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Home Office

The use of Geographic Information Systems by crime analysts in England and Wales

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Home Office Online Report 03/07

The views expressed in this report are those of the authors, not necessarily those of the Home Office (nor do they reflect Government policy).

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Introduction

This report presents findings from a survey of crime analysts designed to assess the extent to which Geographic Information Systems (GIS) are being used across the crime analysis community in England and Wales. The last decade has seen a significant increase in the use of GIS as a tool for crime analysis. This application of GIS technology, known as crime mapping, has become well established in many police forces and Crime and Disorder Reduction Partnerships (CDRPs). Documented case studies (as shown, for example, in Home Office, 2005) gathered from these forces and CDRPs have clearly demonstrated the power of GIS in crime analysis to help police and other community safety practitioners to better understand the crime and disorder problems they face and to help develop approaches to tackle them. However, beyond these case studies and anecdotal evidence of good practice comparatively little is known about how GIS is being used for crime analysis in CDRPs and police forces across England and Wales.

Previous research carried out in the late 1990s has assessed the extent of GIS use in crime analysis. A survey of all local authorities and police forces in England and Wales (Hirschfield *et al*., 1999) showed that around two-thirds of police forces and one-third of local authorities had access to a GIS. Another survey of police forces in the UK (Ratcliffe, 1999) reported that over half of forces had no crime mapping at a divisional level. However, as the results of this research show, the situation has changed somewhat since these surveys were carried out.

Key lessons

- The large majority of crime analysts surveyed used GIS in their analysis. Seventy per cent of respondents indicated that GIS was very important in enabling them to carry out their role effectively, and three-quarters of respondents used GIS once a week or more frequently.

- Concerns were expressed over the adequacy of resources in the area of GIS training. Over 30 per cent of respondents indicated that provision for GIS training had been ‘very poor’ or ‘insufficient’.

- GIS tends to be used extensively for descriptive analysis and to a lesser extent for problem-solving. Survey results suggest that respondents’ time spent was focused on producing maps for crime and disorder audits and strategies and to assist in resource allocation.

- Analysts reported that the majority of their problem-solving crime mapping work focused on descriptive analysis of crime patterns, and that they were less involved in explanatory GIS analysis that would help them understand better the causes of a crime problem or evaluate the impact of an intervention.

- The quality of data available for mapping was also a concern, with just over one-third of respondents indicating that available data were either ‘insufficient’ or ‘very poor’. Three-quarters of respondents indicated reliable geo-referencing for more than 75 per cent of recorded crimes. However, ten per cent of respondents reported that less than half of crime records had a reliable geographic reference.

- The impact of GIS analyses varied between different organisations. Twenty-nine per cent of respondents felt that results of their GIS analyses were always or frequently used in making operational decisions. In contrast, 25 per cent of respondents felt that their analyses were ‘very infrequently’ or ‘never’ used.

Methodology

A self-completion questionnaire survey was developed by the authors and piloted by three crime analysts. The questionnaire was sent to CDRP and police analysts who were members of regional analyst forums. It was also sent to principal analysts in police forces for further distribution to analysts in their force and local CDRPs.

There were 171 responses to the survey. Although the survey was initially distributed at the end of 2004, the large majority of responses were received in the first quarter of 2005. The number of responses received was lower than hoped and results presented are based on a relatively small sample of the total number of analysts.

Responses were received from analysts working in 35 of the 43 police forces and 78 of the 376 CDRPs in England and Wales, with a handful of forces returning a single response[1] and some others returning responses from more than ten analysts. This means that whilst the survey provides a useful way of understanding more about the use of GIS, it is not necessarily representative of the full crime analysis community across England and Wales.

In police forces and CDRPs where GIS is not well established, identifying suitable candidates to complete the survey is likely to have been more difficult. This means that since CDRPs and forces that are less active in crime mapping analysis may be underrepresented the results of this survey could present a better picture of GIS use than actually exists.

Respondent profile

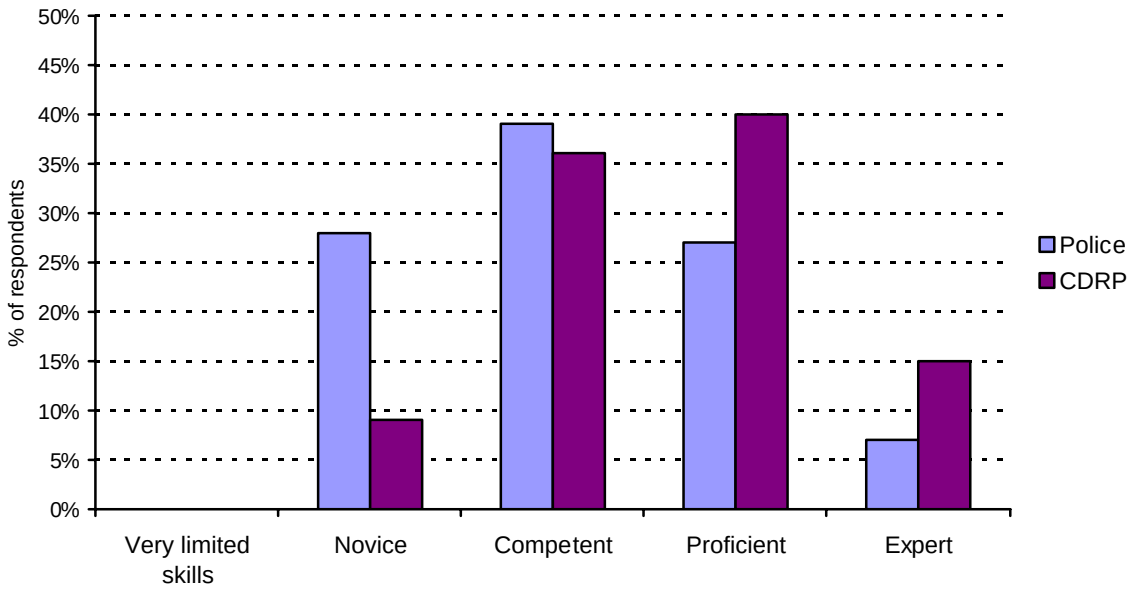
The large majority of respondents (just over 90%) indicated that they were GIS users. Respondents were fairly evenly split between police forces (53%) and CDRPs (44%), with a small number of respondents from other agencies involved in crime reduction and community safety. Responses were received from people with a wide range of roles within these agencies. Most had roles where crime analysis was a primary function, the largest groups being CDRP analysts or researchers, police intelligence analysts and police crime analysts. Responses were also received in smaller numbers from analysts focusing on more specific areas such as the analysis of drug crime, DNA intelligence, or serious crime.

Seventy per cent of respondents indicated that GIS was very important in enabling them to carry out their role effectively. Only 13 per cent of respondents considered it to be only 'moderately important' or 'not important at all'. Three-quarters of respondents used GIS once a week or more frequently, and of these over half were using it every day.

Respondents were asked to rate their ability to use GIS for crime analysis. As Figure 1 shows, no respondents assessed themselves as having very limited skills. Most assessed themselves as either competent (for instance, able to conduct basic analyses such as calculating offence rates) or proficient (for example, able to conduct more complex analyses using multiple datasets). The results of the survey show a difference between police and CDRP respondents, with a greater proportion of CDRP respondents having assessed themselves at a higher level of proficiency. In contrast, over a quarter of respondents working within a police force felt that they were novice GIS users. However, given the possible respondent bias towards established users of GIS, this apparent difference between police and CDRP analyst skill levels should be treated with caution. The results will also reflect differing lengths of time respondents have been in post.

[1] Some of these respondents indicated that the information they provided in the questionnaire response was representative of GIS use across their organisation.

Figure 1: Respondents' self-assessment of ability to use GIS for crime analysis, by police and CDRP respondents



Tools and resources

Resources required to operate a GIS can be broadly grouped into four categories – computer hardware, computer software, data, and people. The survey asked about the adequacy of resources available. Figure 2 shows how respondents assessed the adequacy of a number of key resources.

These results indicate that computer hardware requirements were seen to be adequately addressed. The majority of respondents (82%) felt that the hardware available to them was 'sufficient', 'good' or 'very good' for conducting GIS-based analysis. However, respondents' assessment of the adequacy of the GIS software available to them was slightly less positive. More than a quarter (28%) of respondents felt that the GIS software resources within their organisation were 'insufficient' or 'very poor'.

Two-thirds of respondents (68%) had received some form of GIS training, either formal or informal, in their current post. Over half (56%) had received formal software-specific training (e.g. a MapInfo Professional or ESRI ArcGIS training course), while one in five had received training in the use of GIS specifically for crime mapping. In most of these cases crime mapping training was provided by external consultants. In contrast around half of respondents who had received software-specific training indicated that this was provided in-house.

Two-thirds of respondents reported that the level of training they had received was 'sufficient', 'good' or 'very good'. However, attitudes were dependent on the form of training that the respondent had received. Those who had received formal training in either use of GIS software or crime mapping techniques were more positive about the adequacy of the training they had received than those who had received informal training from colleagues. In addition, as shown in Table 1, analysis of survey results concerning GIS skills show that those who had received formal training were more likely to assess themselves as being proficient or expert users of GIS for crime analysis.

Figure 2: Respondents' assessment of the adequacy of resources available for using GIS in crime analysis

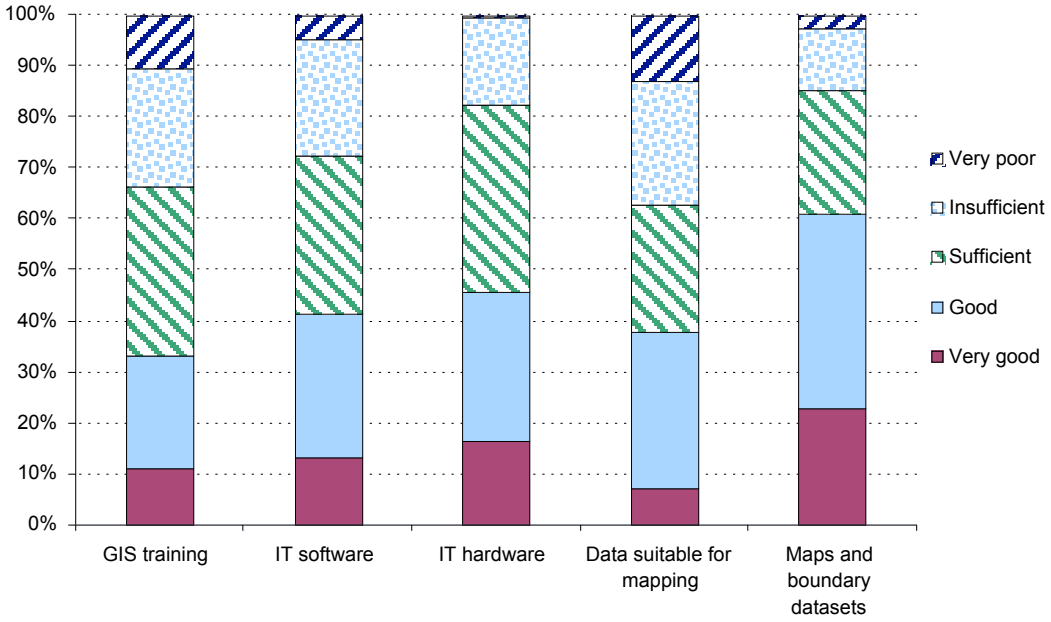


Table 1: Respondents' self-assessment of GIS skills by type of training received

Self-assessment of GIS ability	Informal GIS training only[1] (n = 39)	Formal GIS training[2] (n = 106)
Very limited skills	0%	0%
Novice	29%	15%
Competent	50%	37%
Proficient	11%	38%
Expert	11%	10%

1. Informal training options specified in the survey included self-guided learning, training by or shadowing of colleagues, and online training.
2. Formal training included both software-specific GIS courses and courses focused specifically on crime mapping.

Data and data quality

The quality of recorded crime data available to analysts is a key factor in determining the level and effectiveness of analysis. The application of GIS in particular relies on precise and accurate geographic information about crimes. Encouragingly, results of the survey indicate that the large majority of respondents (94%) had access to point level recorded crime data, where location information is available for each crime record.

Respondents were asked about the adequacy of data available to them to enable them to conduct crime mapping using GIS. The response concerning map and boundary data (i.e. digital map files on which data can be overlaid) was very positive, with 85 per cent reporting that the available data were 'sufficient', 'good' or 'very good'. In contrast, survey results indicate some concern over the adequacy of other data available for mapping (e.g. geo-referenced recorded crime data, and other agencies' data used in analyses). Over a third (37%) of respondents reported that access to data suitable for mapping was either 'insufficient' or 'very poor'.

The quality and completeness of geographic information on recorded crime varies between organisations. Almost a third of respondents reported that a reliable geo-reference was available for over 90 per cent of recorded crimes and three-quarters of respondents indicated reliable geo-referencing for more than 75 per cent of records. However, ten per cent of

respondents reported that less than 50 per cent of records had a reliable geo-reference – a rate significantly below that achievable using robust 'data cleaning' and geo-referencing processes that can be undertaken to improve data quality, consistency and completeness.

Data cleaning processes are essential to maximise the quality and utility of crime data used in geographic analysis. Nearly half of all respondents reported that their recorded crime data had not been cleaned before they received or downloaded them. Of these respondents, the vast majority reported that they were themselves responsible for data cleaning of crime data. The most commonly used data cleaning methods were manual cleaning and correcting processes. Only a quarter of all respondents used automatic address matching software to clean geographic elements of their crime data. Such software was more commonly used by CDRP respondents, with 43 per cent reporting using automatic address matching compared with ten per cent of police respondents.

Respondents were also asked to comment on specific problems observed within their recorded crime datasets. The most commonly reported problems were street or place names spelt incorrectly or inconsistently, and multiple crimes geo-referenced to default locations. Around half of all respondents reported that they always or frequently observed these problems within their recorded crime data. Just under half of all respondents indicated that they always or frequently had numerous crimes recorded at mid-points of streets – a problem that often occurs when data are recorded with insufficient location information (for example, no house number has been recorded). Without proper management, the use of default locations like these can be misleading, producing false crime hotspots. (For further information on the importance of high quality data, data cleaning processes, and how to manage data quality see Chainey and Ratcliffe, 2005; IGGI, 2005.)

Further datasets used in crime mapping

Analysis used in crime reduction and community safety can extend beyond crime data alone. Analysts make use of a large number of multi-agency datasets in order to better understand crime problems and more effectively target interventions. Survey results indicate that analysts have access to a range of multi-agency data. Table 2 gives a breakdown of the proportions of all respondents with access to different data types.

There are also a number of supplementary datasets available to analysts that can offer further context for analysis of a crime problem. Over three-quarters of analysts used census data in their analysis. The Indices of Multiple Deprivation were also widely used, with half of the respondents making use of this dataset. Fewer used geodemographic data (18%), commercially available datasets which classify local areas according to socio-economic characteristics.

Table 2: Multi-agency datasets accessible by respondents

Data type	Obtained in house or from another agency
Fire incidents	77%
Anti-social behaviour (e.g. locations of youth nuisance)	68%
Road traffic accident locations	58%
Business locations (e.g. locations of licensed premises)	54%
Youth offending	49%
Health (e.g. alcohol and drug misuse, Accident and Emergency)	47%
Drug treatment agencies	46%
Probation Service	46%
Education (e.g. truancy records)	44%
Environmental health	42%
Graffiti incidents	39%
Stop and search locations	32%
Intelligence	29%
Forensic science (e.g. locations of linked scenes)	23%
Trading standards (e.g. doorstep incidents)	23%

How is GIS being used?

GIS offers a variety of different ways of representing and analysing data. Respondents were asked to specify techniques they commonly use to analyse the spatial distribution of crime in their area.

- Most analysts (86%) had used GIS to plot point data, a simple method that produces the digital equivalent of pin maps. It can, however, be difficult to identify hotspots using this method, especially when there are a large number of points.

- Eighty per cent of respondents had used boundary thematic maps. This method of mapping uses aggregate data which can be mapped to boundaries such as local authority, ward or beat. The method works best if the data are combined with an appropriate denominator, such as population or number of households.

- Other methods used to identify hotspots include grid thematic and continuous surface[2] maps (52% and 51% of recipients respectively had used these methods). Each of these approaches has its merits and the selection of which approach to use should depend on the available data and the how the map is intended to be used. (For more detailed coverage of these mapping techniques see National Institute of Justice, 2005.)

Respondents were also asked to rank different analytical and mapping tasks according to the amount of time they spent on each. Table 3 breaks down responses by police and CDRP analysts. Tasks most frequently ranked first and second by respondents were 'producing maps for crime and disorder audits and strategies', with 36 per cent of respondents ranking this first, and 'producing maps and analysis for resource allocation', ranked first by 28 per cent of respondents. As might be expected, police and CDRP analysts tend to focus their time on different analytical tasks. All CDRPs have been required to provide crime audits and a new crime strategy every three years. Sixty-five per cent of CDRP analysts ranked mapping for audits and strategies first, while for police respondents more time was spent on mapping for resource allocation, and for analysis of police intelligence data.

[2] Continuous surface hotspot maps are normally created using a technique known as kernel density estimation.

The CDRP reform programme, which was developed based on results of the Crime and Disorder Act (CDA) Review, will introduce new approaches to managing intelligence, information sharing, and the use of analysis in developing community safety policies. With the adoption of National Intelligence Model (NIM)-style processes, the analytical products produced by CDRPs and police analysts are likely to become more similar. The CDA review recommends that CDRPs adopt an "intelligence-led, problem-solving and outcome-orientated approach to community safety" (Home Office, 2006) following principles and practices similar to those encapsulated in the NIM. The current audit and strategy process will be replaced by an annual rolling three-year plan informed by an annual strategic assessment (though a six-monthly strategic assessment is recommended where CDRPs are failing to deliver sufficient reductions in crime).

Table 3: Summary of respondents' ranking of analytical and mapping tasks according to time spent on each

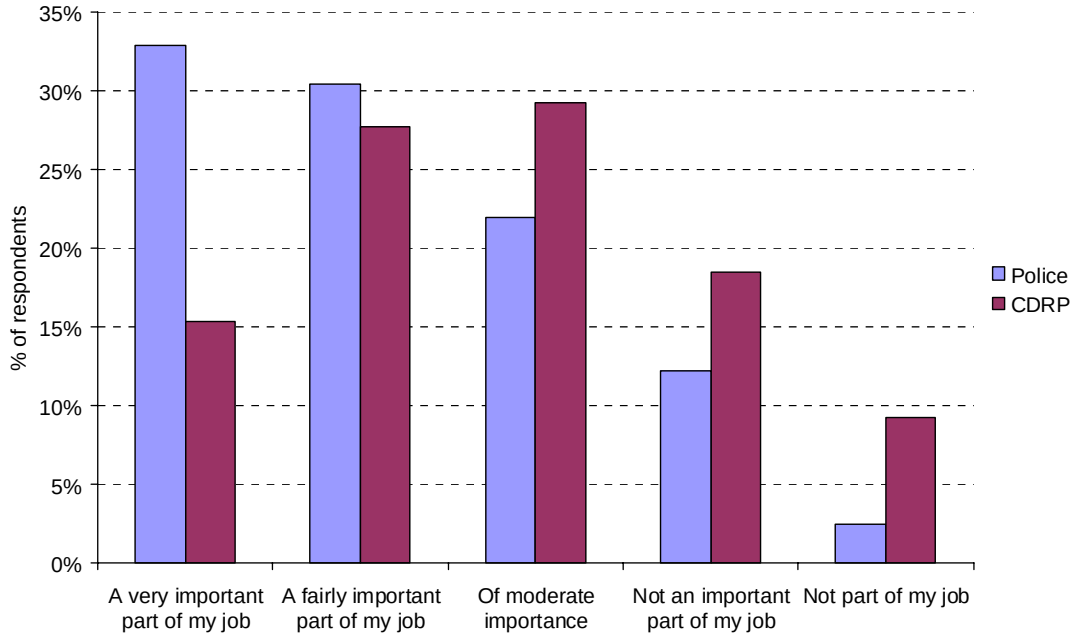
GIS analytical task	Ranked 1st			Ranked 2nd			No time spent[1]		
	Police	CDRP	Total	Police	CDRP	Total	Police	CDRP	Total
Producing maps and analysis for crime and disorder audits and strategies	9%	65%	36%	10%	25%	16%	39%	0%	21%
Producing maps and analysis for resource allocation (e.g. National Intelligence Model tasking and co-ordinating meetings)	45%	8%	28%	19%	13%	16%	14%	47%	30%
Using GIS to assist with problem-solving	13%	18%	15%	19%	23%	21%	14%	26%	19%
Conducting impact evaluations of specific crime and disorder reduction initiatives	3%	6%	4%	6%	22%	13%	42%	34%	38%
Using GIS to assist police officers with serious crime investigations	5%	0%	3%	5%	0%	3%	29%	94%	59%
Using GIS to assist police officers with volume crime investigations	12%	3%	7%	31%	2%	18%	17%	77%	45%
Using GIS for analysis of police intelligence data (e.g. mapping linked series of burglaries)	21%	0%	11%	17%	5%	11%	17%	76%	45%

1. Indicates the percentage of respondents who reported that their role never requires them to conduct the task.

Beyond hotspotting

The findings presented so far suggest that there is fairly widespread use of GIS to help display the spatial distribution of crime using thematic or hotspot maps. This research also attempted to assess the extent to which analysts were using crime mapping techniques to conduct more detailed 'problem orientated' analysis. The overwhelming majority of both police and CDRP respondents felt that problem-solving analysis was part of their job, and a large proportion of these viewed it as an important aspect of their role. As Figure 3 shows, police analysts are more likely to view it is a 'very' or 'fairly' important part of their job. In addition, a very large majority of respondents reported that they had a 'moderate' to 'very good' understanding of problem-solving analysis. However, the data presented in Table 3 indicate that, for some analysts, the time spent on problem-solving analysis is limited.

Figure 3: Respondents' assessment of the importance of problem-orientated analysis in their current role



The principles of crime analysis involved in developing targeted crime and disorder reduction interventions are encapsulated in problem-solving methodologies such as the SARA model (Scan, Analyse, Respond, Assess) (Eck and Spelman, 1987). Respondents were asked the extent to which they use GIS to support problem-solving methodologies. The results are presented below against the different stages of the SARA model.

Scan	Eighty-five per cent of respondents used mapping techniques to identify crime and disorder problems and to improve understanding of these (e.g. exact geographical location and patterns).
Analyse	Just under half of all respondents used crime mapping to help establish the possible causes of the crime and disorder problem (e.g. closer analysis of crime hotspots, or analysis and mapping of crimes with a similar modus operandi).
Respond	Thirty-nine per cent reported using GIS to assist in the design of a crime and disorder reduction measure.
Assess	Just over half of respondents used GIS to help evaluate the impact of action taken.

These figures support the view presented by others in the research community that there is a focus on applying crime mapping techniques to the descriptive 'scanning' stage of the process. Fewer respondents had used these techniques in the more detailed analysis stage or to help develop or evaluate interventions.

The survey findings give some indication of why this might be the case. Of those who said that problem-solving analysis was either not part of their job or not an important part, the most commonly cited reason for this was that much of their time was occupied with other forms of crime analysis (e.g. creating maps for performance management or tasking and co-ordinating purposes). Other reasons given for not engaging in problem-solving work included not having access to the required intelligence or software – this was a particular issue for CDRP respondents.

Another factor that could be stifling more in-depth problem-solving analysis is that in some organisations crime data do not contain a sufficient level of detail to allow patterns or series to be identified. Robust and reliable geo-coded data will allow repeat victims and recurring crime locations to be identified.

Previous research has shown how understanding of repeat victimisation patterns can provide useful insights into the nature of a crime problem and the contributing factors. However, results from this survey suggest that reliable repeat victimisation data are often not available. For a number of offence types[3], respondents were asked whether they could identify repeat victims in their crime records and whether or not the data were reliable. The results show that for most of the selected offence types, around a quarter of respondents indicated that repeat victims could be identified and that these data were either fairly reliable or very reliable. The highest rates were for domestic burglary with 31 per cent of respondents who felt able to reliably identify repeat victims within their recorded crime data. The percentage of those with identifiable repeat victim data corresponds closely with the number of respondents who were conducting repeat victimisation analysis – a quarter of respondents carried out this type of analysis.

Using the results of crime mapping analysis

The survey asked analysts whether they felt that enough use is made of their GIS analysis in making operational decisions. Twenty-nine per cent felt that it was always or frequently used, 45 per cent felt that it was only occasionally used, while 25 per cent of respondents felt that their analyses were very infrequently or never used. These findings indicate that there may be more to be done in promoting the use of crime mapping outputs to inform decision-making by crime reduction practitioners.

As Table 4 shows, respondents indicated that the results of their GIS analysis were being disseminated through a variety of routes. The most common methods were publication in audit and strategy reports (this was largely the case for CDRP respondents), and sending out analysis by email. Due to limitations of sample size it is difficult to infer much about how different methods of dissemination affect how analysts perceive their work is being used in decision-making. However, of the small number of respondents who indicated that results of their analyses were not passed on to frontline staff, over half felt that their work was either very infrequently or never used. In contrast, analysts whose maps were used in the daily briefing of police officers felt that more use was being made of their analyses, with almost half indicating that it was always or frequently used.

Table 4: Methods of dissemination for outputs of respondents' GIS analysis

Method of dissemination	Proportion of respondents
Publish in audit or strategy reports	46%
Email to police officers or other crime reduction practioners	46%
Present in meetings (other than NIM)	42%
Distribute hard copies of their maps to frontline officers	36%
Present in National Intelligence Model meetings	35%
Publish in other reports	30%
Use in daily briefing of frontline staff	17%

[3] Offence types used in the survey were domestic burglary, non-domestic burglary, domestic violence, robbery, and vehicle crime.

Conclusions

The application of GIS and crime mapping techniques is widespread in police forces and CDRPs in England and Wales. However, this survey demonstrates the considerable variation in availability of resources for crime mapping and the types of analyses being conducted. This survey has helped to highlight a number of areas that would benefit from further development. These are:

- GIS and crime mapping training for analysts;
- the quality of geo-coded data available for crime mapping analysis;
- the time (and other resources) available for analysts to enable them to focus more on explanatory problem-solving GIS analysis; and,
- the communication of products of crime mapping analysis to ensure that they are fed into appropriate decision-making processes.

The Home Office is currently exploring ways of enhancing crime mapping skills in partnerships. The CDRP reform programme is likely to impact on the work of analysts in all partner agencies. With a focus on intelligence-led business processes, information sharing, and problem-solving analysis, crime analysis and crime mapping will be key to successful delivery of the programme. This should provide impetus at a local level for greater utilisation of GIS approaches to analysis.

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