

Following on from this analysis of the clinics, a description of a number of clients who attended these clinics is provided. This is in order to give a client profile of the background and treatment needs of clients who presented to these clinics seeking treatment.

3.4 Conclusion

A detailed survey of seven methadone maintenance clinics located in and around Dublin, Ireland was carried out. The aim was to extract from this information factors that would succinctly describe the clinics and at the same time encompass the variability existing between the clinics with the ultimate aim of using data in a Ball and Ross modelling analysis. As was expected, a number of similarities and differences were highlighted across a range of measures including urine sampling regimes, staffing, ancillary services offered and treatment policy. As far as can be ascertained, no such previous analysis of methadone clinics, as is presented here, had been carried out before in Ireland. As with the ROSIE (2008) study and other large-scale well known studies such as National Treatment Outcome Research (NTORS undated) Study and Drug Treatment Outcome research (DTORS undated) study and the Drug Outcome Research in Scotland (DORIS undated) study, the main focus is usually on the client and whether their particular treatment experience (and not the actual physical treatment setting) has an effect on their treatment outcome. However, an important element of treatment to consider should be the actual treatment facility attended (along with the patient and treatment process).

In order to expand upon the information provided within this chapter, the following chapter describes a sample of clients attending these clinics in terms of their demographic, drug-use, crime, health and social functioning profile.

Chapter 4

Ball and Ross: Patient and Process Variables

4.1 Introduction

The ROSIE (2008) Study collected very detailed client information. Of the total ROSIE cohort of 404 clients who were entering or had recently entered a new treatment episode, 58 of those clients attended the seven clinics detailed within chapter three. To gain an insight into the type of client who presented to these seven clinics, detailed information on the ROSIE Study cohort of the 58 clients follows. Data is derived from the Maudsley Addiction Profile (MAP) Instrument (Marsden et al. 1998) which has been validated for use in this population and applied worldwide.

4.2 Patient and Process Variables

4.2.1 Demographics

	n	%
<hr/> <hr/>		
Gender		
Male	38	65.5
Female	20	34.5
<hr/> <hr/>		
	Mean (sd)	Median
<hr/> <hr/>		
Age (years)		
Male	26.8 (5)	26.0
Female	25.9 (4)	24.0

Table 4.1: Gender and age of study population

	Mean	(sd)
Age left school(years)	14.8	2.12
	n	%
Highest Education Level		
No formal education	1	1.7
Primary	10	17.2
Lower secondary	37	63.8
Highest Education Qualifications		
No qualifications	28	48.3
Junior Cert/basic skills/NCVA level 1	25	43.1

Table 4.2: Education

Of those 58 ROSIE clients who attended the seven clinics in question, 65.5% (n=38) were male and 34.5% (n=20) were female. The ages of this cohort ranged from 18 to 41 with a mean of almost 26.5 years of age.

The age of school-leaving ranged from five to 19 with a mean of 15 years of age. Most had none or basic educational qualifications as detailed in Table 4.2. In Ireland, around three out of every four clients entering drug treatment are early school leavers, early school leaver being those who left education at age 16 or earlier. This equates to 16 times the level seen in the general population (Comptroller & Auditor General 2009). This cohort of 58 clients were parents to 36 children in total with 13 clients having children under age 18 years in their care. Drug-use affects the quality of parenting and it has been reported that compared to children whose parents do not misuse substances, children of drug-users are more likely to experience problems across many areas of their lives including mental health, social skills, academic achievement and drug-use (Horgan 2011) although Barnard & McKeganey (2004) in a review of literature on parental drug-using, found that the evidence on harms to children was not conclusive. Approximately 15% of those entering drug treatment in 2007 in Ireland had dependent children. For those entering treatment, it has been reported that a lack of childcare can be a barrier to access to treatment (Comptroller & Auditor General 2009).

	n	%
Have children under 18 years	36	62.1
Number of children in care of participant		
None	23	39.7
One	5	8.6
Two or more	8	13.8

Table 4.3: Children

4.2.2 Health

Table 4.4 highlights the risky injecting practices or behaviours that a number of clients had taken part in. Just over 79% (n=46) had ever injected illicit drugs. Irish figures for 2007 (Carew *et al.* 2009) show that of the new cases entering drug treatment where opiates were their main problem substance, 40% used injection as the route of administration.

	n	%
Ever injected	46	79.3
Ever used needle after someone	25	43.1
Ever reused own injecting equipment	37	63.8
HCV status		
Positive (of those tested)	23	62.2
HIV status		
Positive (of those tested)	4	11.4
	Mean	(sd)
Age first injected	21.12	5.12

Table 4.4: Injecting-related health variables

Of the 58 clients, almost 40% (n=23) reported being Hepatitis C (HCV) positive and four reported being HIV positive at treatment in-take with eight awaiting HIV test results. Smyth *et al.* (2005) reported that the incidence of HCV infection among injecting drug users in Dublin was high when compared to international figures. That study performed HCV testing on 159 injecting drug users and found that 61% were found to be positive for the HCV antibody, which is in line with the figure reported here. Prevalence of HIV infection

among injecting drug-users range from 1% to 17% (NDST & NACD 2008) and the figures here fall within this range.

	Mean	(sd)
Physical/Mental health symptoms (days experienced, last three months)		
Poor appetite	60.73	37.27
Tiredness/fatigue	46.82	40.76
Nausea	14.89	30.59
Difficulty breathing	15.63	33.15
Chest pains	11.06	27.65
Feeling tense	35.57	37.73
Feeling no interest in things	29.20	37.48
Feeling lonely	27.21	37.31
Feeling hopeless about the future	24.19	34.79
Feeling fearful	22.83	36.56
	n	%
Overdose/suicide		
Have ever overdosed	26	49.1
Ever seriously thought of committing suicide	24	41.4
Ever attempted suicide	18	31.0

Table 4.5: Health, overdose and suicide

Physical and mental health symptoms relating to drug-use were recorded. Looking at a number of those physical and mental health symptoms as detailed in Table 4.5 poor appetite and feeling tense were on average experienced on the most number of days by this cohort of methadone clients. It can also be seen that that overdose and suicide attempts were an issue for a number of the 58 methadone clients. In Europe, overdose represents the biggest cause of avoidable death associated with illicit drug-use. Toxicological analysis has shown that heroin is implicated in most of these deaths. It is estimated that for every fatal overdose there are 20 to 25 non-fatal overdoses. Further, it now seems that non-fatal overdose can cause significant health damage and indicates an increased risk of future overdose (EMCDDA 2010).

	n	%
Ever used		
Heroin	58	100.0
Non-prescribed methadone	49	84.5
Alcohol	48	82.8
Cannabis	47	81.0
Cocaine	44	75.9
Benzodiazepines	41	70.7
Ecstasy	35	60.3
Other opiates	26	44.8
Amphetamines	26	44.8
LSD	25	43.1
Crack-cocaine	25	43.1
Previous treatment received	49	84.5%
	Mean	sd
Current treatment		
Time in treatment (days)	25.3	20.6
Time waiting for treatment (weeks)	15.3	23.4

Table 4.6: Drug history and treatment

4.2.3 Drug-Use and Treatment

Table 4.6 lists a selection of the illicit drugs which had ever been used by this cohort of 58 clients. This underlines the complicating factor of poly-drug use for clients in a treatment such as methadone which has been designed for opiate addiction treatment. Figures for 2002 to 2007 (Carew *et al.* 2009) show that of those entering treatment for opiates including heroin, cannabis, benzodiazepines and cocaine were the most common additional problems drugs reported. These three drugs are also common drugs ever used by this cohort after heroin, although ‘street’ methadone and alcohol were more common. Table 4.6 also shows that the clients were waiting for treatment for an average of just over fifteen weeks at the time of first interview.

4.2.4 Crime

A link between drug-use and crime has long been established. Most Irish drug-users who receive a custodial sentence don’t necessarily receive it for drug offences *per se* but for offences such as theft, burglary, larceny or prostitution (Connolly 2006). Table 4.7 lists the handling

of stolen goods and theft from a shop as being the two crimes which were perpetrated by over half of this cohort. Well over half of this cohort had been in prison or remanded in custody at some time in their lives and a number were experiencing some legal difficulty; either on probation or doing community service, out on bail, having outstanding warrants against them or outstanding fines to be paid.

Seven out of the 58 reported to have ever solicited sex. Research has found that drug treatment services in Dublin consider drug-using sex-workers as an extremely challenging group to treat and are seen as clients with complex needs (Cox & Whittaker 2009).

	n	%
Crime committed		
Handling stolen goods	31	53.4
Theft from a shop/commercial property	30	51.7
Theft of a vehicle	17	29.3
Breach of the peace	17	29.3
Assault	16	27.6
Theft from a person	15	25.9
Selling/supplying drugs	14	24.1
fraud/forgery/deception	14	24.1
Criminal damage	14	24.1
Theft from a house/home	12	20.7
Soliciting	7	12.10
Imprisonment		
Ever been in prison	34	58.6
Ever remanded in custody	34	58.6
Ever received custodial sentence	24	41.4
Current legal problem*		
On bail - awaiting trial/hearing	12	20.7
Outstanding warrants	7	12.1
On Probation/community service	2	3.4
Outstanding fines	2	3.4

*Categories are not mutually exclusive

Table 4.7: Crime, imprisonment and legal status

4.2.5 Employment

Table 4.8 illustrates that very few of this cohort were working and earning a regular wage. Most were relying on social welfare payments. Many of those receiving treatment for problem drug-use have a history of unemployment which goes hand in hand with a history of early school leaving and low educational attainment (Comptroller & Auditor General 2009).

	n	%
Occupation (last six months)		
Not working	9	15.5
Working(PT/FT)	41	70.7
In prison	3	5.2
Disability	2	3.4
Recent employment*		
Employed in the last three months	6	10.3
Currently employed	6	10.3
Main sources income (last three months*)		
Family/friends	16	27.6
Social welfare	50	86.2
Other crime	27	46.6
Drug dealing	13	22.4
Wage/salary	5	8.6

*these categories are not mutually exclusive

Table 4.8: Recent employment and income status

4.3 Conclusion

Analysis on the 58 ROSIE (2008) study clients who were attending these seven clinics at the time of their baseline interview illustrated a number of complicating issues that a client brings with them to the treatment process. In general, a number of the drug, health and social problems were reported. These particular issues such as criminality, low educational attainment and poly-drug use are not new findings for this cohort profile but highlight that drug treatment is a complicated process which has many strands. In particular, 13 of these clients were parents to children under eighteen years of age. This emphasises how important treatment is, not just to the client themselves, but to their family.

The following chapter applies the Ball & Ross (1991) model to the Irish treatment data

Chapter 5

Applying the Ball and Ross Model

Don't feel bad Leonard. Negative results are still results

(The Big Bang Theory 2009)

5.1 Introduction

Ball & Ross (1991) published their methadone treatment outcome research in the United States using a linear regression model as the main model for investigation of treatment outcome. In essence their model was constructed as follows;

$$\boxed{\text{Outcome}} = \boxed{\text{constant}} + \boxed{\text{patient variables}} + \boxed{\text{programme variables}} + \boxed{\text{process variables}} + \boxed{\text{error}} \quad (5.1)$$

Hendriks (1999) recommended the application of the Ball and Ross type model in Europe. With this recommendation in mind, this model-type was applied to Irish treatment data within this thesis, where the outcome variable described the number of days clients were using heroin out of 90 days one year on from their baseline interview i.e. their heroin-use after one year from treatment in-take.

5.2 Methods

5.2.1 Multiple Linear Regression

Prior to the application of the multiple linear regression model a power analysis was carried out. Of the seven clinics that were detailed in chapter three, the cohort attending these clinics

who were the subject of chapter four number 58. According to Cohen (1992), a sample size of 50 would detect a large effect size at power $\beta = 0.2$ where $\alpha = 0.05$ and eight independent variables entered into the regression equation. To detect a medium effect size at the same α and the same level of power would require a sample size of 67 with a restriction of two independent variables being entered into the regression equation. It is acknowledged that the relatively small sample size of 58 is a limitation of this study, however it is sufficient to detect a large effect. The results of the linear regression are presented in section 5.3.

Regression analysis is used to describe the distribution of values of one response variable as a function of another explanatory variable or variables (Ramsey & Schafer 2002).

A general expression of the model is

$$y_i = \mu_i + e_i \quad (5.2)$$

with

$$\mu_i = \beta_o + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_p x_{ip} + e_i \quad (5.3)$$

The parameters β_1, \dots, β_p of the model are unknown. The parameter β_o is the intercept and as with the simple linear regression model, often has no practical meaning. β_1 represents the mean change in y that is associated with a one unit change in x_{i1} when β_2 etc. does not change. β_2 represents the mean change in y that is associated with a one unit change in x_{i2} when β_1 etc. does not change. The error term e_i describes the effect on y_i of all factors other than the effects contributed by the independent variables x_1, x_2, \dots, x_p .

Linear regression analysis has a number of assumptions. These are:

- The Assumption of Linearity.
- The Assumption of Constant Variance. The different populations of potential values of the dependent variables corresponding to different combinations of values of x_1, x_2, \dots, x_p have equal variances.
- The Assumption of Independence. Any one value of y is statistically independent of

any other value of y . Also any one value of e is also independent of any other value of e .

- The Assumption of Normality. For any combination of dependent variables, the corresponding population of potential values of the dependent variable has a normal population (also, the corresponding error terms have a normal distribution).

Ball & Ross (1991) used principal components analysis (PCA) to reduce the number of variables they would leave in the regression outcome model. Hence, a brief overview of principal components analysis is presented before details of the application of PCA to the Irish treatment data are presented.

5.2.2 Principal Components Analysis

Principal components analysis (PCA) is a useful and widely used multivariate data reduction technique for transforming a set of related or correlated variables into a set of unrelated or uncorrelated variables. The set of uncorrelated variables each form a particular linear combination of the original variables (Everitt & Dunn 1991). The rationale behind this method is to attempt to reduce the complexity of the data by decreasing the number of variables. The transformed variables become a much smaller set and so the goal of data reduction is achieved (Duntman 1989). The ‘new’ derived variables or principal components are derived in decreasing order of importance, accounting for decreasing proportions of the variation of the original observations, providing a convenient summary of the data and to simplify subsequent analysis (Everitt & Dunn 1991). The coefficients defining the principal components are found by solving a series of equations involving the elements of the observed covariance matrix (or correlation matrix if the variables have different scales)(Landau & Everitt 2004). The idea was originally conceived by Pearson in 1901 and independently developed by Hotelling in 1933 (Duntman 1989).

The first principal component accounts for as much as possible of the rest of the variation of the original data. The second principal component is chosen to account for as much as

possible of the variation of the data subject to being uncorrelated with the first principal component, and so on with subsequent components. Usually, the first few components account for most of the variation in the original data and are used to summarize the data with little loss of information. In this way, a reduction of dimensionality is achieved which might then be useful in simplifying later analyses (Everitt & Dunn 1991) such as discriminant analysis, cluster analysis and regression analysis. In the case of regression analysis in particular, principal components may be useful when:

- There are too many explanatory variables relative to the number of observations.
- The explanatory variables are highly correlated.

Both situations lead to problems when applying regression techniques, problems which may be overcome by reducing the explanatory variables to a smaller number of principal components.

Details of Component Derivation

Authors Everitt & Dunn (1991), Duntman (1989) and others (The University of York 2006) provide details of the PCA method. Let

$$x = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix} \quad (5.4)$$

be a column p -vector of observations or random variables. The transpose of this vector is

$$x^T = (x_1 \ x_2 \ \dots \ x_p) \quad (5.5)$$

The first principal component, y_1 , of the observations is the linear combination of the original variables $x_1, x_2 \dots x_p$ that is,

$$y_1 = a_{11}x_1 + a_{12}x_2 + \dots + a_{1p}x_p \quad (5.6)$$

$$= \mathbf{a}_1^T \mathbf{x} \quad (5.7)$$

whose sample variance is greatest among all such linear combinations. The values $a_{11}, a_{12}, \dots, a_{1p}$ are scalar weights where

$$\mathbf{a}_i = \begin{pmatrix} a_{i1} \\ a_{i2} \\ \vdots \\ a_{ip} \end{pmatrix} \quad (5.8)$$

and

$$\mathbf{a}_i^T = [a_{i1}, a_{i2}, \dots, a_{ip}] \quad (5.9)$$

The scalar weights altogether form \mathbf{A} , a $p \times p$ matrix where

$$\mathbf{A}^T = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1p} \\ a_{21} & a_{22} & \dots & a_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ a_{p1} & a_{p2} & \dots & a_{pp} \end{pmatrix} \quad (5.10)$$

In general, the linear combinations can therefore be expressed more succinctly in a matrix formulation as,

$$\mathbf{y} = \mathbf{A}^T \mathbf{x}, \quad (5.11)$$

or $y_i = a_{i1}x_1 + a_{i2}x_2 + \dots + a_{ip}x_p$, ($i = 1, \dots, r$). where \mathbf{y} is a vector of principal component scores. For example,

$$\begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_r \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1p} \\ a_{21} & a_{22} & \dots & a_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ a_{r1} & a_{r2} & \dots & a_{rp} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_p \end{pmatrix} \quad (5.12)$$

giving

$$\begin{aligned} y_1 &= a_{11}x_1 + a_{12}x_2 + \dots + a_{1p}x_p. \\ y_2 &= a_{21}x_1 + a_{22}x_2 + \dots + a_{2p}x_p. \\ &\vdots \\ y_r &= a_{r1}x_1 + a_{r2}x_2 + \dots + a_{rp}x_p. \end{aligned} \quad (5.13)$$

These r values y_1, y_2, \dots, y_r are the r principal component scores. As the sample variance of y_1 can be increased without limit by increasing the coefficients $a_{11}, a_{12}, \dots, a_{1p}$, restriction

must be placed on these coefficients by letting the sums of squares of the coefficients equal one, that is,

$$\mathbf{a}_1^T \mathbf{a}_1 = 1. \quad (5.14)$$

Further on, it becomes clear why this constraint makes sense. The second principal component is the linear combination

$$y_2 = a_{21}x_1 + a_{22}x_2 + \dots + a_{2p}x_p = \mathbf{a}_2^T \mathbf{x} \quad (5.15)$$

which has the greatest variance subject to the following two conditions:

$$\mathbf{a}_2^T \mathbf{a}_2 = 1$$

and

$$\mathbf{a}_2^T \mathbf{a}_1 = 0$$

ensuring y_1 and y_2 are uncorrelated and therefore orthogonal. The remaining principal components are selected following similar conditions.

To find the coefficients defining the first principal component, we need to choose the elements of the vector \mathbf{a}_1 as to maximise the variance of y_1 subject to the constraint

$$\mathbf{a}_1^T \mathbf{a}_1 = 1. \quad (5.16)$$

Since the variance of y_1 could be increased without limit by increasing the coefficients (i.e. the elements of vector \mathbf{a}_1), a constraint is applied to the sums of squares of the coefficient.

The variance of y_1 is given by

$$Var(y_1) = Var(\mathbf{a}_1 \mathbf{x}) = \mathbf{a}_1^T \mathbf{S} \mathbf{a}_1, \quad (5.17)$$

where \mathbf{S} is the sample variance-covariance matrix, that is $\mathbf{S} = Var(\mathbf{x})$. The diagonal terms of \mathbf{S} give the variance of the p variables and the off-diagonal terms give the covariances between the variables. The matrix \mathbf{S} is symmetrical and non-negative.

In general, to maximise a function of several variables subject to one or more constraints, the method of Lagrange multipliers is used. This method is employed on the matrix of weights \mathbf{A} described earlier in Eqn. (5.8). This leads to the solution that \mathbf{a}_1 is the eigenvector of \mathbf{S} corresponding to the largest eigenvalue. If the eigenvalues of \mathbf{S} are $\lambda_1, \lambda_2, \dots, \lambda_p$, then the variance of the i^{th} principal component is λ_i . For example, if the eigenvalues of \mathbf{S} are $\lambda_1, \lambda_2, \dots, \lambda_p$, and \mathbf{a}_1 is an eigenvector of \mathbf{S} , then

$$\mathbf{S}\mathbf{a}_1 = \lambda_1\mathbf{a}_1 \quad (5.18)$$

Therefore

$$Var(y_1) = \mathbf{a}_1^T \lambda_1 \mathbf{a}_1 \quad (5.19)$$

$$= \lambda_1 \mathbf{a}_1^T \mathbf{a}_1 \quad (5.20)$$

$$= \lambda_1 \quad (5.21)$$

as, from the constraint discussed earlier, $\mathbf{a}_1^T \mathbf{a}_1 = 1$. The total variance of the p principal components is therefore the sum of the λ_i 's, that is

$$\sum_{i=1}^p \lambda_i = trace(\mathbf{S}) \quad (5.22)$$

Thus, the j^{th} principal component accounts for proportion \mathbf{P}_i of the total variation on the original data, where

$$\mathbf{P}_i = \frac{\lambda_j}{trace(\mathbf{S})}. \quad (5.23)$$

Principal component scores for individual i with vector of values \mathbf{x}_i are obtained from

$$y_{i1} = \mathbf{a}_1(\mathbf{x}_i - \bar{\mathbf{x}}) \quad (5.24)$$

$$\vdots \quad (5.25)$$

$$y_{ip} = \mathbf{a}_p(\mathbf{x}_i - \bar{\mathbf{x}}). \quad (5.26)$$

	Statistic	Standard Deviation
Skewness	1.537	0.218
Kurtosis	0.895	0.433
		Sig.
Kolmogorv-Smirnov	0.280	0.000

Table 5.1: Normality statistics

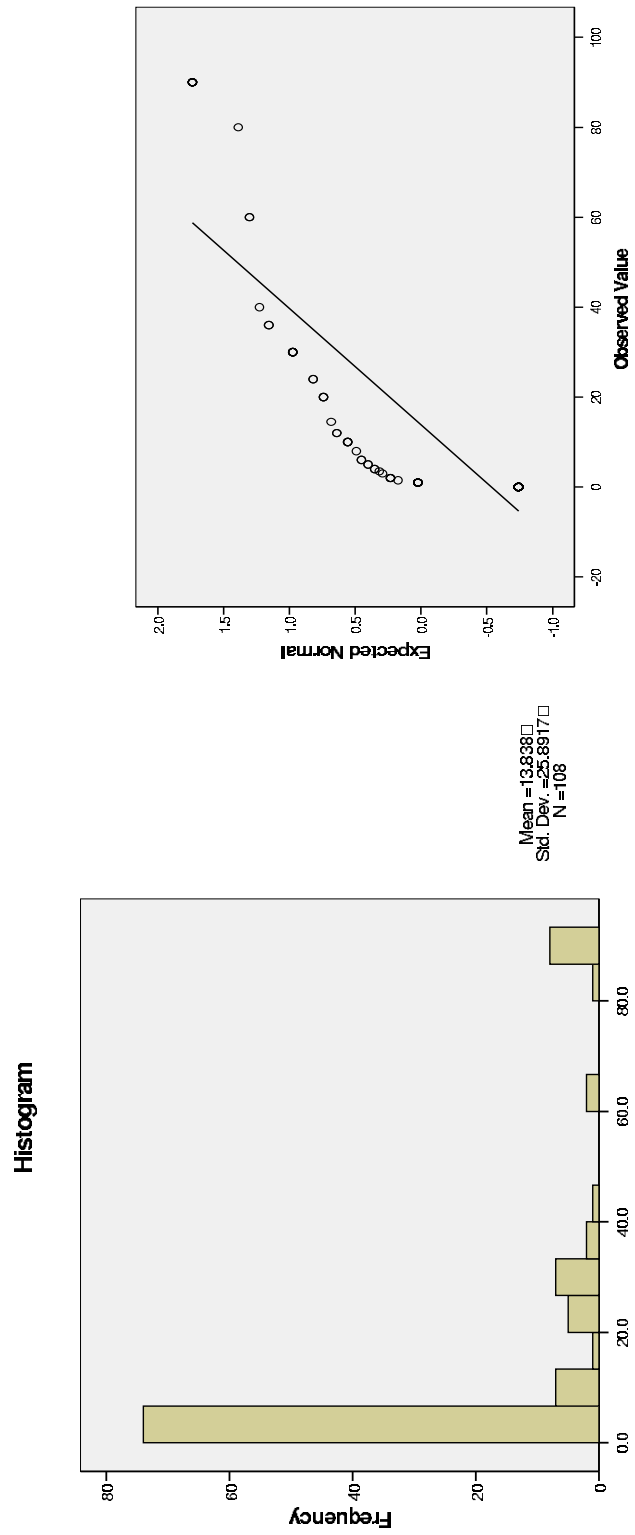
5.3 Results

5.3.1 Applying the Ball & Ross (1991) Model to Irish Data

Essentially the Ball and Ross model is a multiple linear regression model and must meet the assumptions of such a model as set out earlier in this chapter. One of these requirements is that the distribution of the outcome or dependent variable is normally distributed.

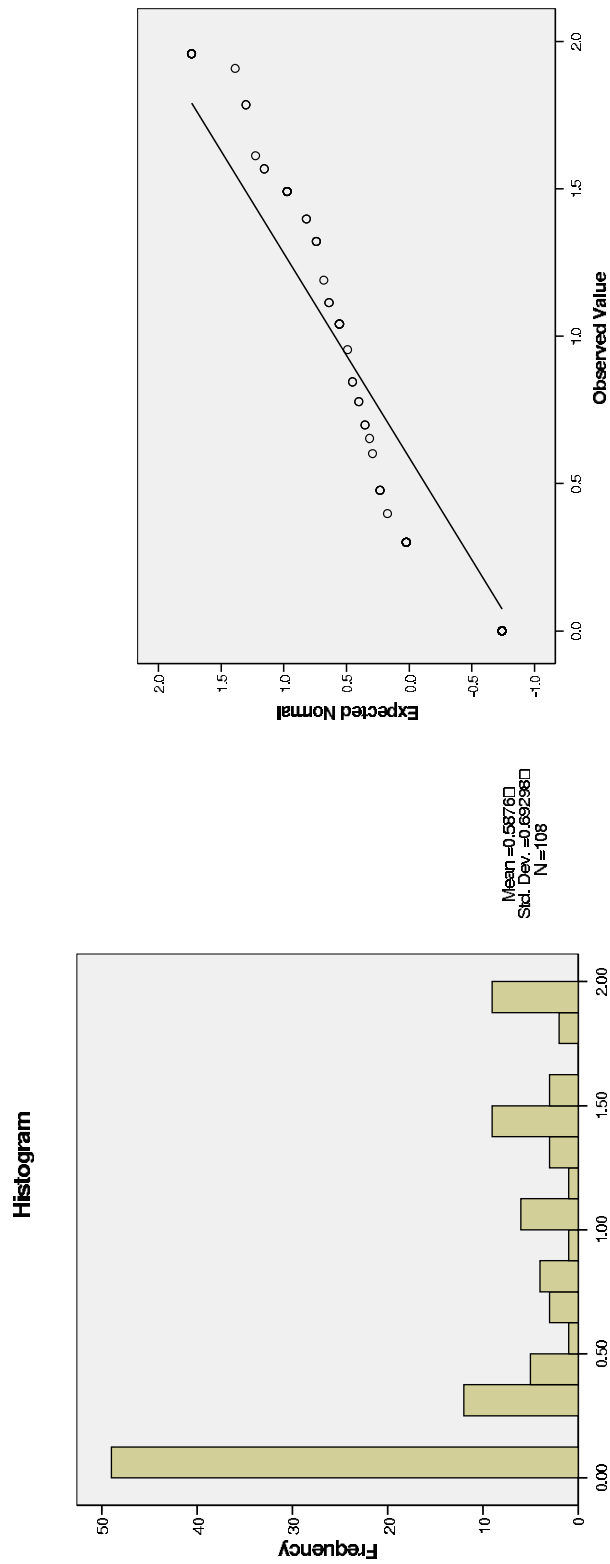
Based on the primary aim of this chapter, the key outcome variable is heroin-use at one year after treatment intake. On examining a histogram of the outcome variable ‘Days of heroin-use during the last 90 days’ at one year, the distribution was found to be non-normal and skewed. Figures are provided in Table 5.1 and the distribution is illustrated in Figure 5.1. The skewness value is an indicator of the symmetry of the distribution whereas the kurtosis value provides information on ‘peakedness’. A perfectly normal distribution would both have a skewness and kurtosis value of zero. The positive skewness value of 1.537 indicates a positive skew and a positive kurtosis value, here 0.895, indicates a peaked distribution with a long thin tail (Palant 2005). In general, a distribution of this type can benefit from a square root or a log transformation to make the data ‘more normal’ and these transformations were conducted on the outcome variable. The aim of choosing this variable was to assess if the cohort who were receiving methadone maintenance had been able to reduce or stop using heroin in the course of their treatment. On inspection, it was found that this variable did not exhibit normality especially given the number of clients who had ceased using heroin altogether explaining the large peak over zero (or no days of heroin-use) on the normality plot. In some cases, a suitable transformation can be applied to the dependent variable converting

it to a more normal appearance and less likely to violate the normality assumption of linear regression. Two transformations, square root and log transformations, were applied but had no real effect. See Figure 5.2 for the resulting distribution of the log transformation. The distribution is still clearly non-normal, therefore linear regression is unsuitable in this case. This chapter proceeds with details of the PCA that was conducted and further models are detailed in chapters seven and eight.



Histogram and normality Q-Q plot of `days heroin use, last 90 days`.

Figure 5.1: Histogram and normal Q-Q plot- Number of days used heroin in the last 90 days at year one



Histogram and normal Q-Q plot of log transformation of the variable `days heroin use, last 90 days`

Figure 5.2: Histogram and normal Q-Q plot: Log transformation: Number of days used heroin in the last 90 days at year one

Ball and Ross applied principal components analysis (PCA) to their ‘Program’ data, specifically the data they collected relating to the clinic setting itself in order to reduce the dimensionality of this data and make it easier to include in their regression model. In the course of attempting to apply the Ball and Ross model, PCA was also applied to the Irish treatment data this is now discussed.

5.3.2 Applying Principal Components Analysis to Irish Data

Principal components analysis was applied to the treatment outcome data relating to the seven Irish methadone treatment clinics described in detail in chapter four. Tabachnick & Fidell (2006) discuss sample sizes required for PCA. As a general rule, they recommend at least 300 cases but indicate there are situations where as few as 50 cases can be sufficient. For this aspect of the study, the case is the clinic and not the client. According to Field (2002), recent work has suggested that if a resulting factor has four or more loadings above 0.6, then it is reliable regardless of sample size and the results comply with this.

5.3.3 Application: Technical Details

Following an examination of the data, a number of variables were removed including variables that had little or no variance, nominal and ordinal data which is incompatible with PCA and variables that had missing values.

The correlation matrix was used in this analysis as it is the standardised form of the covariance matrix. When working with the correlation matrix each variable has unit standard deviation. It was considered that this was needed as the programme variables had differing measurements, for example millilitres of methadone, number of staff and number of hours open each week. Without standardisation, derived components are likely to be dominated by single variables with large variances (Landau & Everitt 2004).

5.3.4 Results of PCA on the Irish Data

After carrying out the PCA procedure, the resulting correlation matrix shows correlations of 0.3 and above as can be seen in Table 5.2.

1.000	0.387	-0.304	-0.885
0.387	1.000	0.243	-0.371
-0.304	0.243	1.000	0.008
-0.885	-0.371	0.008	1.000

Table 5.2: Correlation matrix

This attests to the factorability of the correlation matrix which is essential in PCA. For illustration purposes, Table 5.2 shows a small section section of the correlation matrix which was a large 24 by 24 matrix.

The correlation matrix represents the relationships between variables. Field (2002) provides a succinct description of the PCA process with regard to the correlation matrix. The linear components of the correlation matrix are calculated by determining the eigenvalues and the eigenvectors. The elements of these eigenvectors provide a loading of a particular variable onto a particular factor.

Component	Total variance	% Variance	Cumulative % variance
1	14.636	60.985	60.985
2	3.987	16.614	77.598
3	2.676	11.150	88.749
4	1.704	7.101	95.849
5	0.537	2.239	98.089
6	0.459	1.911	100.000

Table 5.3: Total variance explained

From Table 5.3, it can be seen that results show that almost 78% of the variance in the data is represented by the first two components. This illustrates the usefulness of PCA in data reduction where the original 1392 observations (from 24 variables relating to 58 clients attending seven clinics) may be represented by two or three underlying factors or components.

Scree Plot

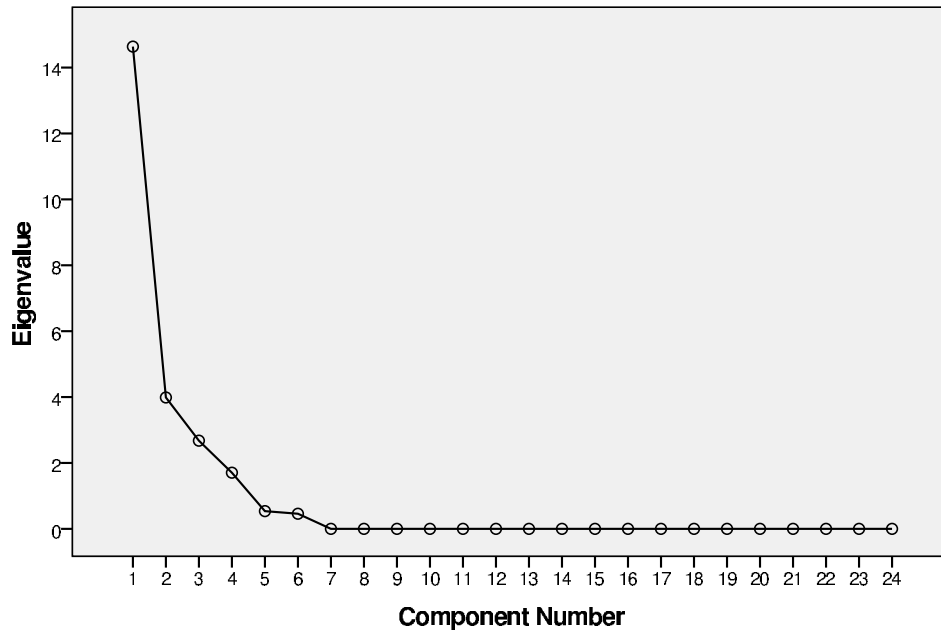


Figure 5.3: Scree plot

The examination of the scree plot in Figure 5.3, can help decide how many principal components are useful. It graphically displays the distribution of variance among the components (Landau & Everitt 2004). For each principal component, the corresponding eigenvalue is plotted on the y -axis. Generally, principal components beyond the “elbow” in the scree plot are discarded. In this case, the elbow is seen at the second principal component so components beyond that can be ignored.

To aid interpretation, a varimax rotation was carried out. A varimax rotation was carried out by Magura et al. (1999) when conducting their principal components analysis. According to Field (2002) when factors have been extracted during a principal components analysis, results show to what degree the variables load onto the factors. In general, most variables will have a high loading onto the most important factor and small loadings onto all other factors. Factor rotation is used to aid interpretation by discriminating between the factors. Varimax rotation, used here, is an orthogonal rotation and attempts to maximise the dispersion of loadings within the factors. Therefore it tries to load a smaller number of variables onto each factor resulting in more interpretable factors.

The results are presented in Table 5.4 which shows the component matrix and displays the coefficients or eigenvalues for each of the first two components from the PCA on the Irish clinic observations. The first two components described 77.598% of the variance of the data according to Table 5.3 therefore these are the two components that are interpreted here. In this case, where the correlation matrix is used, this table provides the correlations between the observed variables and the principal components. It is these coefficients that are used in the interpretation of the components (Landau & Everitt 2004). Because there is a high positive loading or correlation on the variables that describe, for example, numbers of staff and years in operation, the first component seems to describe the larger clinics that have a high number of staff and clients. The second principal component is not so easy to interpret but seems to describe clinics with a high number of community and full-time pharmacists and a high number of part-time nurses. It can also be seen that there are four or more loadings above the prerequisite 0.6 on component 1 that is discussed in Field (2002) to engender confidence in the results. Component 2 does not meet this requirement.

Therefore, these results should be interpreted with caution. The results provided by the software SPSS (Statistical Package for the Social Sciences) note that the correlation matrix is a non-positive definite matrix. To carry out a PCA, a positive definite correlation or covariance matrix is required to ensure non-negative and non-zero eigenvalues. According to

	Component 1	Component 2
Counsellors employed longer than one year	0.978	0.000
Years clinic has been in operation	0.974	0.000
Number on waiting list	0.971	0.000
Full-time doctors	0.964	0.000
Total number medical staff employed on-site	0.962	0.000
Full time nurses employed	0.948	0.000
Average waiting time (mths.)	0.948	0.000
Number clients in treatment	0.974	0.000
Approx. min dose for the clients (ml)	0.946	0.000
Number clients in treatment less than one year	0.941	0.000
Percentage of clients on dailies	-0.874	0.000
Counsellors employed part-time	0.868	0.000
Part-time doctors employed	-0.853	0.000
Counsellors employed full-time	0.827	0.000
Number community pharmacists	0.000	0.973
Pharmacists employed full-time on-site	0.000	0.968
Part-time nurses employed	0.000	0.865
Number urines per patient per week	0.000	0.000
Number hours clinic open per week	0.000	0.000
Pharmacists employed part-time on-site	0.000	0.000
Number days open per week	0.000	0.000
Counsellors employed longer than 5 yrs	0.000	0.000
Approx. weekly missed methadone rate	0.000	0.000
Approx. max dose (ml)	0.000	0.000

Table 5.4: Component matrix

Field (2002), there are two possible reasons for this result. Either there are too many variables for too few cases of data or there are too many highly correlated items within the matrix. One recommendation is to remove items and re-run the analysis. This recommendation was carried out in a backward elimination method. All variables were entered in the analysis with variables being removed one at a time and the analysis re-run.

Component	Total variance	% Variance	Cumulative % variance
1	3.454	57.572	57.572
2	1.431	23.845	81.417

Table 5.5: Total variance explained in the reduced data set

From Table 5.5, it can be seen that results show that just over 81% of the variance in the data was represented by the first two components following the backward elimination

method. Two components were extracted and are detailed in Table 5.6.

	Component 1	Component 2
Approx. min. dose for the clients (ml)	0.982	0.000
Years clinic has been in operation	0.964	0.000
Percentage of clients on dailies	-0.845	0.000
Approx. max. dose (ml)	0.680	-0.477
Number hours clinic open per week	-0.381	0.885
Number days open per week	0.489	0.583

Table 5.6: Component matrix of the reduced data set

Table 5.6 illustrates that although the reduced data set resulted in a positive definite matrix, the outcome of the analysis does not show four or more loadings above the prerequisite 0.6 on either component. The results provided the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett's test of sphericity shown in Table 5.7 for interpretation.

The Keiser-Meyer-Olkin (KMO) test is a measure of sampling adequacy. This KMO value varies between 0 and 1, with 1 indicating a sample of adequate size. A value close to 1 also indicates that PCA is an appropriate procedure to carry out on the data as the patterns of correlations are compact and will produce reliable factors. A value close to 0 indicates that the sum of partial correlations is relatively large to the sum of correlations, and PCA is inappropriate. Bartlett's Test of Sphericity examines whether the correlation matrix resembles an identity matrix. If the correlation matrix resembles an identity matrix then every variable correlates badly with every other variable (i.e. all correlation coefficients are close to zero) and are independent of each other. A significant Bartlett's test allows an acceptance of the alternative hypothesis, that the correlation matrix is not an identity matrix and that there is some relationship between the data (Field 2002). According to Palant (2005), a KMO value above 0.6 is required along with a significant Bartlett's test result. In this case, the Bartlett's test is significant but the KMO value is 0.57 and it therefore just below the required level. Field (2002) describes values above 0.5 as barely acceptable and considers values above 0.7 as 'good'.

KMO and Bartlett's Test	
Kaiser-Meyer-Olkin Measure of sample adequacy	0.57
Bartlett's test of sphericity	
Approx Chi Square	485.218
Sig.	0.00

Table 5.7: KMO and Bartlett's test

Therefore, results of the PCA proved unreliable, even after remedial action was taken.

5.4 Conclusion

On first inspection, the Ball and Ross multiple linear regression model appeared to be a compact and simple model which would be readily applied to Irish data. It proved to not be so as the outcome being investigated did not exhibit a normal distribution therefore precluding linear regression as a suitable model type. Remedial action was taken but did not help. Therefore the conclusion was taken that the Ball and Ross model was not suitable in the case of primary outcome variables.

Principal components analysis (PCA) was performed on data collected from seven clinics attended by the cohort of methadone maintenance clients. Results also proved somewhat unreliable. Taken together, both the results from the multiple linear regression analysis and the principal components analysis show that the Ball and Ross model is not easily applied to existing available Irish treatment data.

As the Ball & Ross (1991) linear regression model was shown to be unreliable, the cohort was extended to include additional methadone maintenance clients that attended more than the seven clinics that were a subject of the PCA allowing for further modelling to be conducted with a larger cohort. Chapter six looks at this extended cohort in terms of one year treatment outcomes.

Chapter 6

The Extended Cohort

6.1 Introduction

As the Ball & Ross (1991) multiple linear regression model concerning 58 clients in seven clinics was unsuitable, the cohort was now extended to include a further 69 clients who took part in the ROSIE (2008) study and were receiving methadone maintenance treatment through out-patient treatment centres. Within this chapter, the focus centres on a statistical analysis of these clients in terms of pre versus post-treatment outcomes across a range of measures. Chapters seven and eight address the key aim of identifying factors affecting treatment outcomes.

6.2 Background

Presented here is an analysis of the 123 ROSIE (2008) cohort who were attending one of 26 methadone treatment clinics at baseline interview and who completed a follow-up interview one year later. Recruitment to the study was confined to those over 18 years of age, who were willing to give consent and certain information to aid tracking for follow-up interview and who had entered a new treatment episode within the previous 90 days. As stated earlier, the full study received ethical approval from the ethics committee of the National University of Ireland, Maynooth (NUIM) and the instrument used to gather the data was an extension of the Maudsley Addiction Profile (MAP) instrument (Marsden et al. 1998).

Methadone cohort	n
Total ROSIE methadone cohort	215
ROSIE methadone cohort attending outpatient clinics at baseline	156
ROSIE methadone cohort attending outpatient methadone clinics, completed follow-up interview	127*
ROSIE methadone cohort attending outpatient methadone clinic, completed follow-up interview <i>and</i> in treatment for heroin-use	123

*Note, four of these clients were in treatment for an opiate other than heroin

Table 6.1: Participants in treatment for heroin-use and completed one year follow-up interview

6.3 Results

6.3.1 Methadone Cohort

As detailed in Table 6.1, a total of 215 clients were recruited to take part in the ROSIE study who were in a methadone programme. These programmes included out-patient programmes, residential programmes, hospital programmes and prisons. Of those 215 clients, 156 were attending an out-patient methadone clinic for their treatment. At one year, 123 of those clients who were in treatment for heroin-use were located and agreed to take part in the one year follow-up interview, giving a follow-up rate of almost 60% among all those in methadone treatment and over 80% among those attending an out-patient methadone clinic. Therefore, there is a bias to be acknowledged, that a number of methadone clinic clients did not take part in the one year interview and are therefore not included in this analysis. Other limitations include the lack of a control group of individuals who did not attend methadone treatment, the fact that clients who did take part in the study were not randomly selected and that over the course of one year a number of factors could affect an individual's treatment outcome.

Key outcome measures included in the analysis presented here are:

- Drug-use.
- Health.

- Social functioning.
- Harm.

The demographic characteristics of the 123 methadone clients are presented here and are illustrated in Table 6.2. These consisted of participants who completed a one year follow-up interview and who were in treatment for heroin-use or heroin-use and one or more other drugs. Please note, missing variables were excluded from all following analyses. This cohort was almost 72% (n=88) male, on average 27 years of age, and were mainly reliant on social welfare. Of the 123 clients, 84.6% (n=104) supported themselves with social welfare payments in the three months prior to baseline interview. Parents to children under 18 years of age accounted for just over 56% (n=69). Just over 76% (n=94) had experienced homelessness in the three month period leading up to baseline interview. Almost 59% (n=72) had previously spent time in prison.

Demographics	
Gender (% male)	71.5
Average age (yrs.)	27.34
No educational qualifications	40.5
Financial support: Social welfare (%)	84.6
Financial support: Salaried employment (%)	12.2
Homeless (any episodes in the three months prior to baseline interview)(%)	76.4
Ever in prison (%)	58.5
Parents (of children under 18 yrs.) (%)	56.1

Table 6.2: Demographic profile of participants at treatment intake

6.3.2 Treatment Retention and Treatment Status at One Year

Table 6.3 details the breakdown of treatment status of the cohort of 123 participants at one year follow-up. Of those 123 participants, 11.4% (n=14) were lost to follow-up and may have dropped out of treatment. When looking at treatment retention, just over 63% (n=78) were still attending their baseline treatment, that is, an outpatient methadone clinic at one year, 17.9% (n=22) were in another methadone programme including a methadone programme in prison with 2.4% (n=3) having completed their treatment

At One Year Interview	%	n
Still in index treatment	63.4	78
Dropped out of any treatment	11.4	14
In other methadone treatment	10.6	13
Prison methadone programme	7.3	9
In other drug treatment (modality)	4.9	6
Completed index treatment	2.4	3

Table 6.3: Comparison of participants treatment status a one year follow-up

6.3.3 Drug-Use Outcomes

The McNemar test was employed in the following analysis to investigate if there were any significant changes in certain outcome variables after one year of treatment. In general, the McNemar test is a test for a comparison of two dependent proportion and is described in Agresti (1996). It tests for marginal homogeneity for matched binary responses has a null hypothesis $H_0 : \pi_{12} = \pi_{21}$.

Classification B	Classification A	
	0	1
0	n_{11}	n_{12}
1	n_{21}	n_{22}

Table 6.4: McNemar test

When the null hypothesis is true the same frequency for the two counts n_{12} and n_{21} (see Table 6.4) is expected. Details of the McNemar test calculation are as follows; let $n^* = n_{12} + n_{21}$ denote the total amount in the two off-diagonal cells. Their allocation to those two cells are outcomes of a binomial variate with n^* trials. Under H_0 , each of these n^* observations has a $\frac{1}{2}$ chance of contributing to n_{12} and a $\frac{1}{2}$ chance of contributing to n_{21} . So n_{12} and n_{21} are numbers of “successes” and “failures” for a binomial distribution having n^* trials and success probability of $\frac{1}{2}$. Results from applying this test to the data are as follows.

Drug Outcome Results

Table 6.5 illustrates that the number of people who reported using heroin, benzodiazepines and cocaine in the 90 days prior to baseline interview decreased significantly between intake

	% Used			
	Intake		One year	
	%	n	%	n
Heroin	92.7	114	62.6	77*
Benzodiazepines	49.6	61	32.5	40*
Cocaine	43.1	53	22.8	28*

*McNemar revealed statistically significant changes

Table 6.5: Drug-use in the last 90 days prior to treatment intake and one year follow-up: Percent used

and one year follow-up.

	% Mean days used			
	Intake		One year	
	mean	sd	mean	sd
Heroin	58.32	33.25	19.37	30.43*
Benzodiazepines	22.66	36.23	9.48	20.71*
Cocaine	6.07	14.57	4.46	15.96

*Paired t-test revealed statistical significance.

Table 6.6: Drug-use in the last 90 days prior to treatment intake and one year follow-up: Mean days used

The average number of days in which heroin, benzodiazepines and cocaine was used also decreased when comparing the 90 days prior to baseline and the 90 days prior to one year follow-up interview in Table 6.6. The decrease in number of days of heroin-use and benzodiazepine-use were significant.

	% Mean daily quantity used			
	Intake		One year	
	mean	sd	mean	sd
Heroin (grams)	1.15	1.07	0.37	0.73*
Benzodiazepines (mg)	43.05	97.93	45.25	186.55
Cocaine (grams)	0.94	2.90	0.31	1.08*

*Paired t-test revealed statistical significance.

Table 6.7: Drug-use in the last 90 days prior to treatment intake and one year follow-up: Mean daily quantity used

Table 6.7 illustrates that consumption levels also fell significantly for heroin and cocaine.

However, on average, slightly more milligrams of benzodiazepines were being used on average on a daily basis. Therefore, benzodiazepines were being used less often at one year but a stronger daily dose was being ingested.

Of the total 123 individuals, 46% (n=37.4) had used no heroin in the 90 days prior to one year follow-up interview.

6.3.4 Crime Outcomes

As reported in Table 6.8 there was a reduction in the percentage of participants reporting involvement in most acquisitive crime except theft from a house or home which rose slightly from 5.7% (n=7) to 6.5% (n=8). In fact, this was the only crime that saw a rise in the proportion of participants reporting involvement. There was a significant decrease in those reporting involvement in selling/suppling drugs, theft from a shop and soliciting.

	% committed			
	Intake		One year	
	%	n	%	n
Selling/supplying	22.8	28	13.8*	17
Theft from a person	9.8	12	4.1	5
Theft form a house/home	5.7	7	6.5	8
Theft from a shop etc.	22.8	28	13.8*	17
Theft from a vehicle	7.3	9	5.7	7
Theft of a vehicle	7.3	9	3.3	4
Handling stolen goods	22.0	27	11.4*	14
Fraud/forgery/deception	9.8	12	3.3	4
Assault	5.7	7	4.1	5
Criminal damage	6.5	8	4.1	5
Soliciting	6.5	8	0.8*	1
Breach of the peace	8.1	10	2.4	3

*McNemar revealed statistically significant changes

Table 6.8: Offending behaviour in the 90 days prior to treatment intake and one year follow-up

6.3.5 Risk Behaviour Outcomes

There was a reduction in the number of participants who reported injecting drug-use. At intake, 50.4 % (n=62) had injected in the previous 90 days. This fell to 39.8% (n=49) at one year follow-up. There was a decrease reported in the average number of days participants reported injecting. At baseline interview, participants injected 27.80 (sd 36.56) days on average in the 90 days prior to interview. This fell to an average of 11.47 days (sd 23.75) at one year follow-up. The average number of times participants injected per day also saw a decrease between the two time points. At baseline, participants injected 1.66 (sd 2.37) times on average. This fell to 1.19 (sd 3.57) times at one year. There was a reduction in those who reported experiencing an episode of overdose. At baseline, 8.9% (n=11) reported an incident of overdose in the 90 days prior to interview. This fell to 6.5% (n=8) at one year follow-up.

	% reported			
	Intake		One year	
	%	n	%	n
Borrowed used needles/syringes	3.5	4	3.3	4
Lent used needles/syringes	5.3	6	5.0	6
Reused own needles/syringes	18.8	18	16.9	20
Used filter/spoons after someone	3.8	4	3.3	4

Table 6.9: Injecting-related risk behaviour in the 30 days prior to treatment intake and one year follow-up

Table 6.9 illustrates that a reduction was also seen in participants injecting-related risk behaviours across all four variables between the two time points. The largest reduction was seen in the re-use of the participants own needles. The proportion of participants reporting this behaviour fell by over 16% (n=20).

6.3.6 Health Outcomes

Across the ten physical health symptom measures outcomes were poor, only two exhibited slight decreases in the proportion of participants experiencing that symptom between baseline and one year follow-up. Those symptoms were poor appetite and nausea and are detailed in Table 6.10. There was a significant *increase* in the proportion that experienced stomach pains and numbness/tingling.

	% reported			
	Intake		One year	
	%	n	%	n
Poor appetite	79.8	87	68.4	84
Tiredness/fatigue	69.1	76	70.8	85
Nausea	49.4	43	41.3	50
Stomach pains	27.8	30	47.1	57 *
Difficulty breathing	30.3	33	33.1	40
Chest pains	21.5	23	22.3	27
Joint/bone pains	27.3	30	35.5	43
Muscle pains	24.8	27	31.4	38
Numbness/tingling arms/legs	16.5	18	27.3	33*
Tremors/shakes	23.6	25	27.3	33

*McNemar revealed statistically significant changes

Table 6.10: Physical health symptoms in the 90 days prior to treatment intake and one year follow-up

A similar pattern emerged among a range of mental health symptoms. Table 6.11 illustrates that there were no reductions in the numbers experiencing a range of mental health symptoms between the two time points of baseline and one year. All the symptoms exhibited an increase, although not significant increases.

	% reported			
	Intake		One year	
	%	n	%	n
Feeling tense	57.5	61	55.2	64
Suddenly scared for no reason	27.1	29	29.9	35
Feeling fearful	31.7	33	35.3	41
Nervous/shakes inside	30.8	33	32.2	37
Panic attacks	18.5	20	26.7	31
Feeling hopeless about the future	52.4	54	54.3	63
Feeling of worthlessness	49.0	51	44.4	52
No interest in things	55.6	60	62.9	73
Feeling lonely	50.0	52	47.8	55
Thoughts of ending life	44.8	25	23.1	28

Table 6.11: Mental health symptoms in the 90 days prior to treatment intake and one year follow-up

6.3.7 Service Contact

There was an increase in participants contact with five of the health and social care services as detailed in Table 6.12. They increased contact with GP (non-prescriber), outpatient services, social services, employment, educational or training services and housing or homeless services. The increase in contact with employment and training services and with housing services was a significant increase.

	% reported			
	Intake		One year	
	%	n	%	n
Stayed overnight in hospital	13.2	16	10.6	13
Treated in A & E	21.2	24	18.7	23
Seen GP	31.0	35	38.2	47
Outpatient appointment	11.6	13	18.7	23
Contact with social services	9.3	11	11.4	14
Employment/education services	7.3	9	36.6	45*
Social welfare services	22.8	28	21.1	26
Housing/homeless service	10.6	13	33.6	41*

*McNemar revealed statistically significant changes

Table 6.12: Contact with health and social care services in the 90 days prior to treatment intake and one year follow-up

6.4 Conclusion

This cohort were mainly male, receiving social welfare payments with an average age of 27 years. More than half had been to prison and more than half were parents to children under 18. A small percentage had dropped out of treatment however, the large majority were still in some form of treatment at one year. There were reductions to be seen across many of the measurements except in one area; health. In the area of physical and mental health, many of the measures saw an increase, which were significant in a number of cases.

Results presented in this chapter provide evidence for the first time in an Irish setting of the impact of outpatient community methadone treatment on a range of drug, health, crime and risk measures. While outcomes in the main are positive, the findings on physical and mental health symptoms have serious implications for the role of methadone treatment in the community. More research is needed internationally to specifically address these poor outcomes. Comiskey & Cox (2010) discuss the impact of methadone treatment setting. While they found in their analysis that physical and mental health symptoms did not improve for individuals in methadone maintenance treatment across three of settings (health board clinic, community clinic and general practitioner (GP)), they highlight that other studies have found improvements in health. However, results from outcome studies such as the Drug Outcomes Research in Scotland (DORIS), National Treatment Outcome Research Study (NTORS) and Australian Treatment Outcome Study (ATOS) found improvements in health measurements (Gossop *et al.* 1999, Macintosh *et al.* 2001, Teeson *et al.* 2006). NTORS looked at health outcomes at six months follow-up for those attending a GP or a methadone treatment clinic. The results from DORIS and ATOS were analysed across a range of treatment modalities including methadone maintenance.

We now expand our repertoire of available models and provide a discussion of logistic regression analysis and Chi-Square Automatic Interaction Detector (CHAID) modelling.

Chapter 7

Modelling Treatment Outcomes for the Extended Cohort

7.1 Introduction

In a time of ever-decreasing resources, it is imperative for treatment-service providers to understand the needs of their clients i.e. those availing of their treatment and services, and to be aware of the profile of the client who is doing well in treatment and what type of client requires a more targeted treatment response. In this chapter, methods for modelling treatment outcomes are presented and their applicability to Irish data are discussed. Chi-Square Automatic Interaction Detector (CHAID) modelling is presented and applied for the first time in an Irish drug treatment outcome setting. Of primary interest are heroin treatment outcomes for methadone maintenance treatment in a clinic setting. The main aim of this chapter is to use a CHAID modelling approach to uncover the baseline treatment variables which contribute to a successful treatment outcome when success is defined as no heroin-use in the previous 90 days post one year after methadone maintenance treatment intake.

7.2 The Data

The cohort of 123 methadone maintenance clients whose treatment outcomes are the subject of this chapter were the subject of a detailed analysis in chapter six. The 123 individuals were the cohort of methadone clients recruited by the ROSIE (2008) project and followed up at one year.

7.3 Logistic Regression

We saw in Table 6.5 that just over 37% of the cohort had not used heroin in the last 90 days one year after baseline interview, hence a logistic regression model was thought to be a suitable alternative approach as the dependent variable could easily be transformed into a dichotomous variable: Abstinence from heroin at one year, yes or no. Logistic regression allows discrete outcomes to be predicted from continuous, discrete, dichotomous or a mix of variables. In health science the discrete outcome is often disease/no disease. Logistic regression has no assumptions about the outcome variable unlike linear regression. The outcome variable does not have to be normally distributed, linearly related or of equal variance within each group and there may be two or more values to the outcome variable. Logistic regression where the outcome has two possible variables is called binary or binomial logistic regression. The outcome variable is \hat{y} and is the probability of having one outcome or another based on a non-linear function of the best linear combination of predictors. Tabachnick & Fidell (2006) provide details of this model. Thus,

$$Y_i = \frac{e^u}{1 + e^u} \quad (7.1)$$

where \hat{Y}_i is the estimated probability that the i^{th} case ($i = 1, \dots, n$) is in one of the categories and u is the usual linear regression equation;

$$u = A + B_1x_1 + B_2x_2 + \dots + B_kX_k \quad (7.2)$$

with constant A , coefficient B_j and predictors X_j , ($j = 1, 2, \dots, k$).

This linear regression equation gives rise to the logit or log of the odds where

$$\ln \frac{Y}{1 - Y} = A + \sum B_j X_{ij} \quad (7.3)$$

Therefore, the linear regression equation is the probability of being in one group divided by the probability of being in the other group. The procedure of maximum likelihood finds the best linear combination of predictors (x 's) to maximise the likelihood of obtaining the

observed outcome frequencies. Essentially, logistic regression assumes a relationship between continuous predictors and the logit transformation of the dependent variable.

7.3.1 Application and Results: Logistic Regression

Hosmer & Lameshow (2006) recommend approaching the logistic modelling process by first using univariate logistic regression models and modelling the outcome against each independent variable. The aim of this is to aid the analyst in becoming more familiar with the data and points toward variables with a significant effect on the dependent variable. As recommended, 628 univariate models were tested in total and results show that 14 baseline variables were shown to be significant predictors of the binary outcome used heroin at one year. These are detailed in Table 7.1 .

Unfortunately, many of the variables contained at least one missing case. The study was designed to have 25 key treatment variables at the heart of the questionnaire. Interviewers were trained to concentrate on these variables if they felt that an interviewee might not complete an interview. Variables with large amounts of missing variables were set aside as logistic regression is not designed to deal with missing data.

To model all possible two-way interactions of 14 variables would consist of 14^2 or 196 models and to test all possible three-way interactions would consist of 14^3 or 2744 models. Given the mammoth task of building these variables into models that made some intuitive or clinical sense and testing for two or even three-way interactions, and given the issue with missing data, it was thought that a CHAID model was the optimal model for this data.

7.4 Application of CHAID to the Treatment data

Given the dichotomous nature of the outcome variable and the amount of missing data, decision tree analysis proved to be a suitable model type to apply to this data. A particular type of decision tree analysis called Chi-Square Automatic Interaction Detector (CHAID) was applied following a process of considering the applicability of other model types.

A power analysis was conducted. According to the tables provided in Cohen (1992), one

	B	Wald	Sig.	Exp(B)	95% CI	
					Lower	Upper
Client hopes to achieve better financial circumstances	-1.197	4.923	0.027	0.302	0.105	0.870
Age of first methadone use	0.108	5.342	0.021	1.114	1.017	1.221
Methadone use ever been a problem	-1.386	5.373	0.020	0.250	0.77	0.807
Age of first alcohol/ethanol use	-0.330	5.349	0.021	0.719	0.543	0.951
Experienced nausea on how many days in last 90 days	-0.012	4.001	0.045	0.988	0.976	1.000
Experienced nausea, yes or no	-1.121	7.392	0.007	0.326	0.145	0.731
Experienced being tense on how many days in last 90 days	-0.011	4.713	0.030	0.989	0.978	0.999
Experienced having no interest in things on how many days in last 90 days	-0.012	5.274	0.022	0.988	0.978	0.998
Experienced having no interest in things, yes or no	-1.213	7.971	0.005	0.297	0.128	0.690
Experienced tremors or shakes, yes or no	-1.440	8.911	0.003	0.237	0.092	0.610
If condoms were always used while having sex in last 90 days or last 6 months if buying or selling sex	-0.470	4.195	0.041	0.625	0.399	0.80
How many days see or speak to child one in last 90 days	-0.019	4.031	0.045	0.981	0.964	1.000
Number of children under 18	0.546	6.739	0.009	1.727	1.143	2.608
Number of children in their care	-0.705	4.878	0.027	0.494	0.264	0.924

Table 7.1: Significant results from univariate logistic models

degree of freedom ($1 df$) and a power of $\beta = 0.20$ with $\alpha = 0.05$, a sample size of 87 is sufficient to detect a medium effect size. Therefore, the sample size of 123 on which the CHAID analysis was conducted is sufficient to detect a medium effect size. Technical details the CHAID model follows with results presented in section 7.5.

CHAID was developed by Kass (1980) in South Africa. CHAID decision tree modelling is a heuristic decision tree method. It has been used in applied fields such as medical diagnosis, computer science, classification in botany and decision theory in psychology (Hoare 2004). It is also widely used in marketing to segment customers into groups (SPSS 2006) thereby providing customer profiles. Given that methadone maintenance clients are customers of the

service they are attending, CHAID modelling is highly applicable to this area. When all types of services have to do more with less it seems sensible to investigate who constitutes one's client base, who is experiencing the service positively and, more importantly, who requires a more targeted approach in terms of treatment. CHAID is designed to include scale, ordinal and nominal variables and is therefore very versatile in handling a mixture of continuous and categorical data. Also, this model type has no difficulty with missing variables and in fact includes these variables as a group on their own. Depending on the relationship between the independent and dependent variables, data is split into statistically significant homogeneous sub groups or nodes using step-wise chi-square analysis. These subgroups are used to construct a summary diagram or decision tree. The predictions of the model are based on the frequency distribution in the terminal nodes i.e. the 'roots' of the tree (SPSS 2006).

Given many potential predictors, this method effectively searches for relationships between the predictors and outcomes measure, and is therefore very suited to analysing large complicated data sets. The output is generally regarded as being highly visual, easy to understand and interpret and this is a plus when conducting applied analysis that is of interest to a non-technical audience.

The CHAID algorithm as described by Kass (1980) proceeds as follows. Assume the dependent variable has d levels and the predictor variable has c levels. This data may then be presented in a c by d contingency table. The objective is to compress the rows of this table to include only levels that are significantly different. Mathematically, the aim is to reduce the c by d table to the most significant j by d with j ranging from 2 to c . Then chose the j by d table that has the most significant chi-square statistic (Soman *et al.* 2006).

Here, the dependent variable Y is nominal categorical. The null hypothesis of the independence of the predictor variable X and Y is tested using the Pearson's Chi-square statistic,

$$X^2 = \sum_{j=1}^J \sum_{i=1}^I \frac{(n_{ij} - \hat{m}_{ij})^2}{\hat{m}_{ij}} \quad (7.4)$$

where n_{ij} is the observed cell frequency and \hat{m}_{ij} is the estimated expected cell frequency where χ_d^2 follows a chi-square distribution with degrees of freedom $d = (J - 1)(I - 1)$ (SPSS 2004).

Taking the outcome variable to be whether the client used heroin in the last 90 days at one year, yes or no, CHAID decision trees were constructed to determine if there was a sub-group or type of individual within the cohort who was less successful than others in their treatment. Given the construction of the MAP questionnaire (Marsden et al. 1998), four CHAID models were constructed. These four models described how social functioning, history of drug-use, health and drug treatment history might effect the key outcome and reflect the sections of the survey instrument.

Social functioning is important to consider for those in drug treatment (DoCRGA 2009). If the treatment is a success then it must have a positive effect on the individuals life outside of the methadone clinic. Three main areas were considered within this domain, the client's accommodation status, crime record and employment. To have stable accommodation is important in the recovery process. Stable employment is also important to consider as is the reduction in crime.

History of drug-use and treatment history both give an indication of the treatment pathway of an individual now in methadone maintenance treatment. Information on length and severity of their drug using past may have an effect on their treatment recovery process as well as other previous treatment received.

Given the recent findings of the Cox *et al.* (2007), specifically methadone outcomes, the health outcomes of the individuals caused concern and this was also found in the results presented in chapter six. Other outcomes for methadone treatment exhibited positive outcomes but health did not. Therefore, health was considered to be an interesting and important area to conduct further analysis on.

The results from four CHAID decision tree models are presented. Note; all models have age and gender included as predictor variables as CHAID helps identify a 'type' of individual

and age and gender are good descriptors.

As discussed, four models are examined. These relate to social functioning, history use drug-use, health and treatment history, important areas of consideration when a client enters a new treatment episode. The results from these four CHAID models are now presented beginning with model one which included variables linked to social functioning.

7.5 Results: CHAID

7.5.1 Heroin-Use at One Year and Relationship with Social Functioning

The outcome variable included in this model was whether the client was abstinent from heroin in the 90 days prior to interview one year after the baseline interview took place. Here, social functioning is taken to be related to areas such as employment, crime and accommodation which may be considered indicators of stability.

Variables included in the first model were:

- Gender.
- Age.
- Age left school.
- Had paid legal employment at baseline.
- Past three months earned money from crime or illegal activities at baseline.
- Remanded in the past three months at baseline.
- Sentenced in the past three months at baseline.
- Married/living with someone, in a relationship or single.
- Where living at baseline.
- Living with whom at baseline.
- Committed acquisitive crime in past three months at baseline.

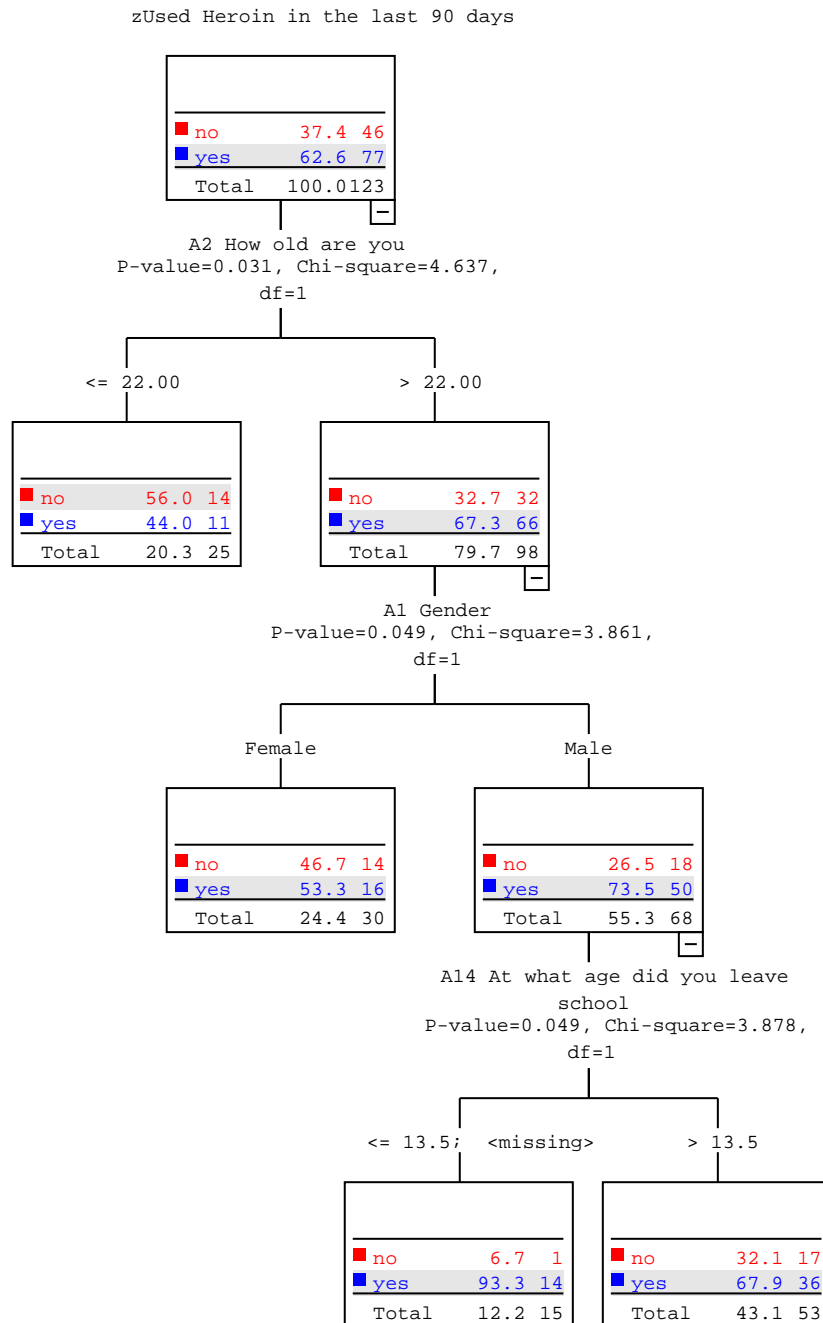


Figure 7.1: Social functioning: CHAID model result

It can be seen from model one that the first segmentation occurred on age. That is, the best predictor of using heroin at one year is age. Therefore of all the social functioning variables included in the model, age at treatment intake was the most important. The next segmentation occurred on gender, with males being more likely than females of those aged over 22 years of age to have used heroin at one year. The third most significant partition occurred on age the clients left school at which are detailed in Table 7.2. Those who left school younger than 13.5 years of age was grouped along with one individual who said they did not know what age they left school at. This group was more likely to have used heroin at one year. The results of this model show that overall, those over 22 years of age, male and having left school at a young age were most likely to be using heroin at one year.

Age left school (yrs.)	Freq.
5.0	1
10.0	1
12.0	1
12.5	1
13.0	16
13.5	1
14.0	17
14.5	1
15.0	33
15.5	5
16.0	22
16.5	3
17.0	13
18.0	6
18.5	1
Don't know	1

Table 7.2: Age left school

7.5.2 Heroin-Use at One Year and Relationship with History of Drug-Use

As with model one, the outcome variable included here was whether or not the client was abstinent from heroin in the 90 days leading up to interview one year after the baseline interview took place. Here we include variables in the model that relate to the history of heroin-use as well as the use of cocaine and benzodiazepines, the use of drug combinations and

whether the client had ever experienced an accidental overdose. Specific variables included in model two were:

- Gender.
- Age.
- Heroin -days used in the last three months at baseline.
- Heroin -age of first use.
- Benzodiazepines -ever used .
- Cocaine -ever used.
- Past three months has used combinations of drugs at baseline.
- Ever had an accidental drug overdose.

The resulting decision tree constructed in model two is very similar to the output from model one. As was detailed earlier in this chapter, CHAID models test all variables using a chi-square test of independence. The first significant partition occurred on age, specifically that those aged over 22 years were more likely to have used heroin at one year. The second most significant split again occurred on gender. Therefore males over 22 years of age were more likely to have used heroin at one year. The third most significant split occurred on the age the clients heroin using career began. The split occurred at age 15 with those males aged over 22 years and having begun their heroin used career over the age of 15 more likely to have used heroin at one year after treatment in-take. None of the other variables exhibited a significant relationship with the dependent variable.

Next, the CHAID model constructed from health variables is presented.

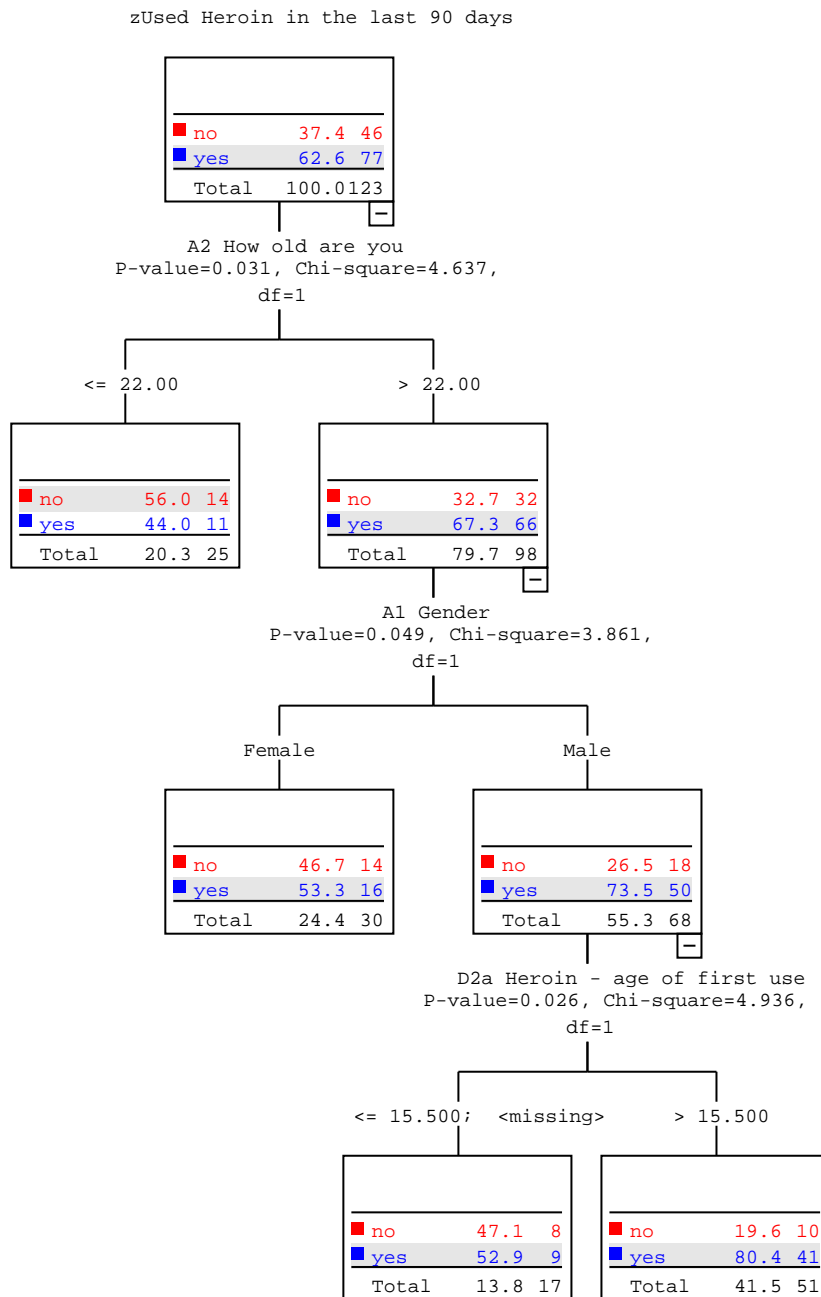


Figure 7.2: History of drug-use: CHAID model result

7.5.3 Heroin-Use at One Year and Relationship with Health

Again, the outcome variable included in the model was whether or not the client was abstinent from heroin in the 90 days leading up to interview one year after the baseline interview took place. Physical and mental health variables were selected for this model. They included the key health variables from the Maudsley Addiction Profile (MAP) instrument (Marsden et al. 1998). These health variables reflect the physical and mental health symptoms experienced by drug-users. These are:

- Gender.
- Age.
- How many days in past year stayed overnight in hospital.
- How many days in past year have been treated at A & E.
- How many days in past three months seen a GP (not prescriber).
- Categorisation of own health.
- Poor appetite - experienced in the past three months at baseline.
- Tiredness/fatigue - experienced in the past three months at baseline.
- Nausea - experienced in the past three months at baseline.
- Stomach pains - experienced in the past three months at baseline.
- Difficulty breathing - experienced in the past three months at baseline.
- Chest pains - experienced in the past three months at baseline.
- Joint/bone pains - experienced in the past three months at baseline.
- Muscle pains - experienced in the past three months at baseline.
- Numbness/tingling - experienced in the past three months at baseline.

- Tremors/shakes - experienced in the past three months at baseline.
- Feeling tense - experienced at baseline.
- Suddenly scared for no reason - experienced in the last three months at baseline.
- Feeling fearful experienced - experienced in the last three months at baseline.
- Nervous or shakiness inside - experienced in the last three months at baseline.
- Spells of terror panic - experienced in the last three months at baseline.
- Feeling hopeless about the future - experienced in the last three months at baseline.
- Feeling of worthlessness - experienced in the last three months at baseline.
- Feeling no interest in things - experienced in the last three months at baseline.
- Feeling lonely - experienced in the last three months at baseline.
- Thoughts of ending your life - experienced in the last three months at baseline.

The resulting model shows that the first most significant split centered on the occurrence of tremors or shakes (yes or no) in the 90 days before baseline interview. However, this category also included the missing variables i.e. those clients who gave no response when asked about experiencing tremor or shakes. Therefore, this result should be interpreted with caution. The next most significant split occurred on gender with males who experienced tremors or shakes at in-take (and those males who gave no response) more likely to have used heroin at one year. None of the other health variables included in the model exhibited a significant relationship with the dependent variable.

Moving on, the following model describes drug treatment history.

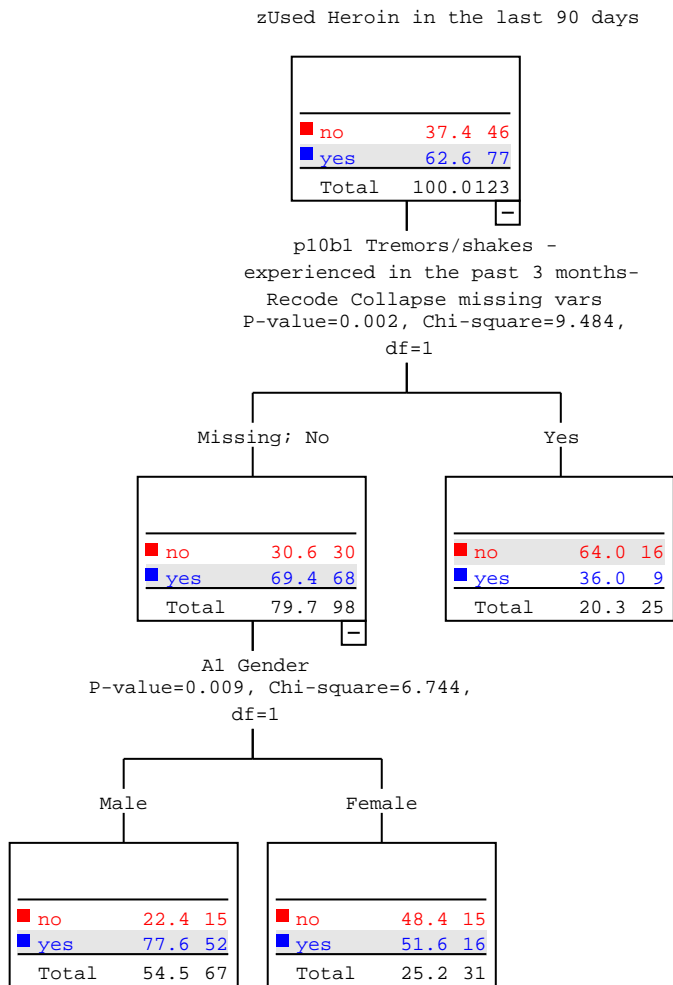


Figure 7.3: Health: CHAID model result

7.5.4 Heroin-Use at One Year and Relationship with Treatment History

Here again the outcome variable was whether the client was abstinent from heroin in the 90 days leading up to interview one year after the baseline interview took place. Variables that described what previous treatments the individuals had received were selected for this model.

They included:

- Gender.
- Age.
- Ever had any treatment for drug/alcohol use.
- Ever used a needle exchange.
- Ever been prescribed methadone/physeptone.
- Ever had a structured/supervised detoxification.
- Ever been in a residential drug treatment programme.
- Ever had one-to-one counselling for drug-use.
- Ever been to Narcotics Anonymous.
- Ever been to Alcoholics Anonymous.

Firstly age and then gender were the two significant variables included in this resulting decision tree. This finding supports what was found in the previous model, that age and gender were important elements in treatment outcome. However, none of the other treatment history variables included in this model were found to be significant.

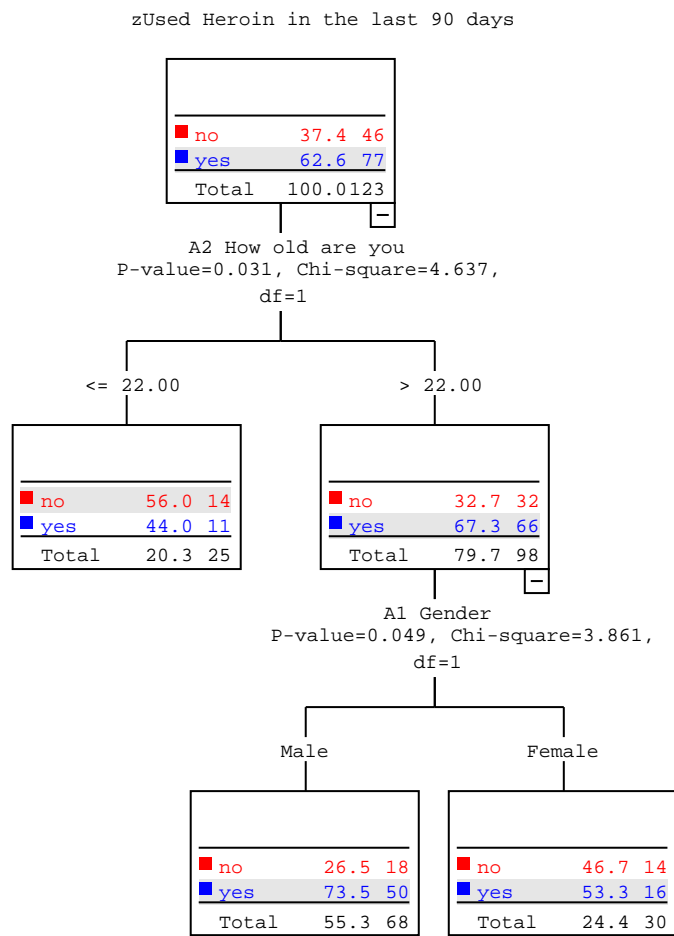


Figure 7.4: Treatment history: CHAID model result

7.6 Limitations of the Models

The dependent variable could be criticised for being rather crude as those who used heroin on one day were grouped with those who had used heroin 90 days, one year after their baseline interview. Specifically, the dependent variable was whether the client had used heroin yes or no. Those who had used for one day in the last 90 days were grouped with those who had used heroin for the entire 90 days. Further work could seek to apply the CHAID model using an ordinal dependent variable where the number of days of heroin used was banded into smaller segments for example used heroin 1-10 days, 11-20 days, 21-30 days etc.

Another limitation, and this is more concerned with the design of the study, is that there is no information on those who did not complete the second interview at one year and were lost to follow-up. Of the 156 individuals who completed a baseline interview, 127 completed one year of treatment and took part in the one-year interview leaving 29 individuals. Of those 29, three were in treatment for opiates other than heroin. Therefore 26 individuals were in treatment for heroin and did not complete an interview one year after treatment in-take. An interview could not be arranged with these individuals and it could be assumed that a number did not complete one year of methadone maintenance treatment. They may have relapsed or that they felt that their treatment was completed. For those who may have relapsed, it would be interesting to find if there was any particular reason why the relapse occurred and for those who may have felt that their treatment was finished, did they reach to conclusion alone and how did they progress out in community away from the support of the methadone clinic? As there is no information on the reasons, this is all supposition but, none the less, leads to the conclusion that the analysis might reach a more rounded and inclusive conclusion if those who were not in treatment one year after baseline were followed up and their data included in the analysis. However, in spite of these limitations a consistent result emerged highlighting the specific needs of males over 22 years of age.

7.7 Conclusion

After trial and error, CHAID decision tree model were deemed to be a suitable type of model to apply to the treatment data. This type of model works well with complicated data sets containing continuous and categorical data, not to mention missing data. CHAID decision tree modelling is usually used in market research to identify a type of customer. This seemed relevant to the clinical setting of methadone maintenance where the client attending the clinic for treatment could be described as their customer. According to the findings of these models, males over the age of 22 years, are important when administering methadone maintenance treatment as they are more likely to have used heroin in the previous 90 days, one year after a baseline interview which took place within 30 days of a new treatment episode. Identifying a treatment sub-population is of practical use to service planners. Recent work by Comiskey & Stapleton (2010) has suggested that providing a greater 'dose' of service within the first year of treatment leads to better treatment outcomes. The usefulness of identifying sub-population that require special interventions has been highlighted by Leshner (1997) and Gossop *et al.* (2000) suggest an important research question centres on achieving a precise differentiation of the ways in which patients respond to methadone treatment as even though, in general, it has been found the treatment works, some individuals achieve better outcomes than others.

What is not known is whether this would be replicated in a larger, representative sample of those attending methadone clinics around the country and further afield. However, the consistent findings across four CHAID models are encouraging and provide direction for treatment services. Results highlight that specific target groups will require additional supportive treatment services if improved results are to be obtained one year following treatment in-take.

Chapter 8

Spatial Analysis of Treatment Outcomes

GIS provide a digital lens for exploring the dynamic connections between people, their health and well-being, and changing physical and social environments.

(Cromley & McLafferty 2002)

8.1 Introduction

This chapter seeks to add a spatial model element to the research on treatment outcomes presented within this thesis. To date, within the EU and Ireland, little has been published on the spatial effects on an individual's treatment and outcome. Presented here, for the first time is a spatial analysis of Irish drug treatment data using GIS (Geographical Information Systems).

In previous chapters a range of methadone treatment clinics in Ireland have been described and the methadone treatment outcome of clients attending methadone clinics in Ireland have been investigated. It was detailed in chapter one how Dublin developed a severe heroin problem in the 1980's and recent research has shown that heroin-use has radiated out to provincial towns where treatment services are having to cope with increased demand (EMCDDA 2010, Farrelly & Barry 2010, MQI 2010). When added to this the complicating factor that many drug-users, who present for treatment as poly-drug users and not just users of heroin alone, it can be seen that these issues provide new challenges for treatment policy today.

Given this spread of heroin-use out from the Dublin city and region, from urban and

to suburban and more rural areas, and given that within Dublin heroin-use is generally linked with areas of social deprivation (Butler 2007), there is clearly a spatial element to this particular problem that requires further investigation and analysis. It is this spatial element that is examined for the first time in Ireland within this chapter. One application of Geographic Information Science (GISc) are Geographic Information Systems (GIS). Provided with attribute data that is spatially referenced, these systems can be digitally mapped using computer software. Further, provided with sufficient geo-referenced data, this information can be queried and modelled in a number of ways. GIS analysis is highly applicable to health data (Longley *et al.* 2005), including drug treatment and the spread of drug-use.

Further, when Hendriks (1999) proposed the application of the regression model:

$$\boxed{\text{Outcome}} = \boxed{\text{constant}} + \boxed{\text{patient variables}} + \boxed{\text{programme variables}} + \boxed{\text{process variables}} + \boxed{\text{error}} \quad (8.1)$$

One of the factors involved in ‘treatment’ was the geographical location of the treatment and its accessibility. In chapter three, programme data concerning the methadone clinic itself in terms of staff, policy, client numbers among others was examined. Here further analysis is carried out on the programme, or clinic, from a different perspective, its geographical or spatial location. Firstly, GIS methods are applied to the Irish treatment outcome data followed by a discussion of early spatial models concerning drug-use and spread.

8.2 Methods

8.2.1 Confidentiality and Data Protection

As discussed in earlier chapters, the Irish treatment data used here was provided by the methadone treatment cohort of the ROSIE (2008) study. In order to map the treated clients, each of their home addresses and treatment clinics were geo-coded that is, they were given a spatial reference. This involved locating each address in the Irish Geo-directory which provided the co-ordinate of each address. However, the outcome data remained anonymous.

Many health data sets contain sensitive information and good ethical practice and in some cases law, requires that this information be kept confidential (Waller & Gotway 2004). This project was part of a the larger ROSIE (2008) project which was carried out within the Mathematics Department, National University of Ireland, Maynooth. Ethical approval, sought from the University's ethics committee as part of the initialisation of the project, stipulated the safe storage of confidential data. The client's home address information along with other confidential data was kept under secure conditions within the University. Access to the client addresses for the purposes of geo-coding was carried out under controlled conditions. This involved arranging a time slot with the administrator of the main project, accessing the addresses under supervision and ensuring no addresses were removed either on soft or hard copy. The database that was created to hold each client's name, address and geographical location was saved in digital format and was stored with the main body of confidential information. No background mapping was used, as will be seen in maps presented later in this chapter, which would help identify an area in which a client lived.

8.2.2 Mapped Data

From the geo-coded data, maps are provided which show the location of the seven clinics and the location of the clients belonging to each clinic, as were the subject of chapters three and four. Maps also show how far the clients were travelling to avail of treatment. One hypothesis investigated was that the longer the distance the client has to travel for methadone, the worse the outcome of treatment. A map examining the location of the clinics and clients with respect to the major road network of Dublin is also provided.

Maps of the Distribution of Clients and Clinics

Figure 8.1 is a simple map which shows the location of the methadone maintenance clients described in this study, with Figure 8.2 providing closer detail of the distribution of these clients in the east-coast region. Each dot represents a client, and the different colours signify the different clinics each client was attending. For example, the clients represented by red

dots attended the same clinic.

Methadone Clinic Clients

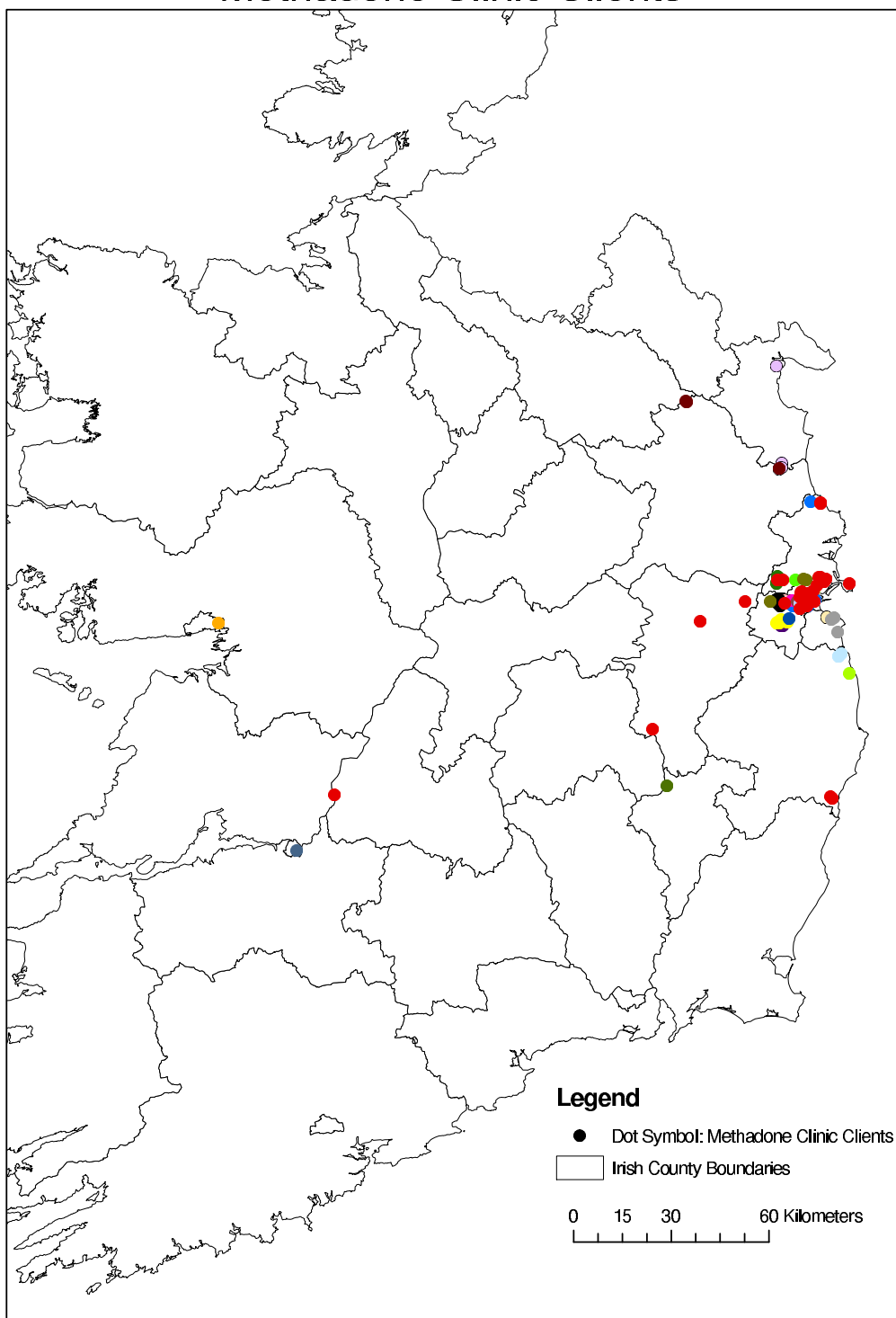


Figure 8.1: Distribution of clients

Methadone Clinic Clients- East Coast Region

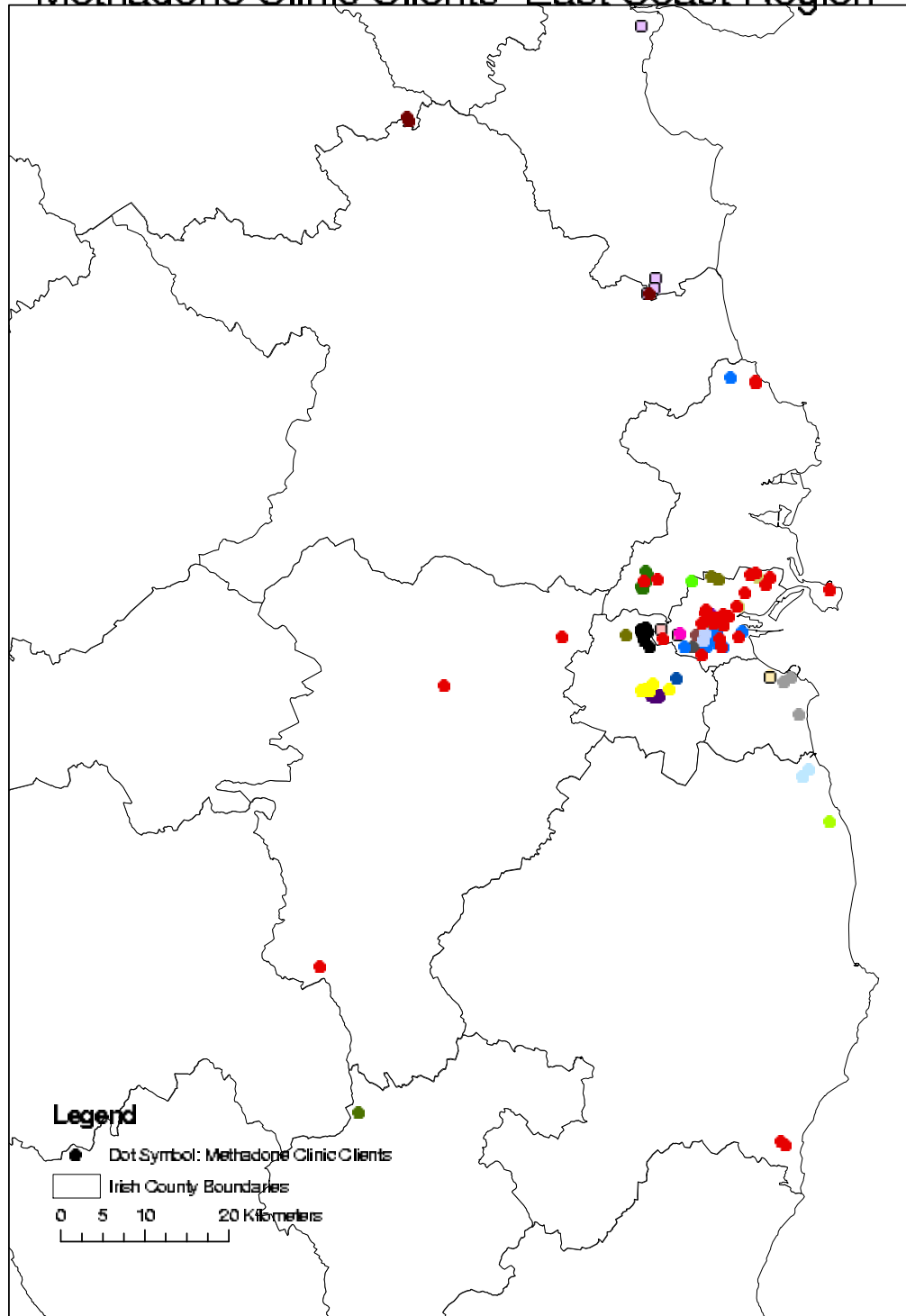


Figure 8.2: Distribution of clients: East coast region

Some clients were located a long distance from the clinic they were attending. For example, it can be seen from Figure 8.1 that there were three clients on the west coast, one of whom, represented by a red dot, was attending a treatment centres in the east coast. The map, Figure 8.2, illustrates the large concentration of methadone clients in the Dublin

region.

The map in Figure 8.3 shows the location of the clinics that were being attended by the clients represented in the previous two maps. Each triangle represents a methadone treatment clinic. Figure 8.4 provides greater detail of the distribution of the clinics around the Dublin region.

Methadone Clinics

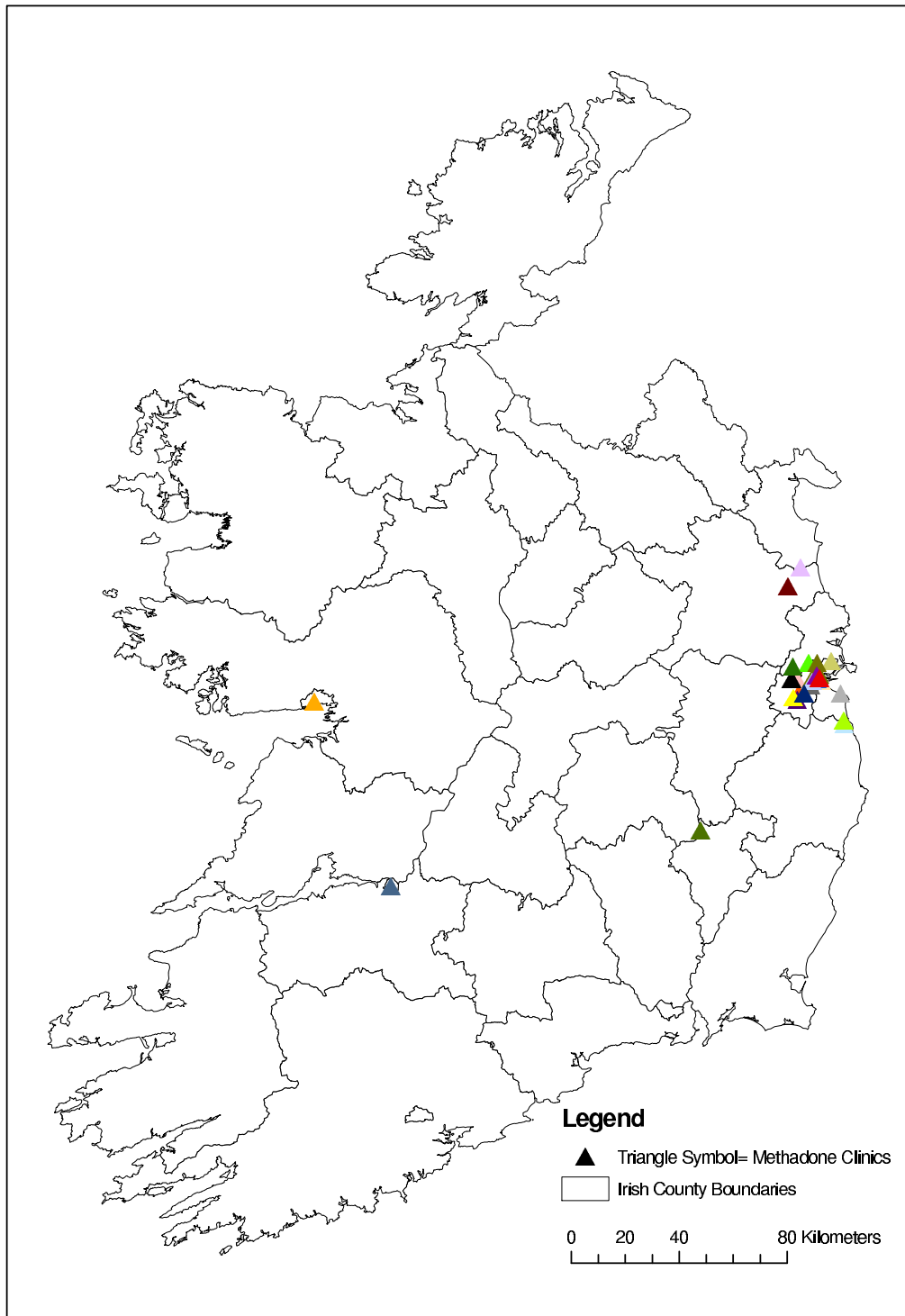


Figure 8.3: Distribution of clinics

Methadone Clinics- East Coast Region

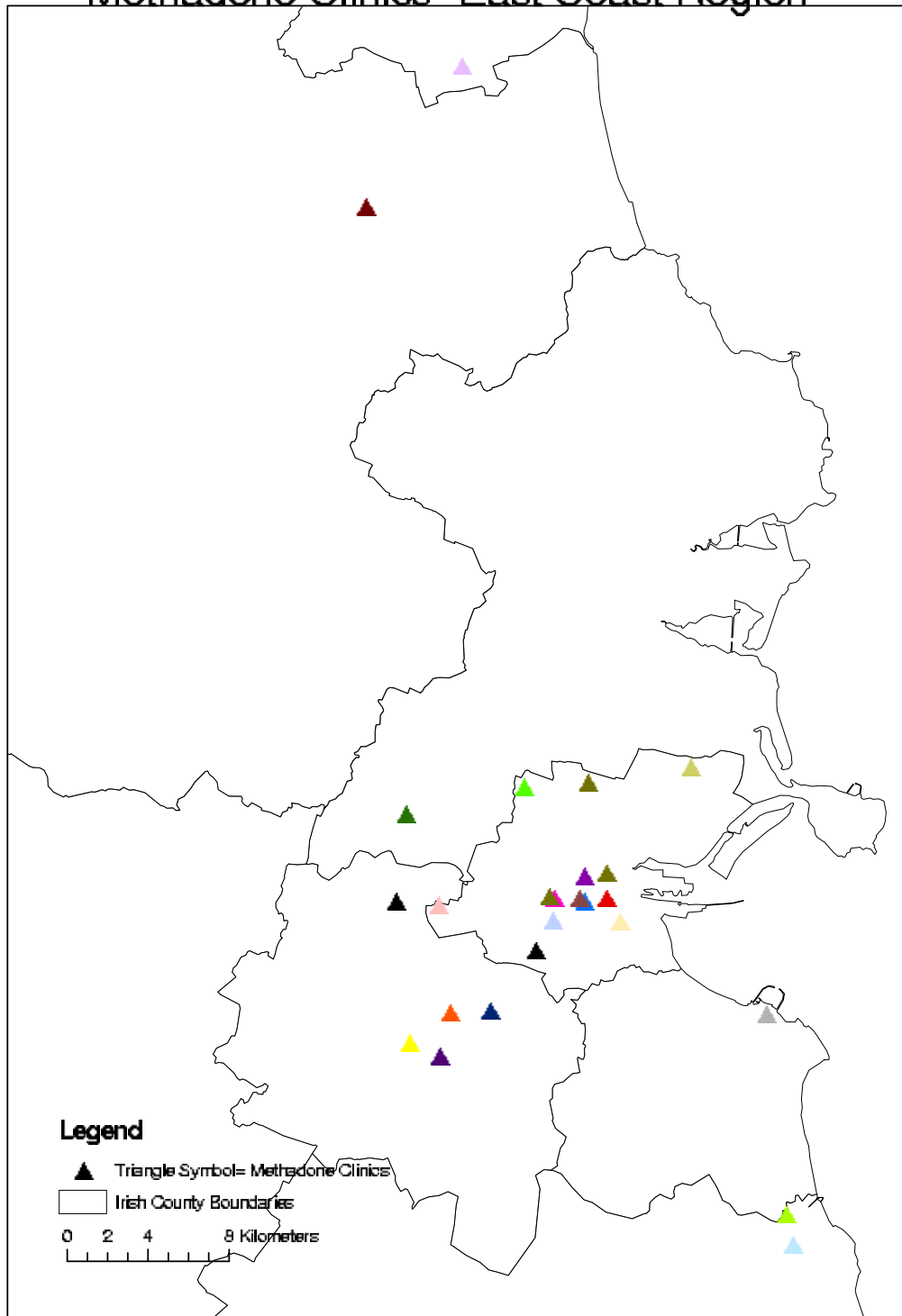


Figure 8.4: Distribution of clinics: East coast region

8.3 Early Spatial Models in the United States.

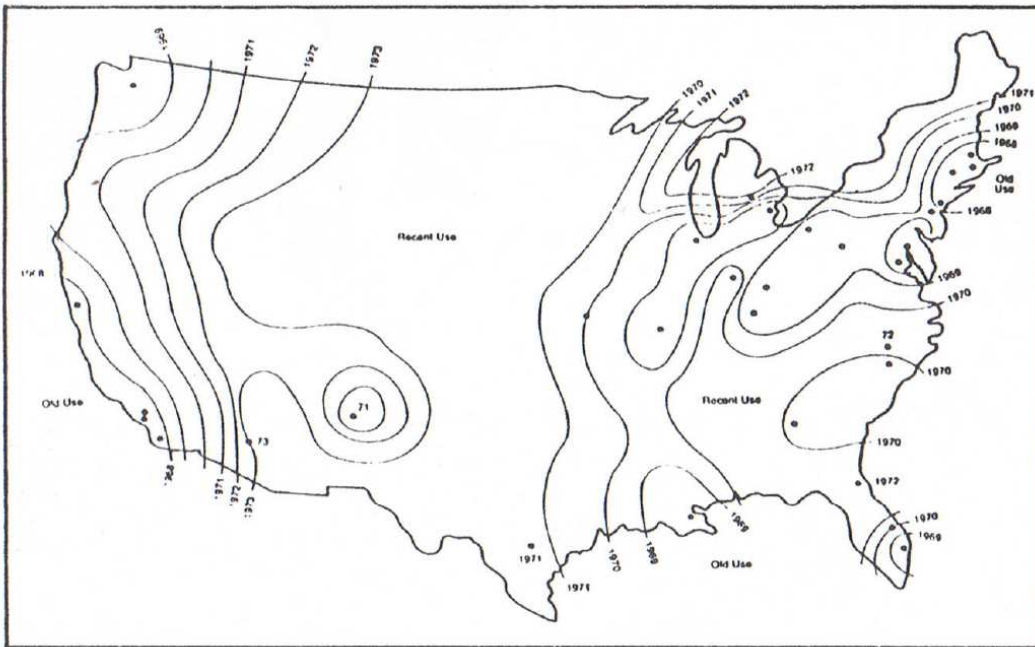
The Heroin Epidemics written by Hunt & Chambers (1976) developed early spatial models of drug-use and was mainly concerned with

- Who are the heroin users?
- How many are there?
- When did heroin-use begin?
- Where is the heroin use happening?

Hunt & Chambers (1976) developed the idea of micro-diffusion (spread from person to person) and macro-diffusion (spread from city to city) of heroin-use. More recent work on a GIS (Geographic Information System) models in Europe date back to these ideas (Frischer & Heathlie 2001).

8.3.1 Hunt and Chambers: Micro and Macro-diffusion

Hunt & Chambers (1976) saw the micro-diffusion of heroin-use as spreading within a group of closely associated youths by a process of peer emulation and influence which seems very plausible. They pointed out that earlier studies had seemed to confirm this (Ball and Chambers (1970), as cited in Hunt & Chambers (1976)), where findings had shown that 85% of two groups studied were initiated into heroin-use by friends. They saw use as being communicated as a kind of social practice or custom and only to those who were susceptible. They postulated that heroin-use showed a contagious nature and it was possible to study transmission. Taking a step up from micro-diffusion was macro-diffusion; new use of heroin passing from region to region and city to city illustrating a clear overall representation of the heroin-use spread in a large area, in contrast to micro-diffusion which was concerned with small populations and social groups. Hunt & Chambers (1976) identified a pattern of new use that can be identified from the 'background noise' of constant underlying use. Many cities experience these sharp peaks or epidemics of use. The sequence of these peaks may represent



Source taken from Hunt L.G. and Chambers C.D. (1976) *The Heroin Epidemics: a Study of Heroin. Use in the United States*, Spectrum, New York.

Figure 8.5: Isochrony of peak heroin-use

diffusion at the aggregate level of cities, i.e. as use spreads from city to city, then each city in turn will experience an epidemic of new use. Between 1950 to the early 1960's most U.S. cities probably experienced low and constant incidence of new heroin-use. Starting about 1960, new use began to grow rapidly, rising to local peaks in the late 1960's and then falling sharply. The pattern is so typical that it has come to be regarded as the definition of epidemic heroin-use. When local data are corrected for delays in entering treatment, treatment programme data become a sequence of local peaks ranging from 1967 to present. Further analysis shows that the sequence of local peaks is related to city size; large cities generally preceded small ones. Interestingly, Hunt and Chambers compared this to the 'hierarchical diffusion', an idea from the field of geography. The data on local peak use was plotted in geographical manner joining cities that experienced peak use in the same year and had the same time line.

Figure 8.5 taken from Hunt & Chambers (1976) shows cities that have experienced peak heroin-use during the same year joined by isochrons or common time lines. This map shows that heroin-use seems to have moved into the interior from coastal areas and cities and spread sequentially from cities in regions of high population density to those of lower population

density. On a more local level the broad trend of peak heroin-use shifted from larger to smaller cities and from the densely populated coasts to the sparse interior, following the same pattern within states, migrating from large cities to adjacent smaller cities.

Analysing the diffusion trends of heroin-use can be useful. By examining the trend of the diffusion (and if the trend is accurate), these trends can provide a basis for estimating the number of future heroin users, leading to further analysis and modelling.

Little work has been done to date on mapping drug data in Ireland. Section 8.4 presents the first maps of drug treatment outcome in Ireland.

8.4 Results

8.4.1 Spider Plot Map: Who Attends Which Clinic?

Previous studies have investigated geographic and neighbourhood context variables in relation to distance from residence to available out-patient treatment facilities for drug-use, alcoholism, psychiatric disorders among others (Stahler et al. 2007). Here GIS software is used along with Irish treatment data to map these distances.

Greater Dublin Area: Client to Clinic Distance

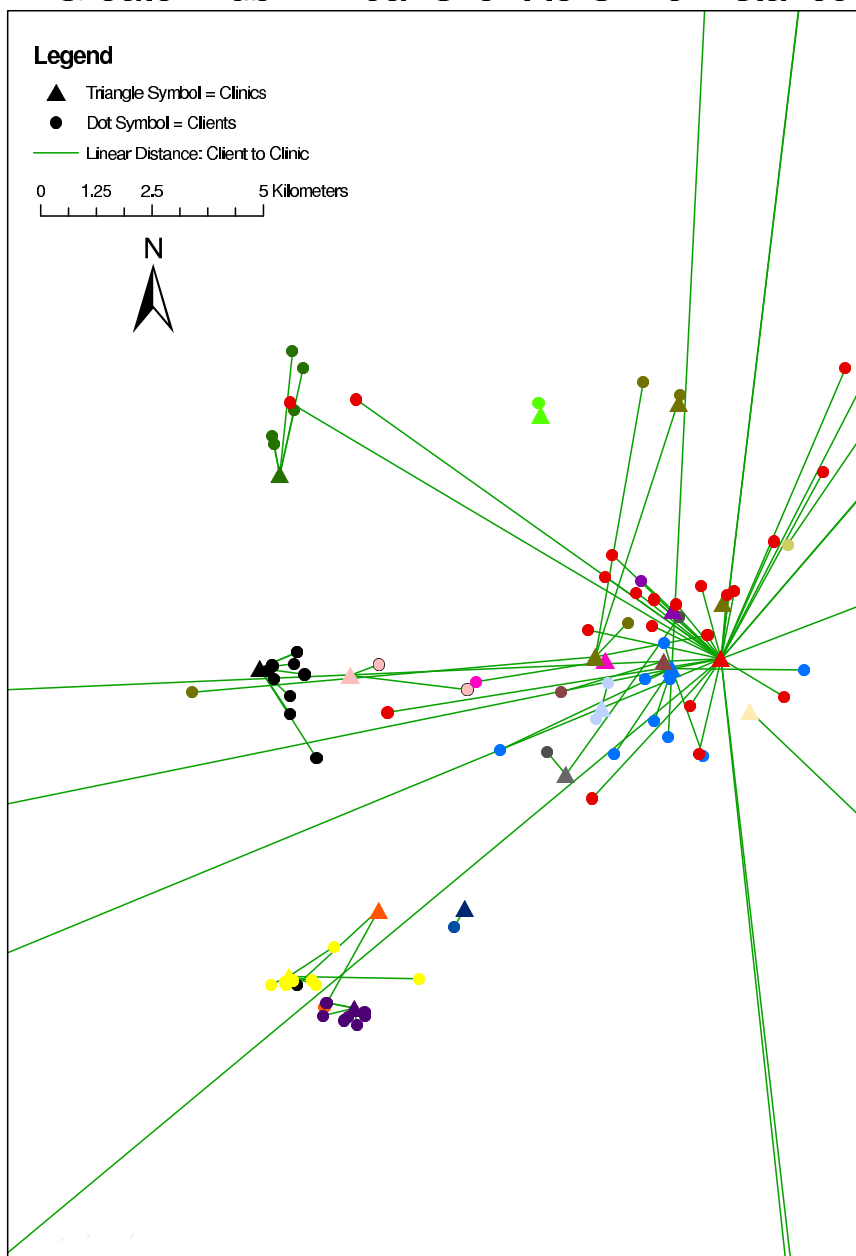


Figure 8.6: Spider plot map

The map in Figure 8.6 shows a spider plot connection of each clinic to their clients, that is the linear distance from the clinic to the client. For illustrative purposes, as the map is quite detailed, clinic and clients within the Dublin region are presented. Lines flowing outside of the map show clients travelling from outside the region to receive their methadone treatment. In some areas, clinics are in close proximity to one another. It can also be seen that some clients who live near one clinic are passing it by and travelling on further to another clinic. Hence, the map shows a complicated criss-crossing of paths to treatment. It is true that this

map shows a linear distance which would not be the path taken in real life. However, it does give an idea of who is attending which clinic and how far they travel to get there. The next map, Figure 8.7, chooses one Dublin clinic and investigates this further.

8.4.2 Buffer Zone Map: Distance to Treatment

Buffering refers to a particular type of spatial query, the definition of an area within a specified point, line or area (Waller & Gotway 2004). The map, in Figure 8.7, has taken the clinic with the largest number of clients in this study and drawn buffer rings radiating out from the clinic location in five kilometre increments. This clinic, located in Dublin, has a wide spread of clients. As can be seen from the map, a number of the clients were living outside the Dublin region, one as far away as 158 km. It could be argued that such a long travelling distance to obtain treatment might adversely affect the treatment outcome. In this case, the green dots which represent the clients on the map are proportional symbols representing the number of days of heroin-use in the last 90 days, one year on from baseline interview. Therefore, the larger the green dot the greater the heroin-use in the last 90 days. In other words, the larger the dot on the map, the less successful the treatment outcomes.

Clinic Buffer Zone and Treatment Outcome

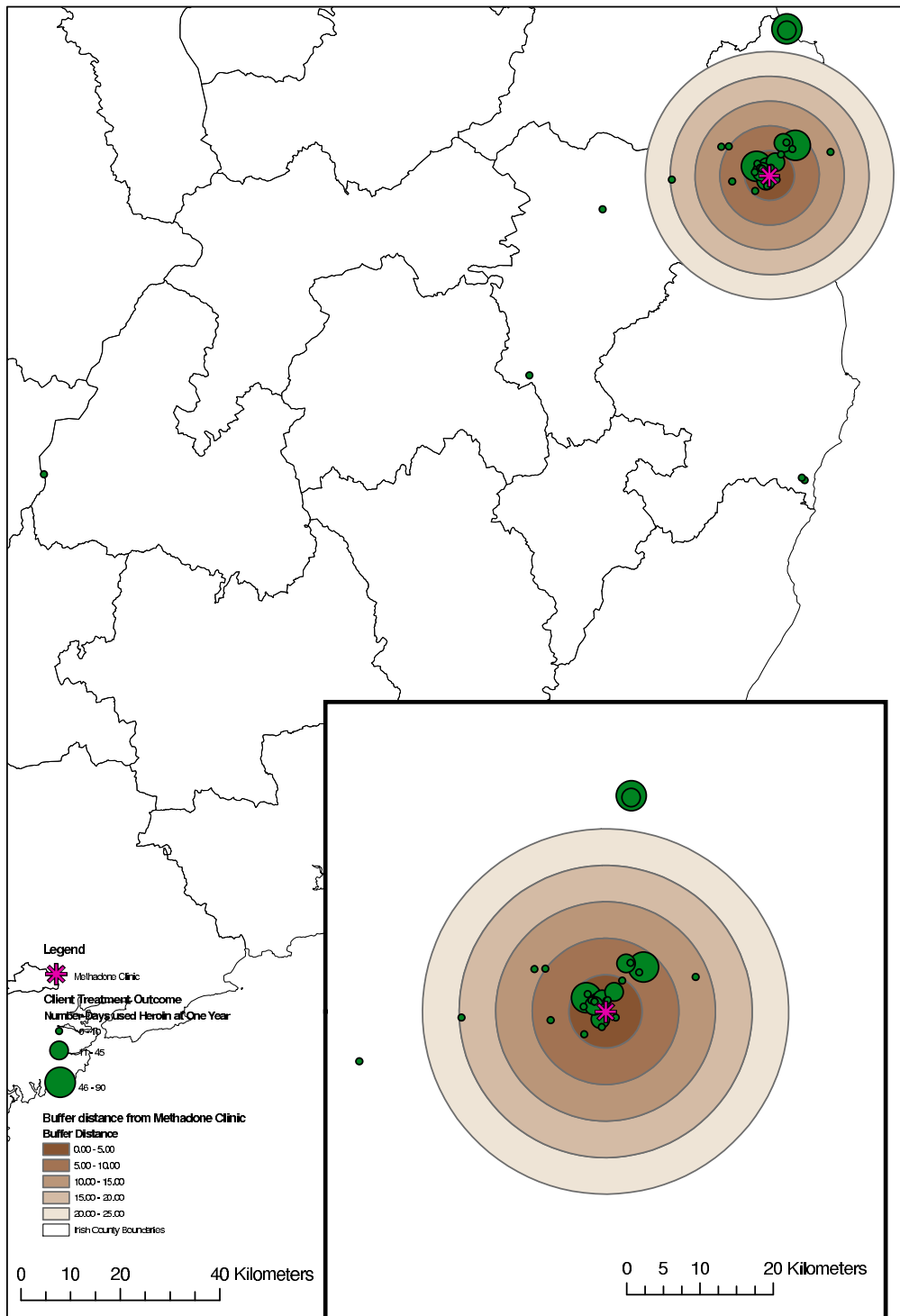


Figure 8.7: Buffer zone map

It can be seen that those who were travelling long distances had reasonably good outcomes. Most of the less positive outcomes were located within a 10 km radius of the clinic. This is an interesting finding and raises many questions, especially whether there is a neighbourhood effect on treatment outcome. For example, for some who live in an area where there is a

high level of drug-use, trying to stabilise and have a successful treatment outcome may be very difficult, especially when living in close proximity to people one might have used heroin with. Local geography and the community context where the clients lives, both in terms of social attributes and environmental factors may effect client treatment outcome (Davis & Tunks 1990). For the clients travelling long distances, they may be more determined to be successful in their treatment and more motivated to engage, and their willingness to travel long distance to avail of treatment could be an indicator of this.

8.4.3 Spread of Use: Diffusion

As mentioned earlier, according to Frischer & Heathlie (2001) GIS has the functionality to incorporate many different types of information when investigating drug-use spread, one possible item being transport routes. The map in Figure 8.8 shows the clinics and clients in this study who are located in the Dublin region. Instead of county boundaries however, this map shows their location relevant to major roads and highways in this east coast region.

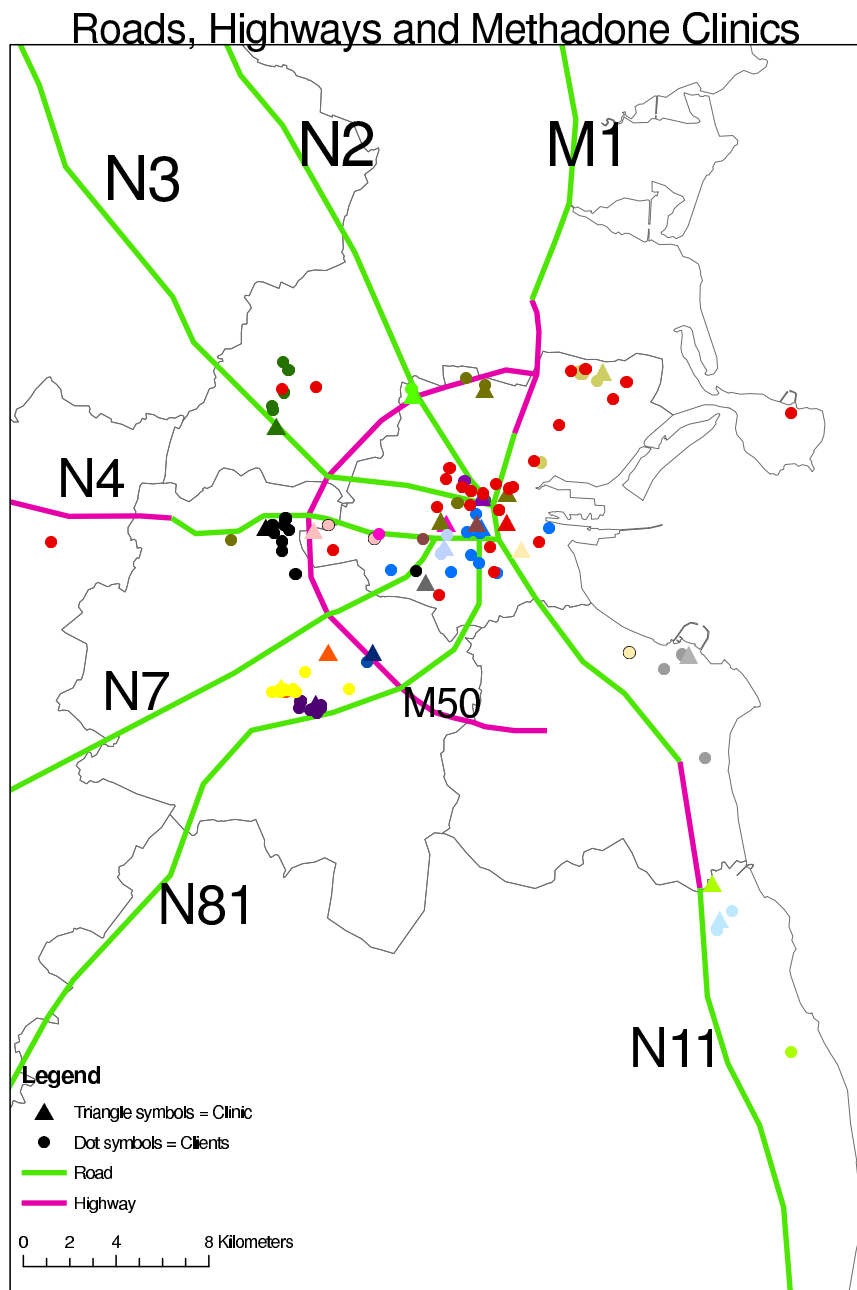


Figure 8.8: Major roads and client/clinic distribution

The major ring road surrounding Dublin is the M50 and the roads which ‘spoke’ out from the M50 are the M1, N2, N3, N4, N7, N81 and N11 as labelled on the map. These are the main arteries feeding Dublin. Putting treatment outcomes to one side, and just considering the location of the clients and clinics, this map is interesting in that it shows the clients and clinics are mainly located along these roads and highways. The areas between the ‘spokes’ are empty. Of course, this map does not show all the methadone clinics in Dublin, nor all of the clients attending the mapped clinics, although one might say that a methadone clinic

exists in an area that requires it (although this can also be further investigated using GIS) An interesting hypothesis then for further study would be to investigate whether the diffusion of drug-use throughout Ireland is facilitated by the major road networks.

8.5 Discussion: The Role and Usefulness of GIS Modelling

Many disciplines use GIS to investigate the association between location, environment and behaviour. GIS mapping allows the flexibility of micro and macro analysis simultaneously. In the area of healthcare alone, GIS is increasingly being used for the purposes of needs assessment, resource allocation, service planning and epidemiological research (Field & Beale 2004). Spatio-temporal spread of a phenomenon such as drug-use can be mapped, queried and analysed. Further, linking modelling with GIS can provide spatio-temporal forecasting, a useful tool in the analysis of the spread of drug-use, especially from a policy and planning viewpoint (Frischer & Heathlie 2001). The visualisation of the data provided in a clear digital map is a powerful tool especially for policy makers, as maps provide a simple means of communicating data to others (Waller & Gotway 2004) especially to the non-technical audience.

GIS software can facilitate the analysis of environmental influences on drug-use and treatment by looking at the individual and the neighborhood and capturing the spatial relationships between the two that may influence certain behaviours (Stahler et al. 2007). A study carried out in 1998 in Baltimore, U.S.A, concerned crack-cocaine use and utilised GIS in the analysis (Latkin et al. 1998). One of the main aims of the study was to assess whether frequency and type of drug-use were geographically located within the city independent of neighbourhood characteristics. Residential locations of 597 inner city intra-venous drug-users who were enrolled in a local HIV prevention study were plotted on a map of the city. Three patterns of drug-use six months prior to the study were examined. These were; daily use of heroin by injection, daily use of cocaine by injection and daily use of crack-cocaine. Results found that daily use of cocaine and any use of crack were statistically associated with residing

in the western portion of the city. Geographic location was not only associated with use but also frequency of use. This type of policy relevant results can then lead to targeted interventions. As far back as 1997, Nolan et al. (1997) reported on the spatial aspects of poverty and deprivation in Ireland. This report focused on elements of poverty such as income, unemployment and housing. As heroin-use in Ireland has historically been associated with areas of poverty and deprivation and as poverty and deprivation itself has been analysed spatially, then it seems logical to analyse drug-use and treatment data from a spatial aspect. GIS mapping software can assist in the assessment of drug-treatment service provision, treatment uptake and treatment outcome.

8.5.1 Future Research: GIS Application in Drug-Use Research

According to the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) (Frischer & Heathlie 2001), the application of GIS to drug-use in Europe could be useful in providing maps of incidence and prevalence and forecasts and trends in drug-use spread, provided the data is available. Building on the Hunt & Chambers (1976) model of spread which incorporated micro and macro-diffusion, other information, such as socio-economic levels and transport routes could potentially be incorporated into models of spread provided there was a spatial reference attached. This would provide a more rounded and detailed view given the higher degree of sophistication of the model and would provide huge scope for further research. In general, however, the application of GIS to drug-use data has been slow due to a number of elements including lack of data, lack of knowledge of GIS capabilities and lack of epidemiology knowledge of drug diffusion.

According to the Frischer & Heathlie (2001)

‘The development of a drug-misuse GIS would create a powerful visualisation and forecasting tool with easily understandable outcomes.....would also be a focal point for integrating and developing epidemiological understanding of trends in drug-use within and across Europe .’

Few researchers have used GIS to investigate drug-use, including spatial patterns of use, environmental patterns of use and drug treatment. Anecdotally, there have been doubts on the side of the service providers about spatialising and mapping their data especially in terms of data privacy and the fear of areas or neighbourhoods obtaining a certain negative 'label'. However, the National Institute of Drug Abuse (NIDA) in the United States sponsored a symposium at the 2006 American Association of Geographers (AAG) meeting. The symposium focused on the geographical aspects of drug-use and is evidence of the increasing recognition of the importance of geographic factors and the usefulness of GIS in the analysis of drug-use in the community (Stahler et al. 2007).

Geographical Information Systems (GIS)/Geographic Diffusion Models

These models can provide three things:

1. spatio-temporal maps of drug incidence and prevalence,
2. dynamic modelling methods which forecast trends which can then be visualised,
3. provision of information on populations at risk (PAR's), cause of disease and nature of transmission.

GIS can capture, analyse and display spatially referenced data. The spatially referenced data can also be linked to databases with statistical and epidemiological functions. The result of any analysis or modelling can then be mapped to show any spatial variation i.e. associations between location, environment and disease which may help explain the underlying processes at work. To carry out this type of analysis four items are required: digital data to create the map, mapping software, appropriate attribute data e.g. census data to add to the digital maps that helps explain drug diffusion and models that explain drug-use diffusion. The usefulness of this type of modelling is the ability to combine the mapping technology with any other type of model i.e. mapping the output. Also, the ability to clearly map and make visible any modelling results is a huge advantage.

8.6 Conclusion

Results within this chapter highlight for the first time, not only in an Irish setting but universally, the usefulness of mapping existing treatment outcome data with GIS tools. Descriptive results give some indication of the role of distance from treatment centre in treatment outcomes. Findings suggest those travelling distances have improved outcomes. Clearly more work is required in this case.

GIS analysis allows, among other things, digital mapping of data which can show retrospective changes over space and time. In the context of drug-use and drug treatment, this functionality lends itself to investigation prevalence and incidence of drug-use, diffusion of drug-use, drug treatment service planning and provision and the analysis of treatment uptake and treatment outcome. However, there are limitations. GIS mapping is only as good as the data allows. The biggest challenge is the availability of spatial data, and as with most health data, there are issues with confidentiality and inter-agency cooperation.

Chapter 9

Conclusions, Discussion and Further Work

9.1 Introduction

It has been estimated that there are approximately 12 to 21 million opiate users globally, with about 75% of these consuming heroin (UNODC 2011). Problem opioid users in Europe are estimated at between 1.3-1.4 million Europeans with approximately 700,000 receiving substitution treatment. The recent EMCDDA (2011) report highlighted the worrying prospect of the potential outbreak of localised HIV epidemics especially given the economic downturn and the increased vulnerability of at-risk groups. Methadone maintenance treatment is known to reduce the incidence of HIV among injecting drug-users. Given this and the evidence, discussed in chapter one, of the spread of heroin-use from urban to rural areas and the possible lack of treatment services within these areas, work on accessing the treatment effectiveness of methadone maintenance treatment remains an important endeavour.

The primary aim of this thesis was to utilise an existing drug-treatment data-set to investigate statistical models of drug-treatment outcome with a view to informing policy on methadone maintenance treatment effectiveness. Recommended for use in Europe was the Ball & Ross (1991) model of methadone treatment effectiveness. This model proved to be unsuitable even after remedial work was carried out. Further models were then applied to the Irish treatment data and these consisted of logistic regression models, Chi-Square Automatic Interaction Detector (CHAID) models and finally spatial models. In particular, the CHAID models and the spatial models elicited policy-relevant findings.

9.2 Conclusions

The conclusion of this thesis can be presented in two sections. These consist of findings from the data and findings from the modelling work.

9.2.1 Conclusions Drawn from Modelling Work

The Ball & Ross (1991) model proved that it was not easily applicable. The model is essentially a linear regression model with three main components, patient, programme and process variables. The programme variables required the application of a data reduction technique and principal components analysis (PCA) was the chosen method utilised by Ball and Ross and applied here. Again it was found that PCA was not easily applicable to clinic data. Overall, as a linear regression model, the model was unsuitable for the data. Remedial work was undertaken but did not remedy the issues. Subsequently the cohort was extended and further modelling techniques were utilised.

Taking abstinence from heroin at one year into methadone maintenance treatment as the outcome, logistic models were employed. A large number of univariate models were tested and 14 variables proved to be significant. The next step, to build up the logistic models to all two-way and three-way interactions would have required a huge number of models to be tested. There was also an issue with a certain level of missing data contained within the dataset that renders variables unsuitable for inclusion in a logistic model. Chi-Square Automatic Interaction Detector (CHAID) modelling was then applied as it is less data intensive and elicited a clear result here. Males older than 22 years of age were less successful when the outcome in question was being abstinent or non-abstinent from heroin prior to interview one year after baseline interview. At baseline interview the cohort were in treatment no longer than 30 days and were therefore entering a new treatment episode.

A novel application of Geographic Information Science (GIS) to Irish drug treatment data was employed. Results show that that proximity of a client to their treatment clinic was not a barrier to successful treatment outcome. Results also show that those residing

in close proximity to their clinic tended to have worse outcomes and may be experiencing a ‘neighbourhood effect’.

9.2.2 Conclusions Drawn from the Treatment Data

In Ireland methadone maintenance clinics fall into two broad categories; statutory and non-statutory. Variation, both within and between these clinic types were found. This variation make it a difficult exercise to measure what Ball & Ross (1991) refer to as the ‘black box’ of treatment and what Comiskey & Stapleton (2010) refer to as the ‘dose’ of service.

In general, analysis of the data when comparing variables at treatment intake to the same variables at one year into a methadone treatment episode, improvements were seen across a number of measures including the number of days and the amount of heroin used. Health variables, relating to both mental and physical health did not show such positive results.

9.2.3 Discussion: Informing Policy and Planning

There is no evidence that the Ball and Ross model is applicable to Irish data and care should be taken when referencing this work in terms if the situation in Ireland.

As a modelling framework has been recommended by the EMCDDA, and as models are reliant on the quality of data to illicit policy relevant results, model types should be considered when planning a research exercise. In other words, starting with useful models and working backward to research design with the aim of gathering suitable data. Spatial models should be included in this consideration as there is huge scope for their application.

9.2.4 Further Work

Magura et al. (1999), building on the work of Ball & Ross (1991) carried out principal components analysis (PCA) on data relating to 17 clinics in New York. These clinics were invited to take part due to their previous interest in research. The PCA analysis within this thesis concerned seven methadone clinics in and around the Dublin region of Ireland. Gaining access to information held by clinics requires negotiation and does not lend itself to random selection. However, finding a method to measure or quantify how the treatment facility contributes to

a successful treatment outcome is still a worthwhile exercise to undertake especially in the current climate. How are recent cut-backs affecting service delivery and does this have an effect on treatment outcome?

A number of individuals did not complete one year follow-up interview and no data from that cohort were included in analyses. This is a common limitation of drug treatment outcome research and treatment outcomes would obviously be expected to be better for those that stayed in treatment. Given the resources and building it into a research plan, further work on drug treatment outcomes in Ireland could endeavour to include this cohort.

The CHAID modelling results highlighted that males over 22 years of age were less likely to be abstinent from heroin after being in treatment for one year. However, what is not known if this finding can be replicated across a wider sample. Further work might seek to replicate these findings and endeavour to uncover reasons why this sub-group may require a targeted treatment response.

The results from the spatial analysis highlighted that those residing nearer to their treatment clinic didn't necessarily have better outcomes than those living far away from their treatment clinic. This seems counter-intuitive and requires further investigation into the possible causes of these outcomes. In general, however, spatial analysis could be employed to assess a number of areas concerning drug-use including treatment service provision, treatment uptake and treatment outcome.

Finally, the research demonstrates how a range of models can be implemented for the benefit of treatment and policy, planning and provision. While limitations are highlighted, results presented can be used to further refine, inform and direct future service provision both in Ireland and beyond.

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Appendix A

Questionnaire for Clinics

Section A

- Q1 How many years has this clinic been in operation?
- Q2(a) Could you please explain briefly how you are funded?
- Q2(b) In your opinion is your funding adequate?
- Q3 What is your treatment policy? -Can you give me a run down of what happens a client who comes to your clinic in need of treatment, starting with how eligibility is decided.
- Q4 Does the clinic employ a key worker system?
- Q5(a) Do you write up customised care plans?
- Q5(b) If so who does this?
- Q5(c) Are they constantly updated?
- Q6(a) Who is responsible for the maintenance of patient records?
- Q6(b) Are the records held on computer or on a card?
- Q6(c) How often are they updated?
- Q6(d) What details are recorded?
- Q7 Does the clinic refer clients to employment/vocational agencies?

- Q8 Are there educational/vocational services provided on-site?

Section B

- Q9 What is your opinion of the adequacy of the clinic/building?
- Q10(a).What security is there at the clinic?
- Q10(b) Has the clinic had any security problems recently?
- Q11 Has the clinic a good relationship with the local community (including the Gardaí) in your opinion?
- Q12(a) Does the building require maintenance on a regular basis?
- Q12(b) Who funds this maintenance?
- Q13 What ancillary services does the clinic offer? e.g. crche, laundry/showering facilities, HIV/Hep testing, complementary therapies, rehab and after-care programmes, sexual health clinic, youth services, child and adolescent services, homeless services, disabled services, vaccination and screening etc.

Please list others.

Section C

- Q14 How many days a week is the clinic open?
- Q15 How many hours a week is the clinic open?
- Q16 About what proportion of clients are on dailys?
- Q17(a) Approx what is the maximum,
- Q17(b) and minimum dose for the clients?
- Q18 Approx what is the missed methadone rate per week?

Section D

- Q19 How many methadone patients are you treating at the moment approx?
- Q20(a) Approx how many of these patients have been in treatment less than one year?
- Q20(b) Approx how many of these patients have been in treatment 5 years or longer?
- Q21(a) How many patients are on the waiting list for methadone treatment?
- Q21(b) What is the average waiting time?

Section E

- Q22(a) Are all clients required to give urines or just new clients?
- Q22(b) Approximate number of clients who provide urine per week?
- Q22(c) Number of urines provided per patient in a week?
- Q23 Is the urine sampling random or is it done on specified days?

Section F

- Q24 What is the General Manager's years of experience being General Manager at this programme?
- Q25 What is the General Manager's years of experience in this position (in general)?
- Q26 What level of Education does the General Manager have?
- Q27 Approx what is the percentage of the General Manager's time is spent employed or in attendance at this clinic?

Section G

- Q28 Do you have any counsellors? If so please answer the following.
- Q29 Number of counsellors employed here (a)Full time- (b)Part time-
- Q30 Average years of experience of the counsellors ?

- Q31 Average years of education of the counsellors? Comments
- Q32 In your opinion, what skills make a good counsellor for this clinic?
- Q33 What percentage of the counsellors hold advanced degrees?
- Q34 Approx. what percentage of the counsellors are ex-drugusers?
- Q35(a) How many counsellors are here longer than 1 year? Q35(b) 5 years?
- Q36(a) Is counselling voluntary? Q36(b) If so, what proportion of clients use counselling facilities?
- Q37.(a) If counselling is not voluntary: Is the number of counselling sessions per client decided on an individual basis or do the clients have roughly the same number of sessions, say, in a week?
- Q37(b) If they have about the same number, how many would this be in an average week?
- Q38 Do the counsellors refer clients to ancillary services?

Section E

- Q39 Average numbers of minutes spent in individual counselling sessions?
- Q40.(a) Do you do therapeutic groups?
- Q40(b) If so, approximately what percentage of clients in therapeutic groups (e.g. relapse prevention, safe injecting etc.)?

Section F

- Q41 How many full time doctors are employed here?
- Q42 How many full time nurses are employed here?
- Q43 How many pharmacists are employed here? Or how many nominated community pharmacists?

- Q44 Total number of medical staff employed here?
- Q45 Where is the urinalysis carried out and who funds this?

Appendix B

Published Paper