

Knife Crime Prediction

Data Analytics Lab

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This is an interim report relating to the questions raised at the previous meeting regarding the knife crime prediction project.

As this project is still under development the full and complete methodology has not as yet been determined. Therefore information is presented here as to the most promising line of enquiry to achieve the aims of the project.

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2 Introduction

The overall aim of this project is to develop a statistical model to predict the likely levels of knife crime over time and space within the WMP area.

Nationally and locally there is concern about the increase in knife crime, particularly involving young people. The Parliamentary Youth Select Committee's report 'Our Generation's Epidemic: Knife Crime' (2019) stated that the number of fatal stabbings in the year ending March 2018 in England and Wales was the highest on record since data collection began in 1946. In 2019, over 100,000 people signed an online petition demanding a Parliamentary debate on knife crime.

Increases in knife crime in the West Midlands reflect the national trend; the Force has seen an increase in reporting from a low in 2012 to levels that were last seen in the early 2000s. Indeed, the mean number of monthly knife crimes (where they were used causing injury) in 2019 represents an increase of 148% over the mean number of monthly crimes in 2012.

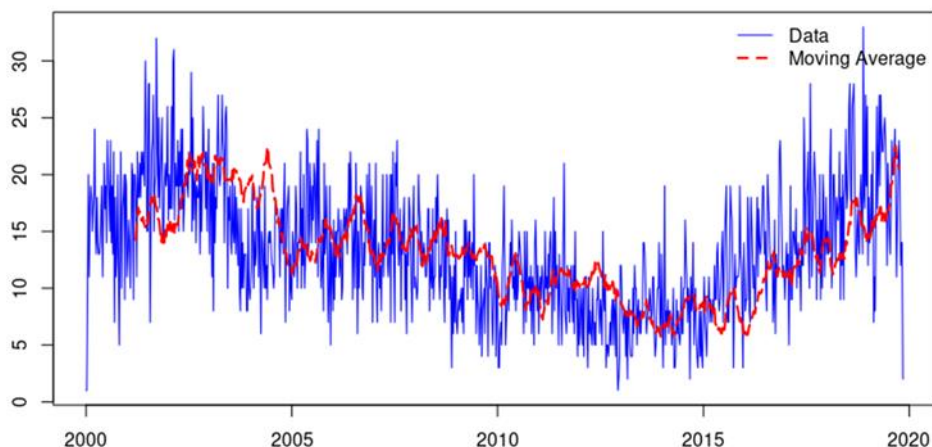


Figure 1: weekly knife crimes 2000 - 2020

In addition, the rate per 1000 residents of 'wounding (serious and other)' offending in the West Midlands is above the average when compared to our most similar forces of Merseyside and West Yorkshire (Office for National Statistics Crime in England and Wales: Police Force Area data tables year ending Sept 2019 – data for Greater Manchester currently unavailable).

At the same time, the average age of those committing offences has also fallen so that knife crime is increasingly affecting younger members of the community.

In April 2019 the Home Office gave West Midlands Police (WMP) £7.62million in police surge funding with the mandate that it is to be used to reduce serious violence in public spaces, with a focus on reducing knife crimes among young people. The force's response has been to create a two year project, known as Project Guardian.

3 Modelling Approach

3.1 Exploratory Spatial Data Analysis

In a spatial sense, the incidents of knife crime tend to exhibit clustering, particularly around Coventry, Birmingham and Wolverhampton city centres.

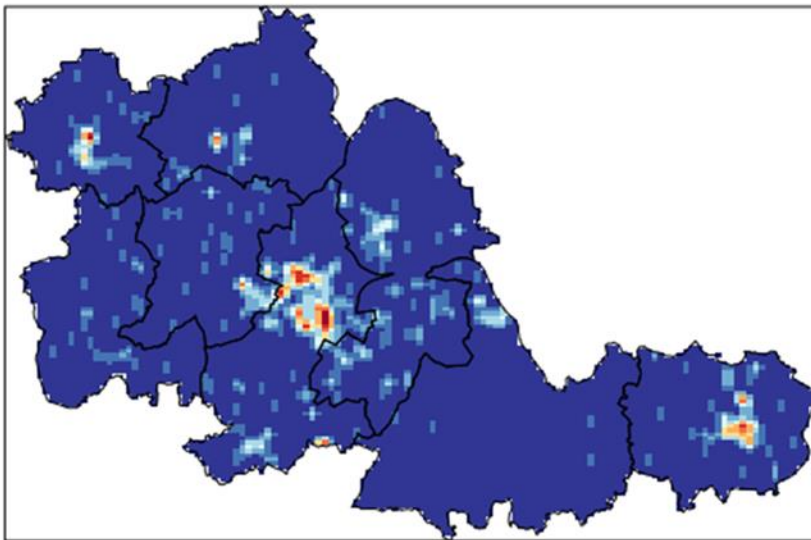


Figure 2: incidents of knife crime 2012

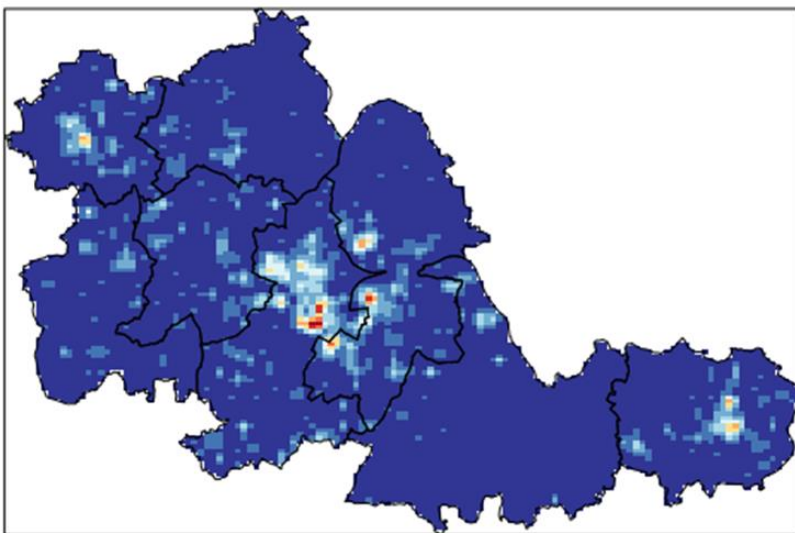


Figure 3: incidents of knife crime 2019

Whilst there are incidents occurring outside these central areas and their surrounds, when examined as a spatial point pattern (on a monthly basis), the knife crime incidents do not appear to follow complete spatial randomness (CSR)¹:

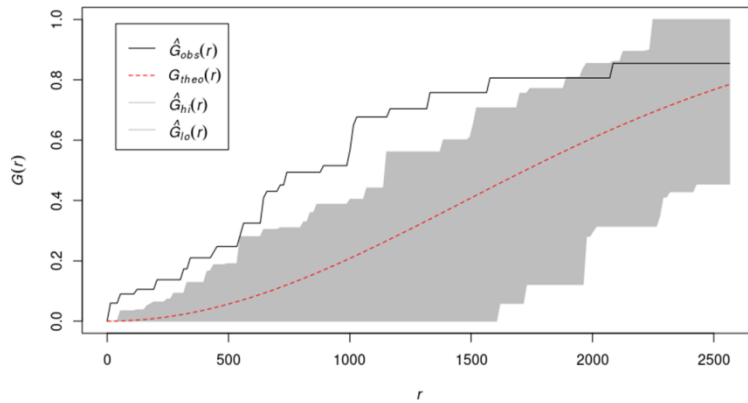


Figure 4: testing for CSR. NOTE: this chart shows the result of testing of the locational patterns of knife crimes against a hypothesis of CSR; the black line being outside of the grey boundaries shows that there is clustering and the patterns of knife crime incidents do not follow CSR.

Due to identifiable areas being most useful operationally, for the purposes of this project the WMP area has been split into a grid with each grid being circa 1 square km. It is on this gridded pattern that the modelling is proposed to be undertaken.

Using this grid the data are now areal. With these type of data it is necessary to gain an understanding of the relationship of the item of interest over both space and time. Figure 5 below shows the relative score of a space time scan statistic. This shows that there are locations that exhibit higher than expected counts of knife crime incidents and that there are clusters of such areas.

¹ This is the case whether incidents inside the city centres are excluded or not and whether or not it is assumed that there is spatial non-stationarity.

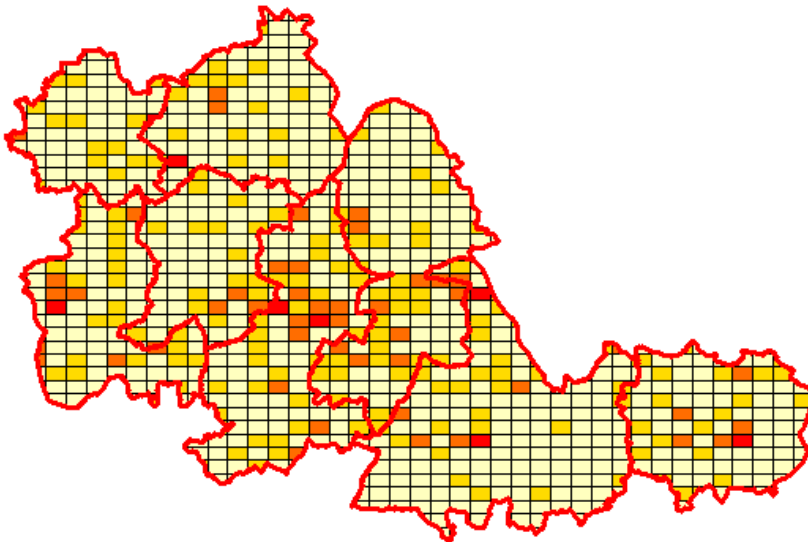


Figure 5: map of the relative score of an EB scan statistic

This points towards a relevant model being space-time inseparable².

3.2 Broad Modelling Approach

From the above, there is information in both the temporal and spatial dimensions that will be key for making predictions of knife crime incidents. Therefore, the approach taken here is essentially to use previous occurrences of knife crime incidents to predict (over a coming 4 week period) future knife crime incidents. This is akin to using a time series to predict future levels of that time series (an often used methodology). The data used are the count of monthly knife crime incidents (and crimes) for the previous 12 months

For additional information the levels of all crime are also used. The number of pubs, clubs, etc. has also been included (which does not change over time), although presently it seems that these data do not provide useful information for predicting knife crime incidents.

So far a number of approaches have been examined (including a gradient boosting machine (GBM) model and neural networks); further details of which will be provided upon finalisation of the project. This section shall therefore outline the most promising approach found so far.

The exploratory spatial data analysis (ESDA) undertaken shows that there is essentially correlation over both time and space of knife crime incidents and this therefore leads to the use of a spatio-temporal model. The results of the scan statistic noted in figure 5

² Haining, R. and Guangquan, L., 2020, *Modelling Spatial and Spatial-Temporal Data A Bayesian Approach*, CRC Press, Boca Rotan, FL.

point towards the use of a space-time inseparable model³. Separable model(s) have been tested and it is indeed found that inseparable models are preferable⁴.

Whilst the final detailed approach is still to be determined, the (broad) most likely candidate to be used is a BYM⁵ model with type I space-time interaction⁶, the basic form of which is (conditional on the y_{it} not being a structural zero):

$$y_{it} = \text{zeroinfPoisson}(\mu_{it}, \pi_{0t})$$

$$\log(\mu_{it}) = a + (S_i + U_i) + v_i + \delta_{it} + \mathbf{X}_{i,t-1}\boldsymbol{\beta}$$

$$S_{i:N} \sim \text{iCAR}(\mathbf{W}_{sp}, 1/\sigma_S^2)$$

$$U_i \sim N\left(0, 1/\sigma_U^2\right)$$

$$v_{1:T} \sim \text{iCAR}\left(\mathbf{W}_{RW1}, 1/\sigma_v^2\right)$$

$$\delta_{it} \sim N\left(0, 1/\sigma_\delta^2\right)$$

$$1/\sigma_S^2 \sim \text{loggamma}(1, 0.0005)$$

$$1/\sigma_U^2 \sim \text{loggamma}(1, 1)$$

$$1/\sigma_v^2 \sim \text{loggamma}(1, 0.0005)$$

$$1/\sigma_\delta^2 \sim \text{loggamma}(1, 0.0005)$$

$$a \sim N(0, 0.01)$$

$$\boldsymbol{\beta} \sim N(0, 10)$$

Where a zero inflated Poisson distribution is used due to the large number of zeros, $S_{i:N}$ is the spatially structured element of the BYM model, U_i is the spatially unstructured element, v_i is the temporal element, δ_{it} is the space-time interaction element, \mathbf{W}_{sp} is a spatial weights matrix employing first order rook contiguity and \mathbf{W}_{RW1} is the adjacency matrix for the random walk of order 1 temporal component. The iCAR model is the intrinsic conditional autoregressive model (essentially the number of knife crime incidents in a location is a function of the numbers in neighbouring areas). Additional

³ A space-time separable model essentially models the data generation process as overall spatial + overall temporal whilst an inseparable model is applied to data generation processes that cannot be fully described by this structure; there is an interaction between space and time.

⁴ The different types of models being tested by way of the deviance information criterion (DIC).

⁵ Besag, York, Millie model.; Besag, J., York, J., and Mollie, A., 1991, Bayesian image restoration, with two applications in spatial statistics. *Annals of the Institute of Statistical Mathematics*, 43(1), pp1 – 20.

⁶ The type of space-time interaction has been tested for by way of the DIC.

covariates (the $X_{i,t-1}\beta$) are the number of crimes and, potentially, the number of bars, restaurants, etc.

It should be noted that due to the stage of the project, details of this model may change, including following sensitivity testing (of the priors), whether a spatially unstructured element is required, etc. Therefore the above should be viewed as a starting point.

Such modelling, or variants thereof, would essentially allow for the prediction of the likely number of knife crime incidents in which location and this information would feed into the decision making for re: allocation of resources.

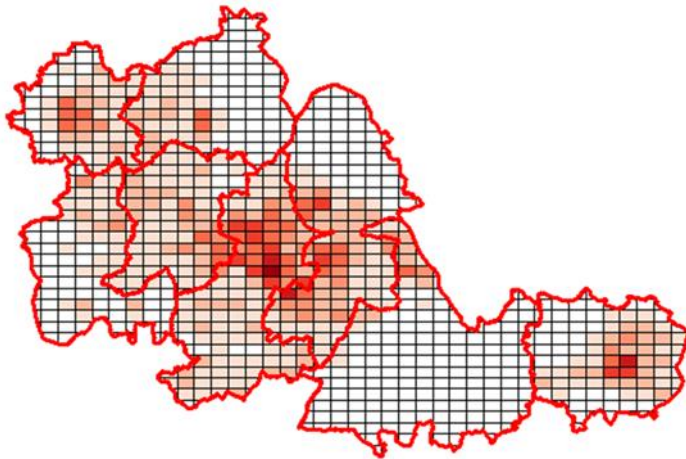


Figure 6: basic output from predictions. NOTE: this is an example of the output, not an actual output.

It should also be noted that this project is aimed at making predictions rather than explaining the presence of hotspots.

4 Efficacy of “Hotspot” Policing

Hotspot policing is a strategy that involves the targeting of resources and activities to those places where crime is most concentrated. The strategy is based on the premise that crime and disorder is not evenly spread within or between locations but clustered. Focusing resources and activities in hotspots aims to prevent crime in these specific areas and potentially reduce overall crime levels in the wider geographic area.

The College of Policing Crime Reduction Toolkit⁷ provides evidence from systematic reviews of research on crime reduction interventions.

The review of the evidence for hotspot policing suggests that it has reduced crime. Hotspot policing programmes that take a problem-oriented approach appear to be more effective than increased traditional policing, such as high visibility patrols. The evidence suggests that hotspot policing was more effective for drug offences, violent crime and disorder than it was for property crime. Hotspot policing can also lead to a diffusion of benefits to the areas immediately surrounding the hotspot. This is a tactic that has been used widely in WMP and other forces; for example most recently in London where Violence Suppression Units focus on ‘micro-beats’.

The DAL analysis aims to identify where knife crime hotspots are because this is one of the four key areas determined by Project Guardian to spend the money from the Home Office on – therefore, to a degree, the Force has already decided that it will focus resources on hotspots – the analysis is simply supporting a pre-determined policy. However, within the identified hotspots a range of activities are planned covering both enforcement and prevention. Of course, some of this planned activity may change in light of CoVID – for example the night time economy is unlikely to require as much resource.

The lion’s share of the funds, over £5m, will go into prevention and enforcement. This is to include the recruitment of 75 brand new police staff investigators (PSIs) on one year contracts. Part of this extra investigative capacity will be used to manage P4 logs. By doing this it’s envisaged that neighbourhood teams will have more time to work on youth violence prevention and enforcement.

This will be topped up by extra money to support policing Birmingham’s night time economy and to combat youth violence via suppression work in neighbourhoods. These extra hours are being made available as overtime options for existing staff.

Neighbourhood teams are also being given the opportunity to bid for a share of the funding to support localised suppression activity.

Supporting the prevention work will be a new out of court disposals pilot which will focus on diverting rather than criminalising children and making the most of ‘teachable moments’ in custody to divert offenders from committing further crime.

The force’s #lifeorknife campaign will continue and expand, focusing on getting young people and their parents to talk about knives by using real victims and offenders.

⁷ <https://whatworks.college.police.uk/toolkit/Pages/Welcome.aspx>

Support for officers, staff and cadet leaders leading conversations with young people will feature off-the-shelf presentations, wristbands and leaflets.

A Guardian Opportunities Fund will give young people ownership over a pot of money they can use to improve their own communities via local initiatives. The allocation of the funding will be at the discretion of the young people themselves.

The Police and Crime Commissioner will use nearly £1.5m for diversion, mediation, support, mentoring and engagement.