Modelling the impact of place on individual methadone treatment outcomes in a national longitudinal cohort study

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Title

~~Using Geographical Information Systems (GIS) to m~~Modelling -the impact of place
on individual methadone treatment outcomes in a national longitudinal cohort study

Background: Little has been published on the effect of geography on methadone
treatment outcomes.

Objective: To measure the effect of place on longitudinal outcomes

Methods: From 2003 to 2006, 215 clients were recruited to a cohort study of
methadone treatment. Participants had their address and clinic geo-coded. Treatment
outcomes were measured at intake, at one and three years post treatment using the
Maudsley Addiction Profile instrument. ~~Spider plot~~Spider diagram and buffer rings
were used to visually map clinics and clients. Regression models were used to
measure the effect of place. **Results** Client’s accommodation and social and criminal
problems in the region had a medium to large effect on heroin use. Analysis of buffer
rings revealed that clients located within a ten kilometre radius of a major clinic
demonstrated poorer outcomes in terms of heroin use.

Conclusion/Importance Findings illustrated the relevance of geography on drug
treatment outcomes and the planning of services.

Words 149

Key words: heroin; longitudinal; cohort; treatment; outcome; spread; methadone; GIS;
urban; regional.

Using Geographical Information Systems (GIS) to model the impact of place on individual methadone treatment outcomes in a national longitudinal cohort study

Background

To date, within Europe and beyond, little has been published on the quantifiable effects of geography on the substance misuse treatment outcomes of an individual.

This study presents one of the first spatial mapping analyses of drug treatment outcome data using GIS (Geographical Information Systems) and this analysis is presented within an Irish setting. The seminal work of Hunt and Chamber (1974) was the first attempt at modelling the geographical spreading of heroin use across the United States using mapping techniques. The spread of heroin across the States continues to be of concern and is addressed in the both the popular media. (<http://www.thetakeaway.org/story/heroin-growing-epidemic/>) and in the academic press over a period of years (Latkin, Glass and Dunkin 1998).

Recent research has shown that across many parts of Europe, problem drug use has now radiated out to provincial towns, where services have to cope with increasing treatment demands in a decreasing, resource constrained environment (Comiskey, O'Sullivan, & Milnes, 2012; European Monitoring Centre for Drugs and Drug Addiction, 2010; Farrelly & Barry, 2010; Merchants Quay Ireland, 2010). Given the spread of problem drug use and the linkages between deprivation and drug use, there is clearly a spatial element to the planning of drug treatment services that requires

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further investigation (Butler, 2007). One novel approach to this investigation is the analysis of treatment outcome data using Geographic Information Science.

One application of Geographic Information Science (GISc) is Geographic Information Systems (GIS). GIS provides a digital lens for exploring the dynamic connections between people, their health and well-being, and changing physical and social environments (Cromley and Lafferty, 2002). GIS analysis is highly applicable to health data (Longley, Goodchild, Maguire, & Rhind, 2005), including data on drug treatment demand and the spread of drug-use. Provided with client treatment data that has a spatial reference, these systems can provide digital maps of clients and their outcomes. In addition, provided with sufficient geo-referenced and outcome data at the individual level, GIS can be used to interrogate and model treatment outcome data in a number of novel ways, many of which may aid and inform national policy and difficult local service delivery decisions.

Early spatial models of heroin use were primarily concerned with who the heroin users were, how many heroin users there were and when heroin use began (Hunt and Chambers, 1976). This early work developed the idea of micro-diffusion (spread from person to person) and macro-diffusion (spread from city to city) of heroin use. 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).

More recent work presents a GIS model of drug use within Europe (Frischer & Healthlie, 2001). Authors have illustrated that by linking modelling with GIS, spatial-temporal forecasting can be provided and this is a useful tool in the analysis of the spread of drug-use, especially from a policy and planning viewpoint. GIS maps provide a simple means of communicating data to others and the visualisation of the data provided is a powerful tool (Waller & Gotway, 2004).

According to the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) (Frischer & Healthlie, 2001), the application of GIS to drug-use in Europe could also be useful in providing maps of incidence and prevalence and forecasts and trends in drug-use, provided the data is available. Building earlier models of spread which incorporated micro and macro-diffusion (Hunt and Chambers, 1976), 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. 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 epidemiological knowledge of drug diffusion.

Few researchers have used GIS to investigate drug-use, including spatial and environmental patterns of use and drug treatment. Anecdotally, there have been doubts on the side of the service providers about spatially referencing and mapping data, especially in terms of data privacy and the fear of areas or neighbourhoods obtaining a 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 and this symposium focused on the geographical aspects

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of drug-use. These developments are clear 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).

Objectives

The aim of this current study was to provide the a geographical analysis of client outcomes given client and clinic spatial location. The objectives were to statistically model the effect of place on treatment outcomes for opiate use within a methadone treatment setting and to measure the impact of distance travelled for methadone treatment on frequency of heroin use one year post treatment intake.

Methods

Study design

A national, three year, longitudinal treatment outcome study was conducted among a cohort of clients entering a new treatment episode for opiate use from 2003 to 2006 in Ireland. This study was called the Research Outcome Study in Ireland Evaluating Drug Treatment Effectiveness, or the ROSIE study, and full details on this study are provided elsewhere (C. Comiskey et al., 2009).

Sample

Within the current study, participants from the ROSIE study who were attending Government health board and community clinics for a new methadone treatment episode were recruited. A new treatment episode was defined as incorporating those who had never presented for treatment before, those who had presented for this type of treatment previously but were not in receipt of this type of treatment in the last six

months and those who had presented for other types of treatment previously. Clients, although recruited within a clinic setting were followed-up regardless of whether or not they were still attending the original baseline setting. Participants in receipt of a new methadone treatment episode from a general practitioner were excluded from the analysis as the primary aim of the current research was to model the impact of the client and clinic location on the primary treatment outcome, days used heroin within the last 90 days at one year follow-up. Details on the full methadone cohort across all settings are provided elsewhere, (Comiskey and Cox, 2010).

A total of 215 clients entering a new episode of methadone treatment for their heroin use were recruited to the ROSIE study. At one year post treatment intake 91% (n=196) were followed-up and located and 78% (n=167) completed a full interview. Of the 215 clients recruited, 156 were attending an out-patient methadone clinic for their treatment and 123 (79%) of these completed a follow-up interview. The 123 clients based within a clinic setting formed the sample for the geo-spatial study.

Ethical approval for this study was sought and granted from the Ethics Committee of the university researchers undertaking the research.

Measures

Outcomes at intake, one and three year follow-up were measured using the Maudsley Addiction Profile (MAP) instrument and a demographic questionnaire. The MAP is a brief, interviewer-administered questionnaire for treatment outcome research and measures problems in the four domains of substance use: health risk behaviour, physical and mental health and personal/social functioning (Marsden et al., 1998).

Data analysis

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In order to map clients, each of their home addresses and methadone 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-ordinates of each address. The client's home address information along with other confidential data was stored under secure conditions within the University carrying out the research and access to the client addresses for the purposes of geo-coding was carried out under controlled conditions. This involved 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. To avoid identifying a street on which a specific client lived no detailed background map information was plotted.

Descriptive statistics were prepared to describe the cohort and their drug treatment outcomes. Demographic characteristics and details of the participant's place of residence at treatment intake were prepared and changes in the participant's drug treatment outcomes over the study period were computed using SPSS version 19. One way analysis of variance and post hoc Dunnetts C tests, for use when equal variances are not assumed, were used to compare mean days clients used a range of drugs at intake and at the one and three year follow-up. Multiple linear regression models were also computed with five independent variables and the data was checked to ensure sufficient caes were obtained to allow this (Tabachnick & Fidell, 2007).

These modelled the dependent variable, number of days within the last 90 days that the client used a specified drug at one year follow-up and the independent variables given by, gender, age, where the client was living at intake (family, own

house/flat/rental, hostel/shelter, house or home of friends, no fixed abode), did the client have housing problems at intake (yes or no) and did the client live in an area with social or criminal problems at intake (yes or no).

For the GIS ~~mapppinganalysis~~, a ~~simple~~ spider ~~diagram plot map~~ illustrating the linear distance of each client from their clinic was computed for the densely populated east coast region of Ireland. This was followed by a more detailed buffer zone map which plotted the primary outcome on days used heroin within the last 90 days at the one year follow-up against the distance travelled by a client to their clinic. Buffering refers to a particular type of spatial query where an area within a specified point, line or area (Waller & Gotway, 2004) is linked with a particular attribute, the attribute in this case being the primary outcome described above. Finally a map illustrating the diffusion of treated clients and clinics along major roads from the urban to provincial regions was plotted.

Results

Demographics and drug use

The majority of clients were male (72%, n=88), the age range of male clients was from 18 to 57 years with a mean age of 27 years (95% CI of 25.9 to 28.6 years) and a median age of 26 years. The age range for female clients was from 20 to 50 years, the mean age was similar to males and was 27 years (95% CI of 25.2 to 29.7 years) and the median female age was also 27 years. Age of first cannabis use for males was 14 years (95% CI of 13.5 to 14.5 years) and age of first heroin use was 18 years (95% CI of 17.2 to 19.3 years). For females the age of first cannabis use was 16 years (95% CI

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of 13.8 to 17.6 years) and mean age of first heroin use was 19 (95% CI of 16.4 to 22.4 years).

Under half (48%, n=59) of all clients were living with their family, 28% (n=34) were living in their own house, flat or rented accommodation, the remaining clients were in a range of unstable accommodation including a hostel or shelter (12%, n=15), a house or home of friends (5%, n=6) or of no fixed abode (3%, n=4). Five clients (4%) did not respond to this question. When asked if clients had housing problems one third (34%, n=42) stated that they did, of these 42 clients, over half (57%, n=24) said they had problems with homelessness reflecting the distribution of clients living in unstable accommodation. When clients were asked if they lived in an area with social or criminal problems over half (56%, n=69) replied in the affirmative. The most prevalent problems were, in order, drug dealing, vandalism, gang violence, burglary and theft, anti social neighbours, assault and muggings and other problems.

Clients used a range of drugs at treatment intake. The mean days a client used a range of drugs in the last 90 days at intake, one year and three year follow-up is provided in Table 1. Statistical analysis of the changes in mean days used are also presented. Results of the multiple linear regression analyses are provided for drugs outcomes which demonstrated a significant change. The model results and effect sizes for place variables are presented.

Table 1 about here

It can be seen from Table 1 that the four most frequently used drugs (heroin, street methadone, benzodiazepines and cannabis) all demonstrated significant reductions in use and with the exception of cannabis, these reductions were observed at the one year follow-up and were sustained at the three year post treatment intake follow-up with no further significant reductions. Regression models for these four drugs, with days used the drug in the last 90 days at one year follow-up as the dependent variable and gender, age and place variables as independent variables demonstrated that place (the accommodation where one was living and if ones area had social or criminal problems) had a statistically significant medium to large effect (0.219 and 0.225 respectively) on the mean number of days one used heroin within the last 90 days at the one year follow-up. At the one year follow-up males used more cannabis than females, those of no fixed abode used more heroin at year one than others and those without social or criminal problems in their area also used more heroin at year one.

Similarly although not statistically significant, where a client was living at treatment intake had a medium to large effect on benzodiazepine use at one year and a small to medium effect on cannabis use. Whether where a client was living had social or criminal problems had a medium to large effect on cannabis use and a small to medium effect on the use of street methadone and benzodiazepines.

Geography of drug use

A GIS spider map illustrating the linear distance clients travelled to their clinic at intake at an east coast regional level was plotted. Spider diagrams or maps have been defined as special operations that compute and show multiple distances from point to point that draw lines from each feature or location of interest to its nearest source, where a source can be a feature with a certain attribute (Davis, 2001). In our study a

line was drawn from each client's residential address to their clinic location. Within Ireland the heroin epidemic started within the capital city of Dublin in the east coast region and has spread from there to less densely populated urban and rural regions across the country (C. M. Comiskey, et al., 2012). This map is provided in Figure 1. Each dot on the map 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 which is also represented by the colour red.

Figure 1 about here

Some clients were located a long distance from the clinic they were attending. The map in figure 2 provides information on the clinic with the largest number of clients in the study and buffer rings also known as multi ring distance buffers are drawn radiating out from the clinic location in five kilometre increments. This clinic, located in Dublin within the east coast region, had a wide spread of clients. As can be seen from the map, a number of the clients were living outside the Dublin region. 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, at the one year follow-up, the larger the green dot the greater the heroin use in the last 90 days.

Figure 2 about here

It can be seen from figure 2, that many of those who were travelling long distances had good outcomes. Most of the less positive outcomes were located within a 10 km radius of the clinic.

Finally figure 3 maps clients who are located in the Dublin east coast region alongside the major national roads and highways from the region. The primary motorway surrounding the capital city is the M50 and the roads which 'spoke' out from the M50 are the M1, N2, N3, N4, N7, N81 and N11 all labelled on the map. This map demonstrates that clients and clinics are mainly located along these roads and highways and that the areas between the 'spokes' are empty.

Figure 3 about here

Conclusion/Importance

Findings from the modelling analysis demonstrated that where a client was living at intake to a new episode of methadone treatment has a statistically significant medium to large effect on the primary outcome of days used heroin within the last 90 days one year post treatment intake. Findings from the application of GIS to Irish drug treatment data provided the first maps of the spread of heroin use and clinic provision along major road networks from urban to regional areas, and while this might have been expected results provided the first confirmed evidence. Findings from the GIS analysis also demonstrated unexpectedly that the proximity of a client to their treatment clinic was not a barrier to successful treatment outcome and results also

indicated that some clients residing in close proximity to their clinic tended to have worse outcomes, these latter findings however require further investigation.

Findings are limited by the design of the study. The maps do not show all of the methadone clinics in the east coast region road network, nor do they map all of the clients attending the study clinics, an interesting hypothesis for further study would be to extend the research to investigate whether the diffusion of drug-use throughout Ireland is facilitated by the major road networks. Similarly findings on the impact of distance travelled to a clinic for treatment raises further questions on the 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). It could be argued that clients travelling long distances 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 may be an indicator of this. Future research on regression modelling of outcomes could if sufficient cases were collected incorporate extra variables on distances from the clinics, deprivation indices of areas where client and clinic were located and other relevant spatial measures.

In conclusion, GIS mapping is only as good as the data allows. The biggest challenge to future research is the availability of spatial data, and as with most health data, there are issues with confidentiality and inter-agency cooperation and sharing. Within

Ireland, interagency case management of clients within addiction services is the key component of the National Drug Strategy (Department of Community Gaeltacht and Rural Affairs, 2009). The national strategy in an approach to drug treatment services has evolved with time, from abstinence based philosophy to a harm reduction one to rehabilitation and recovery based philosophy (Doyle & Ivanovic, 2010). This strategy reflects changing philosophies at a European level (Sumnall & Brotherhood, 2012). In order to ensure the equitable delivery and planning of services with these new philosophies at a regional and urban level, new paradigms and methods from other disciplines need to be employed within drug treatment research. GIS modelling as recommended by the EMCDDA is one such tool and findings within this research demonstrate its potential and possible future scope.

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Table 1 Changes in mean days used drugs from intake to one year and three year follow-up and regression analysis modelling the effects of place on drug outcomes which demonstrated a significant change

Drug	Mean days used in the last 90 days at:			ANOVA		Post hoc Dunnett's C test, p values		
	Intake	1 year	3 years	F, p		Intake vs. 1 year	Intake vs. 3 years	1 year vs. 3 years
Heroin	58.3	19.4	22.5	53.9, <0.001		<0.001	<0.001	0.836
Street Methadone	16.2	3.9	2.2	21.2, <0.001		<0.001	<0.001	0.639
Benzodiazepines	22.7	9.5	14.9	6.2, 0.002		0.002	0.193	0.274
Cocaine	6.1	4.5	4.2	0.5, 0.590		0.788	0.713	0.999
Crack	3.2	1.6	1.0	1.6, 0.203		0.602	0.248	0.911
Cannabis	46.3	41.2	31.5	4.0, 0.019		0.719	0.016	0.168
Alcohol	12.3	10.6	11.0	0.2, 0.836		0.914	0.961	0.999
Dependent variable, mean days used in the last 90 days at 1 year follow-up	Independent variables measured at intake with model standardised absolute beta values (effect size, β) and p values where a small effect = 0.02, a medium effect =0.15 and a large effect =0.35 (Cohen, 1992)							
	Gender effect β , p	Age effect β , p	Where living effect β , p	Has housing problems effect β , p	Area has social or criminal problems effect β , p	Model R ²	Model F, p	
Heroin	0.129, 0.178	0.172, 0.082	0.219, 0.030	0.032, 0.737	0.225, 0.016	0.129	3.175, 0.010	
Street Methadone	0.111, 0.270	0.052, 0.613	0.004, 0.969	0.125, 0.207	0.065, 0.506	0.041	0.941, 0.475	
Benzodiazepines	0.175, 0.080	0.182, 0.075	0.183, 0.080	0.028, 0.774	0.083, 0.386	0.062	1.403, 0.229	
Cannabis	.0217, 0.026	0.149, 0.138	0.136, 0.184	0.059, 0.535	0.175, 0.064	0.109	2.589, 0.030	

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Figure 1 Spider plot map of distance client travels to clinic

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Figure 2 Buffer zone map illustrating relationship between distance from clinic and the outcome, days used heroin in the last 90 days at one year follow-up. The greater the dot size the greater the number of days heroin was used within the last 90 days.