Can Statistics Help?

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Introduction

There is plenty of uncertainty associated with crime. From a layperson's point of view, it is part of the allure. From Agatha Christie to Kathy Reichs, from *Homicide* to *Underbelly*; from *Hawaii Five-O* to *Law and Order*, and all the myriad, forensics-based TV dramas, crime has long been a popular and dependable entertainment theme. I expect it is not just the 'who?' out of the 'whodunnit?' that draws people in, but also the 'how?' and the 'why?', and the possibility that the perpetrator just might get away with it. From the comfort of one's own home, we try to get into the headspace of the 'villain' and fathom what drives them to cross the line and risk the consequences of breaking the law. Equally absorbing is to get into the headspace of the detectives. They are faced with similar uncertainties, but from a different viewpoint. What actual offence has been committed? Were there witnesses? What evidence is at the crime scene? Is there a suspect? Is there sufficient evidence for an apprehension, a charge, a guilty verdict? Even if the suspect is found guilty and sent to prison, can they be rehabilitated or is it just a matter of time before they re-offend?

For the sort of crime most commonly depicted on television or as the subject of crime fiction, I think the public's fascination with the uncertainties of crime is built on the premise that they are unlikely to become a victim of serious crime or cross paths with the mafia. In addition, few would expect ever to find themselves in such dire or extreme circumstances that they would be compelled to break the law. Terrorism, on the other hand, is different. With terrorism, as the name itself suggests, uncertainty and fear are brought into the realm of everyday life. Cyber-crime is slightly different again. We are not so absorbed by it, since we tend to be unaware that crimes such as identity theft, online scams, and even online sexual exploitation might be only a mouse-click away from us, or our children. Crimes such as these are increasingly prevalent and, in fact, thrive on the fact that the public are unaware of how susceptible they are.

My task is to provide an understanding of uncertainty in policing serious crime from my background in statistics. My perspective is not quite that of the general public, nor the police practitioner, but of someone relatively new to policing (I joined the Australian Federal Police at the end of 2007) and from the

outside. As a statistician I am pretty comfortable with numerical uncertainty. In earlier work (Attewell 2008), I postulated that statisticians have much to offer in terms of dealing with uncertainty. We like to count things, draw samples, test hypotheses, and fit probability models, but can statistics really help in a patrol car or at a crime scene, an operations control centre or an executive management meeting at headquarters? Policing serious crime is a key function of the Australian Federal Police. The Australian Federal Police is responsible for protecting Australia's security, as well as preventing and investigating crimes against Commonwealth law such as importation of border controlled drugs, people smuggling, human trafficking, fraud and other economic crime, cyber-crime, environmental crime, terrorism and serious organised crime.

In this chapter I start by exploring what policing may learn from public health and medicine about the use of statistics. I then review some significant challenges to the effective use of statistics, followed by areas where statistics is making major contributions to dealing with uncertainties in policing serious crime.

Disease and crime: peas in a pod?

Most of my statistical perspective is grounded in biostatistics which is the application of statistics in the study of disease and, more generally, the human condition. This is an area in which statistical principles have been well accepted and applied. I do not mean that all doctors know what a chi-square test is or could interpret a logistic regression. However, advances in knowledge in epidemiology and the treatment of disease have occurred through research which has been undertaken with the application of sound statistical methodology. The evidence base for prevention and treatment of disease has moved from personal experience and chronicles of case histories to global randomised controlled trials, longitudinal cohort studies and meta-analyses. The movement within the fields of public health and medicine towards a quantitative evidence base is so strong that the pharmaceutical industry, for example, is very highly regulated. New drug treatments are not able to be registered or receive government subsidy unless supported by a structured compilation of efficacy and safety data. It has to be proven beyond reasonable doubt that new medications work and their positive impact on the target disease outweighs any negatives through adverse side effects.

Similarly, policing could benefit from being further along the continuum in the adoption of statistical principles and incorporation of scientific methodology into research and practice. This is not a new notion. See, for example, Laycock (2001), who calls for a greater link between research and practice in policing. In fact, Porter (1986) points to the origins of statistical thinking, not only in

the health discipline, but also in the social science sphere in France in the early 1800s. He writes, 'Statistics could provide an understanding not only of the prevailing causes of death and disease, but also of crime and revolution, respectively, the chronic and epidemic disorders of the human spirit'. He further reminds us of the work of Quetelet (lived 1796–1874)—variously described as an astronomer, mathematician, statistician and sociologist—who was one of the first criminologists in that he was interested in how crime rates varied with factors such as age, sex, profession and location. Much has been achieved since then, including comprehensive reviews of what works in preventing and reducing crime (Sherman 1992, 1998, Sherman et al. 2002) and, indeed, a whole movement towards an evidence-based approach with data analysis playing a key role along with intelligence analysis in intelligence-led policing (Ratcliffe 2008).

There are many interesting similarities between disease and crime, although there are also important differences (see Box 1). Sherman (1992) also draws the analogy between doctors and police officers. But how does this help? From a purely mathematical point of view, the dichotomous nature of the outcomes (healthy/unhealthy, crime committed/not committed), as well as the requirement to look at trends and comparisons of incidence and prevalence mean that the statistical approaches that work well in medicine do translate to crime. Differences occur, however, in the inability to control the environment in which crime takes place and the difficulty in collecting relevant information on criminals and criminal activity, which means that traditional epidemiological approaches such as randomised controlled trials will be less widely applicable in the evaluation of various policing strategies. It should be noted, though, that Sherman and colleagues (2002) do cite examples of both controlled and quasi experiments in policing.

In the remainder of this paper, I provide examples of where basic statistical principles and techniques, many of which have been applied successfully in medicine, are being used to address uncertainty in policing crime, as well as where we are falling short of the mark, with regard to serious crime. In particular, I will focus on data collection, measurement, surveys, mapping, descriptive statistics and graphics. Let me begin with some of the challenges, which mainly relate to the collection of data.

Box 1: Disorders and disorderly conduct: the correspondence between disease and crime

Disease and crime are characterised by dichotomous states: sick/well, guilty/not guilty and two main stakeholders: patients/doctors, criminals/police. Both doctors and police are professionals with high ethical standards in whom the public place much faith. Disease and crime both have negative associations. Hospitals and prisons are places to avoid, but are nevertheless essential and costly institutions in our society. Even the terminology overlaps. The words, 'cases' and 'investigations' are commonly used in both fields. There is a continuum of minor ailments to life threatening disease, so too for crime from petty theft to murder. Disease treatment and crime punishment options also range in scale from diet/exercise regimes to surgery, and from fines or restorative justice to more punitive measures. Some patients have more than one condition. Some persons commit more than one type of crime. Some diseases are genetic. Some criminals are psychopaths. Patients relapse. Criminals re-offend. Some diseases, pandemics, have global impact; so do global terror acts. In fact, sometimes the threat of the disease, or the threat of the crime, can have just as much or more impact than the disease or crime itself. Diagnosis and treatment are becoming more sophisticated. This is also the case for crime detection and investigation, with technical advances in surveillance and forensics. New diseases emerge, such as HIV/AIDS, or evolve historically, such as influenza. The same can be said for crime. For example, consider the changing preferences in illicit drugs and the evolution of the manufacture of synthetic drugs, or the emergence of online scams and the evolution of face-to-face confidence tricks. There are also policy and management parallels. Pandemics and terrorism have much in common in that they require both global and local approaches. Prevention of disease and prevention of crime are also both widely acknowledged as being key, since just focusing on better detection and treatment of disease or better crime detection and conviction rates will only lead to further overburdening hospital and prison systems. Further, neither disease nor crime will ever be able to be completely eradicated, so the prioritisation of resources requires careful evaluation and justification.

There is plenty of disparity as well. Sickness usually is not planned, but crimes often are. Disease often has a biological basis that is well understood, which allows for specific cures to be developed for specific diseases. Crime on the other hand, may be a result of many factors related to human behaviour. The 'cure' may never be clear cut. Patients want to get better, and therefore, usually provide information, undergo tests, agree to various treatment options. Criminals do not want to be caught, and are rarely willing to provide substantial information, leading to it being gathered through other means such as coercive powers requiring witness protection. Doctors often have established protocols to follow, but police may have more discretion in pursuing an investigation, depending on resources and priorities.

Challenges

Scepticism abounds

Unfortunately, just the mere mention of the word ‘statistics’ is enough to raise some suspicion, but there is particular scepticism related to ‘crime statistics’. This is from both outside and within the policing profession. The community tend to lose confidence on hearing reports of police focusing on low end crimes to meet performance targets. Police lose confidence in management if they feel that their efforts are not accurately reflected in official figures.

The public also lose faith in the police service when official crime figures and trends do not match their perceptions regarding the incidence of crime. Official figures show that crime is trending downwards, but the public are influenced by repeated media reports of crime in their cities, on their doorsteps. As Carmen Lawrence (2010) also describes in her chapter, fear of crime becomes out of proportion with actual risk. Innes (2004) has examined the relationship between media reporting of crime and public perceptions of risk and postulates that certain incidents or ‘signal crimes’ have particular impact. So it is not surprising that there is a discrepancy between recorded crime and public perception.

We see it in Australia on a regular basis; most recently in the state of Victoria, resulting in an inquiry by the State Ombudsman, (Brouwer 2009), described in more detail below, but also previously in New South Wales (Dixon 2005). Similarly in Britain, where official crime statistics indicated a reduction in overall crime and violent crime in 2007–08 in England and Wales (Kershaw et al. 2008), the public were increasingly concerned about personal safety in the light of many reportedly random and apparently unprovoked knife attacks. Interestingly, the 2008–09 figures published recently (Walker et al. 2009) still do not show any upward turn in overall or violent crime statistics.

Apples and oranges

The State Ombudsman’s report on an investigation into the validity of crime statistics in Victoria (Brouwer 2009), which was tabled in the Victorian Parliament, was a response to concern that the crime figures and police numbers were being distorted. The Ombudsman found that there was underreporting of crime due to both poor recording practices and inadequate data systems. He concluded, however, that there was no systematic, deliberate manipulation of the data. Nevertheless, much public debate ensued, reflecting not only that this is a particularly sensitive topic for the public, government and police alike, but also that there are complexities that need to be understood. One of the complicating factors is recurrent in Australia where the various states and

territories do not all do things in the same way. This is especially so in policing, with eight separate police forces plus the Australian Federal Police. Until 2008 the Victorian police used different criteria from the other jurisdictions to record crime in their databases. Most states use a *prima facie* system in that essentially, all crime reported is recorded, but Victoria previously used an 'evidentiary' system where only the crime with evidence was recorded. Inconsistencies and administrative changes such as these invalidate comparisons between jurisdictions and across time.

The Australian Bureau of Statistics (ABS) plays an important role in compiling and promoting nationally consistent data. They produce data on offenders, victims, courts, prisoners and corrective services under the National Criminal Justice Statistical Framework which was first released in 2001 (ABS 2007). One of the coding systems of particular relevance to the topic of serious crime is the National Offence Index (ABS 2009). It is an ordinal ranking of offences by perceived seriousness; from traffic offences to murder (with approximately 150 other crime types in between these). It is used to determine a principal sentence if multiple offences occur and ensures nationally comparable offence information from across jurisdictions.

Underestimation adds to uncertainty

Underreporting of crime is a major source of uncertainty and a root cause of much of the concern regarding crime statistics. This is widely acknowledged and referred to universally as the 'dark figure' of crime (Biderman & Reiss 1967). Underestimation occurs through lack of detection, underreporting by the public and underrecording by the police. It impacts on official crime statistics. This has led to the augmentation of police-recorded crime statistics with surveys of the general public (generally referred to as crime victim surveys) or surveys of offenders. The gaps between the police-recorded statistics and the self-reported statistics of victims or offenders are marked, but depend on the type of crime. For example, Clare and Morgan (2009) noted that only 31% of assaults were reported to the police in Australia in 2005, but they also highlight that this may depend on the victim's perception of the act as a criminal event. There are many other methodological issues with these types of surveys. For example, the survey sample needs to be large enough to provide reasonably accurate estimates for relatively rare crimes. The sampling frame needs to be sophisticated enough to address the problem that the people who are most likely to be victims are probably the least likely to be in a position to participate in a survey.

Key examples of these kinds of surveys are the British Crime Survey in the United Kingdom and the National Crime and Safety Survey conducted by the Australian Bureau of Statistics. There is also the International Crime Victims

Survey coordinated by several European countries and by the United Nations Interregional Crime and Justice Research Institute (Van Dijk et al. 2007). The United Nations Office on Drugs and Crime also promotes the cross-national collection of statistics on a different group of crimes such as bribery/corruption, fraud and extortion in both the private sector (Crime and corruption business surveys) and the public sector (Corruption/integrity surveys). For an example, see Alvazzi del Frate (2007). In Australia, the first national Personal Fraud Survey was conducted in 2007 (ABS 2008). It was estimated that 5% of the adult population had been a victim of a personal fraud—3% through identity fraud and 2% by responding to a scam such as lotteries, pyramid schemes or phishing.

These surveys, however, still have limitations in terms of scope. They do not include children, and yet children are often the targets of very specific, serious crimes, such as sexual exploitation and underage labour. The surveys also do not cover the problem of estimating the magnitude of so-called ‘victimless’ or ‘consensual’ crimes where there is unlikely to be a complainant. These include not only activity in contravention of the law in which the main impact is on the perpetrator (e.g. illicit drug use and prostitution), but also other crimes against the state or government when there is generally no single, direct victim. Examples include the trafficking and importation of illegal drugs, sale of pornography, illegal gambling, immigration crime, intellectual property crime, piracy, terrorism and all aspects of organised crime such as money laundering and corruption.

Indeed, the dark figure of crime just gets ‘murkier’ once we move into the realm of trying to estimate the incidence and impact of serious and organised crime. The lack of victims or complainants in this area of crime is highlighted in the Witness Protection Report by the Parliamentary Joint Committee on the National Crime Authority (1988).

In summary, there are difficulties in demonstrating the effectiveness in policing through difficulties in obtaining accurate and valid estimates of crime incidence. Despite the wide availability of administrative police databases and survey information, both nationally and internationally, these are limited by problems of scope and coverage, as well as inconsistent definitions across jurisdictions.

Advances

Mapping

One broad area of successful application of statistical techniques in policing (as well as public health) is in geospatial analysis. This involves plotting crime incidents by location and formally comparing the incidence of events by their spatial distribution to identify hotspots of criminal activity. This is either done for individual incidents (point based) or for aggregate data in pre-defined geographical units (area based), for example, precincts or local government areas. Crime mapping—and using it to target police responses—was one aspect of an entire police management strategy referred to as CompStat that was developed by the New York City Police Department. That strategy was associated with marked decreases in community crime statistics at the time (late 1990s). Since then, it has been applied in many locations, including the Australian Capital Territory, New South Wales and Queensland (Ratcliffe 2008, Mazerolle & Rombouts 2007). To date, the main application appears to have been used in localised community policing.

An interesting new spatial application that could ultimately have an impact on policing is the analysis of waste water in order to map the patterns of illicit drug use. This is achieved through the detection of drugs and their metabolites in sewerage (Frost & Griffith 2008) and is already being trialled in Europe.

The Australian Federal Police is currently employing geospatial techniques to characterise the movement in and out of Australia of funds associated with criminal activity. Understanding money flows is a key strategy in addressing organised crime groups. The aim of this work is to identify financial hotspots in Australia and offshore, profile different routes for different crime types and establish a benchmark that can be monitored over time.

Cluster analysis

Clustering is a multivariate data analysis technique that has many applications in the policing arena apart from the geospatial analysis described above. Cluster analysis classifies individual data items into groups which have similar characteristics. The Australian Federal Police are currently funding research applying this technique to fraud data (Higginson 2009), with the aim of characterising fraud against Australian Commonwealth agencies comparing it to fraud in relation to individuals or businesses. The data analysed includes the size and context of the offences and information about the offenders. This is

part of a larger research project that also looks at how to best monitor activity related to fraud investigations, identifying factors which predict successful prosecution.

Process control

Statistical process control has traditionally been applied in industry to ensure that consistent quality is maintained in a production process. Statistical models are used to estimate variation in time series and thereby differentiate unusual occurrences from normal behaviour. The Australian Federal Police has invested in research applying these techniques to monitor its own activity and performance (Haynes et al. 2007). The benefit of this application is that variation in monthly series of case counts, drug seizures or other performance indices can be assessed graphically to either dismiss or investigate unusual data points and also address longer term trends. The control charts typically consist of a time series plot of monthly data, which displays considerable variability around an average level of activity. A control area within which 95% of the data is expected to occur is also provided on the plot (Figure 1). The control limits are based on a comparison period or reference period (generally a period of up to five years' historical data, for example within the vertical dashed lines in Figure 1). Any points outside the control limits are identified as outliers. Any variation within the control limits can be effectively discounted as within expected limits of statistical random variation. From a statistical point of view some difficult problems were addressed in this work. The usual application of this technique is based on the standard normal distribution, however certain series, such as drug seizures and proceeds of crime, were skewed. Different probability distributions, such as the negative binominal and gamma distributions, provided a much better fit to the data.

Descriptive statistics

Not all statistical applications in policing need to incorporate high-powered statistical models. In 2008, a descriptive summary was compiled to establish a statistical profile of online child sex offenders. This was based on a survey of offenders completed by the investigating officers and was aimed at characterising the socio-demographics of the offenders, the content of the child exploitation material and the means by which the offences occurred. This consisted primarily of tabulations, straightforward graphical presentations and chi-squared tests on two-way tables (testing independence between two factors/characteristics). The outcome of this research is to assist investigators in this area, particularly in terms of detection, to inform prevention strategies and policy initiatives. The research is ongoing in the sense that the profiling will be

more accurate when expanded to a larger and more representative sample using the same questionnaire. Indeed, the results have been shared in international fora and there is collaboration with other researchers to contribute to a meta-analysis relating to criminal history and risk of offender recidivism. These data summaries will be used to contribute to further research to understand the likelihood of, and the triggers for, progression from online offending to actual sexual assaults of children.

Figure 1: Control chart showing reference period (within the dashed vertical lines) and 95% control limits (upper and lower horizontal lines). This is a generic plot where the y-axis could be cases, drug seizures or any other variable of interest.

Graphs

Graphs are another basic tool that should not be underestimated in terms of how to convey a clear message from a mass of information. They are one of the key components of the Australian Federal Police’s current approach to building an operational planning tool for prioritisation of serious organised crime targets, referred to as the target enforcement prioritisation index (TEPI). Figure 2 is a simplified depiction of a typical plot.

Each target is rated on two different types of factors: first, the elements that indicate the potential effectiveness of the organised crime target, such as resources, skills and relationships. This is the target dimension (the vertical axis). Second, the law enforcement dimension is made up of the elements that influence law enforcement decision-making, such as investigational complexity, cost, risk, likelihood of success, value to agency and external direction (the horizontal axis). These two dimensions form the x-y coordinate space for comparing different potential targets. The total of the individual target ratings is plotted against the average enforcement rating (the large square symbols in Figure 2). The five component enforcement ratings are also depicted along the total target level (asterisks in Figure 2). The targets most likely to be prioritised will score highly along both dimensions and lie in the upper right hand or 'glory' quadrant. On the other hand, low priority targets will have low scores on both scales (the lower left or 'barge pole' quadrant). The most interesting quadrant is the upper left and is referred to as the 'Call for volunteers' quadrant. Targets within this quadrant may need to be investigated due to their high target value, but they present organisational challenges that require consideration and treatment. A single graph can be used to compare multiple targets (as in Figure 2), trace the progress of a target as new information is incorporated, conduct sensitivity analysis on the source data making up the scales or identify intelligence gaps between the estimated position (on the graph) and other positions predicted by other sources or agencies.

Figure 2: Simplified graphical presentation of priority index information for two separate potential targets using a TEPI model being developed by the Australian Federal Police

Discussion

The role of statistics in addressing uncertainty associated with policing crime is achieved through the systematic collection, analysis and presentation of data associated with crime.

There are major parallels between the application of statistics in public health and medicine and the application of statistics in policing. Unfortunately, this does not extend—to any great extent—to convenient study designs such as randomised controlled trials of different policing strategies. However, policing could benefit from having a stronger evidence base, closer links between research and practice, developing standardised classification systems, collaboration across jurisdictions, both nationally and internationally, and looking at cost-benefit analysis of prevention strategies. This would assist with informing policy, ensuring effective interventions.

But what about serious crime? The wins from a statistical perspective are harder to show. Statistics generally come into their own when there is too much data to deal with manually, which is often not the case for serious crime. Graphs provide a relatively simple way of understanding data which is otherwise inaccessible through sheer size or complexity. Exploratory data analysis, mapping, and simple descriptive statistics all help to elucidate patterns that are hidden in large data sets. However, in many cases, we just do not have the data to work with, either in the sense that the events are sparse (terror attacks), difficult to classify consistently (disruption of organised crime activity), difficult to detect (people smuggling), there are no complainants (drug trafficking, organised crime), or the data are generally only accessible through liaison with other agencies (cyber-crime, drug importation). By highlighting the difficulties in accurately estimating the incidence of criminal activity, I have shown that statistics can also add to uncertainty. Measuring police performance in terms of changes in criminal activity is therefore fraught with difficulty.

Nonetheless, there are several examples of the successful application of standard statistical techniques in the context of serious crime, such as following money trails through mapping, characterising clusters of fraud or child sex offenders and providing graphical images to steer management decisions on prioritisation and performance monitoring. Further application is merely a matter of persistence and imagination.

Disclaimer: These are the views of the author and do not necessarily represent the official position of the Australian Federal Police.

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