E.M.C.D.D.A.

# FINAL REPORT

## PILOT PROJECT TO DEVELOP A MODEL OF GEOGRAPHICAL SPREAD OF DRUG MISUSE IN THE EUROPEAN UNION

## CT.98.EP.04


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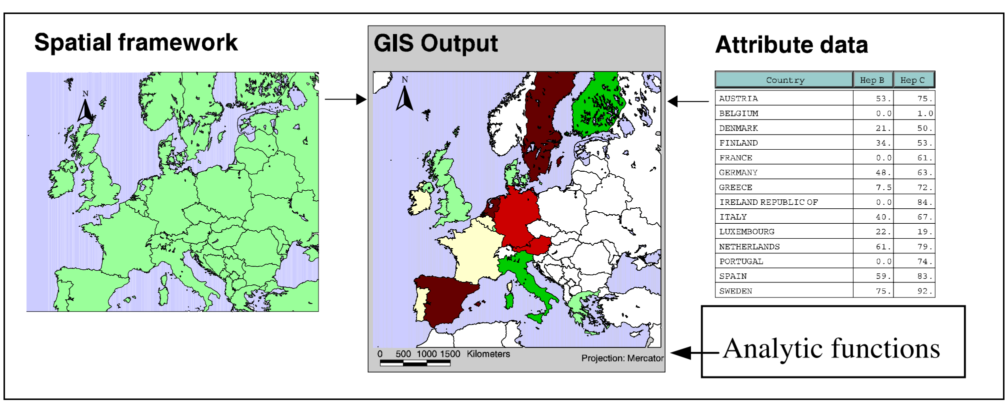
## EXECUTIVE SUMMARY

Disciplines such as ecology and environmental health are increasingly using Geographical Information Systems (GIS) to study associations between location, environment and behaviour. Advances in computing and graphical technology enable spatially referenced data to be linked to relational databases and epidemiological functions. GIS thus provides a powerful tool for analysing the spread of phenomena over time and space. The development of a European drug misuse GIS would be a logical progression in view of improvements in drug misuse surveillance and would provide a dynamic and flexible approach to visualising drug use in Europe.

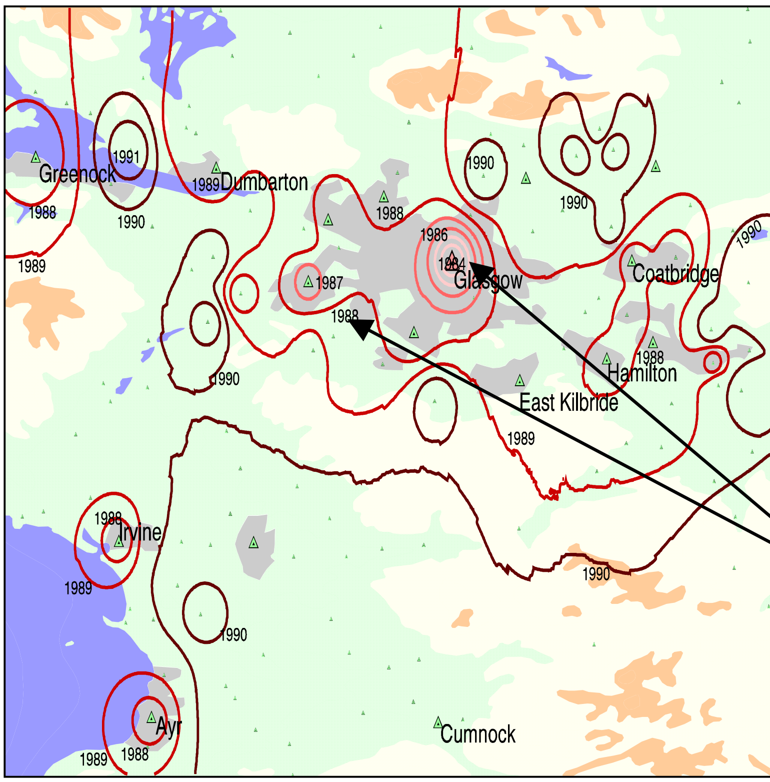
The objectives for this project were:

1. To create a pilot GIS mapping package and database for drug misuse in the area covered by the EMCDDA.
2. To produce detailed spatio-temporal maps of diffusion of drug use in Scotland.
3. To produce illustrative maps for European regions.

**<u>Objective 1 - Pilot GIS mapping package and database</u>**. This was achieved by using the GIS package ARC INFO (7.1.1) and Arc View (v3.0a). Detailed spatial and topographical data is now available for the area covered by the EMCDDA. The package contains both spatial map and attribute data. The main characteristic of a GIS is the ability to link and analyse the geographical framework and a relational database that contains relevant information (e.g. drug misuse statistics, population data, transport routes). These features, together with more powerful spatial analysis tools, distinguish GIS from early mapping programmes that simply displayed information.



**<u>Objective 2 - Detailed spatio-temporal maps of diffusion of drug use in Scotland.</u>** A series of maps were developed showing both temporal and spatial diffusion of drug use in the West of Scotland from 1980-2000. A Specially created software package [Drug Incidence & Prevalence Estimation Program (DIPEP)] was run for the West of Scotland; this produced both prevalence and incidence rates for the named towns and cities within the region. The program output was then linked to the GIS program to illustrate changes in drug misuse prevalence and incidence in the West of Scotland.

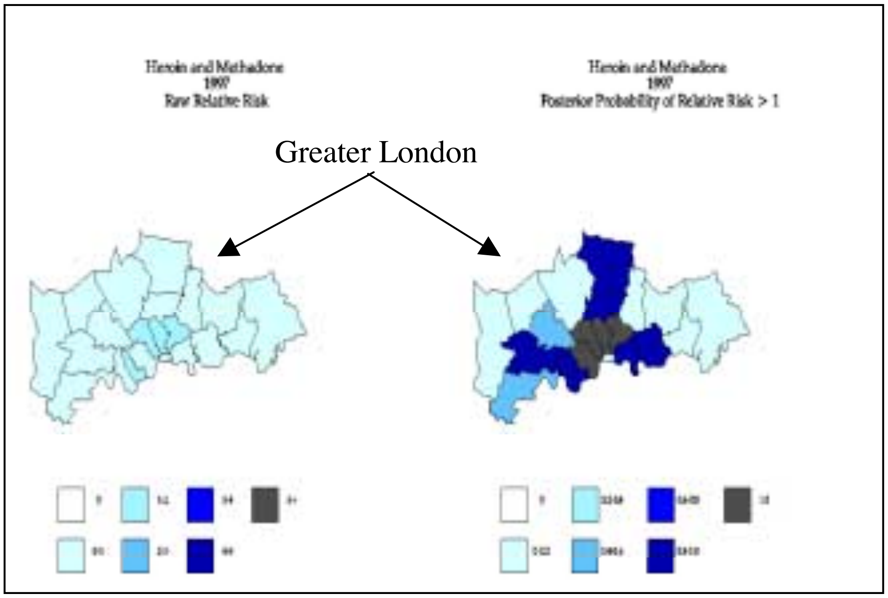



This map illustrates estimated peak incidence of drug misuse in the <u>West of Scotland</u> from 1984-1991. Each 'isoline' represents peak incidence of drug use at a particular point in time. Policy makers can see areas where and when drug use is spreading most rapidly.

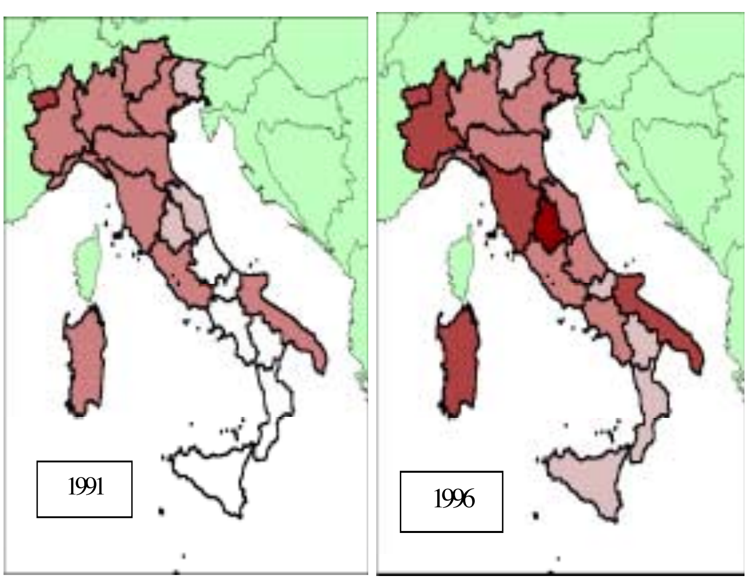
For example, here the isoline shows drug misuse starting in the city centre in 1984, then spreading most rapidly in the suburbs of Glasgow in 1988, having started in the city centre.

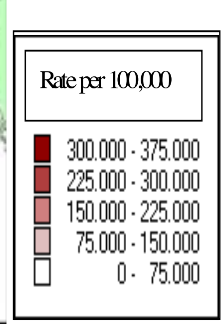
**<u>Objective 3 - Illustrative maps for European regions.</u>** Illustrative maps were produced from English, Italian and European data. At the aggregate European level, GIS was used to display known prevalence estimates for cities and regions, thus highlighting both areas with some information and those where at present little is known. The English and Italian data show how regional data require careful interpretation so as to take account of the unit of analysis. These problems have been addressed in other disease areas and it is important to draw on this experience when considering drug misuse.

This figure shows treatment data for London. In 1997 the raw map is almost uniform – suggesting that drug use does not vary geographically. Mapping the posterior probability of exceedence (a form of statistical significance), however, highlights central and inner-London. This is because although the differences in the size of the relative risks (regional rate relative to the overall rate) in 1997 were small, they were significantly different. These maps demonstrate the potential of mapping drug use – highlighting effectively the areas with greatest problem – but also the potential dangers of using incomplete data, and of not investigating geographical differences.




The Italian maps for treated heroin use indicate that the heroin epidemic in the early 1990s resulted, after a few of several years, in treatment demand for problematic heroin use. This is indirectly measured by the prevalence of clients in drug treatment services and shows a shift from North to South and from



border regions, including the coasts of Puglia and Sardegna, to the internal ones. By 1996 the epidemic reached a plateau or is even decreasing in the regions where it was more severe in the first years whereas it is possibly still increasing in others, where few clients were present at the beginning of the nineties. The geographical spread of the epidemic follows the main drug trafficking routes. In the map the viewer can easily visualise changing patterns of heroin notification, whereas in tabular date in the full report it is much more difficult to gain a sense of temporal and spatial trends.

Summary and Recommendations

This project achieved its the three objectives.

- **A Europe wide GIS mapping package and database has been established.**
- **GIS analysis enabled the creation of detailed spatio-temporal maps of diffusion of drug use**
- **Illustrative maps for aggregate national and European drug data regions have been created, providing greater understanding of spatial and temporal aspects of drug use.**

In achieving these objectives, the project has created a powerful tool for analysing other European drug misuse datasets with a geographical element.

In order to further develop the work presented here, the following steps are recommended. First, the Drug Incidence & Prevalence Estimation Program (DIPEP) needs to be modified to include European data for primary, secondary and tertiary centres of population. Second, the DIPEP/GIS interface needs to be enhanced to incorporate European socio-economic data as well as allowing anchor points from local estimates. The rate-limiting step is obtaining drug attribute data, such as incidence and prevalence estimates and related socio-economic indicators such as deprivation, with a breakdown by region. However the maps can be readily altered as more information becomes available. One possibility would be to obtain detailed Europe wide socio-economic data and investigate their predictive capacity for drug use, so that, for example, projections could be made from areas with much data on drug misuse to areas where little is known. In order to develop this work to cover a European wide spatial system more work is required. Third, drug agencies should be encouraged, wherever possible, to obtain clients' postcode. This information would serve two purposes; a) to enable more accurate mapping of data on known drug users and b) provide better input into GIS.

These developments would provide policy-makers with an effective platform for visualising complicated data in a visually attractive format that is both easy to understand and interpret.

## INTRODUCTION

In many areas of Europe patterns of drug use are changing. The mechanisms of diffusion are diverse: introduction of new practices by new users, tourism and migration, cross-border contact, drug transportation, and increasing opportunities for economic and international contact. The 1997 EMCDDA annual report notes that:

> *there is a geographical diffusion of drug use from cities to towns and rural areas, which has implications for needs assessment, service provision and training. Differences in patterns of diffusion may also improve our understanding of the distribution of drug behaviours at European, local and regional levels.*

A Geographic Information System (GIS) offers a dynamic and flexible approach to visualising the diffusion of drug use in Europe. The potential use of GIS models in drug misuse research has been described by the authors in an earlier EMCDDA project: *Study of options to develop dynamic models of drug use* (CT.96.EP.05)-[Frischer and Heatlie, 1997]. The development of a European drug misuse GIS would be a logical progression in view of improvements in drug misuse surveillance in Europe.

This report aims to show how a geographical information system can be used to develop a model of geographical spread of drug misuse in the European Union.

In March 1998, the tender for project CT.98.EP.04 was awarded to the Department of Medicines Management, Keele University, UK.

The objectives and timetable for the project are:

1. To create a pilot GIS mapping package and database for drug misuse covering the EMCDDA area.
2. To produce detailed spatio-temporal maps of diffusion of drug use in Scotland.
3. To produce illustrative maps for selected European regions (London and Italy).

| TIME | WORK |
|---|---|
| September | 1. Reviewing use of GIS in epidemiological and social research.<br>2. Obtain European GIS digital maps and databases for three regions. |
| October-December | 1. Mission to EMCDDA to access drug misuse data.<br>2. Create a pilot GIS database for drug use in the three regions.<br>3. Run Drug Incidence & Prevalence Estimation Program (DIPEP) for the West of Scotland from 1980-2000. |
| January | 1. Run GIS using existing data from three European regions.<br>2. Integrate results from Drug Incidence & Prevalence Estimation Program (DIPEP) into a detailed GIS analysis. |
| February | 1. Complete analysis and write report. |

Following the award from DGXII/TSER to the EMCDDA on the topic European Network to develop policy relevant models and socio-economic analysis of drug use, consequences and intervention it was decided to use project CT.98.EP.04 as the basis for creating this network. Consequently a meeting was arranged at the EMCDDA in Lisbon to review the work done on this project with the aid of experts in this field (see section 5). A further objective agreed between Keele and the EMCDDA was to use the mapping software to illustrate local and national prevalence estimates in Europe.

**STRUCTURE OF REPORT**

1. GIS and its capabilities.
2. Estimating and mapping incidence and prevalence of drug misuse in Scotland.
3. Mapping existing individual data (London, Italy).
4. Mapping European aggregate data.
5. Report on the first DGXII/TSER meeting in Lisbon, December 4-5, 1998.
6. Summary and Recommendations.

**SECTION 1: GEOGRAPHICAL INFORMATION SYSTEMS CAPABILITIES**

Various disciplines (e.g. ecology and environmental health) are increasingly using Geographical Information Systems (GIS) to study associations between location, environment and behaviour. Advances in computing and graphical technology enable spatially referenced data to be linked to relational databases and epidemiological functions. GIS thus provide a powerful tool for analysing the spread of phenomena over time and space and GIS models have been used to predict disease spread from infected to susceptible populations (Haggett 1994).

### 1.1 What is a Geographical Information System (GIS)?

Although there are many types of Geographical Information Systems, they are all capable of capturing, analysing and displaying spatially referenced data. GIS development has been facilitated by the availability of digital map data which provides a spatial framework on which to attach attribute data (figure 1). The main characteristic of a GIS is the ability to link spatially referenced data to a relational database that contains relevant information (e.g. population data, transport routes or other socio-economic data). These features, together with more powerful spatial analysis tools, distinguish GIS from early mapping programmes that simply displayed information.

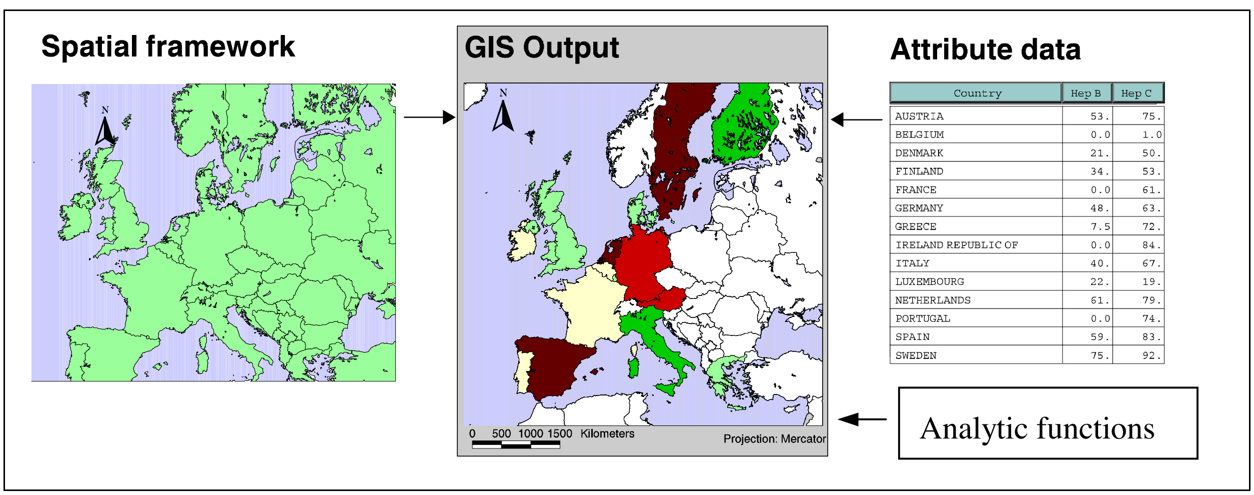



**Figure 1. GIS linking attribute data to the spatial framework**

A GIS stores both spatial map data and associated attribute data. Attribute data is stored in a relational database management system contained within the GIS and accessed by a spreadsheet or query driven user interface. The GIS can accomplish everything that a traditional database system can, querying, selecting and manipulating data.

### 1.2 Software and Hardware

ARC INFO (7.1.1) and Arc View (v3.0a) were used to manipulate, analyse and display the data used in this report. The software is run on a Sun Ultra 10 SPARC processor.

### 1.3 Digital Spatial Data

The framework used for spatial referencing was the Bartholomews 1996 digital data. These data are available for three spatial areas at three levels of detail. The largest scale digital data is available at a scale of 1:250,000 but is available only for the United Kingdom and was therefore not used for this report. The largest scale digital data used during this project was the 1:1,000,000 database. This is available for the whole of the European area (from -29W 27N degrees to 70E 82N degrees [excluding Greenland and North Africa]). This data was used for country specific maps in section 2 (Forecasting drug diffusion) and section 3 (Mapping existing individual data). A sample of this data set is shown below (figure 2). The European Bartholomews database is split into grids 5°'s East West and 4°'s North South. Each grid contain layers of information detailed below (see appendix 1).

General European maps, shown in section 4 (Mapping European aggregate data) used the Bartholomews 1:20,000,000 world database, a sample of this data is displayed below (figure 3). These data are available as a single world-wide coverage and contains information detailed below (see appendix 1).


**Figure 2. Sample data showing topographical and road networks from the 1:1,000,000 coverage.**

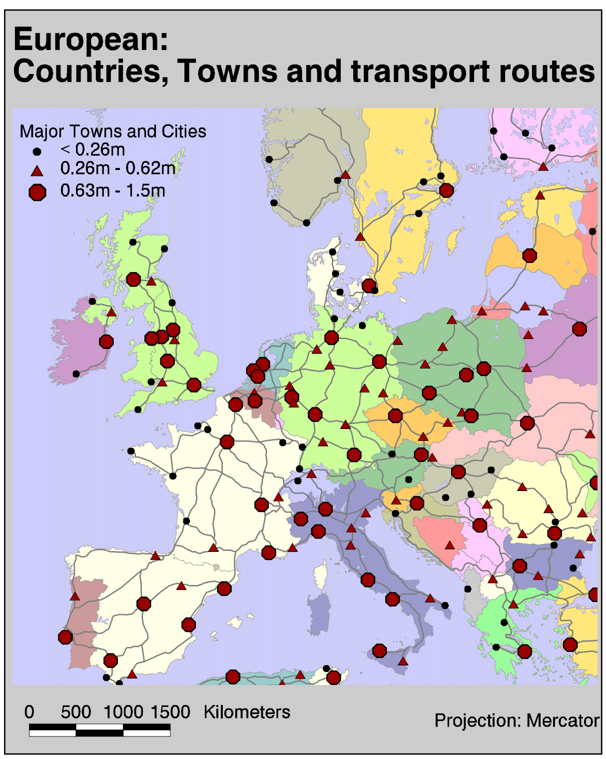



**Figure 3. Sample European data showing towns and administrative regions from 1:20,000,000 coverage.**

## SECTION 2: FORECASTING DRUG DIFFUSION

### 2.1 Introduction

Drug use is both dynamic and social, spreading throughout populations and across regions. Pioneering work by Hunt and Chambers (1976) in the United States focused on two processes. The first process called microdiffusion refers to the spread of drug use among individuals within groups and depends on known drug users' propensity to 'transmit' drug use to new users in a similar manner to infectious diseases. The second process, macrodiffusion refers to the transmission of drug use across geographical boundaries. By analysing incidence data from drug treatment programmes, Hunt and Chambers were able to create a map showing the spread of heroin epidemics in the United States during the 1970s (Figure 4).

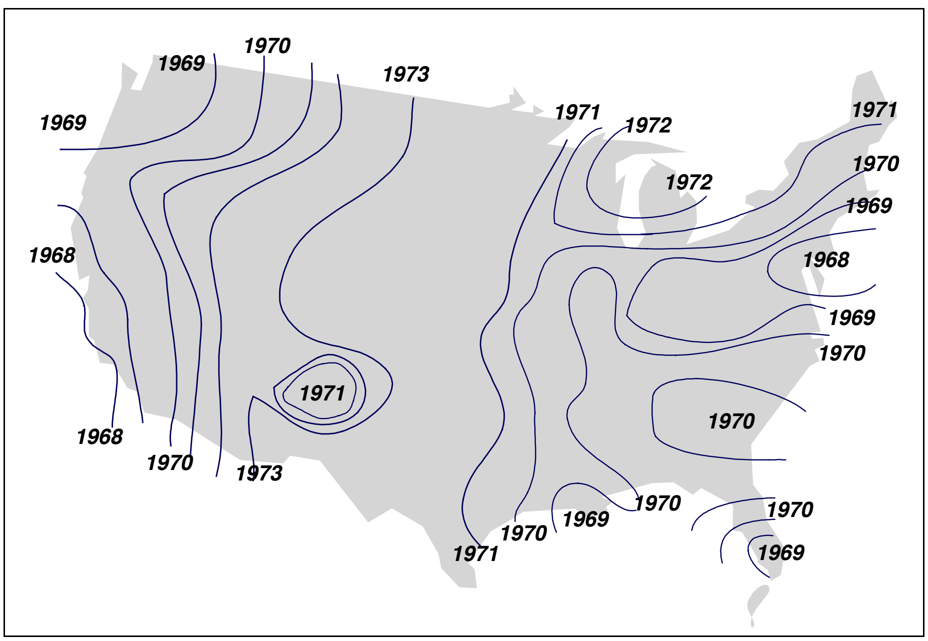



**Figure 1. Isochrony of peak heroin use in the United States, 1968-1973. (Adapted from Hunt and Chambers, 1976).**

Heroin use appears to have begun on the North East coast along the chain of cities from Boston to Washington, and in Southern California. Large inland and Gulf Coast cities were also early centres of epidemic use. From the continental margins, heroin moved to the interior, spreading sequentially from cities in regions of high population density to those of lower density.

### 2.2 Predicting drug use - the Drug Incidence & Prevalence Estimation Program (DIPEP)

The Drug Incidence & Prevalence Estimation Program (DIPEP) forecasts incidence and prevalence, based on the assumption that drug misuse spreads in a similar manner to infectious diseases. Epidemics occur where there is a rapid increase in the number of new cases relative to a stable endemic baseline, which is caused by changing circumstances which in turn lead to the number of 'susceptible' people being exposed to the infectious agent (or in the cases of drug misuse, individual and social contacts). A key assumption of this model is that only a certain proportion of the population is susceptible and that the epidemic will have a life cycle because eventually the pool of potential drug users will be exhausted. In this situation, the distribution of the time of disease occurrence often follows the pattern shown in figure 5. Graphically this means that drug epidemics will be negatively skewed.

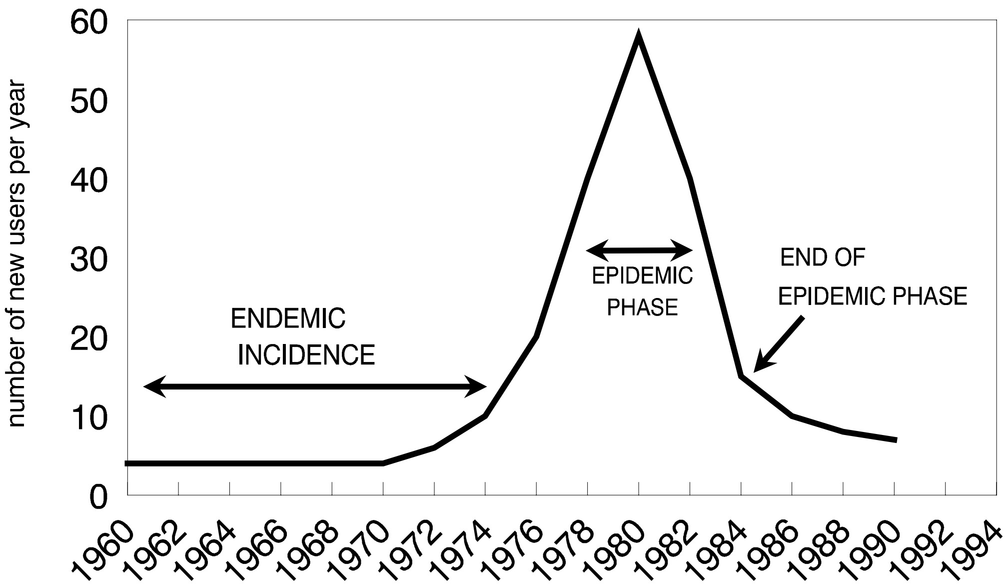



**Figure 2. Schematic model of a drug epidemic.**

In DIPEP the epidemic is represented by a simple distribution e.g. (1,2,4,8,10,8,1,1 etc) and the parameters shown in table 1 [The program is described in detail in a forthcoming paper by Ditton and Frischer]. The program is linked to a database which contains information on population distribution for the UK and socio-economic status for Greater Glasgow.

The parameter values were chosen from previous research and are intended to be illustrative. Parameter 1 was derived from an unpublished paper documenting the explosive increase in psychiatric referrals for drug abuse in Glasgow starting in 1979. Parameter 2 is an empirical observation by Hunt and Chambers from their observations of US heroin epidemics. Parameter 3 is derived from a capture-recapture study of injecting drug use in Glasgow. Parameter 4 is the quickest spread speed that the model in its current form permits and was thought to most accurately reflect the epidemic spread. Parameter 5 is another empirical observation from Hunt and Chambers. The results of applying these parameters to the known population distribution (parameter 6), at least from 1989-1998 correspond fairly closely to what is known about the diffusion of drug use in the West of Scotland.

**Table 1. Parameters in the Drug Incidence & Prevalence Estimation Program.**

| MODEL PARAMETER | PARAMETER VALUES (EXAMPLE) |
|---|---|
| 1. Year epidemic trends were first observed. | 1978 |
| 2. Length of epidemic cycle. | 20 |
| 3. Estimated peak prevalence (can be variable over town size: highest in large towns). | 1-2% |
| 4. Speed of spread across types of area. | 1 year between town sizes |
| 5. Duration of addicts' drug using career. | 10 years |
| 6. Population of the various areas (graded 1 to 15 in terms of town size). | total population: 2,405,543 |

## 2.3 Method

The digital spatial data was obtained for the West of Scotland from the previously discussed sources. The attribute data available in these datasets are more detailed than is required and were therefore simplified and classified according to the level of detail to be displayed; for example, bathymetric details were unnecessary and reclassified simply as water areas.

The drug estimation software was run for the West of Scotland; this produced both prevalence and incidence rates for the named towns and cities within the West of Scotland. This output was then extracted and imported into a database before being linked to the digital data. This link was made using the population centre's name. Finally, GIS functions were then applied to interpolate a continuous surface and calculate contours; this is discussed in the following section.

## 2.4 Principles of using Geographic Information Systems

### 2.4.1 Geographic Functions

The GIS uses the predicted values at population centres to create a continuous surface variable. This process is similar to the creation of height contours on topographical maps, however in this example the height (z) value represents drug misuse.

The resulting calculated surface is the best estimate of what the quantity is on the actual surface for every location. The surface interpolations make certain assumptions about how to determine the best estimated values. In general, the more input points with values and the greater their distribution, the more reliable the results.

The interpolation technique used for the surface creation was the Inverse Distance Weighted (IDW). The IDW interpolator assumes that each input has a local influence that diminishes with distance. It gives greater weight to the points closer to the known value than those further away.

This method assumes that the variable being mapped decreases in influence with distance from its sampled location.

Factors which determine the best representation of the data include:

a) Whether nearest neighbours or a fixed radius will be used to determine isolines. [The maps here used the default value of the nearest 12 neighbours to determine the contours.]
b) The power of the distance factor. This controls the significance of the surrounding points. [The maps here used the default value of 2]
c) The selection of a contour interval, too high a value and fine detail may be omitted, too low a value and individual contours will blur and become merged. [The prevalence maps displayed below used a value of 100 persons whilst the incidence maps used values of 10 persons].
d) The selection of a base contour. [This was always set as 0 for the calculation but lower contours were omitted in order to aid display on the maps.]

### 2.4.2 Cartographic Principles

This study is attempting to demonstrate changes in the patterns of drug misuse over time and space. The maps shown here treat drug misuse data as having continuous quantitative propoerties. However this is not strictly true because drug use can only occur in populated areas of the map.

The maps in this study therefore aim to construct a complete distribution, even though the information is fragmentary. The standard cartographic technique for this is based upon elevation contours. Maps of this style, when used for themes other than topography, are called isarithmic or isoline maps. The isolines are automatically generated by the GIS.

Both spatial and temporal diffusion were calculated for the West Coast of Scotland (this area is shown in figure 6). Spatial diffusion of incidence is shown in figure 7 and prevalence in figure 8. These figures illustrate timepoints; 1980, 1985, 1990,1995 and 2000 and enable the viewer to see where drug use was incident and prevalent. As explained above, this obviously only makes sense in populated areas. Just as there are areas where incidence and prevalence is unknown, the GIS can also produce isolines of peak incidence based on the known incidence data. Figure 7 shows the isoline for peak incidence. Thus in the early 1980s peak incidence was in Glasgow, moving to suburban areas in the late 1980s. By 1990, the isoline for peak incidence had moved to outlying towns in the West of Scotland.

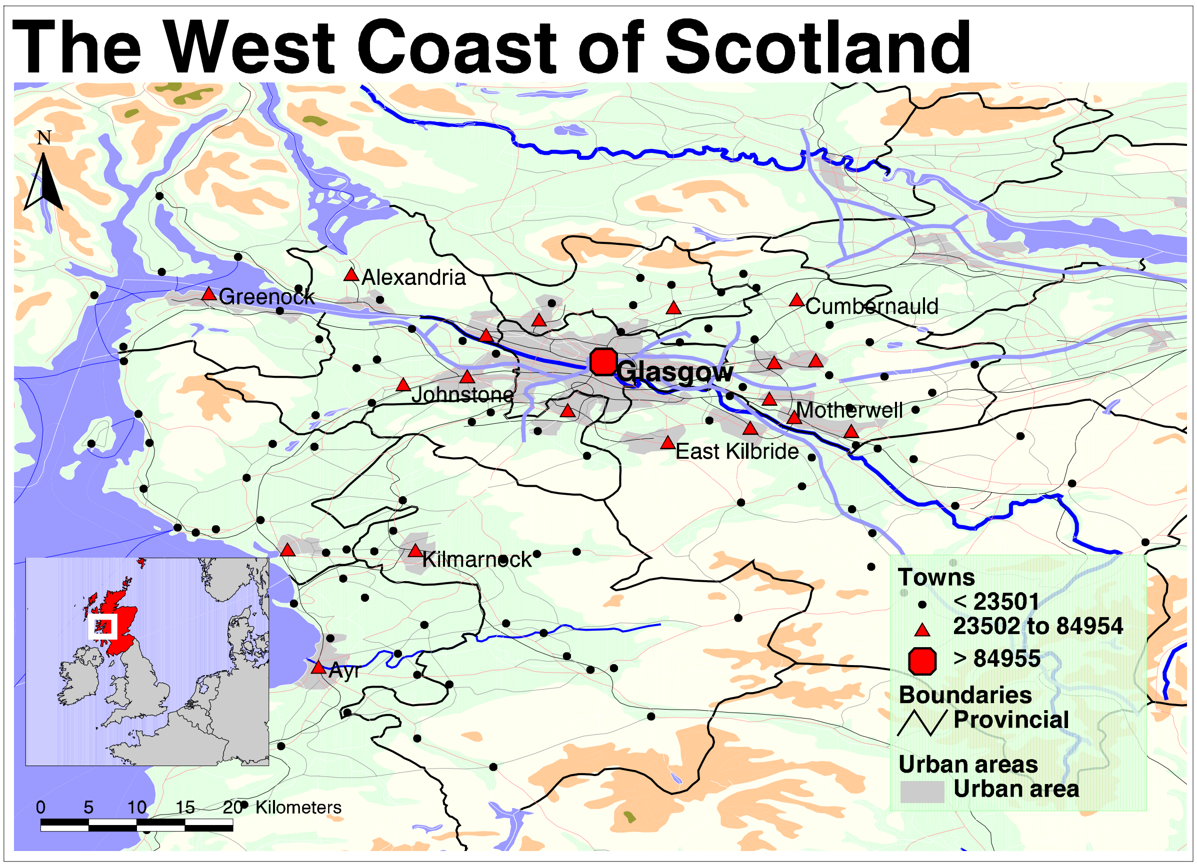



**Figure 3. Topographical and road networks in the West coast of Scotland.**

These maps enable the viewer to understand temporal and spatial trends in drug misuse more easily than comparable tabular data (see appendix 2). Furthermore the maps enable drug agencies and other organisations to gain some idea of probable drug incidence and prevalence in areas where there is little information.

## 2.5 Interpretation of Scottish Drug Incidence and Prevalence Maps

Figure 7 shows that the initial drug epidemic in 1980 was highly concentrated in the city of Glasgow. By 1985, new cases were still occurring in Glasgow and there were also new cases in surrounding towns and also in towns further from Glasgow. By 1990, there were few new cases in the region outwith Glasgow, indicating that the peak of the epidemic has passed. However this does not mean that the epidemic per se is declining (figure 8). As the average drug using career is 10 years, incidence cases between 1980-85 continued to result in increasing prevalence to 1995. Thereafter, the declining incidence from 1985 resulted in relatively low prevalence between 1995 and 2000.

This diffusion over time is illustrated in figure 9. Peak incidence occurred in Glasgow between 1984 and 1987. By 1988 peak incidence was occurring in towns of medium population, principally on the periphery of the city and in coastal areas. The next phase of peak incidence between 1990 and 1991 occurred in smaller settlements throughout the study area. This time period corresponds to the interval up to peak cumulative incidence, i.e. where the overall number of new cases is greatest (see figure 7).

The scenario portrayed in these maps is dependent on the model parameters and the extent to which drug misuse is epidemic in nature. Although available information on known drug use is largely restricted to Glasgow, the pictures presented do seem to be concordant with what is known of drug misuse at the macro level (e.g. for the region as a whole). However, there are few time series data at the micro-level (i.e. at the level of detail shown in the map), to evaluate the mapped values.

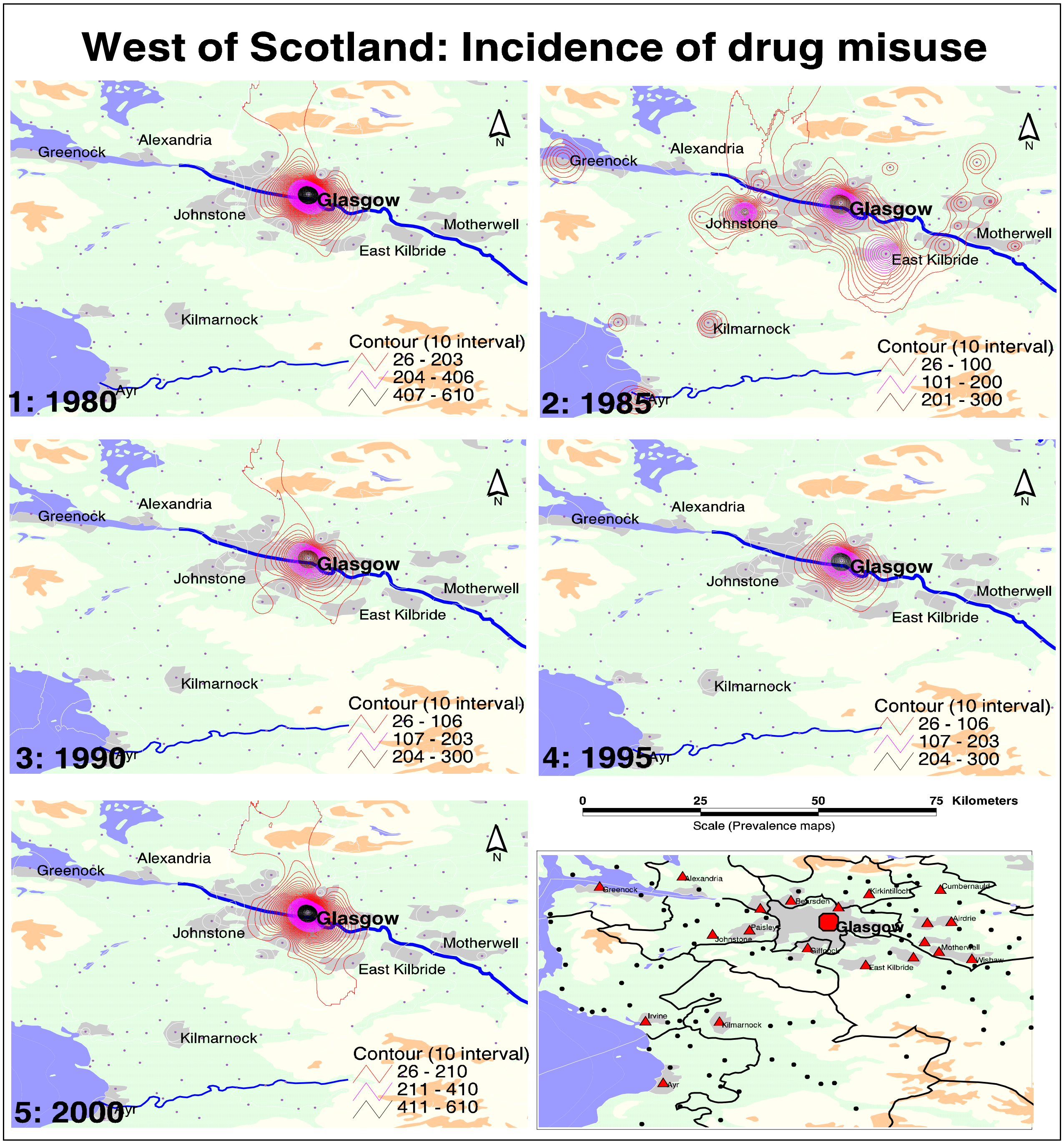



**Figure 4. Predicted drug misuse incidence in the West of Scotland, 1980-2000. New cases of drug misuse were centred around Glasgow in 1980. Incidence increases in surrounding areas by 1985. The epidemic cycle of the model can be seen as new cases reached their lowest level in 1995, before increasing again in 2000.**

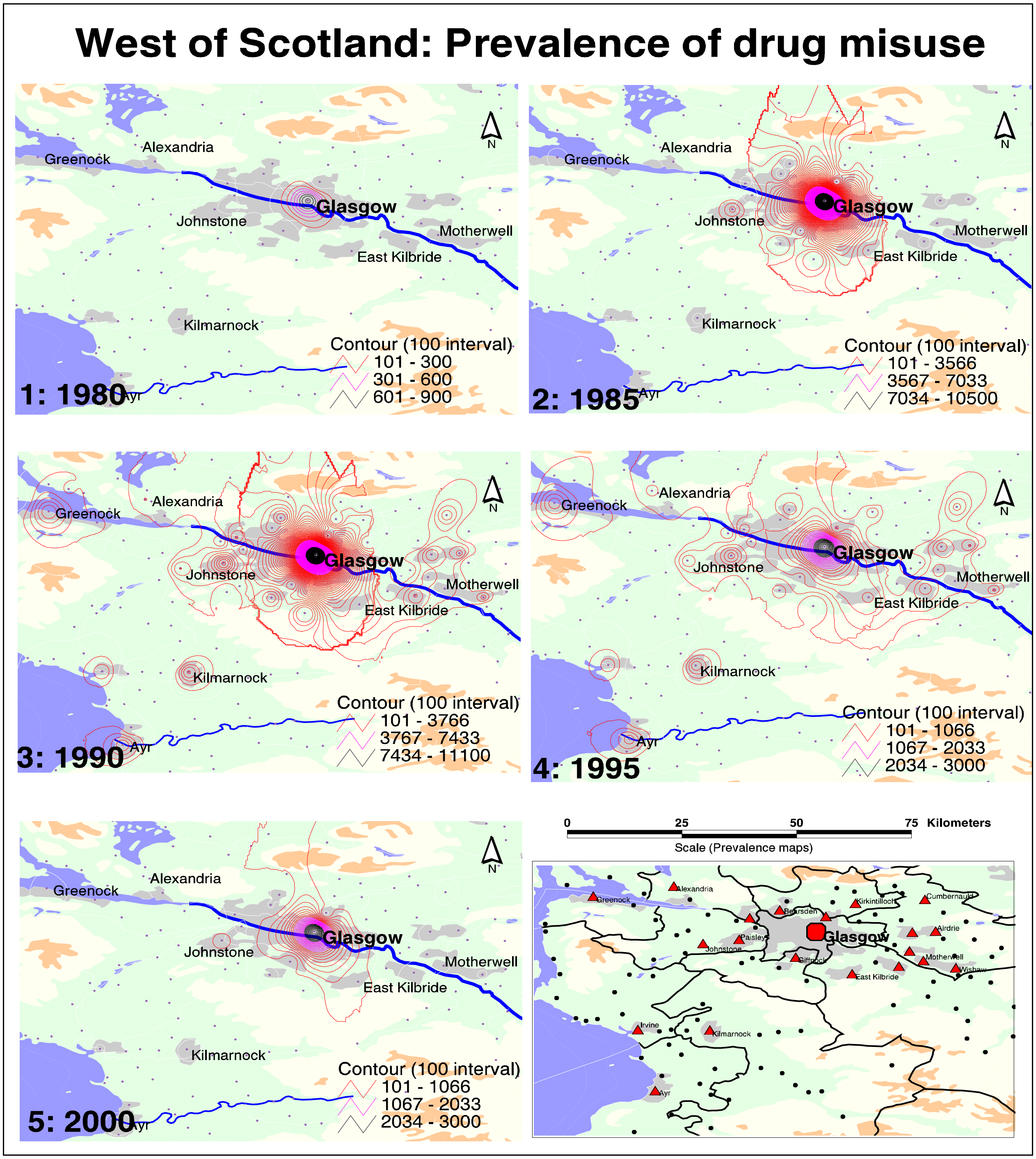



**Figure 5. Predicted drug misuse prevalence in the West of Scotland, 1980-2000. Drug misuse was initially centred around Glasgow in 1980. Prevalence increased between 1980 and 1985 in Glasgow before spreading to surrounding areas in 1990.**

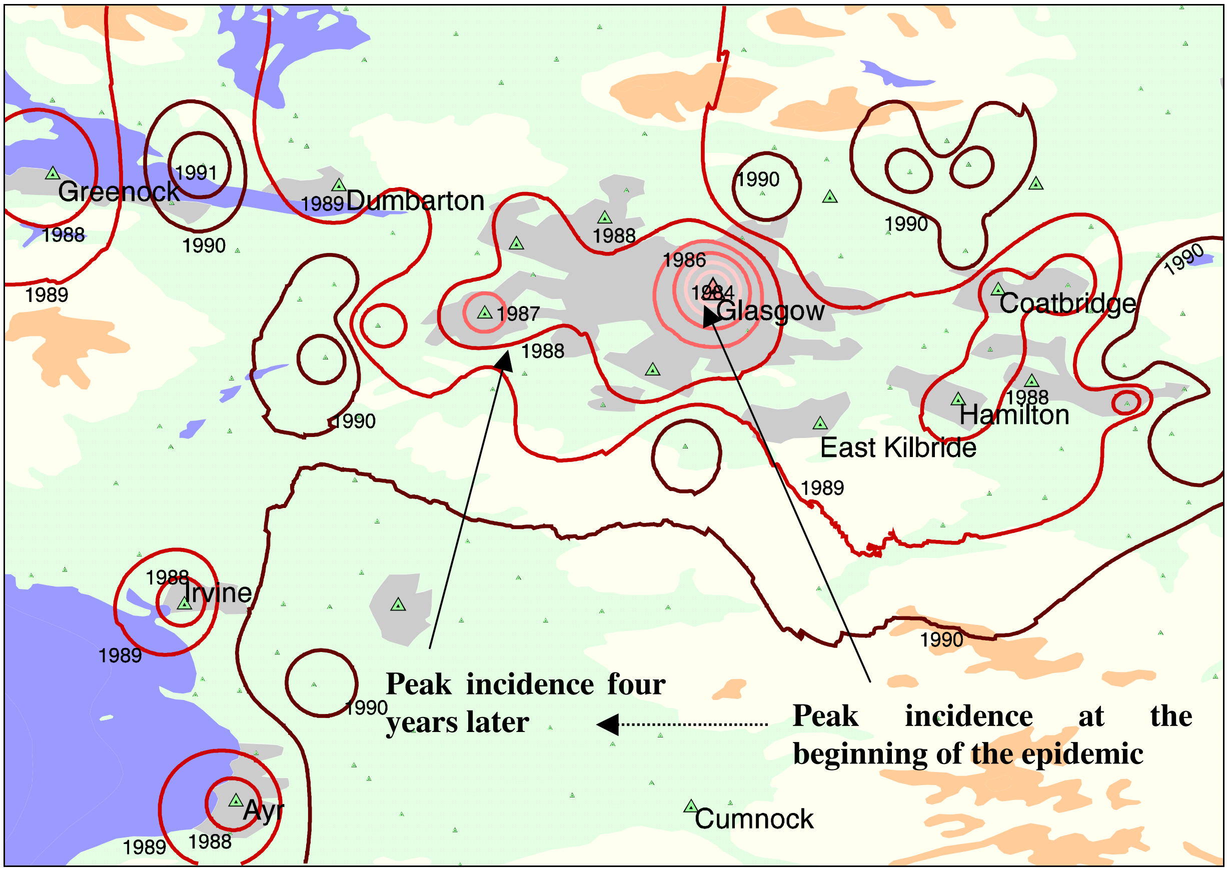



**Figure 6. Estimated peak incidence of drug misuse in the West of Scotland. Peak incidence was originally centred in Glasgow but spread to suburban areas by 1988. The isolines indicate that at this time drug misuse also began to increase in the more distant towns of the region.**

## SECTION 3: MAPPING EXISTING INDIVIDUAL DATA

The aim of this section is to show how geographical representation of existing data can help to interpret trends in drug use. Unlike the previous section, no GIS analytic features are used. The maps simply portray the distribution of existing data. However, other areas of epidemiology have shown the dangers in interpreting what seem to be straightforward data. There are issues to do with level of aggregation and reference populations for rate calculation.

These issues are explored in two data sets. The first data set from London, England show new cases of treated drug dependence. The second data set show prevalence of treated heroin use in Italy.

### 3.1 North London – Epidemiology of Mapping of Data from the Regional Drug Misuse Database

Mapping problem drug use constitutes the first step in exploring differences in the population, as was the case with the early maps of cancer and other diseases. For example, maps of rickets were used to suggest the association with lack of sunlight, maps of melanoma led to the hypothesis that sunlight was a cause of melanoma, and maps of nasal cancer suggested that its excess was associated with furniture-manufacturing.

There are several types of geographical study (Hertz-Picciotto,1998; Elliott et al., 1992):-

- descriptive - to describe the geographical distribution of disease
- ecological (or "geographical correlation") - to describe the geographical distribution and relationship of disease with exposure
- cluster/ investigative - to study clusters or clustering (disease excess with or without an identifiable source); and to investigate potential point sources (e.g industrial pollution and chemical accidents)
- migrant (or "environmental genetics") - to study changes in disease patterns among people that move from high or low risk to another region with low or high risk respectively.

The most relevant studies for mapping problem drug use are descriptive and ecological, although cluster studies may become possible given greater information on drug supply. Ecological studies depend on how closely area of residence relates to exposure. Where this is not the case, or where the relationship is complicated or mitigated by other factors, ecological studies can suffer substantial bias and need to be interpreted cautiously. Similarly, there is a danger with descriptive studies that much variation will be found leading to areas being falsely identified as having a high or low disease occurrence.

Problems with the data in terms both of the population counts (denominator) and accuracy of event data (numerator), as well as socio-economic confounding may be the cause of exaggerating or hiding geographical variation. Interpretation of maps and mapping studies, therefore, need to take account of potential problems with the source data, and potential statistical problems - before concluding that geographical variation exists or that the observed risks truly correspond to the scale of disease. Most of the data used to map drug use will be subject both to potential biases in under-reporting and coverage, and concerns over how closely it reflects underlying occurrence.

Nonetheless, maps are the best way of summarising geographical data and have been used extensively, firstly with communicable diseases and more recently with chronic diseases. However, a single map may also be misleading. Two key decisions when mapping diseases are the choice of scale and whether to show the observed rates or measures of risk (e.g. SMRs or RR). Maps of large areas run the risk of ecological confounding; maps of small areas may be dominated by sampling variability due to small numbers and may need to be adjusted for the spatial dependence between contiguous geographical areas. This issue is especially acute for rare diseases. If observed rates are used, the maps will highlight areas with smaller populations, which have greater instability of rates and the greater likelihood of having a very high or very low rate. Similarly, if significance levels are mapped, areas with larger populations may be more likely to be highlighted, which even with comparatively small differences can achieve statistical significance. Thus, the maps tend to highlight population density rather than differences in disease occurrence. The first cancer maps raised these methodological problems (Howe, 1989).

One important solution to these problems is to reduce the “noise” from within area variability in order to show between-area variability (Hertz-Picciotto, 1988). Empirical or fully Bayesian smoothing methods are employed to do this. These methods use a series of weights based on national or regional averages to adjust the observed rates according to population size. Thus, large areas will be adjusted very little, whereas estimates from areas with smaller populations will be moved (“smoothed”) towards the overall mean. Extreme values with low precision are made less extreme to be consistent with areas with more precise estimates. High rates in adjacent or contiguous areas can also be “shrunk” less than adjacent areas with different rates if risk and disease are believed to be spatially autocorrelated: to give local as opposed to global smoothing.

This process further corrects individual area estimates for the chance of finding heteregenous rates in neighbouring areas that should be more like each other.

It is may be important also to map measures of statistical significance in a number of ways. This is because even with a smoothed SMR or RR the range of point estimates are mapped (some of which still may be high or low) rather than the confidence intervals (which may cross unity and not be significantly different from national or baseline rates). Therefore, a further map can be produced which shows the likelihood (based on the posterior mode of the "exceedence probability") that an area is the same, higher or lower than the average. One way to take account of the various ways that disease occurrence can be mapped is to present multiple maps including adjusted and unadjusted (perhaps also with supporting information).

The maps in figure 10 illustrate some of the techniques of environmental epidemiology, and some of the problems associated with mapping drug misuse.

Regional Drug Misuse Database (RDMD) – North London.

All reports to the RDMD from GPs and specialist drug agencies mentioning heroin or methadone as a problem drug from 1990 to 1997 were selected. These data were mapped by local authority (LA) with a rough population size of 200,000, for each year showing raw RR, smoothed RR, and posterior probability of exceedance. The RRs were calculated for each year separately. Overall, the number of events increased each year except 1997. It is unlikely that this indicates an increase in the level of problem drug use, and may not even indicate an increase in the treated population over and above changes in the completeness of reporting. The shortfall in 1997 was due to an unexpected increase in under-reporting from GPs and selected drug agencies. The RDMD first started in 1990 and had a much poorer compliance than later years.

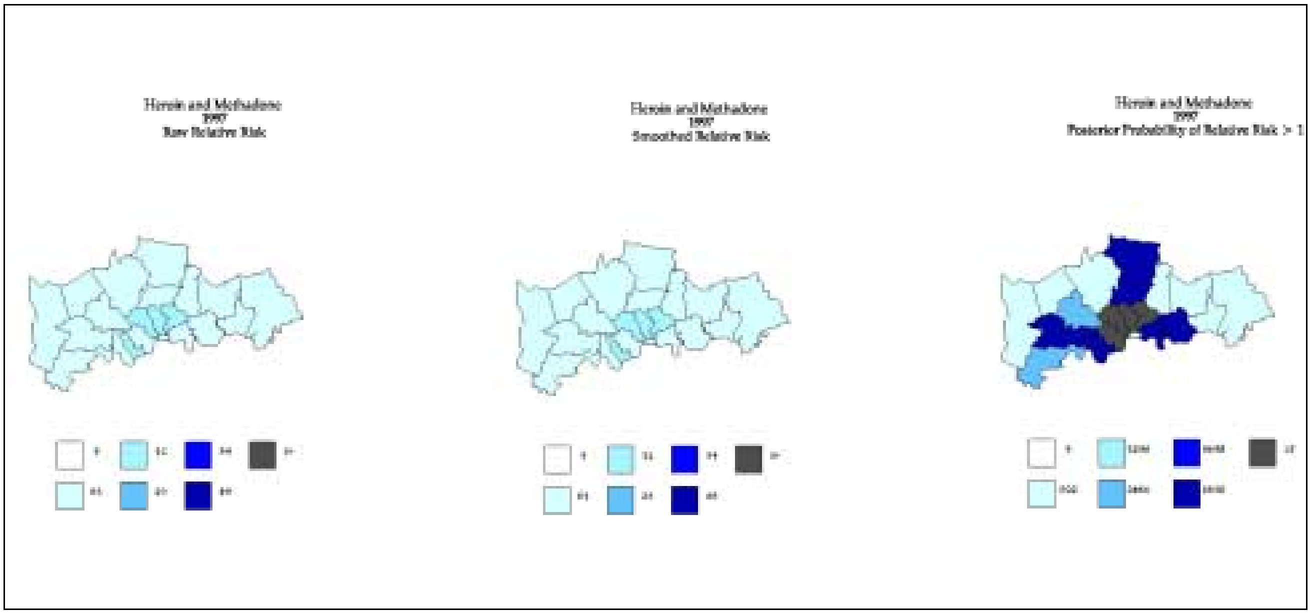



**Figure 1. Relative risk (RR) of reported drug misuse in London, 1997.**

Figure 10 shows maps for 1997. The smoothed maps do not vary from the raw RR in 1997 because the counts in each geographical area were large enough to provide robust estimates. In 1997 the raw and smoothed maps are almost uniform – suggesting that drug use does not vary geographically. Mapping the posterior probability of exceedence, however, highlights again central and inner-London. This is because although the difference in the size of the RR in 1997 was small, they were significantly different. These maps demonstrate the potential of mapping drug use – highlighting effectively the areas with greatest problem – but also the potential dangers of using incomplete data, and of not investigating geographical differences fully.

### 3.2 Italian Data from the Annual Census Survey of Public Therapy Services for Drug Users

The data are derived from the national database containing data of people that are under treatment for use of drugs in Italy. Each map (created using MapInfo) shows data aggregated by Italian regions (see appendix 3). The data used for the maps come from the annual census survey of public therapy services for drug users. Clients may be sub-divided by sex, age class, drug of primary use, drug of secondary use, province, and type of therapy. One example, showing prevalence of heroin use among treated drug addicts is shown in figure 11 below.

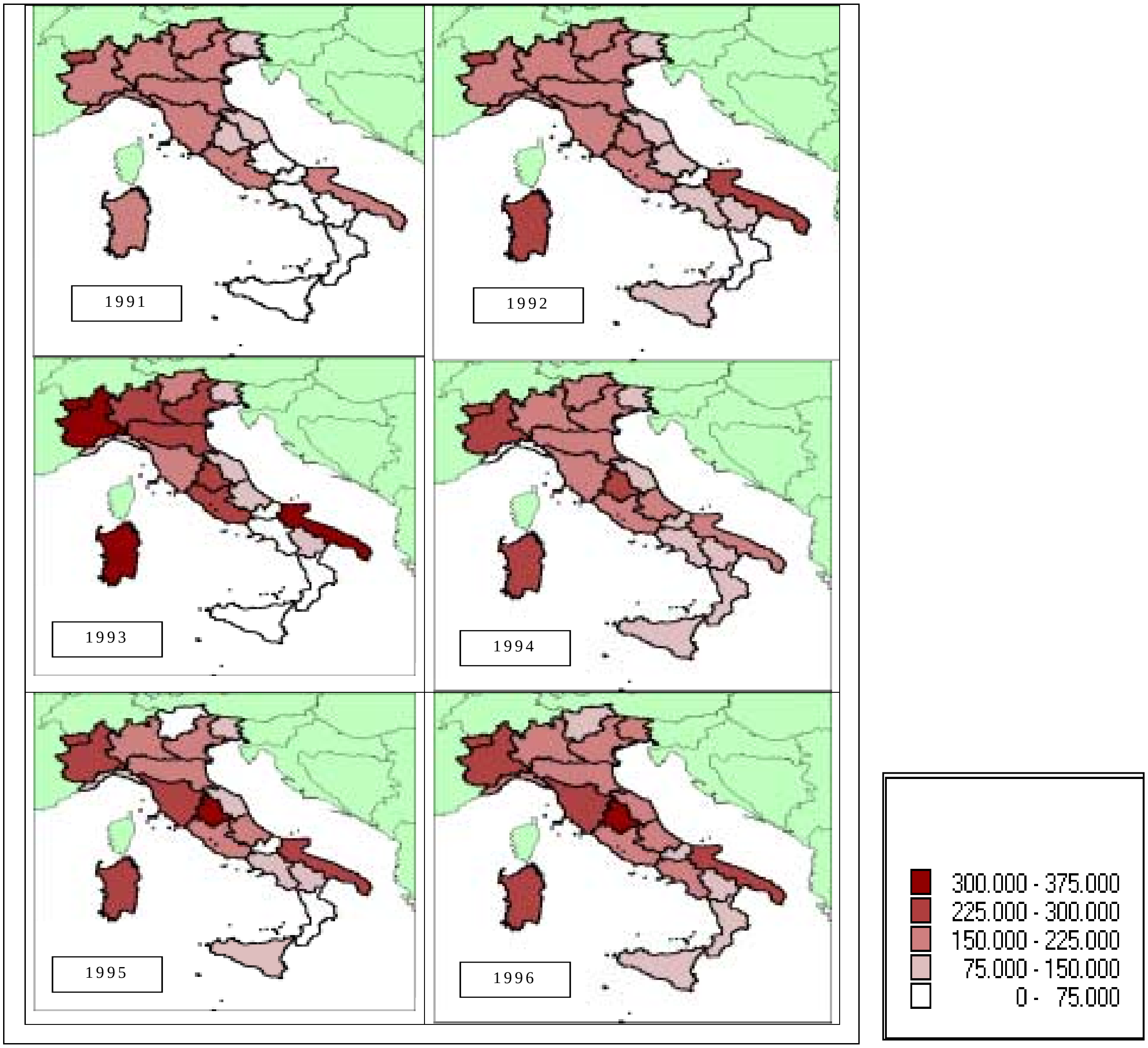



**Figure 2. Prevalence of reported heroin use (per 100,000 population) among registered drug addicts in Italy, 1991-1996.**

The maps in figure 11 may be used to infer the heroin epidemic that caused, after a few of several years, treatment demand for problematic heroin use. This is indirectly measured by the prevalence of clients in drug treatment services and shows a shift from North to South and from border regions, including the coasts of Puglia and Sardegna, to the internal ones. The last two years reported show that the epidemic reached a plateau or is even decreasing in the regions where it was more severe in the first years whereas it is possibly still increasing in others, where few clients were present at the beginning of the nineties. The geographical spread of the epidemic follows the main drug trafficking routes, including, due to the geographical position in the middle of the Mediterranean sea, the main sea routes, namely the Balcanian and Turkish route, which has terminals in the various harbours of Puglia, and the South Mediterranean route. Sardegna has a position which is geographically more linked to the southern region, but by cultural traditions it is indeed more linked to the northern and central regions, important links exist with Toscana and Liguria. This may partly explain the characteristics of the heroin epidemic in Sardegna which are much more similar to those of the northern and central regions than to those of the southern ones.

As with the Scottish data, the Italian data show the utility of the maps compared to the table. In the map the viewer can easily visualise changing patterns of heroin notification, whereas in the table it is much more difficult to gain a sense of temporal and spatial trends.

## SECTION 4: MAPPING AGGREGATE EUROPEAN DATA

The aim of this section is simply to shows maps of existing aggregated data. Figure 12 shows drug prevalence estimates collated by the EMCDDA (see appendix 4 for further details).

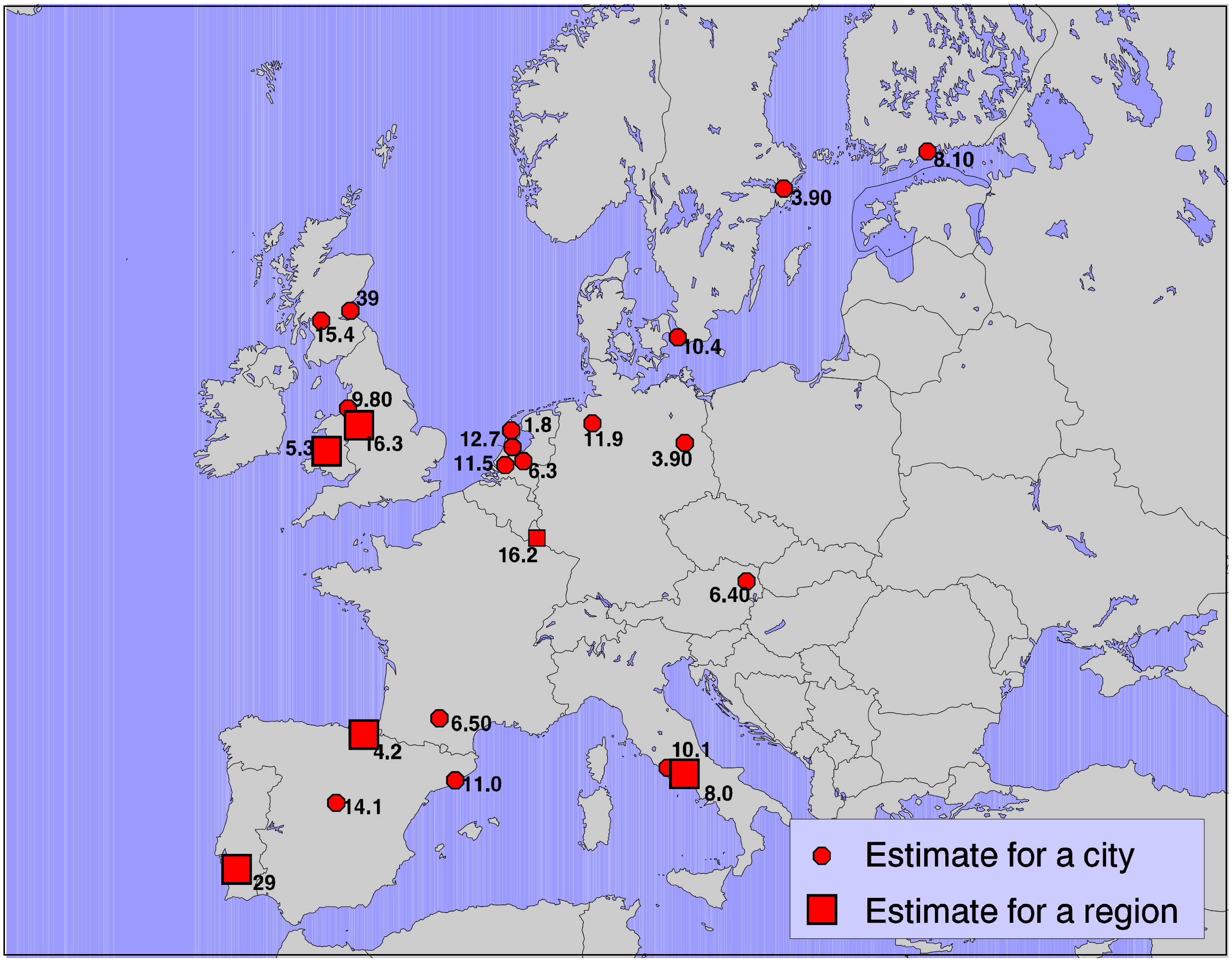



**Figure 1. European locations with drug prevalence estimates (rates per 100,000 population).**

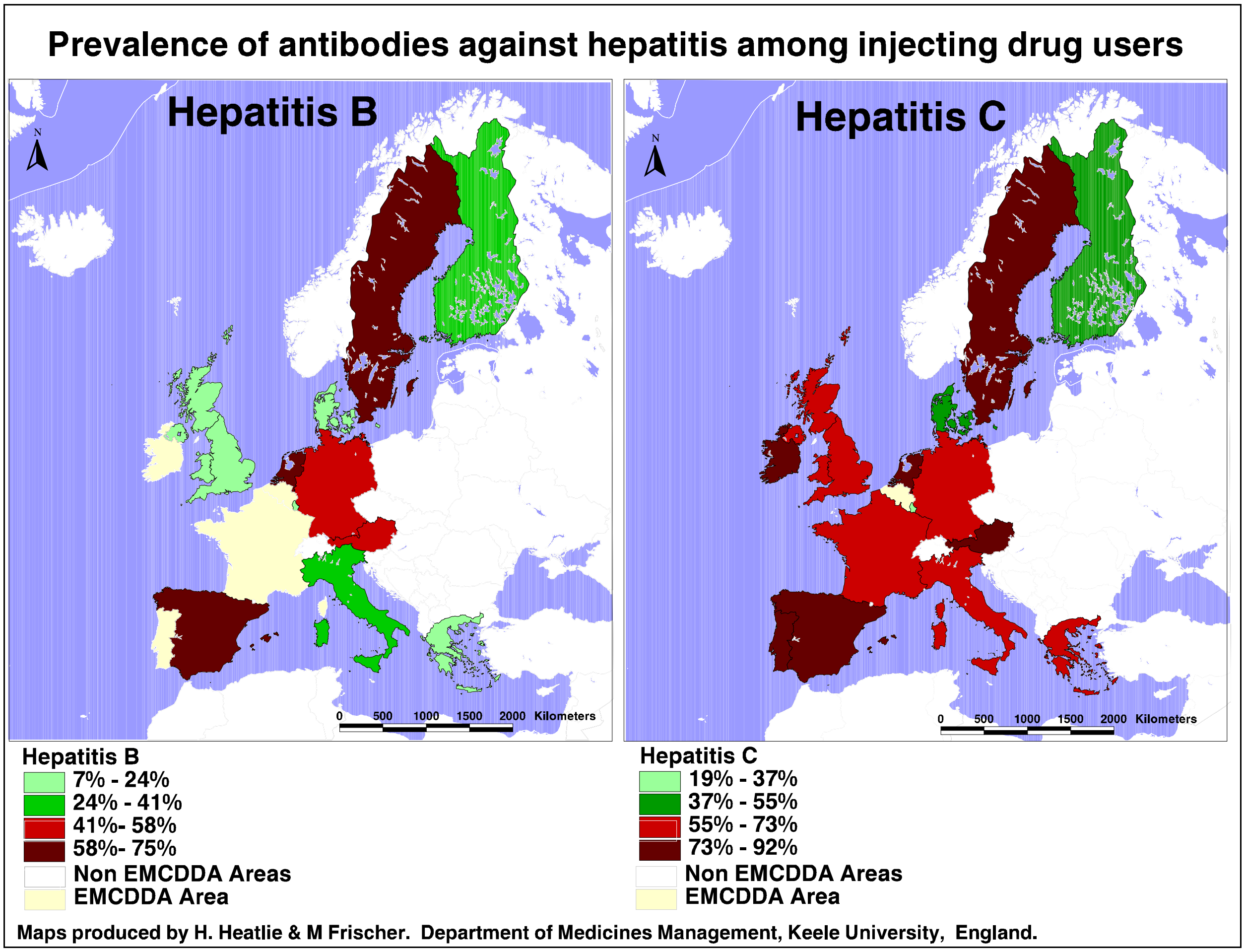



**Figure 2. European Hepatitis B and C prevalence estimates.**

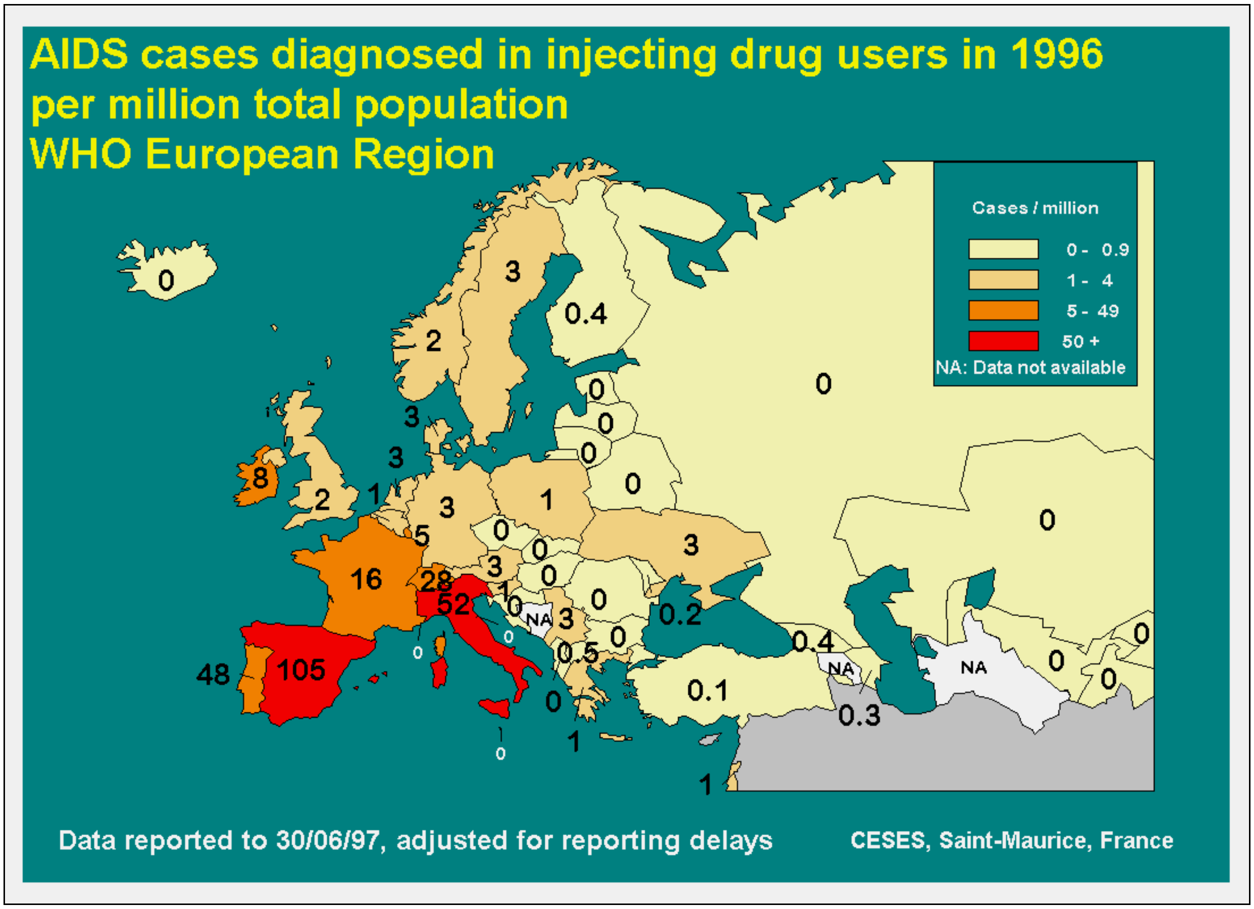



**Figure 3. Number of AIDS cases in injecting drug users. [Map supplied by CESES to the EMCDDA].**

## SECTION 5. REPORT ON THE FIRST MEETING TO CREATE A NETWORK OF RESEARCHERS FOCUSING ON DYNAMIC GEOGRAHICAL MODELS OF DRUG MISUSE

The first meeting of the project funded by DGII/TSER was held in Lisbon 4-5 December 1998. The initial network comprises the following:

| Name | Institution, Location | Country |
|---|---|---|
| Martin Frischer | Keele University | UK |
| Heath Heatlie | Keele University | UK |
| Carla Rossi | Rome University | Italy |
| Paulo Penna | Rome University | Italy |
| Catherine Comiskey | Department of Mathematics, Dublin | Ireland |
| Peter Hanisch | Vienna | Austria |
| Mathew Hickman | Centre for Research on Drugs and Health Behaviour, London | UK |
| Linda Nicholls | Middlesex University | UK |
| Gordon Hay | Centre for Drugs Misuse Research, Glasgow University | UK |
| Alojz Nociar | Department of Health, Bratislava | Slovakia |
| Jaap Toet | Trimbos Institute, Utrecht | Netherlands |
| Lucas Wiessing | EMCDDA | Portugal |
| Richard Hartnoll | EMCDDA | Portugal |

### 5.1 Introduction

Lucas Wiessing opened the meeting and outlined the principal roles of the EMCDDA and the role of this project in the context of the EMCDDA work plan.

## 5.2 Background to Project and Aims & Objectives

Martin Frischer introduced the pilot project setting out previous drug diffusion work. This included the role of epidemic spread in drug misuse. Empirical evidence was also shown to support the effect of drug diffusion in the West of Scotland. The themes of epidemic spread and drug diffusion form the basis for the work described in section 1 above. This model was called the Scottish Drug Forecasting Program (SDFP). Following discussion (see below) this has been changed to the Drug Incidence & Prevalence Estimation Program (DIPEP)

## 5.3 Introduction to Geographic Information Systems (GIS)

Heath Heatlie gave a presentation on the use of Geographic Information Systems (GIS). He outlined what they were, how they worked and gave examples of the types of data that could be included.

## 5.4 Contributions from Participants.

- **Carla Rossi** and **Paulo Penna** demonstrated the mapping software used in Italy. It detailed regional and provincial disease prevalence data for selected years. One example of the use of this system was shown to highlight the spread of AIDS from the northern urban areas to the rural areas in the south of Italy. One area, Sardinia was shown to be unusually high, although the causes for this were unknown. It was speculated in the discussion that this might have been due to drug traffic from Corsica, which was not included in the Italian system.
- **Catherine Comiskey** outlined the data available within Southern Ireland that would act as anchor points for the Scottish Drug Forecasting Program. It became evident it would be possible to adapt the technique used for the West Coast of Scotland for Southern Ireland. Discussion followed as to the length of the epidemic spread used in the West Coast of Scotland (20 years), Catherine thought this was longer than that of the epidemic in Southern Ireland. It was explained however that this aspect of the forecasting software could be easily adapted.

- **Peter Hanisch** showed some examples of the way a GIS had been used to assist engineering projects, notably the disposal of snow as well as a project to ecologically enhance a river basin. He suggested some of the dynamics involved in engineering may be applicable to drug misuse.
- **Mathew Hickman** showed examples of mapping across England and within London using individual treatment and drug related mortality data. He outlined epidemiological analysis of small areas; in particular the use of Bayesian methods to smooth small region variation.
- **Linda Nicholls** showed how raster mapping could be used to overcome potential problems of postcode geo-referencing in London. She used an example of insurance risk estimation.
- **Gordon Hay** demonstrated the use of 'Supermap' which is a mapping package attached to the UK census. He displayed maps at varying levels of detail including regional, district and small postcode areas. This highlighted the potential for mapping demographic indicators as a predictor for drug misuse problems. The discussion also mentioned 'Eurostat' who provide census data for the whole of Europe.
- **Alojz Nociar** described treatment and survey data available for Slovakia. This appeared to support the concept of drug diffusion from large to small towns described earlier by Martin Frischer. Alojz mentioned that more data of this type may be available for other Eastern European countries.

### 5.5 Review of European GIS Drug Misuse as Part of Project CT.98.04.

Heath Heatlie reviewed each of the three project objectives. He showed how a digital data source had been found that provided detailed digital data for the whole of Europe. This included city and towns, regional and provincial boundaries as well as numerous other topographical data. Examples of this data were displayed. The second aspect of this work was to provide illustrative maps for three European regions. He explained this was the aspect of work still to be done, based upon the data to be provided from this meeting.

The third aspect of this work was the detailed spatial temporal mapping for one area. This was the amalgamation of the modelling program into the GIS. The cartographic methods used to portray this information were explained before two series of five maps were displayed. These maps showed prevalence and incidence over a 20 year period for the West Coast of Scotland.

A fourth section of the project was added to include the mapping of existing European drug misuse data. Two examples were included showing local and national drug estimates.

Discussion highlighted the limitations of the model, particularly the fact it should include more than its current nine variables, for example demographic indicators. It was noted however that there was potential for developing a more sophisticated model of drug diffusion.

**5.6 Review of Meeting**

Martin Frischer summarised the key points to come from the previous days meeting. The discussion included the use of a modelling system for drug misuse as well as the use of a GIS to show geographic variations in drug misuse. An important point was the use of GIS to show changes over time as well as space.

The discussion also considered the scale at which data can be provided and mapped. Three levels of data were considered useful, these being a) European, showing variations between countries, b) national showing variations within countries and c) local showing variations down to the towns or cities.

The following tasks were agreed for each participant.

<u>Martin Frischer and Heath Heatlie</u>

- Obtain contributions from meeting participants.
- Write final report for the project (February) and the network (April).

<u>Carla Rossi and Paulo Penna</u>

- An overview of MAP INFO and the method used for their system.
- Examples of Italian map output.

Gordon Hay

- Drug estimates for towns and cities around the West Coast of Scotland. (These data would provide more anchor points for the work already done on the West of Scotland; see figures 4 and 5).

Mathew Hickman

- Description of Bayesian approaches to mapping aggregate data in small and large areas.
- Example maps from England.

Catherine Comiskey

- Anchor data for the forecasting program.
- Postcoded data for arrests, hospital admissions and a social index for Dublin.

Peter Hanisch

- Details of Geo statistics, statistical packages and models available for drug spread.

Linda Nichols

- Description of potential mapping methods.

Jaap Toet

- Provide maps of methadone treatment in Rotterdam and description of method used.

Lucas Wiessing

- Investigate availability of European demographic data which could be linked to the GIS program.

## SECTION 6: SUMMARY AND RECOMMENDATIONS

This project has shown how GIS can be used to map and interpret patterns of drug use in Europe. At the aggregate European level, GIS was used to display know prevalence estimates for cities and regions, thus highlighting areas with some information and those where at present little is known. More sophisticated analysis of individual data from drug treatment programs in Italy and England enabled displays of regional variation over time and space. In the case of Italy, the data were interpreted as following the course of the epidemic. The English data show how regional data require careful interpretation so as to take account of the unit of analysis. These problems have been addressed in other disease areas and it is important to draw on this experience when considering drug misuse.

Much of the work for this project consisted of modelling drug diffusion in one area of Europe, namely the West Coast of Scotland. By linking the output of the drug diffusion program to the GIS, a series of maps were created showing both temporal and spatial diffusion of drug use. Based on known and estimated characteristics of drug use, the GIS predicts areas of high drug use and maps the output in a similar way to weather forecasts. Like weather forecasts, the drug forecasts will sometimes be wrong; however, the maps provide policy makers with a clear point of reference. Furthermore the maps can be readily altered as more information becomes available. One possibility would be to obtain detailed Europe wide socio-economic data, so that, for example, projections could be made from areas with data on drug misuse to areas where little is known.

In summary the project has achieved its main aims by:

1. Developing a pilot GIS mapping package and database for drug misuse.
2. Producing illustrative maps for European regions.
3. Producing detailed spatio-temporal maps of diffusion of drug use in Scotland.

In order to develop this work to cover a European wide spatial system more work is required. First, the Drug Incidence & Prevalence Estimation Program (DIPEP) needs modification to include European data for primary, secondary and tertiary centres of population.

Second, the DIPEP/GIS interface needs to be enhanced to incorporate European socio-economic data as well as allowing anchor points from local estimates. The rate limiting step is drug attribute data, such as incidence and prevalence estimates and related socio-economic indicators such as socio-economic status.

Third, drug agencies should be encouraged, wherever possible, to obtain clients' postcode. This information would serve two purposes; a) to enable more accurate mapping of data on known drug users and b) provide better input into GIS.

The updated program would enable geographic spread of drug use to be more accurately modelled. These developments would provide policy makers with an effective platform for visualising complicated data in a format easy to understand and interpret.

## SECTION 7: REFERENCES


ACMD. (1998). Drug Misuse and the Environment. London: HMSO.

Ditton J, Frischer M. (1999) Computerised projection of future heroin epidemics: a necessity for the 21st century? (submitted to *Substance Use and Misuse*).

Elliot P, Cuzick J, English D, Stern R. (1992) Geographical & environmental epidemiology. Oxford: OUP.

Frischer M, Heatlie H. (1997) *Modelling drug misuse in Europe using geographical information systems*. Centre for Health Economics, York University

Haggett P. (1994) Geographical aspects of the emergence of infectious diseases. *Geografiska Annaler* B; 76, 91-104.

Hertz-Picciotto I. (1998) Environmental Epidemiology. In Rothman and Greenland (Eds). Modern Epidemiology. Phildelphia: Lippincott-Raven

Howe GM. (1989). Historical evolution of disease mapping in general and specifically of cancer mapping. In Results in cancer research – cancer mapping,(ed. Boyle P, Muir CS, Grundmann E). Berlin: Springer Verlag.

Hunt LG, Chambers CD. (1976). *The heroin epidemics: a study of heroin use in the United States, 1965-1975*. Spectrum Books, New York.

**APPENDIX 1: DESCRIPTION OF DIGITAL DATA SETS.**

Digital data available in the 1:1,000,000 Bartholomews digital data

| Data layer | Description |
|---|---|
| Administrative areas | Includes coastline, lakes and, lagoons. |
| Communications | Includes roads, railways and ferries |
| Contour & Bathymetric | Includes coastlines and freshwater lakes |
| Drainage | Permanent and impermanent rivers and glacial form lines in the alps |
| Deserts | Includes lava flows |
| Heights | Mountain summits, spot heights and mountain passes |
| National Parks | |
| Other lines | Includes road junctions and places of interest |
| Regional parks | |
| Reserves | |
| Sand | Beaches, sandbars and mudflats |
| Scenic areas | Currently for UK only |
| Built up | Major urban areas |
| Woodland | Currently for UK only |
| Other water | Impermanent lakes, marshes and glaciers |

Digital data available in the 1:20,000,000 Bartholomews digital data

| Data layer | Description |
|---|---|
| Administrative areas | Includes coastline and fresh water lakes. |
| Contour & Bathymetric | Includes coastlines and freshwater lakes. |
| Drainage | Permanent and impermanent rivers and glacial form lines in Antarctica. |
| Cities and Towns | |
| Mountain passes | Named passes and passes points. |
| Other points | Point symbols for ports, airports. |
| Roads | Principal roads. |
| Railways | Principal railways. |
| Time zones | Standard international time zones. |
| Topography | Other features such as salt lakes, marshes and desserts. |

## APPENDIX 2: SELECTED OUTPUT FROM DRUG INCIDENCE & PREVALENCE ESTIMATION PROGRAM (DIPEP)

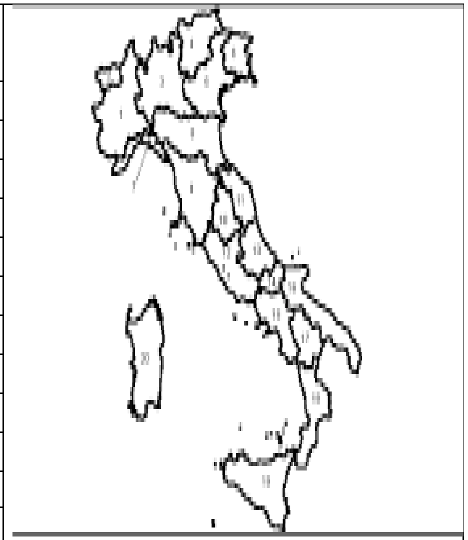
INCIDENCE AND PREVALENCE FOR THE STRATHCLYDE REGION OF SCOTLAND, 1980-2000.

| | TOWN SIZE, GRADED 1 TO 15 IN TERMS OF POPULATION | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
| INCIDENCE | 8,000,000 | 4,000,000 TO 8,000,000 | 2,000,000 TO 4,000,000 | 1,000,000 TO 2,000,000 | 500,000 TO 1,000,000 | 250,000 TO 500,000 | 125,000 TO 250,000 | 62,500 TO 125,000 | 31,250 TO 62,500 | 15,625 TO 31,250 | 7,813 TO 15,625 | 3,900 TO 7,813 | 2,000 TO 3,900 | 1,000 TO 2,000 | 0 TO 2,000 | ALL |
| 1980 | 0 | 0 | 0 | 0 | 620 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 620 |
| 1985 | 0 | 0 | 0 | 0 | 310 | 0 | 0 | 421 | 850 | 177 | 65 | 0 | 0 | 0 | 0 | 1822 |
| 1990 | 0 | 0 | 0 | 0 | 310 | 0 | 0 | 53 | 212 | 89 | 516 | 310 | 173 | 48 | 63 | 1773 |
| 1995 | 0 | 0 | 0 | 0 | 310 | 0 | 0 | 53 | 212 | 89 | 65 | 31 | 22 | 12 | 31 | 824 |
| 2000 | 0 | 0 | 0 | 0 | 620 | 0 | 0 | 53 | 212 | 89 | 65 | 31 | 22 | 12 | 31 | 1134 |
| PREVALENCE | 8,000,000 | 4,000,000 TO 8,000,000 | 2,000,000 TO 4,000,000 | 1,000,000 TO 2,000,000 | 500,000 TO 1,000,000 | 250,000 TO 500,000 | 125,000 TO 250,000 | 62,500 TO 125,000 | 31,250 TO 62,500 | 15,625 TO 31,250 | 7,813 TO 15,625 | 3,900 TO 7,813 | 2,000 TO 3,900 | 1,000 TO 2,000 | 0 TO 2,000 | ALL |
| 1980 | 0 | 0 | 0 | 0 | 930 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 930 |
| 1985 | 0 | 0 | 0 | 0 | 10545 | 0 | 0 | 789 | 1487 | 266 | 65 | 0 | 0 | 0 | 0 | 13151 |
| 1990 | 0 | 0 | 0 | 0 | 11165 | 0 | 0 | 1893 | 7434 | 3017 | 2129 | 776 | 324 | 84 | 94 | 26914 |
| 1995 | 0 | 0 | 0 | 0 | 3101 | 0 | 0 | 1367 | 7009 | 3194 | 2387 | 1148 | 777 | 419 | 1066 | 20468 |
| 2000 | 0 | 0 | 0 | 0 | 3101 | 0 | 0 | 526 | 2124 | 887 | 645 | 527 | 561 | 395 | 1129 | 9895 |

## APPENDIX 3: ITALIAN POPULATION AND TREATMENT DATA, 1991-1996

**Table 1. Resident population in millions (census 1991) and numbers of heroin addicts assisted by public health care services in Italy, 1991-1996, by region (regions are shown in the following map by code).**

| Region | Code | Res. Pop. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (census '91) | | | | | | | | |
| | | | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
| Piemonte | 1 | 4.3 | 8999 | 8730 | 9425 | 10994 | 10862 | 11693 |
| V. d'Aosta | 2 | 0.1 | 284 | 300 | 288 | 290 | 284 | 321 |
| Lombardia | 3 | 8.9 | 14347 | 16790 | 16414 | 17335 | 17946 | 17967 |
| Trentino A.A. | 4 | 0.9 | 1459 | 1603 | 1426 | 1429 | 855 | 876 |
| Veneto | 5 | 4.4 | 8286 | 7151 | 7813 | 8634 | 8522 | 8743 |
| Friuli V.G. | 6 | 1.2 | 1368 | 1541 | 1519 | 1732 | 1917 | 1851 |
| Liguria | 7 | 1.7 | 3499 | 3523 | 2276 | 685 | 2102 | 2755 |
| Emilia Rom. | 8 | 3.9 | 6440 | 6753 | 6591 | 7110 | 6931 | 7734 |
| Toscana | 9 | 3.5 | 5735 | 5947 | 5188 | 7878 | 8565 | 8398 |
| Umbria | 10 | 0.8 | 1160 | 1820 | 1434 | 1844 | 2256 | 2487 |
| Marche | 11 | 1.4 | 1228 | 1669 | 1539 | 1777 | 1818 | 2845 |
| Lazio | 12 | 5.1 | 8597 | 7894 | 8911 | 8447 | 10402 | 9206 |
| Abruzzo | 13 | 1.2 | 681 | 1263 | 1675 | 2222 | 2550 | 2581 |
| Molise | 14 | 0.3 | 170 | 205 | 206 | 319 | 344 | 410 |
| Campania | 15 | 5.6 | 4154 | 5941 | 5165 | 6855 | 8003 | 9925 |
| Puglia | 16 | 4.0 | 8062 | 9311 | 9075 | 8862 | 9724 | 10281 |
| Basilicata | 17 | 0.6 | 433 | 744 | 705 | 687 | 726 | 887 |
| Calabria | 18 | 2.1 | 827 | 1219 | 1564 | 1554 | 1929 | 2801 |
| Sicilia | 19 | 5.0 | 3400 | 4452 | 4473 | 5195 | 5915 | 7402 |
| Sardegna | 20 | 1.7 | 2981 | 4125 | 3974 | 4058 | 4185 | 4776 |
| Total | | 56.7 | 82,110 | 90,237 | 89,661 | 97,907 | 105,836 | 114,299 |



## APPENDIX 4: EUROPEAN DRUG MISUSE PREVALENCE ESTIMATES

| | City | Year | Data (&) | Methods (&) | Definition | Prevalence | Rate /1000 in ages 15-54 |
|---|---|---|---|---|---|---|---|
| AU | Vienna (1) | 1995 | treatment, deaths, police | consistency checks, case-finding | opiate addicts | 5,000-6,000 | 5.3-6.4 |
| FI | Helsinki (2) | 1995 | hospital drug treatments, police, traffic offences | 3 sample C-RC | amphetamine and opiate users | 2,280-4,450 ($) | 4.2-8.1 |
| FR | Toulouse (3) | 1995 | repressive, medical/social, low-threshold | case-finding, 3-sample C-RC | opiate users in difficulty | 1700-2600 | 4.3-6.5 |
| GE | Berlin (4) | 1995/96 | GPs | C-RC, monitor GPs | IDUs | 6,500-8,000 | 3.2-3.9 |
| | Bremen (5) | 1996/97 | medical/social, justice | case-finding | illegal drug users in contact with services | 4,347 | 11.9 |
| IT | Lazio region (6) | 1992 | publ.treatment, therapeut.comm., police | 3 sample C-RC | opiate addicts | 24,060 | 8.0 |
| | Rome (7) | 1996 | surveillance system, hospital, emergencies | 3 sample C-RC | drug abusers (mostly opiate users) | 12,742-16,167 | 7.9-10.1 |
| LU | Luxembourg-city (8) | 1997 | treatment, drug offences, prison | multi-indicator register, demographic model, police multiplier | 'high risk drug consumers' ($$) | 760 | 16.2 |
| NL | Alkmaar (9) | 1991 | field study | case-finding, nomination, snowball | opiate users | 98 | 1.8 |
| | Amsterdam (10) | 1996 | treatment regist., methadone in police cel | 2-sample C-RC | opiate addicts | 3,564-5,769 (~) | 7.8-12.7 |
| | Rotterdam (11) | 1994 | low threshold methadone treatment | truncated Poisson | problematic opiate users | 3,497-3,990 | 10.1-11.5 |
| | Utrecht (12) | 1993 | police, methadone, field study | C-RC, nomination, network analysis | opiate users | 950 | 6.3 |
| PO | Setúbal (13) | 1996 | health centre, specialised centre (2 semesters) | 3 sample C-RC | opiate users with health problems | 620-1,423 | 12.7-29.0 |
| SP | Barcelona (14) | 1993 | emergencies, treatment, prison | 3 sample C-RC | opiate addicts | 10,594-16,132 | 7.2-11.0 |
| | Madrid (15) | 1992 | deaths, treatment, aids regist., prison | 3 sample C-RC and multipliers | heroin addicts | 41,000 | 14.1 |
| | Navarra region (16) | 1990 | Health and justice systems | case-finding | heroin users in treatment | 1,231 | 4.2 |
| SW | Malmö (17a, 17b) | 1992 | needle exch, treatment, social serv., detention | case-finding, C-RC | severe drug abusers (>) | 1,100-1,300 | 8.8-10.4 |
| | Stockholm (18) | 1996 | treatment, social services | case-finding | drug users in contact with services (<) | 1,633 | 3.9 |
| UK | Dundee (19) | 1990/94 | treatment, police, hiv test | 4 sample C-RC | misusers of opiates/benzod. | 1,974-3,458 | 22.3-39.0 |
| | Glasgow (20) | 1990 | treatm., police, hiv test, needle exch | 4 sample C-RC | IDUs | 7,491-9,721 | 11.9-15.4 |
| | Liverpool (21) | 1991 | treatment, police, infectious diseases unit | 3 sample C-RC | users of opiates/cocaine | 2,344 | 9.8 |
| | South and East Cheshire region (22) | 1993 | police, GPs, needle exch, comm drug teams | 4 sample C-RC | opiate, amphetamine or cocaine misusers | 682-4,153 | 2.7-16.3 |
| | Wales region (23) | 1994 | treatment, police, needle exch, probation | C-RC | serious drug users (#) | 8,357 | 5.3 |

**Footnotes to Appendix 4 on next page.**

## FOOTNOTES TO APPENDIX 4.

&) C-RC = Capture-recapture, IDUs = Injecting Drug Users, GPs = General Practitioners
$) amphetamine users: 1590-3780 opiate users: 490-1390
$$) Almost all are opiate misusers or injecting drug users
~) Dutch 3,564 foreign 2,205 total 5,769 The estimate of foreigners and thus the total could be too high, as these form an open population
<) includes cannabis and ecstacy users in contact with social services Of these 44% were opiate users and 95% injected in the last year (mostly amphetamine)
>) Injected at least once in last year, or daily/almost daily use of any illegal drug (including cannabis and ecstacy).
#) Includes IDUs, arrests data may be confined to problem users of opiates and amphetamines.


1) Vienna drug co-ordination 1997.
2) Partanen P. Report on the number of amphetamine and opiate users in the Greater Helsinki area in 1995. Helsinki: Stakes, Aiheita 40/1997.)
3) Bello P-Y, Chéne G. In: European Monitoring Centre for Drugs and Drug Addiction (EMCDDA). Methodological Pilot study of Local Level Prevalence Estimates. Lisbon: EMCDDA, December 1997.
4) Kirschner W, Kunert M. Berlin: EFB, 1996.
5) Zenker C, Greiser E. Erprobungsvorhaben zur Prävalenzschätzung des regionalen illegalen Drogenmißbrauchs und seiner Folgen. Bremen: Bremer Institut für Präventionsforschung und Sozialmedizin (BIPS), 1998.
6) Department of Epidemiology, Lazio Region 1998.
7) D'Ippoliti D. In: European Monitoring Centre for Drugs and Drug Addiction (EMCDDA). Methodological Pilot study of Local Level Prevalence Estimates. Lisbon: EMCDDA, December 1997.
8) Origer A. Luxembourg National Focal Point, 1998.
9) Korf DJ, Hes J, Van Aalderen H. Alkmaar: Brijder Stichting, 1991.
10) Van Brussel G, et al. Amsterdam: Municipal Health Services, 1997.
11) Netherlands Focal Point 1998. (Smit F, Toet J, van der Heijden P. In preparation)
12) Ten Den C, Bieleman B, de Bie E, Snippe J. Groningen: Intraval, 1995.
13) Freire S, Moreira M. In: European Monitoring Centre for Drugs and Drug Addiction (EMCDDA). Methodological Pilot study of Local Level Prevalence Estimates. Lisbon: EMCDDA, December 1997.
14) Domingo-Salvany A, Hartnoll RL, Maguire A, Brugal T, Albertin P, Caylà JA, Casabona J, Suelves JM. Analytical considerations with capture-recapture prevalence estimation: case studies of estimating opiate use in Barcelona metropolitan area. Am J Epidemiol (in press).
15) Paredes D, del Llano J, del Llano J, et al. Comunidad de Madrid, Plan Regional sobre Drogas, 1994. (Estimate refers to Madrid metropolitan area)
16) Moreno Iribas C, Urtiaga Dominguez M. Gaceta Sanitaria 1993; 7: 55-62.
17a) Swedish Council for Information on Alcohol and other Drugs (CAN), UNO-92 (report 34), Stockholm, 1993.
17b) Department of Social Welfare and Public Health, City Office, Malmö.
18) Finne E. (1997) Socialtjänstens kontakter med missbrukare, psykiskt störda och hemlösa 1996. FoU-rapport 1997:15. Stockholm.
19) Hay G, McKeganey N. Journal of Epidemiology & Community Health 1996; 50: 469-472.
20) Frischer M, Leyland A, Cormack R, et al. American Journal of Epidemiology 1993; 138: 170-181.
21) Squires NF, Beeching NJ, Schlecht BJM, et al. Journal of Public Health Medicine 1995; 17: 103-109.
22) Brugha, RF, Swan, AV, Hayhurst, GK, Fallon, MP (1998) A drug misuser prevalence study in a rural English district. European Journal of Public Health, 8, 1101-1262.
23) Bloor M, Wood F, Palmer S. Cardiff: University of Wales, 1997.